APPENDIX B:

PRELIMINARY DESIGN REPORT (INCLUDING DESIGN DRAWINGS)

GARDEN CITIES NPC

BAYSIDE CANAL OUTFALL UPGRADE INTERVENTIONS

30964.13/BB-REP-003 REV3

PRELIMINARY DESIGN REPORT

APRIL 2018

PREPARED FOR:

PREPARED BY:

GARDEN CITIES
PO BOX 166
EDGEMEAD
7407

BVi CONSULTING ENGINEERS WC (PTY) LTD
BLOCK B2, EDISON SQUARE,
C/O EDISON WAY & CENTURY AVENUE
CENTURY CITY
CAPE TOWN
7441

ISSUE & REVISION RECORD

QUALITY APPROVAL

	Capacity	Name	Signature	Date
By Author	Project Engineer	Zakiti Bhengu		26/04/2018
Approved by Design Centre Leader	Project Director	Sampie Laubscher		26/04/2018

This report has been prepared in accordance with BVi Consulting Engineers Quality Management System. BVi Consulting Engineers is ISO 9001: 2008 registered and certified by NQA Africa.

REVISION RECORD

Revision Number	Objective	Change	Date
0	Issued for comments and approval	None	13/04/2016
1	Incorporate comments from EPA	Additional intervention investigated, key sections clarified	22/07/2016
2	Incorporate comments	Comments from Municipal Officials and Table Bay Nature Reserve Advisory Committee investigated and clarified	11/04/2017
3	Additional information added	Comments on Rev 2 addressed	26/04/2018

APPROVAL RECORD

	Name	Capacity	Signature	Date
City of Cape Town				

EXECUTIVE SUMMARY

The capacity of the Bayside Canal is severely compromised by extensive reed growth downstream of the canal's outlet. The aim of this project is to obtain Environmental Authorisation for the best option to increase the capacity of the Bayside Canal stormwater outfall and to provide treatment facilities to also address the quality of the stormwater discharged into Rietvlei. This Report deals with the engineering aspects related to the investigations and preliminary design of the interventions required to alleviate the abovementioned issues.

Bayside Canal runs along the western boundaries of two shopping centres: Bayside Mall and Table View Mall. The open canal serves as the only stormwater outfall culvert for a large catchment that includes West Beach, a large portion of Table View as well as existing and new developments in Parklands and Sunningdale.

BKS (2009) conducted a study on this outfall system, they brought forward a number of recommendations to improve the system and most of these were implemented. The study also found that although the canal has the hydraulic capacity to handle a 1 in 50 year storm, the water levels in Rietvlei contribute significantly to the reduced available capacity in the lower part of the canal. This was further confirmed in the BVi (2014) report where a survey was conducted and found that the water level in the canal upstream of the sewage pump station is higher than the water level in the water sport area of Rietvlei. It was found that the water level difference is caused by dense reed growth at the Bayside Canal outlet. The reed growth impedes discharge of stormwater and causes surcharges upstream.

Five interventions were investigated in order to alleviate the backwater and capacity problem in Bayside Canal as follows:

Intervention 1 investigated reducing stormwater runoff entering Bayside Canal by diverting stormwater flows from the northern-most development of the catchment (Sunningdale Phase 12A and Phase 13-15) to the Big Bay outfall, thereby reducing the catchment size and total runoff entering Bayside Canal.

Intervention 2 investigated reducing peak flows at Bayside Canal by increasing stormwater attenuation facilities of new developments in Sunningdale and Parklands. This also included an investigation to utilise the full capacity of existing detention ponds in Table View, the Grey Avenue pond was identified as a possible intervention. For all new developments in Sunningdale and Parklands, detention facilities have been designed and constructed to allow a permissible runoff discharge of 5.6 ℓ/s/ha for all storm events up to the 1 in 100 year storm. 5.6 ℓ/s/ha is an improvement to the 1 in 2 year storm pre-developed runoff of 6.7 ℓ/s/ha.

Intervention 1 and 2 were previously identified and investigated as options in the Stormwater Master Plan compiled by BVi (2014). These interventions were adopted and are currently being implemented. Environmental Authorisation has already been granted for the Big Bay stormwater outfall extension to Sunningdale (Intervention 1). The combined effect of Interventions 1 and 2 will result in the reduction of peak flows entering the Bayside Canal by 3.16 m^3/s for a 50 year storm event and 3.31 m^3/s for a 100 year storm event. This reduction of peak flows would assist in relieving pressure on the Bayside Canal, however further intervention is required to solve the capacity problem at the outlet.

Three additional engineering interventions have been identified and investigated to further address these concerns, as illustrated in **Figure A.** These can be summarised as follows:

Intervention 3 investigated further reduction of the total stormwater runoff entering Bayside Canal by diverting the flows from the West Beach catchment away from the canal for discharge into the Waves Edge wetland or directly into Rietvlei. It was found that a high water level in Rietvlei would cause water to back up into the Waves Edge wetland and ultimately up the outfall culverts. The diverted flows coming from upstream would surcharge and discharge onto the surface leading to the flooding of immediate property. This poses an imminent threat to the surrounding property. It was also found that only part of the West Beach flows (runoff for the 5 year storm event) can be diverted, all flows exceeding this capacity would still have to pass on to the Bayside Canal. The estimated cost for this diversion is **R 32 450 000** (incl. VAT).

Intervention 4 also investigated reducing the total stormwater runoff entering Bayside Canal by diverting the runoff from the Table View catchment away from the canal and along new culverts in Pentz Drive discharging to the proposed Rietvlei stormwater treatment ponds. Similarly to Intervention 3, only a portion of the Table View flow can be diverted and all flows exceeding this capacity would still have to be passed on to the Bayside Canal. A high water level in Rietvlei would also cause water to back up in the culverts. The diverted flows coming from upstream would create pressure and cause the stormwater to surcharge and discharge onto the surface via manholes and catchpits along Pentz Drive. This would also lead to the flooding of immediate property. This intervention would also require construction to take place in an already fully developed and occupied residential and commercial area. Working space for construction would be very limited and the accommodation and relocation of existing services would be a major constraint. The estimated costs for this intervention is **R 42 350 000** (incl. VAT).

Intervention 5 investigated increasing the capacity of the Bayside Canal by clearing and lining the side slopes of the canal. It was found that, with the flow path being cleared and the side slopes lined, the stormwater runoff from 50 year RI and 100 year RI storm events can be accommodated without flooding the Table View Mall site. Intervention 5 also investigated installing a trash collection facility to capture solid waste by installing a floating boom; constructing sedimentation ponds; and compartmentalising the existing reed beds into successive ponds for the treatment of stormwater runoff. A bypass channel running parallel to the reed beds is further proposed to act as an escape route around restrictions for major storms (storms greater than the 50 year RI) to flow freely to Rietvlei. The bypass canal would reduce the risk of flooding upstream property.

The cost of implementing Intervention 5 is estimated to be **R 50 155 000** (incl. VAT). This allows for the construction of the bypass channel, clearing and lining of the Bayside Canal side slopes at an estimated cost of R 30 055 000 (incl. VAT), as providing floating booms to intercept litter and for construction of the reed bed pond system at an estimated cost of R 20 100 000 (incl. VAT).

Based on the investigations, Intervention 3 and 4 are not supported due to technical and financial constraints. Intervention 5 is the preferred option in terms of the fundamental objectives of the project:

- Alleviating the backwater and allow the canal to drain fully;
- Increasing capacity of the Bayside Canal south of Blaauwberg Road;
- Providing a bypass channel where high order storms can directly discharge into Rietvlei without flooding the Bayside Canal;
- Reducing the reed growth while ensuring good water quality at the Rietvlei water sport area;
- Providing facilities to remove litter and trash from the stormwater and improvement of quality stormwater discharged to Rietvlei.

Intervention 5 can be implemented in two phases:

- **Phase 1** consists of clearing and lining of the side slopes of Bayside Canal between Blaauwberg Road and the reed beds, the construction of a control weir and bypass channel, and the installation of a floating boom to trap floating litter and trash up stream of the overflow weir.
- **Phase 2** consists of organising the existing natural reed beds by clearing, construction of earth berms to form ponds, organise flow patterns and provide access for operation and maintenance of the reed beds, and the construction of sedimentation ponds as pre-treatment of stormwater.

DATE	INITIAL	No./CODE	REVISION DESCRIPTION
19/07/2016	ZB	A/D	FOR PRELIMINARY DESIGN REPORT
27/02/2017	ZB	B/D	BYPASS CHANNEL UPDATE
26/04/2018	ZB	C/D	UPDATED DRY-VEGETATION RIDGE

CLIENT

CESA

bvi ENGINEERING PROCUREMENT MANAGEMENT

INCORPORATING basil nair and associates consulting mechanical engineers

Western Cape — Cape Town — (021) 527-7000 — cpt@bviwc.co.za

Registration no. 1998/000157/07

PROJECT

UPGRADE OF THE BAYSIDE CANAL OUTFALL

DRAWING TITLE

BAYSIDE CANAL OUTFALL INTERVENTIONS

APPROVED BY BVI

ENGINEER/TECHNOLOGIST | REG. NO. | DATE

SCALE	1 : 5 000 @ A3	DRAWN	ZB
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SECTION 1- INTRODUCTION

1.1 BACKGROUND

Garden Cities act as Agent for the City of Cape Town to obtain Environmental Authorisation for improvements and upgrading of the Bayside Canal stormwater outfall which is currently experiencing capacity problems due to backwater in the lower portion of the canal. This is largely caused by extensive reed growth downstream of the canal outlet.

The Bayside Canal is also experiencing an accumulation of litter and solid waste along the canal invert (possibly originating from the adjacent business centres), this waste eventually ends up in the reeds at the outlet creating an eyesore and a threat to the water quality at Rietvlei.

Garden Cities appointed BVi Consulting Engineers to undertake the necessary engineering work to investigate interventions required to address the abovementioned issues. Environmental Authorisation for the implementation of the proposed interventions would be required and an investigation documented in a preliminary design report would form part of the Basic Assessment.

1.2 PROJECT BRIEF

The aim of the project is to obtain Environmental Authorisation for the best option to increase the capacity of the Bayside Canal stormwater outfall and to provide treatment facilities to improve the quality of the stormwater discharged into Rietvlei.

The aspects requiring investigation are as follows:

- Determining the total catchment served by the Bayside Canal outfall;
- Investigating possible measures to reduce stormwater runoff entering the Bayside Canal;
- Assessing the existing canal capacity and investigating measures to increase this;
- Assessing the effect of extensive reed grow at the canal outlet and mitigation thereof; and
- Improving the quality of stormwater discharged into Rietvlei.

1.3 OBJECTIVES

This report serves to provide engineering input for a Basic Assessment conducted by CCA Environmental. The objectives of this report are outlined as follows:

- Assess and provide recommendations to improve the current situation at Bayside Canal by reducing flows and/or increasing capacity to safeguard upstream properties against flooding;

- Assess and provide recommendations to reduce the negative impact of reed growth on the capacity of the canal while ensuring good water quality at the Rietvlei water sport area; and
- Assess and provide recommendations to address solid waste pollution in the canal and at the canal's discharge point to prevent suspended matter from reaching the Rietvlei Water Body.

SECTION 2- PROJECT BACKGROUND

2.1 BAYSIDE CANAL AND CATCHMENT SERVED

The Bayside Canal runs along the western boundaries of the two shopping centres, Bayside Mall and Table View Mall. The open canal serves as the only stormwater outfall culvert for a large catchment that includes West Beach, a large portion of Table View as well as new developments in Parklands and Sunningdale, as indicated in **Figure 2-1**. The total area served by Bayside Canal is approximately 1 540 Ha.

2.2 UPGRADING OF THE BAYSIDE CANAL: PRELIMINARY REPORT BY BKS (2009)

Aecom (formally BKS (Pty) Ltd, and henceforth referred to as BKS) was appointed by the City of Cape Town (Roads and Stormwater) to assess and provide recommendations regarding the hydraulic capacity of the Bayside Canal. This was commissioned following flooding incidences at the canal during high order storms and also to address pollution concerns within the canal.

BKS used a software package, PC-SWMM, to model stormwater flows for the following three development scenarios for the Blaauwberg catchment (see **Annexure A** for the stormwater flows for each scenario):

- **Existing Infrastructure**: this determined the stormwater runoff for the then existing development in 2009.
- **Fully Developed Infrastructure**: this determined the stormwater runoff where all the planned development frameworks are fully constructed (Sunningdale, Parklands and Sandown), including the then planned detention facilities.
- **Upgraded Infrastructure**: this determined the stormwater runoff for the fully developed system however with the following upgrades put in place to increase the available capacity at the Bayside Canal:
    - Flow restrictions were implemented along the Sunningdale Canal and Eskom Servitude Canal in order to reduce flows and utilise the upstream detention capacity;
    - An additional culvert was installed at the Blaauwberg Road crossing to alleviate flow restrictions which caused a backwater effect upstream and elevated flooding levels;
    - The Bayside Canal capacity downstream of Blaauwberg Road was improved by reshaping and landscaping portions of the canal as shown in **Annexure B**.

The BKS study found that, although the Bayside Canal has the hydraulic capacity to handle the runoff of a 1:50 year storm, the water levels in the Rietvlei contribute significantly to the available capacity in the lower part of the canal.

The water levels in Rietvlei, in turn, are impacted upon during the rainy season by the increased flows in the Diep River and by stormwater discharged from the upstream urban catchments of Table View, West Beach, Sunningdale and Parklands. Rietvlei acts as a large detention facility where the water level rises after storm events but drops gradually as Rietvlei drains out to the Milnerton Lagoon. The water level in Rietvlei at any given time is a function of a number of factors, of which the flood runoff from the upstream Diep River catchment plays the predominant role.

The water level in Rietvlei for extreme storm events with a return interval of 50 and 100 years was applied to determine floor levels of buildings adjacent to Diep River, Rietvlei and Milnerton Lagoon as laid down in the Water Act. The highest water level is produced approximately 24 hours after the start of the storm event, this is when flood water from the furthest point of the larger Diep River catchment (Malmesbury) reaches the Rietvlei. By then, the discharge from the smaller Bayside Canal catchment for that storm event has already been absorbed in Rietvlei. In light of this, it would be unrealistic to use the high water level created by a 1:50 year storm from the Diep River catchment for testing the capacity of the Bayside Canal for another 1:50 year storm event.

A more realistic approach was taken by BKS who considered the joint coincidental probability of two storm events in the Bayside Canal and the Diep River occurring at the same time to adequately determine the backwater effect of the Rietvlei on the Bayside Canal. In the BKS report it was noted that a short duration storm, which causes peak discharges on a small catchment such as for the Bayside Canal catchment, may not be critical for the larger Diep River catchment. If the same storm causes a peak discharge on both catchments, the peaks would be out of phase due to the catchment areas being different in sizes. The time to peak for each drainage area would be different, the peak flow from the small catchment would have passed before the peak flow from the large catchment would have maximum impact.

Based on the above, BKS used the approach as outlined in the Urban Drainage Design Manual (Hydraulic Engineering Circular (HEC) No. 22) of the Federal Highway Administration of the United States Department of Transport (FHWA, 1996) to adopt frequencies for coincidental occurrences in Diep River/Rietvlei and Bayside Canal as follows:

Table 2.1: Frequencies for Coincidental Occurrence (BKS, 2009)

	Diep River Catchment Main Stream (Diep River)		**Bayside Canal Catchment** Tributary (Bayside Canal)
Catchment Size Ratio	**122**		**1**
Scenario 1	1:10 year Return Interval 10% Probability	Rietvlei Flood Level 3.49m MSL	1:50 year Return Interval 2% Probability
Scenario 2	1:25 year Return Interval 4% Probability	Rietvlei Flood Level 3.90m MSL	1:100 year Return Interval 1% Probability

In Scenario 1, a 10 year RI storm event in the Diep River catchment would result in a water level of 3.49m MSL at Rietvlei. In Scenario 2, a 25 year RI storm event in the Diep River catchment would result in a water level of 3.90m MSL at Rietvlei. Scenario 2was used for modelling the stormwater runoff for Bayside Canal outfall as this was seen as the worst case scenario. The water level at Rietvlei was kept at a constant 3.90m MSL while all storms of up to a 1:100 year Return Interval were modelled for the Bayside Canal.

2.3 CENTRAL AND WESTERN BLAAUWBERGSTORMWATER MASTER PLAN BY BVi (2014)

BVi updated the BKS stormwater model to reflect the fully developed catchments of future and existing development frameworks in Sunningdale, Parklands and Sandown. The permissible stormwater discharge for the new developments was further reduced from 6.7 ℓ/Ha/s (as per the approved Stormwater Master Plan prepared by CIVtech, 2008) to 5.6 ℓ/Ha/s. This resulted in the increase of detention capacities.

The stormwater networks of the new developments, with reduced permissible stormwater discharge and increased detention facilities, were incorporated in the updated model. This model showed that the ultimate flow in the Bayside Canal would be reduced with additional detention facilities provided in the new developments**.**

In the BVi Stormwater Master Plan Report (2014), two post-developed scenarios were tested with the stormwater model. The first scenario allows the runoff from the new Sunningdale development (Phase 12 to 15) to discharge into the Bayside Canal outfall, while the second scenario entailed discharging a portion of this runoff to the existing Big Bay outfall. The model showed that the Bayside Canal can theoretically accommodate both scenarios, however the second scenario provided relief for the canal due to the reduced runoff.

BVi also found that the capacity of the Bayside Canal is governed by the water level in the wetland at the discharge point. A survey of the Bayside Canal was conducted for the BVi Report (2014) and it indicated that the water level in the canal upstream of the sewage pump station is higher than the water level in the water sport area of Rietvlei. It was found that the water level difference is caused by dense reed growth at the Bayside Canal outlet. The reed growth impede discharge of stormwater and causes surcharges upstream. The reeds extend above the water levels and would therefore also prevent a clear passage for large stormwater flows. Refer to **Annexure C** for the survey and longitudinal section showing water levels at Bayside Canal.

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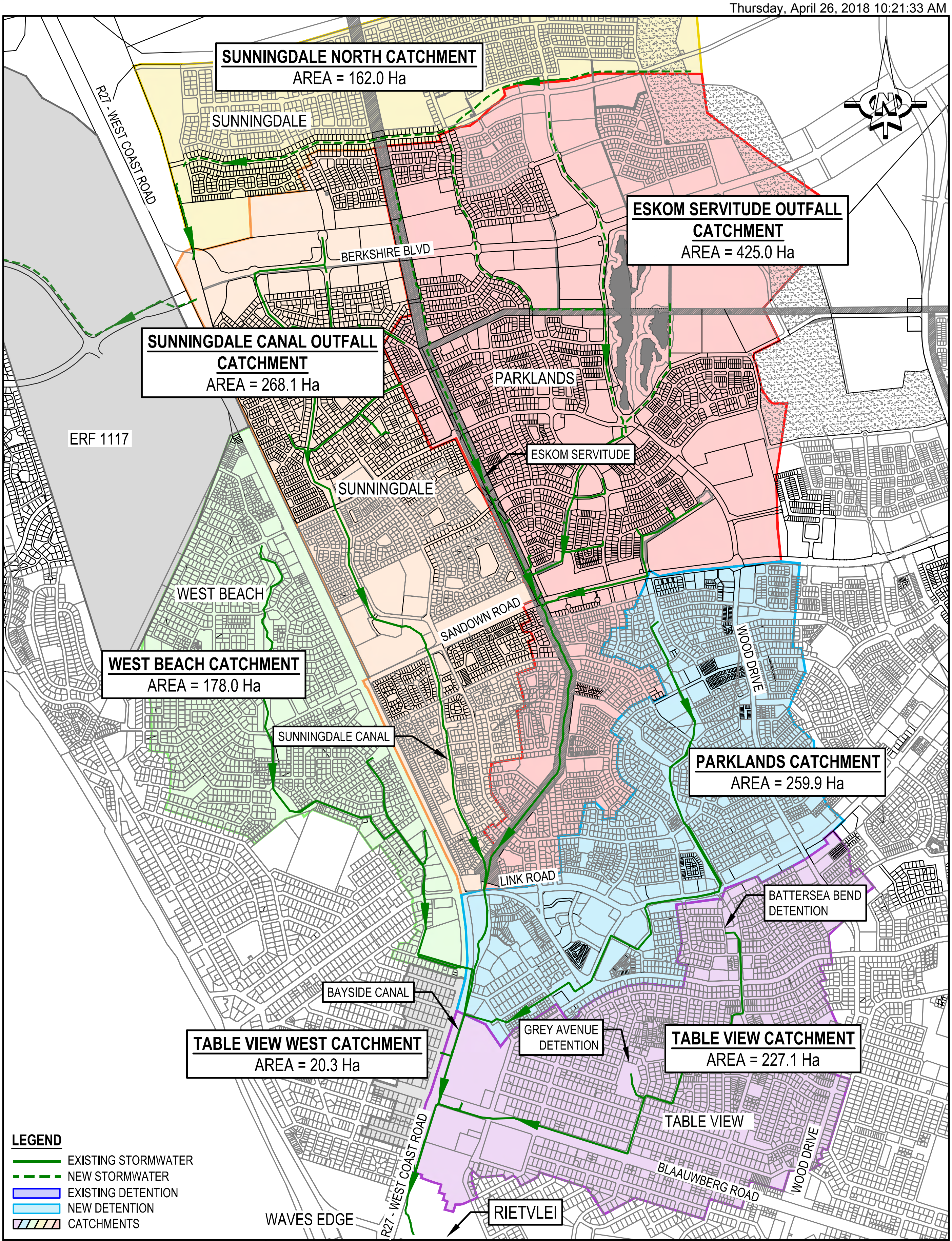

bvi ENGINEERING PROCUREMENT MANAGEMENT; INCORPORATING basil read and associates; CESA	PROJECT: UPGRADE OF THE BAYSIDE CANAL OUTFALL	APPROVED BY BVi: ENGINEER/TECHNOLOGIST, REG. NO., DATE	
	DRAWING TITLE: CATCHMENTS OF BAYSIDE CANAL OUTFALL	SCALE: 1 : 25 000	DRAWN: ZB
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2.4 OPTIONS IDENTIFIED TO ADDRESS THE CAPACITY PROBLEM AT THE BAYSIDE CANAL

For the preparation of this preliminary design report, provisional engineering solutions were identified by BVi to address the litter and capacity problems at the Bayside Canal. The provisional solutions were briefly investigated and presented to the Client, City of Cape Town representatives, freshwater specialists, heritage specialist and botanical specialist. The purpose of this was to receive input from the various parties, address major concerns and make the necessary alterations prior undertaking thorough investigation of each solution.

Five solutions, henceforth referred to as interventions, were identified as reflected in **Figure 2-2**:

2.4.1 Intervention 1: Reduction of Bayside Canal Outfall Catchment

The objective of this intervention is to reduce the stormwater runoff entering the Bayside Canal by reducing the catchment. This entails diverting stormwater runoff from the northernmost portion of the catchment (Sunningdale Phase 12 to 15) to the Big Bay outfall.

2.4.2 Intervention 2: Reduction of Permissible Stormwater Discharge

The objective of this intervention is to reduce stormwater peak flows by increasing stormwater attenuation upstream the Bayside Canal. This entails constructing larger detention facilities in the new developments of Sunningdale, Parklands and Sandown, and introducing new detention facilities at Grey Avenue in Table View.

2.4.3 Intervention 3: West Beach Stormwater Diversion

The objective of this intervention is to reduce the total stormwater flows entering the Bayside Canal by diverting the stormwater runoff from the West Beach catchment and discharging directly into one of two possible outlet points.

The provisional design entailed intercepting the flow in the existing stormwater pipe in Rose Innes Road and diverting the runoff to a new culvert that would be laid underneath the existing NMT lane along the western boundary of the R27.

2.4.4 Intervention 4: Table View Stormwater Diversion

The objective of this intervention is to reduce the total stormwater flows entering the Bayside Canal by diverting the stormwater runoff from the Table View catchment to the east and discharging it directly into Rietvlei.

The provisional design entailed intercepting the flow coming from the 1500mm diameter pipe, running east-to-west in Blaauwberg Road, and diverting it into a culvert that may follow three possible routes to the Rietvlei stormwater treatment ponds proposed in Intervention 5.

2.4.5 Intervention 5: Rietvlei Stormwater Ponds and Bayside Canal

The objective of this option is firstly to increase the canal's capacity and secondly to address the litter problem and improve water quality. The provisional design consist of the following components:

- Lining of the Bayside Canal from Blaauwberg Road southwards;
- Reducing the reed growth at the canal's discharge point to Rietvlei;
- Installing a trash collection system, i.e. a screen structure;
- Constructing a stormwater pond system which includes sedimentation ponds and large reed bed ponds; and
- Constructing a new bypass channel for high order storms adjacent the pond system.

DATE	INITIAL	No./CODE	REVISION DESCRIPTION
13/04/2016	ZB	A/D	FOR PRELIMINARY DESIGN REPORT
18/07/2016	ZB	B/D	REVISED FOR PRELIMINARY DESIGN REPORT
27/02/2017	ZB	C/D	UPDATED DRY-VEGETATION RIDGE
26/04/2018	ZB	D/D	UPDATED DRY-VEGETATION RIDGE

CLIENT

CESA

bvi ENGINEERING PROCUREMENT MANAGEMENT

INCORPORATING basil nair and associates consulting mechanical engineers

Western Cape — Cape Town — (021) 527-7000 — cpt@bvi.co.za
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PROJECT

UPGRADE OF THE BAYSIDE CANAL OUTFALL

DRAWING TITLE

SUMMARY OF INTERVENTIONS

APPROVED BY BVI

ENGINEER/TECHNOLOGIST — REG. NO. — DATE

SCALE	1 : 5 000 @ A3	DRAWN	ZB
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SECTION 3- BASELINE REPORTS FROM SPECIALISTS

3.1 FRESHWATER SPECIALIST

The Freshwater Specialist conducted a baseline study with reference to the engineering options prepared by BVi and the following was found with regards to Intervention 3 to 5:

Intervention 3: West Beach Stormwater Diversion

The study found that the sedge open water pans at the Marine Drive/R27 Intersection (henceforth called the Waves Edge wetland) contain unique characteristics that may be altered by the additional stormwater from the West Beach catchment. It was therefore recommended that the wetland be bypassed and the runoff be discharged directly into Rietvlei. Further investigation of the sensitivity of the wetland would be done for the Basic Assessment.

Intervention 4: Table View Stormwater Diversion

It was found that a diversion of stormwater along Pentz Drive with a discharge point at the north-eastern corner of the proposed pond system would have a low impact on the existing Rietvlei.

Intervention 5: Rietvlei Stormwater Ponds and Bayside Canal

The direct habitat loss impacts with regards to upgrading the canal are likely to be low and can be easily mitigated. It was recommended that the kikuyu grass that has invaded the area be removed and the Typha bulrushes not be replanted.

Construction of a stormwater treatment system between the Bayside Canal discharge point and Rietvlei is supported by the study. However, it was recommended that the size of the proposed treatment system be revised and relocated north of the naturally occurring ridge, see green arrows in **Figure 3-1**. It was noted that cognisance should be taken of the Estuary Management Plan for the area as well as outcomes of the hydrodynamic modelling of the Rietvlei Wetland. (Blue Science, 2015)

Figure 3-1: Recommended Extent of Stormwater Ponds (Blue Science, 2015)

3.2 BOTANICAL SPECIALIST

The botanical baseline investigation found that all elements of the existing Bayside Canal have been disturbed and transformed (i.e. not in its natural form), therefore the proposed engineering interventions would have little to no impact. It was further noted that the presiding assessment for this area would be from the Freshwater Specialist. (Bergwind Botanical Surveys & Tours CC, 2015)

3.3 HERITAGE SPECIALIST

No surface archaeological heritage was located during the inspection along the areas of concern. The Rietvlei area at the Bayside Canal discharge point has been disturbed during construction and maintenance activities. It is highly unlikely that archaeological remains would be encountered in this area. (Agency for Cultural Resource Management, 2015)

SECTION 4- BAYSIDE CANAL OUTFALLINTERVENTIONS

The findings and recommendations of the specialists were taken into account for the updating and detailing of the Engineering Interventions. Where applicable, preliminary designs were prepared to allow technical evaluation of the options. The resultant designs are discussed in this section.

4.1 INTERVENTION 1: REDUCTION OF BAYSIDE CANAL OUTFALL CATCHMENT

The objective of this intervention is to reduce the stormwater runoff entering the Bayside Canal by reducing the catchment. A total area of 162.0 Ha from the future Sunningdale Phase 12-15 development would now be diverted to the Big Bay outfall system (see yellow area in **Figure 4-1**). A peak runoff of 3.68 m^3/s pre-developed flow would thus be prevented from entering the Bayside Canal outfall for a 100 year storm event, and 2.99 m^3/s for a 50 year storm event. Stormwater runoff from this catchment would be further attenuated such that a maximum peak flow of 0.88m^3/s would permitted to discharge into the Big Bay system during 50 year and 100 year storm event.

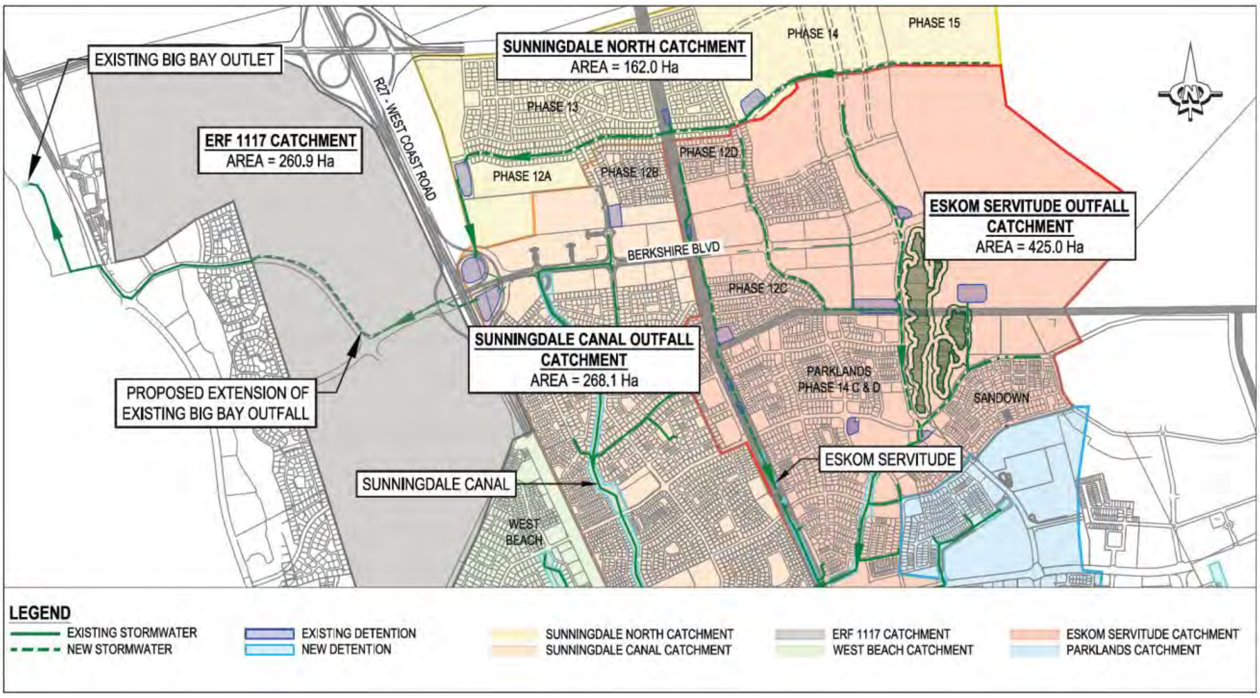

Figure 4-1: Diversion of Sunningdale Phase 12 - 15 to Big Bay Outfall

BVi has compiled a report which fully discusses and validates this intervention. As a result, a Basic Assessment for this intervention is currently underway. Refer to the BVi (2016) report: *"Extension of the existing Big Bay stormwater outfall pipe to the West Coast Road to serve Erf 1117 and Sunningdale Phases 12A, 13 and 14"*.

4.2 INTERVENTION 2:REDUCTION OF PERMISSIBLE STORMWATER DISCHARGE

The aim of this intervention is to reduce total flows at the Bayside Canal by increasing stormwater attenuation facilities and thereby reducing the permissible discharge entering the Bayside Canal.

4.2.1 Existing Sunningdale and Parklands Detention

The existing detention facilities in Sunningdale and Parklands (south of Sandown Road) were upgraded as per BKS recommendations. The implemented upgrades included closing one of two culverts downstream of a series of detention facilities along the Eskom servitude and Sunningdale Canal. This reduced the stormwater peak flow entering the Bayside Canal by making further use of the available capacities in these existing detention facilities.

4.2.2 Existing Table View Detention

The Table View catchment has two detention facilities which were identified in the BKS report. The detention facility at Battersea Bend has a total capacity of 2 415m^3 and Grey Avenue detention has a total capacity of 6 280m^3.

When modelled on SSA, it was evident that these detention facilities only act as emergency detention facilities as they are only utilised for the major storms (50 year and 100 year storm events) when the underground pipe system surcharges. Neither detention facilities are in use during minor storms (i.e. 2 year and 5 year storm events).

Table 4-1 below shows the maximum volume that is stored in the respective ponds for three storm events, the percentage signifies the percentage of the used capacity of the detention.

Table 4.1: Maximum Detention Volume Stored

Storm Return Interval	Battersea Bend detention Storage capacity: 2 415m^3		Grey Avenue detention Storage capacity: 6 280m^3	
5 years	0 m^3	(0%)	0 m^3	(0%)
50 years	55 m^3	(18%)	27 m^3	(1%)
100 years	1015 m^3	(42%)	240 m^3	(6%)

During a 50 year RI storm event, Battersea Bend detention utilises up to 18% of its capacity and Grey Avenue detention utilises up to 6% of its capacity. During a 100 year RI storm event, Battersea Bend detention utilises up to 42% of its capacity and Grey Avenue detention only utilises up to a maximum of 6% of its capacity. There is 1 400 m^3 and 5 647 m^3 of unused detention available at Battersea Bend and Grey Avenue detention facilities respectively.

The Grey Avenue detention facility was further investigated. It was found that if the entire storage capacity of the detention pond is utilised during a 100 year storm event, the outflow would have to be restricted to 1.50 m^3/s. The Table View flow would thus be reduced by 1.60 m^3/s for a 100 year storm (9.3% of the Bayside Canal peak flow) and by 1.53 m^3/s for a 50 year storm (9.5 % of the Bayside Canal peak flow).

4.2.3 New Sunningdale and Parklands Developments

As an objective of the Stormwater Master Plan (BVi, 2014), the allowable discharge for new developments contributing to the Bayside Canal Outfall was reduced from 6.7 ℓ/Ha/s (as per the 2008 Stormwater Master Plan) to 5.6 ℓ/Ha/s. The allowable discharge of 5.6ℓ/Ha/s is less than the pre-developed runoff rate from these catchments as illustrated in **Table 4-2** below.

Table 4.2: Pre-developed Stormwater Runoff

Storm Return Interval	Pre-developed runoff rate*
2 years	6.67 ℓ/Ha/s
5 years	9.09 ℓ/Ha/s
50 years	18.46 ℓ/Ha/s
100 years	22.72 ℓ/Ha/s

* For new developments in Sunningdale, Parklands and Sandown Development Frameworks

New developments in Sunningdale, Parklands and Sandown Development Frameworks that form part of the Bayside Canal catchment would thus be required to provide detention facilities that would meet the requirement of a permissible discharge of 5.6ℓ/Ha/s for all storms up to and (for some) including 100 year return interval. Limiting the peak runoff discharge rate to 5.6 ℓ/Ha/s further improves on the Stormwater Policy requirements.

4.2.4 Results

The combined effects of the reduced catchment and reduced permissible discharge for new developments on the stormwater flows at the Bayside Canal using the BVi stormwater model are illustrated in **Table 4-3**.

Table 4.3: Reduced Stormwater Runoff at Bayside Canal Outfall due to Intervention 1 and 2 as modelled on SSA

Storm Return Interval	Fully Developed *(BKS, 2009)**	Reduced - Fully Developed *(BVi Model)**
5 years	12.61 m^3/s	11.97 m^3/s
50 years	17.71 m^3/s	16.08 m^3/s
100 years	18.85 m^3/s	17.14 m^3/s

**Excluding the Grey Avenue intervention*

4.3 INTERVENTION 3: WEST BEACH STORMWATER DIVERSION

4.3.1 Description

The objective of this intervention is to reduce the total stormwater runoff entering the Bayside Canal by diverting stormwater flows from the West Beach catchment. The runoff would be diverted at Rose Innes Road, via a diversion structure, into a series of culverts along the R27 western boundary to discharge into the wetlands at Marine Drive (referred to as the Waves Edge wetland).

Comments received from the Freshwater Specialist indicated that alternative outlet points for direct discharge into Rietvlei need to be assessed for this intervention. Two additional options were identified to satisfy this requirement, as a result three options for this intervention were investigated, as indicated in **Figure 4-3**.

Option 3.1: Discharging into the Waves Edge wetland

Option 3.1 consists of a series of culverts constructed along the western boundary of the R27 from Rose Innes Road to the Waves Edge wetland. Stormwater from West Beach and part of the Table View West catchment would be diverted along this diversion system to discharge into the Waves Edge wetland.

It is proposed that a 1200mm wide by 900mm high box culvert be constructed inside the R27 road reserve underneath the existing NMT lane, from Rose Innes Road to just south of Blaauwberg Road, to convey the diverted stormwater.

An open canal would be installed downstream of Blaauwberg Road due to the shallow depth and flat gradient of the existing ground levels. The existing open channel from Blaauwberg Road to the Waves Edge wetland would be formalised into an inverted open culvert of size 3600mm x 900mm. Due to limited space available between the existing internal service road and the R27 road reserve boundary, the new open canal would have to be located inside the R27 road reserve.

At the discharge point at the Waves Edge wetland, the stormwater runoff would pass through a screen structure and a sedimentation basin to trap and collect litter and suspended solids prior to discharging into the wetland.

Option 3.2: Discharging directly into Rietvlei

Option 3.2 would follow the same route as Option 3.1, however the open canal that terminates at the Waves Edge wetland would be extended as a closed box culvert of 3000mm x 900mm in size. The closed box culvert would bypass the wetland and cross Marine Drive to the existing culvert underneath the R27 for direct discharge into Rietvlei. By bypassing the wetlands, the identified negative impacts on the existing environment can be avoided.

Option 3.3: Discharging into Bayside Canal

Option 3.3 would also follow the same route as Option 3.1 up to Sceptre Crescent where the open culvert transitions into a 3000mm x 900mm closed culvert. The closed culvert would cross the R27 to discharge into the Bayside Canal outlet point. Stormwater flows would be diverted away from the Waves Edge wetland whereby possible negative impacts can be eliminated. Screening and treatment of stormwater would be combined with the Bayside Canal outflow.

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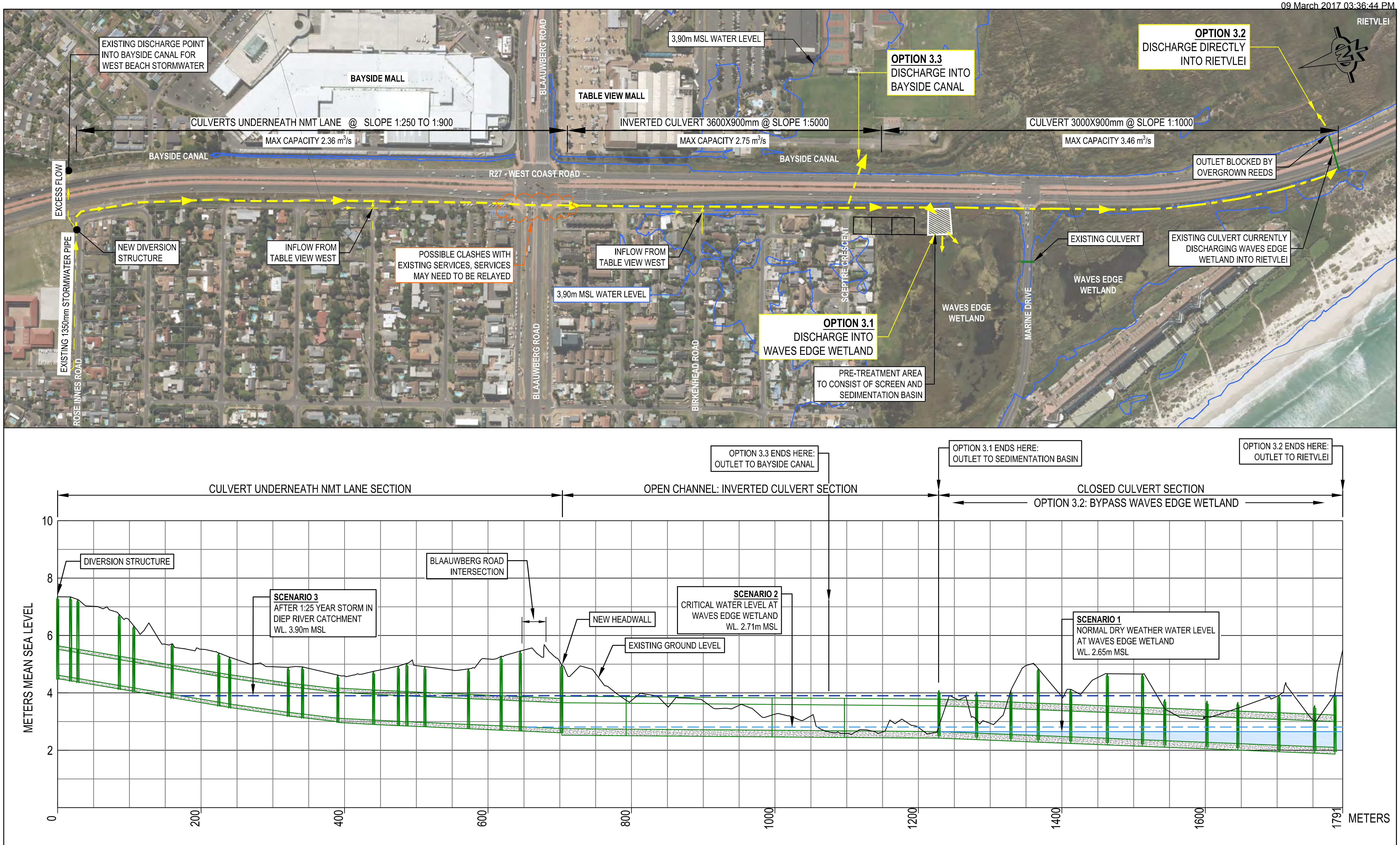

DATE	INITIAL	No./CODE	REVISION DESCRIPTION
13/04/2016	ZB	A/D	FOR PRELIMINARY DESIGN REPORT
18/07/2016	ZB	B/D	UPDATED FOR PRELIMINARY DESIGN REPORT
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CLIENT

CESA

bvi ENGINEERING PROCUREMENT MANAGEMENT

INCORPORATING basil nair and associates consulting mechanical engineers

Western Cape — Cape Town — (021) 527-7000 — cpt@bviwc.co.za

Registration no. 1998/000157/07

PROJECT

UPGRADE OF THE BAYSIDE CANAL OUTFALL

DRAWING TITLE

INTERVENTION 3
WEST BEACH STORMWATER DIVERSION

APPROVED BY BVI

ENGINEER/TECHNOLOGIST | REG. NO. | DATE

SCALE	1 : 5 000 @ A3	DRAWN	ZB
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FIGURE 4-2		C	09 March 2017

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4.3.2 Discussion

4.3.2.1 Capacity of the diversion system

The capacity of the system to divert stormwater flows from West Beach is governed by the flat gradient of the existing ground at the downstream end, south of Blaauwberg Road. A wide open canal would have provided the best option to accommodate the expected flows. However the limited space available within the existing road reserves negates the use of a wide canal.

It was found that a 3600 mm wide by 900mm high open concrete canal can be accommodated in the space available. This system would provide capacity to deal with stormwater flows of up to 2.75 m^3/s, which equates to the runoff from West Beach for a 5 year RI storm event while still providing some freeboard.

Stormwater flows in excess of this would have to continue to be discharged into the Bayside Canal as illustrated in **Table 4-4.**Flows in excess of this would cause the open canal to surcharge and flow on to the service roads as overland flows.

Table 4.4: West Beach and Table View West Catchment Stormwater Runoff

Storm Return Interval	**Total Flow** (West Beach &Table View West)	**Diverted Flow** (to Waves Edge wetland)	**Excess Flow** (to Bayside Canal)
5 years	2.56 m^3/s	2.56 m^3/s	0 m^3/s
50 years	4.03 m^3/s	2.75 m^3/s	1.28 m^3/s
100 years	4.39 m^3/s	2.75 m^3/s	1.64 m^3/s

The critical storms for the functioning of the diversion system is the 50 year and 100 year storm, i.e. when the Bayside Canal is under pressure. The percentage of the diverted flow from the Bayside Canal catchment is 17 % for the 50 year storm and 16% for the 100 year storm.

4.3.2.2 Flood Levels

The water level at the discharge point plays a determining role in the capacity of the open canal section of the stormwater outfall. Three scenarios were assessed with regards to the water level at their outlet points. **Scenario 1** assesses a freely flowing outlet when the water level in the wetland is below the invert of the canal. **Scenario 2** assesses the system when the water level in the wetland is at a critical level such that it causes stormwater to overflow the open canal. **Scenario 3** assesses the system when the water level in Rietvlei is 3.90m MSL, i.e. after the full effect of a 1:25 year storm in the Diep River catchment.

<u>Scenario 1: Freely flowing</u>

Option 3.1: Discharging into the Waves Edge wetland

The 3600mm x 900mm concrete canal would have an invert level of 2.65m MSL at the discharge point at the Waves Edge wetland. With the water level in the wetland below this, maximum capacity would be achieved in the open canal and the 1:5year storm runoff from West Beach can be diverted. The current water level (summer 2015/16) is below 2.65m MSL, therefore the above scenario with a free-flow discharge would prevail.

Options 3.2: Discharging directly into Rietvlei& Option 3.3: Discharging into Bayside Canal

The attainable invert at the outlet for Option 3.2 is 2.40m MSL and 2.10m MSL for Option 3.3. These are both above the summer water level at Rietvlei of 2.0m MSL. Free flowing conditions would therefore apply for Options 3.2 and 3.3 where the maximum capacity of the system would be utilised.

Scenario 2: Effects of a raised water level at the outlet

Option 3.1: Discharging into the Waves Edge wetland

The situation would change during the rainy season. The runoff from the existing Table View West catchment, which drains directly into the Waves Edge wetland, would raise the water level above 2.65m MSL. This would gradually reduce the open canal's capacity due to water pushing back into the canal upstream of the outlet. The water level at the Waves Edge wetland must be below2.71 m MSL in order to accommodate the stormwater flow of a 1:5 year storm event without causing the canal to overflow.

Should the water level rise above this, the water level in the open canal would eventually rise above the level of the adjacent Ruben Street, south of Birkenhead Road, where the ground levels range between 3.15m MSL and 4.00m MSL. The road would thus be flooded by the discharge from the diverted West Beach stormwater flows.

Options 3.2: Discharging directly into Rietvlei & Option 3.3: Discharging into Bayside Canal

The water level in Rietvlei would have the same effect on the open canal section of the diversion culvert when Rietvlei fills up during the rainy season. As the water level rises above the canal outlet invert level, the canal in Ruben Street would start to overflow and stormwater would flow down Ruben Street to the Waves Edge wetland.

Scenario 3: Major storm events

The Waves Edge wetland currently serves as a natural detention area for the southern Table View West catchment as well as for the Dunbar Street area north of Blaauwberg Road. The water level in the wetland would generally be higher in winter thus already posing a flooding risk to the surrounding property.

The water level at Rietvlei during the 100 year storm event would be at 3.90m MSL, which governs the water level at the Waves Edge wetland as the wetland drains into Rietvlei. If additional discharge is routed to the wetland, water levels would rise faster above 3.90m MSL within the wetland. The immediate surrounding property which lie between 3.15m MSL and 4.00m MSL would be at an even greater flooding risk during major storms.

4.3.2.3 Physical Constraints

The proposed diversion route lies within the R27 road reserve and therefore approval would be required from the provincial roads authority. The intersection of Blaauwberg Road and the R27 is riddled with numerous underground services. It is highly probable that many of these services would have to be relocated or temporarily terminated during construction at a great cost. The construction process would also greatly affect the traffic flow at this heavily trafficked intersection, dealing with the traffic would increase costs even further.

The existing open channel along the R27 south of Blaauwberg Road would be formalised with the construction of a concrete canal within the R27 road reserve as no space is available on the existing services road verge.

4.3.2.4 Waves Edge Wetland

Concern was expressed by the Freshwater Specialist with regards to the negative impact of discharging additional stormwater directly into the Waves Edge wetland. The specialist's baseline study suggested bypassing this wetland by discharging directly into Rietvlei (Option 3.2), or into the Bayside Canal (Option 3.3). However, Option 3.3 is generally not favoured as discharging directly into Rietvlei without prior treatment may compromise the water quality of the water sport area.

Stagnant water in the Waves Edge wetland, resulting in a foul smell, is a prevailing complaint amongst residences near the area. The stagnant water suggests that the outlet leading into Rietvlei is frequently blocked. Additional stormwater to this wetland would raise the water level to a level much higher than anticipated even during minor storms. An outlet that is frequently blocked results in reduced outflow capacity thus further worsening the flooding risk.

4.3.3 Cost Estimate

The estimated costs for Intervention 3 as per March 2017 rates are as follows:

Table 4.5: Intervention 3 Cost Estimate

Item	Option 3.1	Option 3.2	Option 3.3
Installing Culverts & Structures	R 21 344 920	R 36 465 920	R 21 972 990
Dealing with Existing Services	R 2 892 610	R 2 892 610	R 2 892 610
Reinstate Pavements and Roads	R 3 579 370	R 4 143 340	R 3 579 370
Sedimentation Pond	R 4 603 220	R 0	R 0
Total (incl. VAT)	**R 32 420 120**	**R 43 501 870**	**R 28 444 670**

4.3.4 Assessment

A high water level at the Waves Edge wetland or at Rietvlei would lead to the submerging of the diversion culvert outlet. This would cause an overflow of the outfall canal south of Blaauwberg Road with the stormwater runoff finding its way down Ruben Street thus flooding property.

A drowned outlet is a severe constraint on the stormwater runoff from the West Beach catchment that can be safely diverted away from the Bayside Canal. A water level of 2.71m MSL or higher at the outlet would not allow any stormwater to be diverted without flooding Ruben Street, and as it stands the normal water level at the Waves Edge wetland is approximately 2.65m MSL.

To summarise, this intervention poses an imminent risk of flooding property during major storms, it can only divert 16% of the Bayside Canal runoff (provided the water level does not rise) and requires an investment of over R25 million. The risks associated with this intervention outweigh the small amount of flows diverted from the Bayside Canal and it is thus not favoured.

4.4 INTERVENTION 4: TABLE VIEW STORMWATER DIVERSION

The objective of this intervention is to reduce the total stormwater runoff entering the Bayside Canal by diverting the runoff from the Table View catchment. The diverted runoff would then directly discharge into the proposed Rietvlei stormwater treatment ponds discussed in the next section (**Section 4.5: Intervention 5**).

4.4.1 Description

Four alternative routes were identified for this intervention. All routes require a diversion structure to be constructed on the existing 1500mm stormwater pipe in Blaauwberg Road where the runoff from Table View would be intercepted and diverted into a new culvert. The discharge point of the new culvert would be at the north-eastern corner of Rietvlei.

Option 4.1: Pentz Drive Route

The diversion structure would be constructed at the intersection of Blaauwberg Road and Pentz Drive at an existing pipe invert level of 3.72mMSL. The diversion culvert would run along Pentz Drive, past Birkenhead Road and the Virgin Active gym, across the Table View Football Club fields and discharging into the proposed Rietvlei ponds.

The summer water level in the water sport area of Rietvlei is 2.0m MSL. An invert level at the outlet of the diversion system higher than this would be ideal to allow free draining. However this cannot be attained due to the existing road levels along Pentz Drive, particularly at the Birkenhead Road intersection. The ground level at this intersection is approximately 4.0m MSL and at this location the invert level of the culvert cannot be higher than 2.3m MSL to ensure sufficient cover above the culvert. This would then result in a fall of 0.30m over 500m, which yields an extremely flat slope along the outfall. In order to ensure an acceptable gradient along the outfall, the outlet invert of 2.0m MSL or higher cannot be used, therefore the outlet of the diversion system would invariably remain partly under water.

The constraints of a flat gradient, limited cover above the culvert at the Pentz Drive/Birkenhead Road intersection and the drowned culvert outlet at the discharge point limits stormwater runoff that can be safely diverted to approximately 3.0 m^3/s. A 1200mm x 900mm box culvert between Blaauwberg Road and Birkenhead Road increasing to a 2100mm x 1200mm box culvert downstream of the intersection would be required to convey this flow as indicated in **Figure 4-3**.Stormwater flows in excess of the diverted 3.0 m^3/s would discharge down the existing pipeline to the Bayside Canal.

Option 4.2: Donkin Avenue Route

The diversion structure for this option would be constructed on the existing stormwater pipe at the intersection of Blaauwberg Road and Donkin Avenue with an invert level of 4.20m MSL. Similar to the Pentz Drive route, a maximum flow of approximately 3.0m^3/s can be diverted due to the same constraints at the discharge point of the culvert. A 1200mm x 900mm culvert would be required increasing to 2100mm x 1200mm downstream of Pentz Drive where the existing ground levels yet again limit the culvert gradient.

The new culvert would have to cross Blaauwberg Road which is riddled with numerous existing services. Most of these services would have to be relocated. Construction of the new culvert along Donkin Road would also require relocation of sections of existing services and a section of the road would have to be closed in order to accommodate construction. Access to properties would have to be closed temporarily.

The two possible construction methods for the installation of these culverts along this route include tunnelling (trenchless technology) and open excavation. The geology of the development generally consists of wind-blown dune sands. Tunnelling is not advisable for this type of material due to the uncertainty of the degree of compaction in the in-situ material.

Open excavation is also not favoured for this route as it would require deep excavations that are in the range of 3 m to 4 m in an already fully developed and occupied development. Both construction methods would result in a disruption of access and services to properties along the route for an extended period.

Option 4.3: Birkenhead Road Route

This route and the associated culvert sizes are similar to Option 4.1, except the culvert would be diverted down Birkenhead Road to discharge into Bayside Canal, just south of Table View Mall.

Option 4.4: Pentz Drive Route Extended

This route was suggested in the Freshwater baseline study and its feasibility was assessed. It is similar to Option 4.1 up to Birkenhead Road, thereafter it follows Pentz Drive in a southerly direction. This system would discharge into the proposed Rietvlei ponds on the north-eastern corner of Rietvlei.

The ground level along Pentz Drive, south of Birkenhead Road, rises sharply up to Donkin Avenue thereafter the road runs along the ridge of a sand dune. The high ground level would require deep excavations of up to 5.5m and renders the route not feasible.

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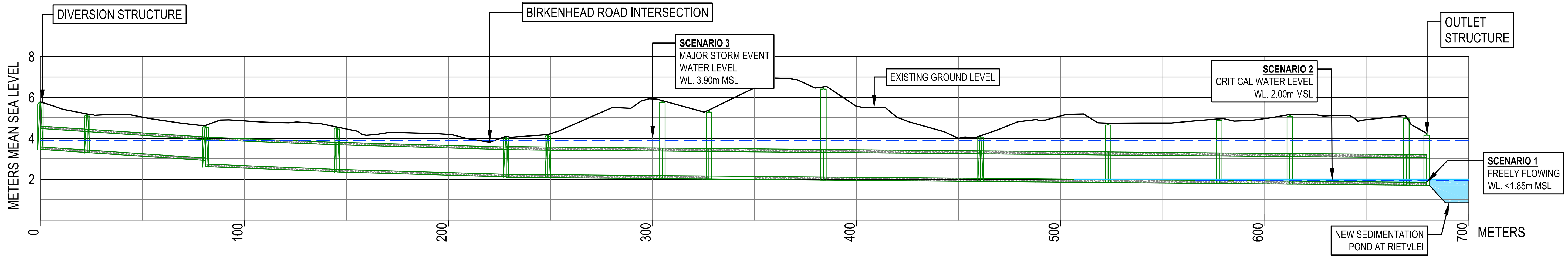
LONGITUDINAL SECTION OF INTERVENTION 4, OPTION 4.1: PENTZ DRIVE ROUTE



DATE	INITIAL	No./CODE	REVISION DESCRIPTION
13/04/2016	ZB	A/D	FOR PRELIMINARY DESIGN REPORT
09/03/2017	ZB	B/D	UPDATED OPTION 4.4

CLIENT

bvi ENGINEERING PROCUREMENT MANAGEMENT

CESA

INCORPORATING basil nair and associates consulting mechanical engineers

Western Cape — Cape Town — (021) 527-7000 — cpt@bviwc.co.za

Registration no. 1998/000157/07

PROJECT

UPGRADE OF THE BAYSIDE CANAL OUTFALL

DRAWING TITLE

INTERVENTION 4
TABLE VIEW STORMWATER DIVERSION

APPROVED BY BVI

ENGINEER/TECHNOLOGIST | REG. NO. | DATE

SCALE	1 : 2 000	DRAWN	ZB
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4.4.2 Discussion

4.4.2.1 Capacity of the Diversion System

Similar to Intervention 3(West Beach stormwater diversion), the allowable runoff entering the diversion culvert is governed by the capacity of the culvert at the downstream portion where the available gradient for the culvert is extremely flat. Even with a very flat gradient, the culvert outlet would be partially drowned.

The maximum flow that can be diverted is approximately 3.0m³/s, this is 17.5 % of the Bayside Canal peak flow for the 100 year storm event and 18.7 % of the 50 year storm event. Any flow in the Blaauwberg stormwater pipe that exceeds this would continue down the existing pipe for discharge into the Bayside Canal. **Table 4-6** shows the excess flow that would still discharge into the Bayside Canal.

Table 4.6: Table View Catchment Runoff

Storm Return Interval	Total Table View Flow	Diverted Flow to Rietvlei	Excess Flow to Bayside Canal
5 years	4.18 m³/s	3.0m³/s	1.18m³/s
50 years	5.65 m³/s	3.0m³/s	2.65 m³/s
100 years	5.93 m³/s	3.0 m³/s	2.93m³/s

4.4.2.2 Flood Levels

The water level at the outlet point plays a determining role in the capacity of the diversion culverts south of Birkenhead Road. Three scenarios were assessed with regards to the water level at the outlet points. **Scenario 1** assesses a freely flowing outlet when the water level at the outlet is below the invert of the culvert. **Scenario 2** assesses the system when the water level at the outlet is at a critical level such that the diversion culverts surcharge. **Scenario 3** assesses the system during a major storm event when the water level at Rietvlei is 3.90m MSL.

Scenario 1: Freely flowing

When the water level at the outlet is below the culvert invert, at a level of 1.85m MSL, stormwater is flowing freely at the outlet. In this scenario the culvert would flow full and provide its maximum capacity of 3.0 m³/s.

Scenario 2: Effect of a raised water level at the outlet

Rietvlei Aquatic Club has a normal water level in summer of 2.0m MSL which is above the invert level of the culvert at the outlet of the diversion system. The box culvert was designed to discharge 3.0 m³/s with the outlet end at an invert level of 1.85m MSL, approximately 150mm submerged below the water level.

A hydraulic analysis indicated that with a water level at the discharge end higher than 2.0 m MSL, the capacity of the culvert south of Birkenhead Road is reduced. Flooding of the Pentz Drive/ Birkenhead intersection may then occur.

Scenario 3: Major storm event

When the water level in the wetland is 3.90m MSL (during major storm events), the diversion outlet and the culvert itself would be completely submerged. Flooding of the Pentz Drive/ Birkenhead Road intersection would occur as indicated by the blue lines on **Figure 4-3**.In this scenario, there would be no capacity available in the diversion culverts and any flows diverted from the Table View catchment would further worsen the flooding, which would occur at the low lying area at the Birkenhead Road intersection.

4.4.2.3 Physical constraints

This intervention requires construction to take place in a fully developed and occupied residential and commercial area. Working space for construction would be limited and the accommodation and relocation of existing services would be a major constraint.

4.4.3 Cost Estimate

Option 4.1 is the most viable option for this intervention based on a technical evaluation and construction methods. The cost estimate, as per March 2017 rates, is as follows:

Table 4.7: Intervention 4 Cost Estimate

Items	Option 4.1
Installing Culverts & Structures	R 28 003 360
Dealing with Existing Services	R 3 602 120
Reinstate Pavements and Roads	R 2 071 030
Screens and Treatment Pond	R 8 670 950
Total (incl. VAT)	**R42 347 460**

4.4.4 Assessment

Similarly as with Intervention 3, a high water level in Rietvlei would result in the outlet of the Table View diversion system to be drowned. A water level of 2.0m MSL at the outlet end of the culvert can be expected only during the summer months. During winter months when the diversion of stormwater from Table View is needed, wetland water levels are likely to be higher thereby causing the capacity of the culvert to be drastically reduced. Stormwater diverted at Blaauwberg Road would then tend to discharge and flood the Pentz Drive/ Birkenhead Road intersection and surrounding property.

To summarise, this intervention also poses an imminent risk of flooding property during major storms, it can only divert up to 17.5% of the Bayside Canal peak runoff (provided the water level does not rise, which is highly unlikely) and requires an investment of over R44 million. The risks associated with this intervention outweigh the small amount of runoff diverted from the Bayside Canal and it is thus not favoured.

4.5 INTERVENTION 5: RIETVLEI STORMWATER PONDS AND BAYSIDE CANAL

The objective of this intervention is to address the capacity issue of the canal south of Blaauwberg Road, the extensive reed growth at the outlet, backwater issues and pollution due to litter and solid waste washed down with stormwater flows.

This intervention entails an engineered solution between Blaauwberg Road and the canal outlet at Rietvlei which includes clearing and lining the side slopes of the Bayside Canal, a stormwater treatment system consisting of a litter and trash removal system, reed beds with various components and a bypass channel. The layout of the proposed reed bed system was adjusted to reflect the findings from the baseline studies conducted by the specialists.

4.5.1 Bayside Canal

The Bayside Canal currently has capacity which can theoretically accommodate the stormwater flows from the full catchment of up to a 50 year storm event (BKS, 2009). However, due to the build-up of sedimentation and extensive reed growth at the outlet, the canal is unable to handle such flows.

Further hydraulic analyses indicated that widening of the canal into the R27 road reserve (between the road reserve boundary and road embankment) would not improve the capacity of the canal during extreme flooding conditions when the water level in the vlei is higher than the existing ground level in road the reserve.

Two flood conditions were further investigated in order to determine the extent of the effect of the water level at Rietvlei on the Bayside Canal.

Normal flow conditions

This scenario prevails for more than 90% of all rain events with the level in the Rietvlei water body less than 3.49m MSL. It was found that tall and dense vegetation growth along the banks of the existing canal together with uncontrolled reed growth at the outlet will tend to restrict free flow and can cause stormwater to back up towards Blaauwberg Road to such a level that some of the canal's flow is discharged to the Pick n Pay Mall site. Refer to **Figure 4-4** for the existing condition of the Bayside Canal with dense reed growth.

The frequent clearing of the downstream portion of Bayside Canal and the R27 road reserve using weed-cutters and "bossiekappers" will allow a smoother surface for stormwater to pass through and maintain the canal's capacity. Installing a lining on the side slopes of the existing canal would provide a solid surface that will assist trimming of vegetation and will improve the flow characteristic of the canal. Refer to Figure 4-5 for the proposed cross-section of the Bayside Canal.

Extreme flood conditions

This situation will occur when the water level in the Rietvlei water body is at 3.90m MSL and stormwater runoff from the catchment for a storm with a 1 in 100 year Return Interval is required to be accommodated. This event has a probability of less than 0.1% to occur (BKS Report) but was nevertheless tested. It was found that, provided the vegetation growth is kept very low, the cross section of the Bayside Canal and adjacent road reserve, will be able to pass the flood through from Blaauwberg Road to Rietvlei without flooding the Pick n Pay site.

4.5.2 Stormwater Treatment System

The reed growth at the end of the Bayside Canal throttles the through flow. The velocity of the flow is drastically reduced and silt settles to form a bank which again reduces the canal's discharge capacity. The net result is that stormwater backs up along the canal and reduces the canals capacity increasing the danger of flooding of upstream property.

The reed growth does, however, perform an important function in that it acts as a filter to retain litter and trash and allows silt and suspended matter to drop out to improve the quality of stormwater that is discharged to the Rietvlei water body.

It is proposed that a portion of the existing natural reed beds downstream of the canal's current discharge point be converted into an engineered treatment system to take advantage of the treatment capacity of the existing reeds. In light of the Freshwater Baseline Study, the treatment system would be constructed north of the naturally occurring ridge as shown conceptually in **Figure 3.1,** allowing a recommended buffer zone of 20m. Detail design will guide the construction of a series of ponds consisting of berms, formed from acceptable imported material, with pipe links and flow control devises to create separate ponds.

The stormwater treatment system would consist of the following elements: litter removal facilities, sedimentation ponds and reed bed ponds which are enclosed by a higher level earth berm, as well as a bypass channel just outside of the treatment area (refer to **Figure 4-6)**.

Each component is further discussed as follows:

4.5.2.1 Litter Removal Facilities

A number of alternatives for the removal of floating and suspended matter from the stormwater flows before being discharged to Rietvlei were identified (refer to **Figure 4-7**). Due to the huge fluctuation of stormwater flows from very low to extreme flood conditions, the ideal to have full screening facilities up stream of the weir will not be practical due to space and hydraulic depth constraints.

A Best Management Practice is proposed to remove litter in three stages:
Stage 1: Remove floating trash and litter upstream of the weir.
Stage 2: Remove suspended matter and solids in the primary sedimentation pond.
Stage 3: Remove remaining suspended matter in the secondary sedimentation ponds.

Stage 1: Use of Litter Booms

A section of the Bayside Canal can be widened to reduce velocity and smooth the water surface to allow the installation of a floating boom to intercept floating litter and debris up stream of the weir. The boom can be installed at an angle to allow floating debris to be pushed to the eastern bank of the canal where a screen box can be provided for trash to accumulate for easy removal. Trash and flotsam should be removed manually on a weekly basis.

The boom system can be provided at a reasonable cost by a South African Supplier. It will require labour to remove trash and litter periodically. Theft of the booms and any steel components poses a risk and will require security measures.

Stage 2: Removal of Suspended Matter

Three options were investigated for the second stage of removing litter and suspended matter as follows:

Option 1 - Fixed Screens
Fixed bar screens have traditionally been used throughout the City of Cape Town. Fixed screens need a structure and will require frequent manual cleaning with associated labour costs. Theft of steel screens is seen as a high risk.

It was, however, noted by the City of Cape Town officials that the screens are not frequently cleared due to a shortage of resources thus causing a problem with blockages and over spilling. The City officials further indicated that they are not in favour of a concrete structure with fixed screen as it will be too demanding on their labour resources due to the frequent manual cleaning required. Fixed screens are therefore disregarded as an option for removal of litter and trash.

Option 2 - Mechanical Screens
This option would be made up of a concrete structure with a set of self-cleaning mechanical screens can be considered (refer to **Figure 4-7**). Due to its self-cleaning ability, litter and trash is raked onto a conveyor belt for disposal into a skip. The bar spacing on the mechanical screens are normally wide due to the robust nature of the equipment. Small floating and suspended matter will still pass through and need to be trapped downstream in the reed beds. The trapped matter will then be removed during normal maintenance of the reed beds.

Due to the large fluctuation in flows, a set of mechanical screens will be require to cater for flows from a 20 year Return Interval storm. Multiple screens and a reinforced concrete supporting structure will be required at a major capital cost. The advantage of the self-cleaning screen system is that labour cost is reduced but maintenance costs will tend to be high due to mechanical and electrical parts that will require repair and replacement.

Estimated capital cost for mechanical screens	R 10 to 12 million
(With loan repayment assessed as	R 100 000 per annum)
Estimated annual operational and maintenance cost	R 600 000
Potential saving in annual labour cost	R 400 000 (1 day/week for a team)

The installation of mechanical screens is considered to be non-feasible due to the large capital investment required and there would be no advantage obtained in reduced labour cost as the team of workers will still be employed to deal with the rest of the treatment system.

A major risk for the plant is the potential theft or vandalism of the plant and thus will require special security measures.

Option 3: Litter Removal in primary sedimentation ponds
Litter can be removed by the primary sedimentation ponds that will be constructed as part of the reed bed system. By providing a second floating boom across the primary sedimentation pond, floating matter will be trapped and prevented from passing through with the flow. The primary settling ponds will also serve as sand traps where heavier suspended matter will drop out due to the reduction in velocity of the stormwater flows.

Two primary sedimentation ponds will be required and should be designed to allow easy access for maintenance with excavators and draglines. Space will be required to temporarily stockpile the excavated material to allow it to drain before being removed to a solid waste disposal site.

The ponds would require cleaning periodically (at least twice per year) where one pond would be taken out of operation while the other is undergoing maintenance.

Preferred Option for Litter Removal:

- Floating boom across the Bayside Canal upstream of the overflow weir;
- Primary sedimentation pond with second floating boom;
- Secondary sedimentation pond.

Stage Three: Removal of remaining suspended matter

Refer to the next section, **4.5.2.2. Secondary Sedimentation Ponds**, for Stage Three of treatment.

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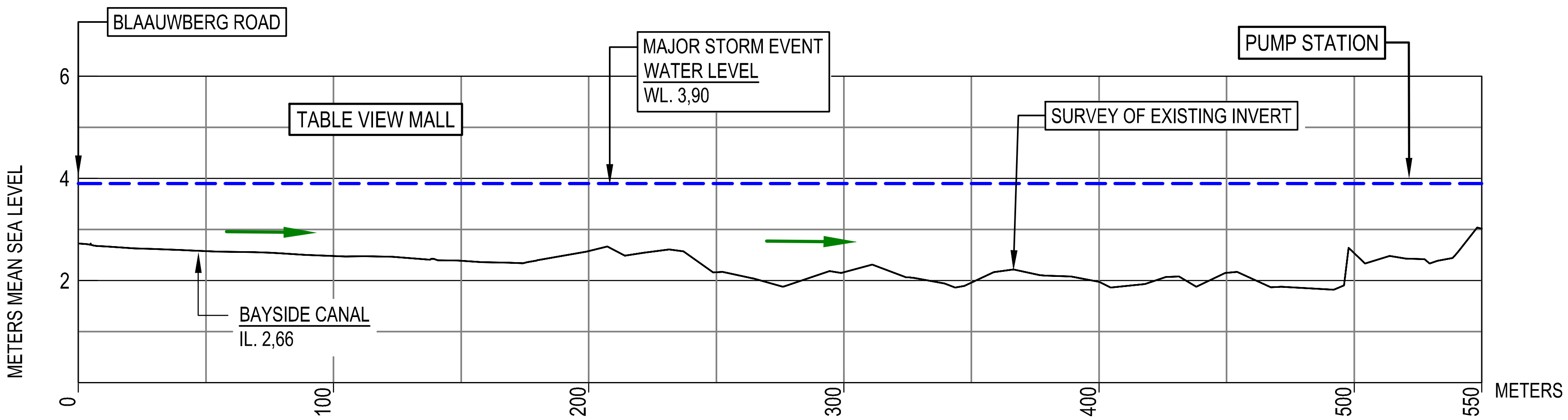

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13/04/2016	ZB	A/D	FOR PRELIMINARY DESIGN REPORT
09/03/2018	ZB	B/D	UPDATED WITH OCTOBER 2016 PHOTOS
26/04/2018	RDT	C/D	ADJUSTING OF ROAD RESERVE SHAPING

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INCORPORATING basil nair and associates consulting mechanical engineers

Western Cape — Cape Town — (021) 527-7000 — cpt@bviwc.co.za
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PROJECT

UPGRADE OF THE BAYSIDE CANAL OUTFALL

DRAWING TITLE

INTERVENTION 5
EXISTING CONDITION OF THE BAYSIDE CANAL

APPROVED BY BVI

ENGINEER/TECHNOLOGIST	REG. NO.	DATE	
SCALE	AS SHOWN @ A3	DRAWN	ZB
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PLAN NUMBER		REVISION NO.	DATE SAVED
FIGURE 4-4		C	26 April 2018

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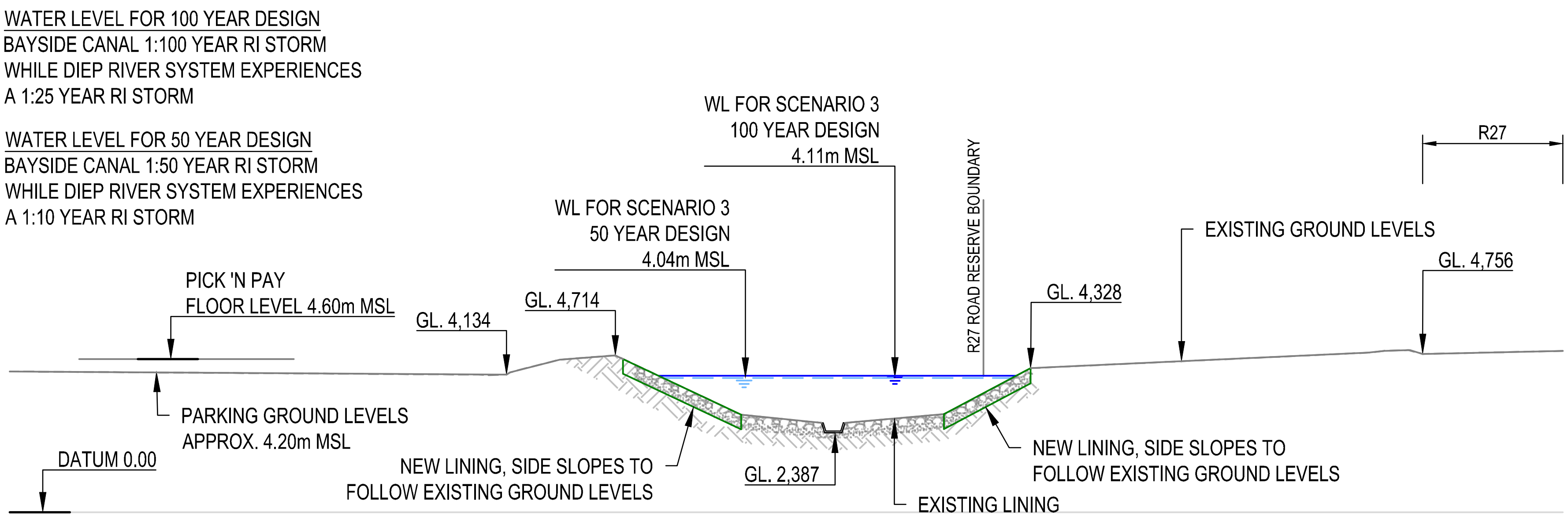
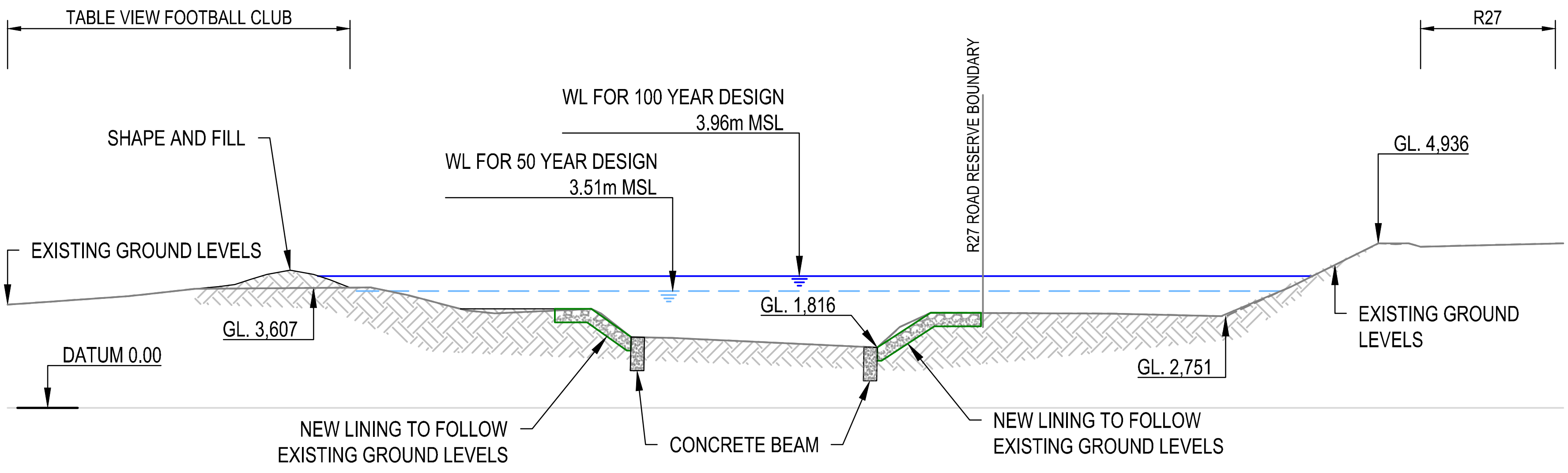


TYPICAL BAYSIDE CANAL CROSS-SECTION (OPPOSITE TABLE VIEW MALL)



TYPICAL BAYSIDE CANAL CROSS-SECTION (OPPOSITE TABLE VIEW FOOTBALL CLUB)

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PROJECT
UPGRADE OF BAYSIDE CANAL OUTFALL

DRAWING TITLE
INTERVENTION 5
TYPICAL CROSS-SECTION OFBAYSIDE CANAL

APPROVED BY BVi

ENGINEER/TECHNOLOGIST	REG. NO.	DATE

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PLAN NUMBER		REVISION NO.	DATE SAVED
FIGURE 4-5		C	26-Apr-18

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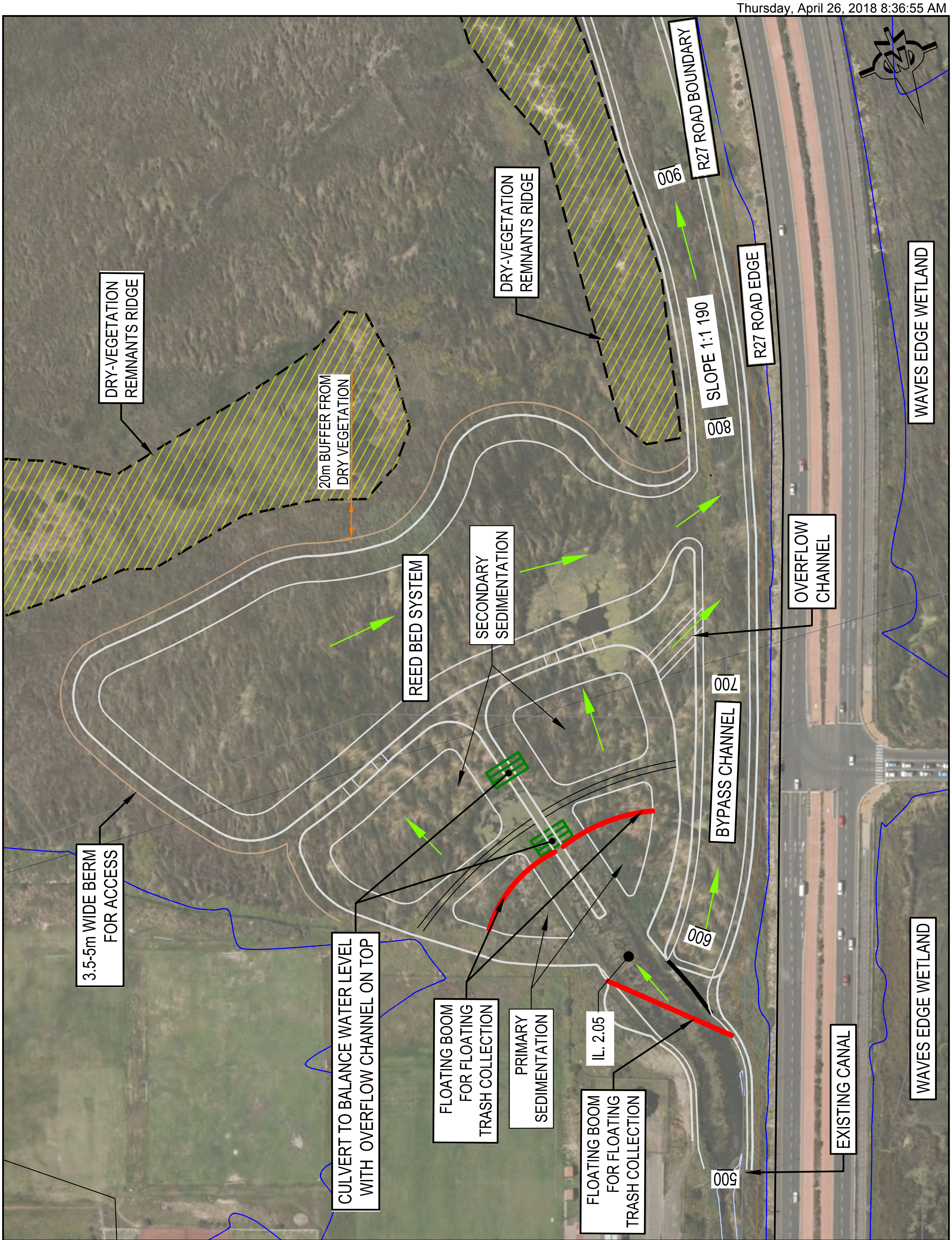

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DRAWING TITLE	SCALE: 1 : 2000 @ A4	DRAWN: ZB	
RIETVLEI STORMWATER TREATMENT POND SYSTEM	DESIGNED: ZB/ FR	CHECKED: SJL	
	PLAN NUMBER: FIGURE 4-6	REVISION NO.: C	DATE SAVED: 26 April 2018

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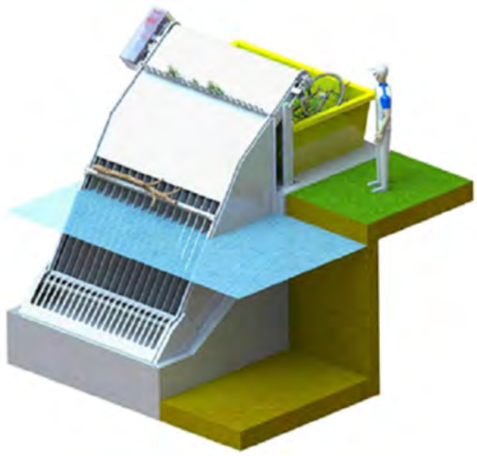
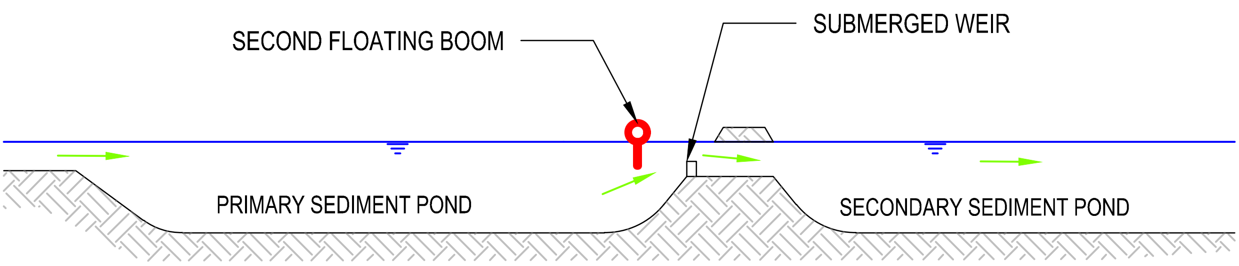


MECHANICAL SCREEN

FLOATING BOOM



FLOATING BOOM IN SEDIMENTATION POND ELEVATION

PROJECT	APPROVED BY BVi			
UPGRADE OF BAYSIDE CANAL OUTFALL	ENGINEER/TECHNOLOGIST	REG. NO.	DATE	
DRAWING TITLE	SCALE: NTS		DRAWN: RDT	
LITTER REMOVAL FACILITIES	DESIGNED: SJL		CHECKED: SJL	
	PLAN NUMBER: FIGURE 4-7	REVISION NO.: A	DATE SAVED: 26-Apr-18	

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4.5.2.2 Secondary Sedimentation Ponds

The main purpose of the two secondary sedimentation ponds is to remove finer suspended matter from the stormwater that has passed through the primary sedimentation ponds. After removal of floating and suspended matter in the primary sedimentation ponds, stormwater is discharged to the secondary sedimentation ponds where the velocity of the incoming water is reduced substantially so that finer suspended matter and silt can settle to the bottom of the pond. The sediment would then be cleared periodically by means of a dragline.

The primary and secondary sedimentation ponds will cover an area of approximately 1.2 Ha.

4.5.2.3 Reed Bed Ponds

After passing through the sedimentation ponds, the stormwater would flow through a reed bed pond and then ultimately drain into the bypass channel. The reeds offer pollutant removal capabilities through wetland plant uptake, absorption, physical filtration, and decomposition of nutrients. The shallow marsh vegetation also helps to reduce the re-suspension of settled pollutants by trapping them.

The reed bed ponds would be formed by constructing a series of earth berms around and between the existing reed beds. The berm around the entire system would be constructed to a level of 3.5m above MSL while internal berms would be constructed to a level of 3.0m above MSL. The enclosed ponds would have a shallow depth of 0.75m-0.90m. Existing reeds would be retained inside the ponds. The reed bed ponds cover an area of approximately 2.3 Ha.

Excessive reed growth at the Bayside Canal outlet is currently restricting the capacity of the canal. By converting the reed beds into an organised manageable treatment system, passageways would be formed along the earth berms for stormwater runoff from high order floods to escape. Stormwater flows from normal rain events (more than 80% of all rain events) would pass through the reed beds for treatment before being discharged to the bypass channel that will convey it to the Rietvlei water sport area. The berms would also allow easier access for operation and maintenance of the reed bed system.

4.5.3 Bypass Channel

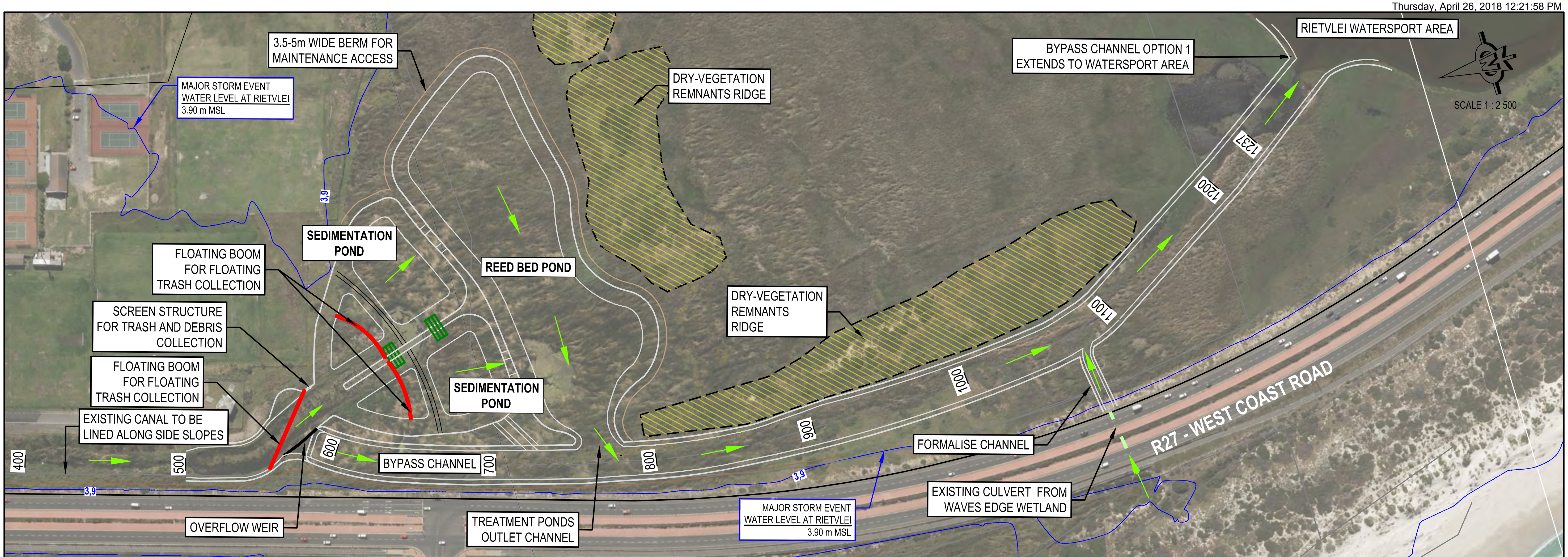
Construction of a bypass channel along the eastern boundary of the R27 is proposed to divert higher order storms around the reed bed system for discharge into Rietvlei. This channel would also serve as an outlet for the stormwater treatment system discussed above. A weir at the bypass channel entrance will prevent lower order storm flows from entering the bypass channel. High order storms will cause a higher water level and flows above the weir crest level will overflow into the bypass channel.

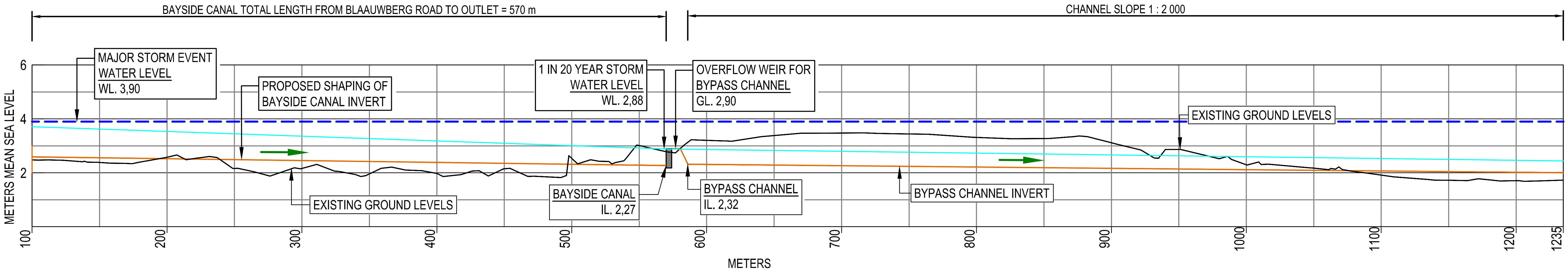
Two options for the end of the bypass channel were identified:

Option 1: Take the bypass channel right through up to the water edge of the existing Rietvlei water sport area as illustrated in **Figure 4-8**. The bypass channel would also collect the outflow from the stormwater culvert that drains the Waves Edge wetlands across the R27, at around Stake Value 1050m, to be discharged with the Bayside Canal flow at the water sport area.

Option 2: The bypass channel is terminated at Stake Value 1050 where it meets the discharge from the Waves Edge wetland across the R27 as indicated in **Figure 4-9**. This will allow final discharge from both outlets to filter through the reeds and wetland downstream up to the edge of the water sport area.

The bypass channel was designed with an optimal weir crest level of 2.90m MSL, this level was determined by finding the highest critical level without flooding upstream properties. The weir would prevent all minor storms from flowing directly into the bypass channel, it forces stormwater to be channelled through the reed bed ponds for treatment prior discharging into the water sport area. All minor storm events will flow through the reed bed pond system (provided that the water level at the water sport area is the normal water level of ±2.00m MSL). For the major storm events, the water level in the reed bed system would increase until it reaches 2.90m MSL, thereafter the stormwater would topple over the weir into the bypass channel and discharge into the water sport area.





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PROJECT

UPGRADE OF THE BAYSIDE CANAL OUTFALL

DRAWING TITLE

INTERVENTION 5 : OPTION 1 REITVLEI STORMWTER TREATMENT POND SYSTEM WITH BYPASS CHANNEL UP TO WATERSPORT AREA

APPROVED BY BVI

ENGINEER/TECHNOLOGIST — REG. NO. — DATE

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FIGURE 4-8		A	26 April 2018

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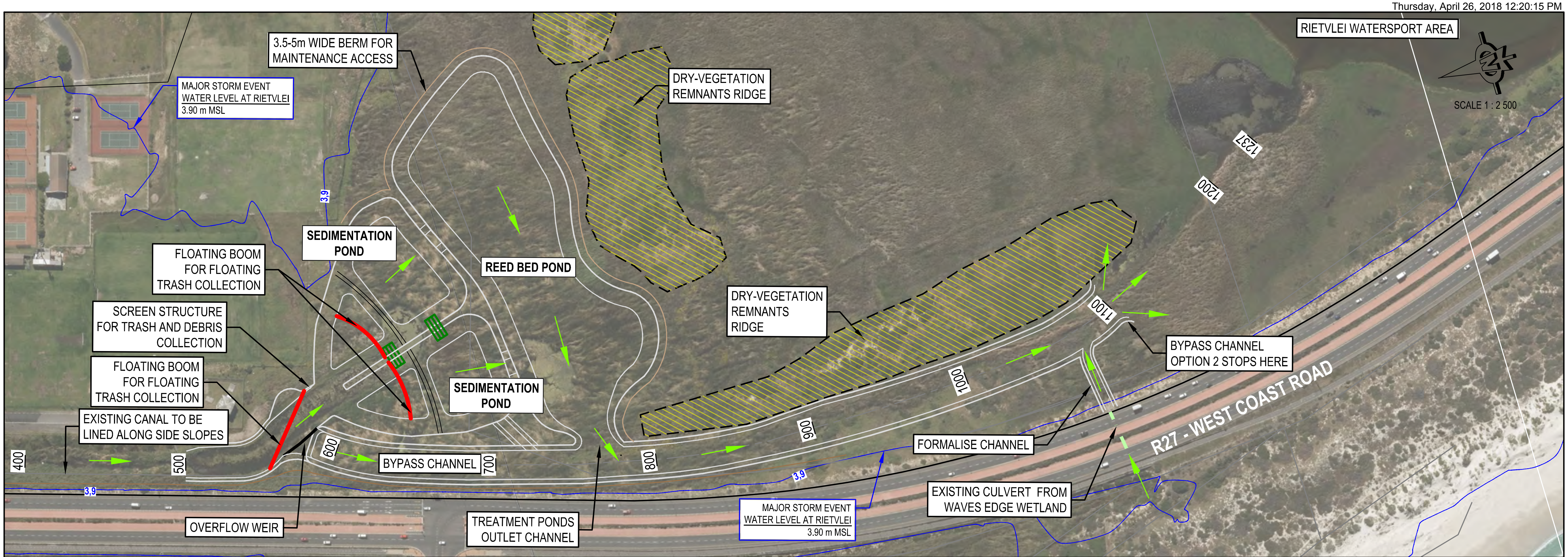

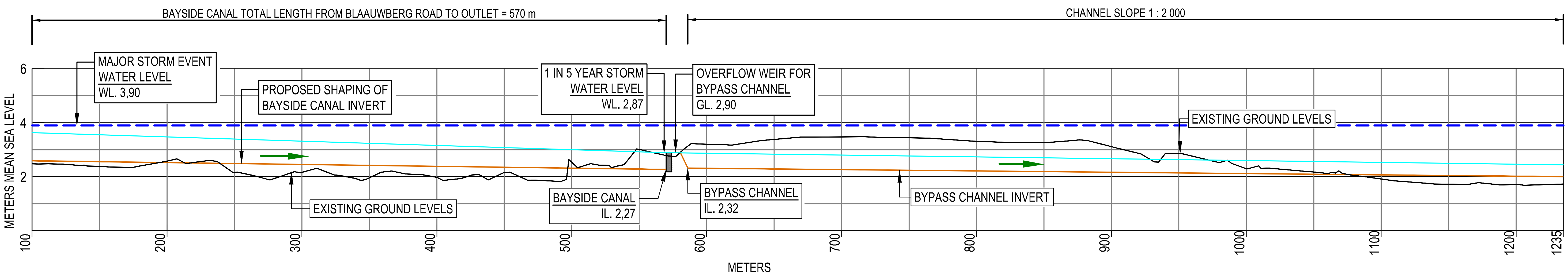

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PROJECT

UPGRADE OF THE BAYSIDE CANAL OUTFALL

DRAWING TITLE

INTERVENTION 5 : OPTION 2
REITVLEI STORMWTER TREATMENT POND SYSTEM
WITH BYPASS CHANNEL UP TO SV1050

APPROVED BY BVI

ENGINEER/TECHNOLOGIST	REG. NO.	DATE

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FIGURE 4-9	A	26-Apr-18

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4.5.1 Discussion

4.5.1.1 Flood Levels

The programme HEC-RAS was used to model and extract the effects of various storm events on Rietvlei. The HEC-RAS 1D model was used as the favoured method. The 1D model calculates the flow pattern per cross-section along a defined water course. Two additional models were used for calibration: the SSA model which uses a PCSWMM engine and another HEC-RAS model which uses 2D modelling to execute flows. The 2D model executes and calculates flow from cell to cell in a grid covering a defined area.

There are many contributing factors affecting the water level at Rietvlei. The main contributors for stormwater discharged to the vlei are the large catchment of Diep River and its tributaries and the catchments of urban development around Rietvlei consisting of the Table View, Blaauwberg Development Area, Montagu Gardens and Milnerton Ridge. Peak flows from these catchments will reach the vlei in succession depending on their location and distance from the vlei. Runoff from the upper reaches of the Diep River (as far away as Malmesbury) will reach Rietvlei 24 hours after the storm event and the peak flow from closer catchments would have passed by then. The vlei is filled over a considerable period of time and acts as a large detention facility. Water is released via the Milnerton lagoon but is subjected to tidal influences.

A series of storms were investigated for two situations of the water level in the Rietvlei water sport area:

- Normal water level of 2.00m MSL, which occurs for the most of the year.
- A water level affected by a storm event in the Diep River Catchment area, this level was different for each of the two major storms at the Bayside Canal Catchment. For the 50 year RI storm the water level of 3.49m MSL was used, and for the 100 year RI storm the water level of 3.90m MSL was used (refer to **Section 2** and **Table 2-1** for the background).

Thereafter, three scenarios were modelled using six critical storm events: the ½ year, 5 year, 10 year, 20 year, 50 year and 100 year RI storm events. The three scenarios are as follows:

<u>Scenario 1: The bypass channel discharges directly to the Rietvlei Water Body</u>

This scenario assumes that the bypass channel discharges directly to the water body at the Rietvlei waters port area, and that the water level would be ±2m MSL for all storms. The water levels at three critical locations along the Bayside Canal and bypass channel are as shown in Table 4-8.

<u>Scenario 2: The effect of shortening the bypass channel by 200m from the water sport area</u>

The Table Bay Nature Reserve officials raised concerns regarding discharging runoff directly into the water sport area via the bypass channel. It was suggested that the bypass channel be shortened and terminated 200m from the water sport area, which is at the outlet of the stormwater culvert under the R27 that drains the Waves Edge wetland, in order to allow the stormwater to filter through the reeds prior discharging into the water sport area. Scenario 2 investigated the effect that this would have on the flood water levels at the same points as for Scenario 1. The water level in Rietvlei was again taken as ±2m MSL

Scenario 3: The effect of a high order storm in Bayside Canal catchment combined with a high water level in Rietvlei due to a major storm event in the Diep River catchment

Scenario 3 assumes that, during the occurrence of a major storm of 50 year RI in the Bayside Canal catchment, the water level at Rietvlei is 3.49m MSL shortly after the Diep River catchment has experienced a 10 year RI storm. For the 100 year storm event in the Bayside Canal catchment, a water level of 3.90m MSL is assumed in Rietvlei shortly after a 25 year RI storm in the Diep River catchment.

Results

The peak runoff rates and water levels along the Bayside Canal for the critical storms are tabulated and compared in Table 4-8. For each storm the water levels at three critical locations along the Bayside Canal were assessed: opposite the Table View Mall, at the bypass weir and at the reed bed outlet.

Table 4.8: A Comparison of the Water Levels for the Three Scenarios

	Peak Runoff (m^3/s)	Water Level in Rietvlei (m MSL)	Water levels (m)								
			Table Bay Mall			Bypass Weir			Reed Bed Outlet		
			Scenario			Scenario			Scenario		
			1	2	3	1	2	3	1	2	3
½ Year RI Storm	3.74	2.00	3.23	3.23	3.58	2.54	2.54	3.51	2.22	2.23	3.51
5Year RI Storm	11.97	2.00	3.75	3.79	3.87	2.77	**2.87**	3.53	2.39	2.40	3.53
10 Year RI Storm	12.50	2.00	3.87	3.89	3.96	2.83	2.94	3.54	2.42	2.57	3.54
20 Year RI Storm	13.84	2.00	3.88	3.99	3.99	**2.88**	3.00	3.55	2.44	2.61	3.54
50 Year RI Storm	16.08	3.49*	3.89	3.95	4.04	2.94	3.07	3.55	2.48	2.65	3.54
100 Year RI Storm	17.14	3.90#	3.99	4.00	4.11	2.98	3.11	3.96	2.51	2.68	3.95

Where Scenario 1: The effect of the various storms on the water level.
Scenario 2: The effect of shortening the bypass channel by 200m from the water sport area.
Scenario 3: The combined effect of the Bayside Canal catchment and Diep River catchment.
** Water level of 3.49m MSL was used for scenario 3 for storms up to the 50 year RI. The water level for Scenario 1 and 2 is still 2.00m MSL.*
 # Water level of 3.90m MSL was used for scenario 3 for the 100 year RI storm. The water level for Scenario 1 and 2 is still 2.00m MSL.

For **Scenario 1** all storms up to and including the 20 year RI storm event can be routed through the reed bed pond system with the weir level at 2.90m MSL. Where the storm event is greater than the 20 year RI, stormwater flow that exceeds the weir level of 2.90m MSL will be hived off to overflow into the bypass channel while the flow below the weir would still be routed through the ponds.

The parameters applied to **Scenario 2** were identical to Scenario 1 except that the formalised bypass channel is shorter and terminated at the R27 culvert outlet. Stormwater would filter through existing reeds downstream of this point to drain into the water sport area. The model also assumed that the water level at the water sport area is ±2.00m MSL at the time of the storm. Only storms up to and including the 5 year RI storm event can be routed through the reed bed pond system, storms greater than this will overflow into the bypass channel.

When comparing Scenario 1 and Scenario 2, it is evident that shortening the bypass channel to allow water to filter through the reeds prior to discharging into Rietvlei will result in a restriction of the free flow and thereby create a backwater effect. For the 50 year RI storm event under Scenario 2, it was found that water levels will increase by ±60mm opposite Table Bay Mall, by ±130mm opposite the pump station and by ±170mm at the bypass channel outlet. Stormwater started to overflow at the weir during the 10 year RI storm by approximately 40mm. It could therefore be reasoned that the reeds downstream of the shorter bypass channel will result in raising the water level upstream, thus overflowing at the weir is likely to occur for storm events in the catchment greater than the 5 year RI for Scenario 2.

For **Scenario 3**, the model ascertained that the Bayside Canal should have sufficient capacity to accommodate a 50 and 100 year storm event even with the initial water level of 3.49m MSL and 3.90m MSL respectively, brought about a storm in the Diep River catchment, as also determined in the BKS report (refer to **Section 2.2**). Only portions of the Table View Football Club field and part of the Virgin Active parking area would be flooded. The blue lines on **Figures 4-6** show the extent of the flooded area provided there are no restrictions at the outlet.

<u>Conclusion</u>

Scenario 1 with the bypass channel taken right through to the Rietvlei water sport area is the best option hydraulically, however it is not favoured from a water quality point of view due to the stormwater that would overflow at the weir would discharge directly into the Rietvlei water sport area. Overflow of the weir under Scenario 1 would occur with storm events greater than the 20 year RI. All stormwater flows for events with a return interval of less than 20 years would be fully treated in the reed bed system.

Scenario 2 reduces the hydraulic capacity of the stormwater outfall system, the natural reed beds downstream of the bypass channel outlet would cause a backwater effect in the upstream system. The occurrence of backwater result would in the overflow of the weir for storms greater than the 5 year RI. On the positive side is the advantage that all stormwater flows will pass through the reeds prior to being discharged to the Rietvlei water sport area. Stormwater flows for rain events of up to the 5 year RI will be fully treated in the reed ponds.

Under **Scenario 3** the entire Rietvlei area, including the proposed reed bed treatment area and bypass channel, is assumed to be flooded. This scenario was modelled to ascertain the findings of the BKS report and to determine the extent of the flooded areas in the worst case scenario. It was found that surrounding properties along the Bayside Canal should not be flooded, with the exception of the Table View Football Club field and Virgin Active parking during storms of 50 year and 100 year RI.

4.5.1.2 Physical constraints to construction

Construction of the treatment facilities and bypass channel would be difficult due to the nature of the marshy reed area. Protection of sensitive areas will also require buffer zones and no-go fences during construction. Work in the wetlands would have to be undertaken during summer months. Due to the extent of the infrastructure to be constructed, the cost thereof and the construction period, implementation can be undertaken in two phases:

- **Phase 1** consists of improving the Bayside Canal and lining of its side slopes, construction of the weir overflow area, providing a floating boom to catch flotsam and construction of the of the bypass channel. This system would allow the floating litter and trash to be intercepted up stream of the weir while low flows will pass through the existing reeds of Rietvlei for treatment. During a large storm, when the water level rises above 2.90m MSL, the stormwater would overflow into the bypass channel.

- **Phase 2** consists of the clearing and constructing of sedimentation and reed bed ponds. The existing reed beds should be retained and ponds can be created by construction of berms at the locations and levels in terms of the design using approved imported material, starting at the dry land side.

4.5.1.3 Water quality discharged to the receiving water body

Highly polluted stormwater is typically brought about by the ½ year RI event (i.e. the first rains which are the minor and more frequent storms). By the time the major (less frequent) storms enter the system, the contaminated flow from the first storms would have been treated in the reed bed pond system. The portion of stormwater that would directly discharge into the water body (without prior reed bed treatment) via the bypass channel would be a major storm that would normally happen after the first minor storms. The major storms that will partially overflow at the weir would normally carry a lesser pollution load.

4.5.2 Operation and Maintenance

An Operation and Maintenance Manual would be compiled as part of the detail design outlining the required maintenance plan, the frequency at which maintenance should take place and the actions to be carried out. The following inspections and maintenance actions are to be anticipated:

Bayside Canal, Overflow Weir and Bypass Channel:

- Monitor vegetation, reed growth and accumulated sedimentation along the invert of the canal and clean annually before the rainy season;
- Inspect the lining of Bayside Canal along slopes (full length) and its invert along Table View Mall for damage once per month and repair where necessary;
- Inspect the lining of the bypass channel over its full length once per month to identify damage or any obstructions that may restrict flow and repair/reinstate;
- Clear the discharge end of the culvert under the R27 that drains Waves End Wetland at the end of summer to ensure it drains freely into the bypass channel.

Litter Removal Facilities (Preferred option):

Floating Booms in Bayside Canal and Primary Sedimentation Ponds

- Inspections to monitor the condition of the booms and volume of trapped litter that needs to be removed after each major rain event, and clear if large volume has been trapped;
- Clear debris and trash trapped by the booms on a weekly basis right through the year;
- Detail inspection of the boom elements and anchorage once per annum during end of summer. Replace damaged sections and parts.

Sedimentation Ponds

- Clear ponds from debris and trash that may have passed through the floating booms on a weekly basis;
- Inspect berms for erosion and damage on a weekly basis and repair where necessary;
- Inspections to monitor the sediment level in the ponds should be done before and after the rainy season;
- Remove sediment deposits if significant (200 to 300mm) in pond.

Reed Bed Ponds

- Clear reeds from trash that may have passed through the floating booms/sedimentation ponds (or got blown in by the wind) once a year before the next rainy season;
- Inspect berms for erosion and damage on a weekly basis and repair where necessary;
- Inspect pipe inlet and outlet ends on a weekly basis and clear from any obstructions;
- Trim and/or remove vegetation from the access berms on a monthly basis;
- Harvest reeds in the ponds according to a program as recommended by a wetland specialist.

Other Infrastructure

- Monthly inspection of fences and repairs to damaged sections (safety procedure);
- Inspections once every six months to identify and implement repairs necessary on structures and erosion control/repairs on slopes and embankments.

Table 4-9 below sums up the total number of inspections required for each major component of the pond system.

Table 4.9: Frequency of Inspections and Maintenance

	Biannually (before & after rainy season)	**Monthly** (during dry season)	**Weekly** (during rainy season)	**After each rain event**
Bayside Canal	✓	✓	✓	
Bypass Channel and Weir	✓	✓	✓	
Floating Booms		✓	✓	✓
Litter Traps Reeds		✓	✓	
Sedimentation Ponds		✓	✓	
Reed Bed Ponds		✓	✓	
Embankments	✓			

4.5.3 Cost Estimate for Intervention 5

Capital Costs

The cost estimate where floating booms and sedimentation ponds are the preferred litter removal facility, is as follows:

Table 4.10: Cost Estimate for Intervention 5 with Floating Booms

Phase 1	**Estimated cost**
Bypass Channel Floating boom up stream of the weir Lining of Bayside Canal	R 20 000 000 R 55 000 R 10 000 000
Total for Phase 1(incl. VAT)	**R 30 055 000**
Phase 2	**Estimated cost**
Floating booms in primary sedimentation ponds Sedimentation and Reed Bed Ponds	R 100 000 R 20 000 000
Total for Phase 2 (incl. VAT)	**R 20 100 000**
Total for Intervention 5 (incl. VAT)	**R 50 155 000**

As per April 2018 rates

Operation and Maintenance Costs

The operation and maintenance costs per year are as follows:

Table 4.11: Operation and Maintenance Costs for Intervention 5 with Floating Booms

Operation	**Estimated cost**
Weekly maintenance by municipal staff: inspection and clearing of Bayside canal, bypass channel and reed beds	R 165 000
Maintenance	
Annual clearing, cutting of reeds and replacing of material required by contractors	R 270 000
Total (incl. VAT)	**R 435 000 p.a.**

As per April 2018 rates

4.6 SUMMARY AND PREFERRED INTERVENTION

INTERVENTION 1 investigated reducing the stormwater runoff entering the Bayside Canal by diverting the future Sunningdale Phase 12-15 to the Big Bay outfall, thereby reducing the catchment size by 162 Ha and with associated pre-developed runoff of 3.68 m^3/s for the 100 year storm event.

INTERVENTION 2 investigated reducing total flows at the Bayside Canal by increasing stormwater attenuation facilities, thereby reducing the permissible discharge entering the Bayside Canal.

Intervention 1 and 2 were previously identified and investigated in the Stormwater Master Plan compiled by BVi (2014). These interventions are currently being implemented.

Although Intervention 1 and 2 would decrease the total flow entering the Bayside Canal by approximately 1.71m^3/s for the 100 year storm event, further intervention is required to solve the capacity problem at the Bayside Canal.

INTERVENTION 3 investigated reducing the total stormwater runoff entering the Bayside Canal by diverting stormwater runoff generated by the West Beach catchment away from the canal and discharging into the Waves Edge wetland or Rietvlei. The estimated cost for the preferred option in this intervention (Option 3.1) is **R32 420 120**. Although a portion of the stormwater runoff from West Beach can be diverted with this intervention, it would expose properties around Birkenhead Road/Sceptre Crescent to potential flooding when the water level in the Waves Edge wetland is high.

INTERVENTION 4 investigated reducing the total stormwater runoff entering the Bayside Canal by diverting the runoff generated by the Table View catchment away from the canal and discharging into the proposed Rietvlei stormwater treatment ponds. The estimated costs for the preferred option in this intervention (Option 4.1) is **R 42 347 460.** Diverting stormwater flows down Pentz Drive would reduce the total flow discharged into the Bayside Canal, however a similar situation would be created as in Intervention 3 where a high water level in Rietvlei would cause water to back up along the culvert. This would cause the diverted stormwater to be discharged at the Pentz Drive/Birkenhead intersection, thus posing a high risk of flooding surrounding property.

INTERVENTION 5 investigated increasing the capacity of the Bayside Canal by clearing and lining the canal’s embankments. This would allow stormwater to flow freely into the Rietvlei area. The intervention also investigated installing a floating boom in Bayside Canal up stream of the overflow weir to capture floating trash and litter, the construction of sedimentation ponds and compartmentalising the existing reed beds into ponds for the treatment of stormwater runoff. A bypass channel is further proposed as an emergency overflow channel for major storms that will allow them to bypass the reed beds. This would reduce backing up of stormwater into the canal and thus minimising the risk of flooding adjacent property.

The total cost of this intervention is **R 50 155 000** (incl. VAT).This includes the cost of the bypass channel and clearing of the canal, estimated to be R 30 055 000 (incl. VAT) as well as the cost of the pond system and reed litter trap pond, estimated to be R 20 100 000 (incl. VAT).

Intervention 5 is the preferred option as it addresses the fundamental objectives of the project:

- Alleviating the backwater that is caused by the uncontrolled reed growth at the existing discharge end of the Bayside Canal and allowing the canal to drain fully;
- Increasing capacity of the Bayside Canal south of Blaauwberg Road;
- Providing a bypass of the reed beds during high order storms;
- Providing facilities to remove litter and trash from the stormwater and addressing the quality of stormwater discharged into Rietvlei.

SECTION 5- CONCLUSION

The interventions that were investigated to address the key objectives of this study were aimed at relieving the pressure on the existing system of the Bayside Canal caused by stormwater runoff from high order storms. This was achieved by reducing flows from the catchment and increasing capacity of the system, by reducing and controlling the extensive reed growth while ensuring that their treatment function to improve the water quality discharged to the Rietvlei water sport area is maintained, and by providing facilities to catch litter and trash to address concerns regarding litter and waste that is washed down with stormwater that could end up in Rietvlei.

The following five interventions were identified:

5.1 INTERVENTION 1: REDUCTION OF BAYSIDE CANAL OUTFALL CATCHMENT

The objective of this intervention is to reduce the stormwater runoff entering the Bayside Canal by diverting the future Sunningdale Phase 12-15 to the Big Bay outfall, thereby reducing the catchment size by 162 Ha and preventing a pre-developed runoff of 3.68 m^3/s from entering the system (for the 100 year storm event). This intervention is supported and was further investigated in the BVi report "*Extension of the existing Big Bay stormwater outfall pipe to the West Coast Road to serve Erf 1117 and Sunningdale Phases 12A, 13 and 14*".

5.2 INTERVENTION 2: REDUCTION OF PERMISSIBLE STORMWATER DISCHARGE

The objective of this intervention is to increase stormwater attenuation by reducing the allowable discharge from new developments in Sunningdale, Parklands and Sandown from 6.7ℓ/Ha/s to 5.6 ℓ/Ha/s. This intervention is currently being implemented for new developments and would reduce stormwater peak flow to Bayside Canal by 1.63m^3/s and by 1.71m^3/s for a 50 year and 100 year storm event respectively.

New detention facilities can also be introduced at the existing Grey Avenue emergency overflow pond to utilise the available capacity to its full extent. This would assist to reduce the stormwater peak flow from Table View for the 50 year storm event by 1.53 m^3/s and 1.60 m^3/s for the 100 year storm event.

Interventions 1 and 2 would be successful in reducing the peak stormwater flows to the Bayside Canal by the following quantities:

1: 50 year Storm Event	3.16 m^3/s
1: 100 year Storm Event	3.31 m^3/s

5.3 INTERVENTION 3: WEST BEACH STORMWATER DIVERSION

The objective of this intervention is to reduce total runoff entering the Bayside Canal from West Beach. It entails the diversion of stormwater runoff away from the Bayside Canal along the western side of the R27 via a culvert and open canal to discharge directly into the Waves Edge wetland. The estimated costs for this option is approximately **R32 450 000** (incl. VAT). The outfall system would, however, expose the residential area around Birkenhead Road/Sceptre Crescent to flooding when the water level in the Waves Edge wetland exceeds the invert level of the canal's discharge point.

5.4 INTERVENTION 4: TABLE VIEW STORMWATER DIVERSION

This intervention entails the diversion of Table View's stormwater runoff via a culvert along Pentz Drive for discharge directly into Rietvlei. The diverted stormwater would reduce the total runoff entering the Bayside Canal. The estimated cost for Intervention 4 (Option 4.1) is approximately **R 42 350 000** (incl. VAT). This outfall system also poses a risk of flooding when high water levels in Rietvlei close up the outlet thus causing diverted stormwater to surcharge at the Pentz Drive/Birkenhead Road intersection.

Intervention 3 and 4 both pose an imminent risk of flooding property when the water level in Rietvlei is higher than the invert level of the culverts at their discharge points. At best, with the water level in Rietvlei low, either interventions can only divert between 16% and 18% of the Bayside Canal peak runoff.

Interventions 3 and 4 are not supported due to the increased risk of flooding surrounding property, major disruptions to existing services during constructions and high capital costs. The small percentage of the diverted flows for either interventions is not comparable to the risks and disadvantages. Both Intervention 3 and 4 are therefore deemed not feasible from a technical perspective.

5.5 INTERVENTION 5: RIETVLEI STORMWATER PONDS AND BAYSIDE CANAL

This intervention addresses the capacity problem at the canal, the extensive reed growth, backwater issues and solid waste concerns. This upgrade entails lining the side slopes of the Bayside Canal south of Blaauwberg Road; providing floating booms to remove solid waste from the stormwater; constructing sedimentation ponds and reed bed ponds for further treatment; and constructing a clear bypass channel to cater for high order storms. The estimated cost for Intervention 5 is approximately **R 50 155 000** (incl. VAT).

5.6 CONCLUSION

Interventions 1 and 2

These interventions can be implemented successfully to reduce the peak flows for the higher order storms to the Bayside Canal by:

1: 50 year Storm Event 3.16 m^3
1: 100 year Storm Event 3.31 m^3

Interventions 3, 4 and 5

It is imperative to first and foremost address the overgrown reeds issue at the Bayside Canal outlet as this is a major hindrance of stormwater flows for both low and high flows, this is also the cause of premature flooding of the canal. Intervention 5 addresses this significant objective and is therefore the primary intervention that is required. This intervention fully addresses the reed growth, the capacity of the canal, the water quality as well as providing a bypass route for high flows to prevent further flooding caused by blockages at the outlet.

Intervention 3 and 4 are classified as secondary interventions which can be implemented as an addition to Intervention 5 to further reduce the risk of flooding at the Bayside Canal. However, they are not supported as they increase the risk of flooding other surrounding property along their routes.

Table 5.1: Summary of Interventions

	Intervention 3 West Beach Diversion	**Intervention 4** Table View Diversion	**Intervention 5** Rietvlei Stormwater Ponds & Bayside Canal
Classification	Secondary Intervention	Secondary Intervention	**Primary Intervention**
Cost (incl. VAT)	R 32 450 000	R 42 350 000	R 50 155 000
Flooding risk to adjacent property	Increased	Increased	Lowered
Litter removal & water quality	Litter removal facility; Treatment of stormwater at the Waves Edge wetland.	Litter removal facility; Treatment of previously untreated stormwater.	Litter removal facility; Treatment of stormwater at Rietvlei Ponds.
Construction: Disruption of existing services	Anticipated at Blaauwberg Road/ R27 intersection	Anticipated throughout route	None anticipated
Preferred Intervention	✘	✘	✓

SECTION 6- RECOMMENDATIONS

6.1 RECOMMENDED INTERVENTION

Intervention 1 and **2** were identified and fully investigated in the previous Stormwater Master Plan compiled by BVi (2014) and are currently being implemented. Additional detention facilities can be introduced at the Grey venue emergency overflow pond to reduce peak flows from Table View. Although these two interventions decrease and attenuate the total flow entering the canal, further intervention is required to solve the problem at the Bayside Canal outlet.

The engineering planning and design exercise indicated that the most favourable and economically viable upgrade is **Intervention 5**. **Intervention 3** and **4** are secondary interventions and they are not supported due to the associated high risk of flooding properties along their routes.

It is therefore recommended that Intervention 5 be implemented as it would provide the following outcomes:

- Increasing capacity at the Bayside Canal;
- Providing a bypass channel where high order storms can directly discharge into Rietvlei without flooding the Bayside Canal;
- Reducing the reed growth while ensuring good water quality at the Rietvlei water sport area;
- Addressing solid waste pollution in the canal and at the reed bed system.

Implementation of this intervention can be carried out in two phases:

- **Phase 1** consists of lining the side slopes of Bayside Canal, the construction of a control weir and bypass channel and installation of a floating boom to trap floating litter and trash up stream of the overflow weir.
- **Phase 2** consists of constructing sedimentation ponds and compartmentalising the reed bed ponds with earth berms.

6.2 OTHER RECOMMENDATIONS

6.2.1 Sewage Pump Station

During the information gathering process, meetings with various officials from City of Cape Town as well as a meeting with the Table Bay Nature Reserve Advisory Committee revealed that there is a growing concern regarding the sewage pump station situated near the Bayside Canal outlet. It has been reported that there may be sewage spillages that finds itself into the Bayside Canal.

The Table Bay Nature Reserve officials have found that the e-coli concentrations in the Bayside Canal (before the reeds) is occasionally extremely high compared to the levels at the water sport area. It is suspected that sewage overflows from the pump station may be spilling into the canal as there is currently no overflow pond for the pump station on site.

The risk of sewage spillages threatens the integrity of the stormwater quality. To further protect Rietvlei and the water sport area from water quality perturbations, it is recommended that the City of Cape Town commissions an independent project to further investigate this issue and implement mitigation measures.

6.2.2 Incorporating the Culvert Outlet from the Waves Edge Wetland

The outlet of the stormwater culvert under the R27 that drains the Waves Edge wetland is also throttled and blocked by reeds. It is recommended that the culvert outlet be linked to the proposed Bayside Canal outfall with a lined section of canal to allow free draining of the upstream pond. Annual maintenance and clearing of the outlet will be required.

6.2.3 Maintenance

In order to retain the efficiency of the proposed stormwater treatment system, i.e. Intervention 5, it is imperative to implement the required operation and maintenance plan as provisionally outlined.

It is recommended that implementation and frequency of maintenance be reviewed and appropriate actions be carried out to ensure that maintenance takes place. The stormwater treatment system and the hydraulic capacity of the system will be severely compromised if maintenance does not take place as proposed.

SECTION 7- BIBLIOGRAPHY

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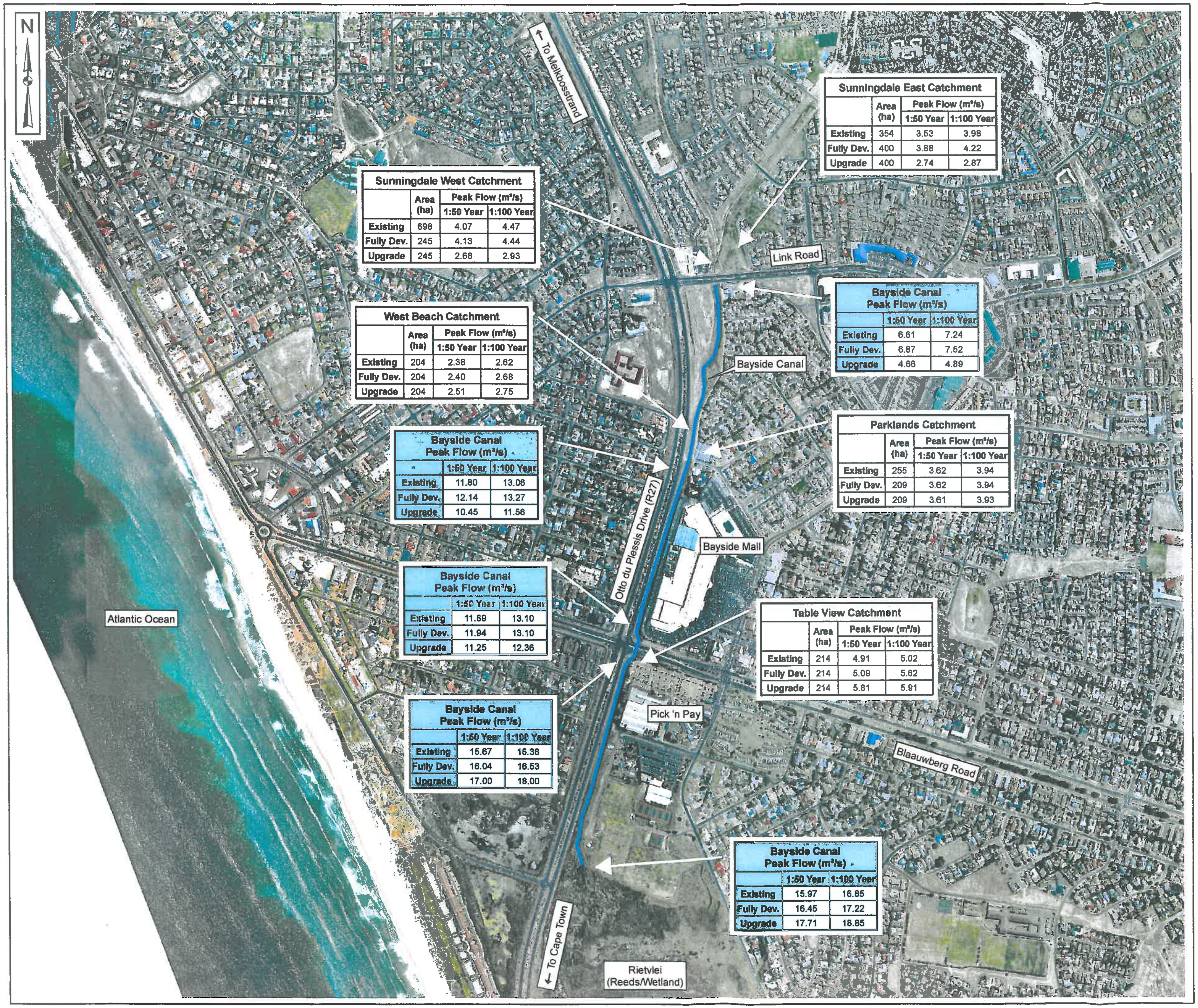
ANNEXURE A
STORMWATER RUNOFF ALONG BAYSIDE CANAL (BKS, 2009)



Sunningdale East Catchment

	Area (ha)	Peak Flow (m³/s) 1:50 Year	1:100 Year
Existing	354	3.53	3.98
Fully Dev.	400	3.88	4.22
Upgrade	400	2.74	2.87

Sunningdale West Catchment

	Area (ha)	Peak Flow (m³/s) 1:50 Year	1:100 Year
Existing	698	4.07	4.47
Fully Dev.	245	4.13	4.44
Upgrade	245	2.68	2.93

Bayside Canal Peak Flow (m³/s)

	1:50 Year	1:100 Year
Existing	6.61	7.24
Fully Dev.	6.87	7.52
Upgrade	4.66	4.89

West Beach Catchment

	Area (ha)	Peak Flow (m³/s) 1:50 Year	1:100 Year
Existing	204	2.38	2.62
Fully Dev.	204	2.40	2.68
Upgrade	204	2.51	2.75

Parklands Catchment

	Area (ha)	Peak Flow (m³/s) 1:50 Year	1:100 Year
Existing	255	3.62	3.94
Fully Dev.	209	3.62	3.94
Upgrade	209	3.61	3.93

Bayside Canal Peak Flow (m³/s)

	1:50 Year	1:100 Year
Existing	11.80	13.06
Fully Dev.	12.14	13.27
Upgrade	10.45	11.56

Bayside Canal Peak Flow (m³/s)

	1:50 Year	1:100 Year
Existing	11.89	13.10
Fully Dev.	11.94	13.10
Upgrade	11.25	12.36

Table View Catchment

	Area (ha)	Peak Flow (m³/s) 1:50 Year	1:100 Year
Existing	214	4.91	5.02
Fully Dev.	214	5.09	5.62
Upgrade	214	5.81	5.91

Bayside Canal Peak Flow (m³/s)

	1:50 Year	1:100 Year
Existing	15.67	16.38
Fully Dev.	16.04	16.53
Upgrade	17.00	18.00

Bayside Canal Peak Flow (m³/s)

	1:50 Year	1:100 Year
Existing	15.97	16.85
Fully Dev.	16.45	17.22
Upgrade	17.71	18.85

LEGEND

Bayside Canal

0 75 150 300 450 600
metres

CONSULTANT

BKS ENGINEERING AND MANAGEMENT

CLIENT

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

CITY OF CAPE TOWN DIRECTORATE: ROADS AND STORMWATER

PROJECT

CONTRACT No Q07/91: UPGRADING OF THE BAYSIDE CANAL

TITLE

PEAK FLOWS IN THE BAYSIDE CANAL AND MAJOR CONTRIBUTORY SYSTEMS

SCALE	FIGURE
1:10000	FIG A.6

ANNEXURE B
LANDSCAPING UPGRADES FOR BAYSIDE CANAL (CNdV, 2009)

SUMMARY OF LANDSCAPING UPGRADES FOR THE BAYSIDE CANAL

CNdV compiled a landscaping master plan for the Bayside Canal and their upgrade proposals included the following:

Section 1: Link Road POS

- Re-grade and re-vegetate the existing canal and side slopes;
- Formalise the existing pedestrian pathway to the east of the canal with a paved walkway of minimum 1.8m in width;
- Create an off-channel pond which is to be created below the invert level of the canal at about 6.9m for top of pond level (maximum depth of 1.5m).

Section 2: Bayside Canal (north)

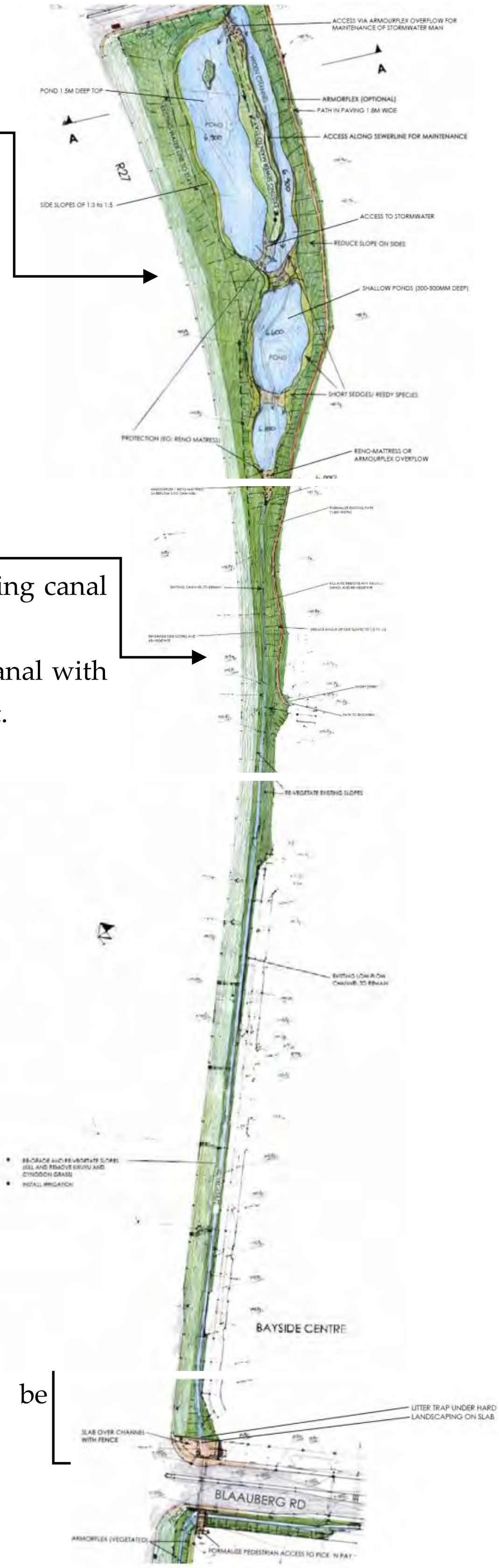
- Re-grade (to flatter slopes 1:3 to 1:5) and re-vegetate the existing canal and side slopes;
- Formalise the existing pedestrian pathway to the east of the canal with a paved walkway of minimum 1.8m in width up to Short Street.

Section 3: Bayside Canal (opposite Bayside Mall)

- Where possible re-grade to 1:3 and re-vegetate;
- Remove all alien vegetation and grass.

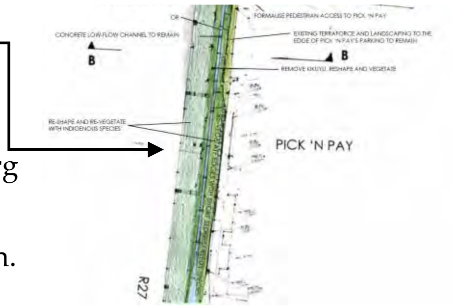
Section 4: Bayside Canal Blaauwberg Road crossing

- Litter trap located out of sit
- Additional width of culvert section (or concrete slab) to be installed on the northern side of the Blaauwberg Road.



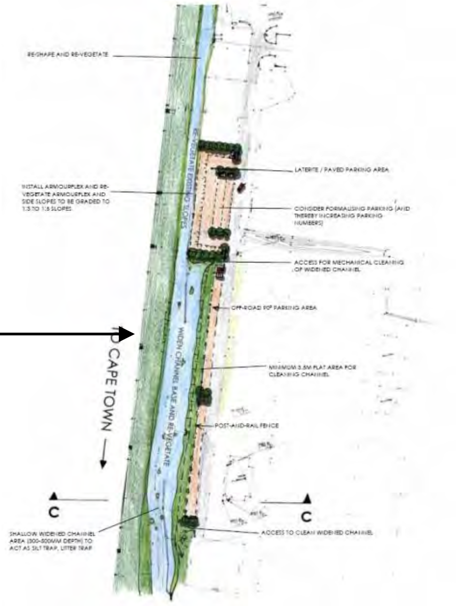
Section 5: Bayside Canal (opposite Table View Mall)

- Kikuyu grass to be killed and removed prior to earthworks;
- Re-grade and re-vegetate western bank to R27 fence line;
- Formalise pedestrian access between the corner of Blaauwberg Road/ R27 intersection and Table View Mall;
- Armorflex channel, however low-flow concrete channel to remain.



Section 6: Bayside Canal (South)

- Kikuyu grass to be killed and removed;
- Armorflex to guide future cleaners of canal depth and shape;
- Re-grade side slopes to as close to 1:3 to 1:5 as possible;
- Fix portion of channel alongside Water World, re-grade side slopes to 1:3 to 1:5;
- Widen portion from parking area: widen channel to form shallow pond (depth 300mm – 500mm) to act as a silt and litter trap prior to water entering the Rietvlei;
- Formalise parking and limit access along edge of this area in order to remove silt and litter (width to accommodate machinery of minimum 3.5m).



ANNEXURE C
BAYSIDE CANAL AND RIETVLEI WATER LEVELS (BVi, 2014)

22 July 2014 11:13:50 AM

PROJECT	STORMWATER MASTER PLAN FOR THE CENTRAL AND WESTERN BLAAUWBERG DEVELOPMENT AREA
DRAWING TITLE	BAYSIDE CANAL AND RIETVLEI WATER LEVELS

Cape Town
WESTERN CAPE

APPROVED BY BVI		
ENGINEER/TECHNOLOGIST	REG. NO.	DATE
SCALE 1:5 000 @ A3	DRAWN ZB	
DESIGNED FR	CHECKED FR	
PLAN NUMBER FIGURE A	REVISION NO. A	DATE SAVED 22 July 2014

0 10 50

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C2320SMP-120-RIETVLEI WATER LEVELS.DWG

24 July 2014 03:46:52 PM

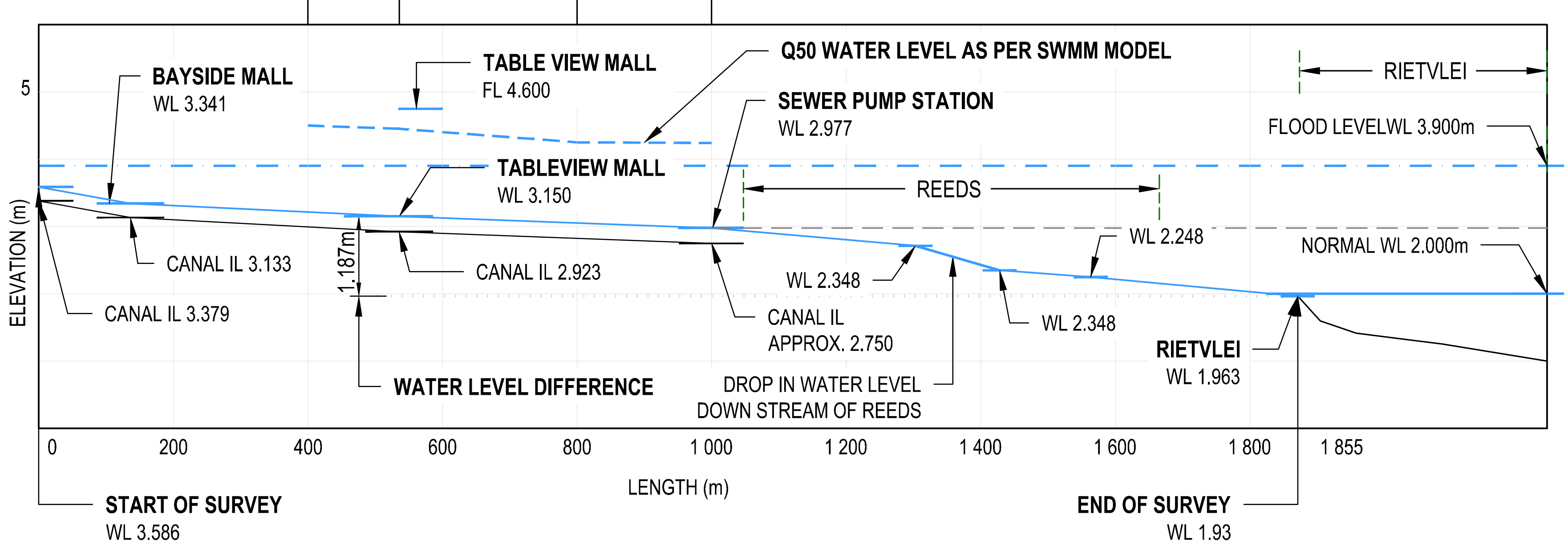
IL INVERT LEVEL
WL WATER LEVEL
FL FLOOR LEVEL

TYPICAL CROSS SECTIONS A TO C FROM SWMM MODEL FOR SUNNINGDALE, REFER TO FIGURE A FOR POSITIONS.

A B C D

NOTE:

1. **NORMAL WATER LEVEL** TAKEN AT BEGINNING OF WINTER WHEN REITVLEI WILL BE AT LOWEST LEVEL.
2. **FLOOD LEVEL** IN VLEI WITH 1:25 YEAR STORM IN DIEP RIVER CATCHMENT (BKS REPORT)
3. Q50 WATER LEVEL AT 1:50 YEAR STORM EVENT



DATE OF SURVEY:25/06/2014
SURVEYED: J BRINK

bvi ENGINEERING PROCUREMENT MANAGEMENT
Cape Town
WESTERN CAPE
CESA

PROJECT
STORMWATER MASTER PLAN FOR THE CENTRAL AND WESTERN BLAAUWBERG DEVELOPMENT AREA

DRAWING TITLE
BAYSIDE CANAL AND RIETVLEI LONG SECTION FROM SURVEY

APPROVED BY BVI

ENGINEER/TECHNOLOGIST	REG. NO.	DATE

SCALE	1:10 000 @ A4	DRAWN	ZB
DESIGNED	FR	CHECKED	FR
PLAN NUMBER		REVISION NO.	DATE SAVED
FIGURE B		A	22 July 2014

C2320SMP-120-RIETVLEI WATER LEVELS.DWG

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