Redevelopment of the River Club

Civil Engineering Report

Indigo Properties & Zenprop

2 March 2018

Revision: C

Reference: 112405

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1. Introduction

This Civil Engineering Report has been prepared for the proposed Redevelopment of the River Club in Observatory Cape Town. A locality plan of the site is included in Annexure A.

2. Scope of Report

This Civil Engineering Services Report will outline the demand the proposed development will place on the existing water and sewer services infrastructure as well as outline the concepts proposed and interventions required to support the development.

The scope of this report is limited to the following disciplines:

- Stormwater Management
- Potable Water
- Non-Potable Water
- Sewer
- Civil Engineering Construction

The following disciplines are excluded from this report:

- Surface Water Hydrology (dealt with in a separate report)
- Traffic Impact Assessment & Transportation (dealt with in a separate report)
- Electricity and Telecommunications (dealt with in a separate report)
- Geotechnical Investigation (included as Annexure B)

3. Description of the Development

The River Club will comprise of approximately 150 000m² of mixed-use development, including retail, office, residential (including inclusionary housing[1]), hotel, community and institutional uses. Development will occur in 2 precincts: Precinct 1, located in the southern portion of the site, will contain approximately 65 000m² of mixed-use floor space (office, retail, hotel, community and residential) in buildings of between 1-10 storeys; and Precinct 2, located in the northern portion of the site will accommodate approximately 85 000m² of residential and office floor space in buildings of between 10-12 storeys. Both precincts will be set upon super basements containing parking.

The quantum of development proposed at the River Club is based on the premise of the following:

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[1] The proponent is committed to ensuring that 20% of the total floor space (estimated at approx. 150 000m²) to be built at The River Club will be devoted to residential use. Of the 20% devoted to residential use, 20% will be allocated to inclusionary housing – these units will be integrated into the same block of apartments as the others residential units, and will be no different in terms of size and quality. In order to achieve this, the proponent is prepared to subsidise up to 75% of the rental in respect of the inclusionary housing units (i.e. a tenant in an inclusionary housing unit will pay only 25% of the market value rental of the unit).

- Berkley Road extension being implemented to link Berkley Road (to the east of the site beyond the Black River) with Liesbeek Parkway (to the west); and
- Approximately ± 55% of the site being raised above the 100-year flood elevation to approximately 6m above mean sea level.

Primary access points to the development will be located along the new Berkley Road extension. An additional access point will be established via a link road emanating from Liesbeek Parkway.

A major feature of the proposal is to rehabilitate the existing canal adjacent to the eastern boundary of the site and implement a riverine buffer of approximately 25 - 40m along its course. This will allow for a visually and ecologically congruent / continuous riverine corridor to be established that will stretch from the lower reaches of the Liesbeek River to the confluence with the Black River adjacent to the River Club site. This intervention will serve to establish a more logical alignment of the lower Liesbeek River in the landscape, whereby it will read as one river system (and not a mishmash alignment as is currently the case).

In order to give maximum effect to the new river alignment it is proposed to infill the degraded old Liesbeek River channel adjacent to the western boundary of the site, leaving only a narrow vegetated stormwater swale along its existing course. This will serve to integrate the site with the existing urban landscape to the west (and effectively end the River Club's appearance as an island in the landscape). A buffer area of approximately 15 – 30m between the stormwater swale and development is proposed.

The reconfiguration of the river courses as proposed will result in the rehabilitated riverine corridor on the eastern boundary of the site taking on more ecological significance.

An 'ecological corridor' extends across the site in an east-west direction between the development parcels of Precinct 1 and Precinct 2, connecting the rehabilitated riverine corridor (to the east) and the stormwater swale (to the west). This 'eco corridor' will form a 'green link' between the River Club site and the remaining TRUP open space system, and will allow for faunal movement through the River Club site, particularly that of the Western Leopard Toad. This space will also allow for flood attenuation during periods of high rainfall, as well as perform the function of a landscaped public space on the site.

High quality landscaping will be a feature throughout the development, including NMT pathways that will meander throughout the development, including along the river course and in the 'eco-corridor'.

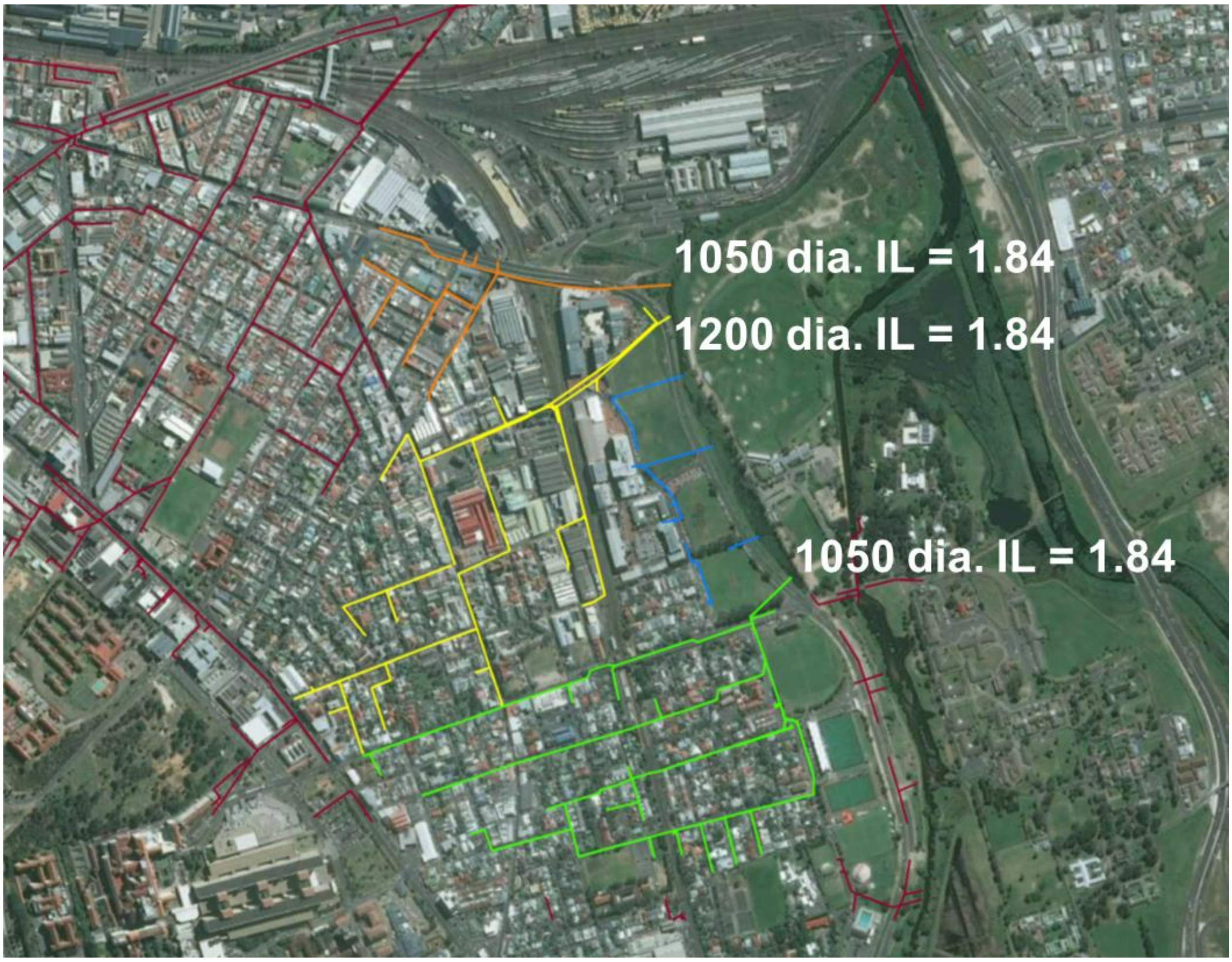
4. Stormwater Management

4.1 Existing Infrastructure and Conditions

The existing stormwater infrastructure for the River Club consists of a limited network of catchpits and pipes which drain directly into the Liesbeek Channel and Old Liesbeek River. Further drainage provision is through a combination of overland flow into the above-mentioned water courses and filtration. There are no visible or known connections to the municipal stormwater network.

Various large diameter municipal stormwater outfalls which drain parts of Observatory discharge into the Old Liesbeek River. An indication of the stormwater infrastructure which is in the vicinity is illustrated in Figure 4-1 below.

Figure 4-1 : Existing Municipal Stormwater Infrastructure



Flooding of the River Club and surrounds is known to occur as it is low-lying and is located within the Black River and Liesbeek River confluence and flood plain. Issues pertaining to flooding are dealt with in a separate Surface Water Hydrology Report.

4.2 Motivation for departure from Stormwater Policy

The River Club site is located within the flood plain and in order to permit development the site will be raised to above the 1:100 year flood.

However, since the site is located within a flood plain and its surrounds are inundated even during low order storm events, such as the 1:2 year storm event, attenuation of stormwater adds no significant value and thus the rate at which runoff is released from the development becomes irrelevant.

Thus, a departure from the Stormwater Policy in terms of attenuation is warranted in this instance and will be requested. Requirements with respect to the City's policy concerning treatment of stormwater to attain the desired quality are still however to be adhered to.

4.3 Conceptual Stormwater Management Plan

4.3.1 Context

This development is subject to the City of Cape Town's Stormwater Policy (Management of Urban Stormwater Impacts Policy – C58/05/09); and hence a Stormwater Management Plan will be prepared to recommend measures to mitigate the hydrology-, hydraulic-, and pollution-related effects of surface water released into the municipal stormwater network, and to demonstrate compliance with policy.

It is our understanding that a Stormwater Management Plan (SWMP) will become a condition of granting development rights and that at this stage a Conceptual Framework is sufficient to demonstrate the intent of the proponent to accommodate and comply with the policy.

The site is located on a slightly elevated portion of land surrounded by the Black River channel (east of the site) and the Liesbeek River (west of the site). The site drains to both sides.

Given the proximity of the site to the Black and Liesbeek Rivers, the position of the river floodlines is an important consideration in determining development setbacks. A separate surface water hydrology report being considered by Aurecon has determined the provisional flood lines and the effect of filling in the flood plain which informed this concept design.

4.3.2 Objectives

The objectives of the Conceptual Stormwater Management Plan are to:

- Identify measures to comply with the Council's Management of Urban Stormwater Impacts Policy (C58/05/09);
- Propose methods (structural controls) for removing, reducing, or retarding runoff flows, and preventing targeted stormwater runoff constituents, pollutants and contaminants from reaching receiving waters;
- Propose operation and maintenance procedures.

4.3.3 CoCT Stormwater Policy

Urbanisation typically impacts on natural waterway health in two key ways:

- The ***quantity*** of stormwater runoff is increased as the proportion of impervious area within a catchment is increased, leading to larger peak flows and more frequent runoff which may have detrimental effects on river health and can cause flooding in downstream areas.
- The ***quality*** of runoff is also negatively impacted with additional pollutant loads in the form of gross pollutants, suspended sediments and various other pollutants such as nitrogen, phosphorus and heavy metals.

The Management of Urban Stormwater Impacts Policy has been prepared by The City of Cape Town's Catchment, Stormwater and River Management Branch in order to address these stormwater impacts and ensure that new developments incorporate Water Sensitive Urban Design elements.

According to the policy, the site fits within the category of a Brownfield and Existing Development Site (Area > 50 000m2). The policy thus outlines target pollutant objectives and stormwater flow restrictions for the development as follows:

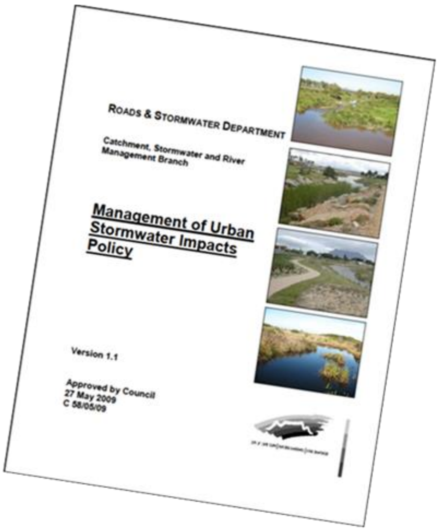
STORMWATER QUALITY

- ½-year Return Interval, 24 hour duration storm is the design storm for stormwater quality
- 80% reduction in post-developed Suspended Solids through on-site treatment
- 45% reduction in post-developed Total Phosphorus
- Litter, oil and grease traps at pollutant sources

STORMWATER QUANTITY

- 24 hour extended detention of the 1 year RI, 24 hour storm event
- Up to 10-year RI peak flow reduced to pre-development level
- Up to 50-year RI peak flow reduced to existing development level
- Evaluate the 100-year RI storm and its impact upon the stormwater system

However, it should be noted that, because our site is sitting within a floodplain and is inundated from low order storm events such as the 1:2yr storm event, attenuation of stormwater is not required as the rate at which runoff is released becomes irrelevant.



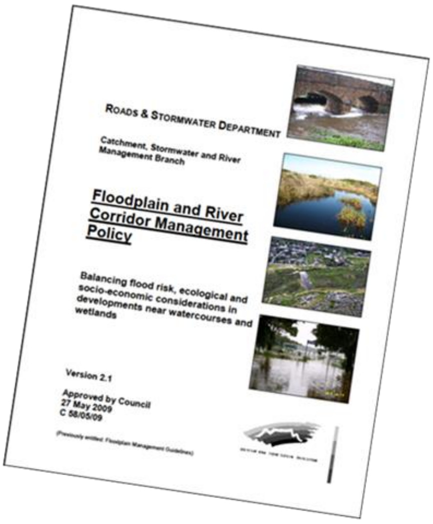
Roads & Stormwater Department

Catchment, Stormwater and River Management Branch

Management of Urban Stormwater Impacts Policy

Version 1.1

Approved by Council
27 May 2009
C 58/05/09



Roads & Stormwater Department

Catchment, Stormwater and River Management Branch

Floodplain and River Corridor Management Policy

Balancing flood risk, ecological and socio-economic considerations in developments near watercourses and wetlands

Version 2.1

Approved by Council
27 May 2009
C 58/05/09

4.3.4 Stormwater Concept

It is proposed to utilise a system of vegetated swales on the perimeter of the site underlain by a formalised piped drainage network. This will ensure that all stormwater runoff will be treated by the swales prior to entry into the river.

The Stormwater attenuation and drainage Concept Layout is illustrated in Drawing 112405-TEMP-301A which is included in Annexure C.

4.3.5 Stormwater Attenuation

No specific measures will be implemented in order to reduce runoff volumes and flow rates, however the swales will slow the stormwater flow velocities, lengthening the catchment response time and decreasing peak flows for the lower order storm events. They will also increase the total storage capacity of the stormwater system. This will provide storage in addition to the piped network.

4.3.6 Stormwater Quality

The vegetated swales will reduce the waterborne pollutant concentration through sedimentation and plant uptake of nutrients. Infiltration of stormwater into the soil underlying the swales will also lead to a reduction in pollutants reaching the downstream waterways.

4.3.7 Impact on Flood lines

The CoCT's latest flood line studies indicate that the flood lines will have an impact on the site. The 1:100 year RI and 1:20 year RI storm events have particular relevance in the City in terms of development set-backs. Applying the City of Cape Town's stormwater policy to this development, no buildings are to be constructed within the 1:20 year flood zone. Buildings are permitted in the 1:100 year flood zone; however the finished floor levels must be above the 1:100 year flood level.

a) Following discussions with City representatives, it was agreed that filling in the floodplain will be allowed if the surface water hydrology study can prove that the loss of floodplain storage (due to filling in the floodplain) will not have an adverse effect on any other properties.

b) Filling of the site would then result in a larger portion of the site being outside of the 1:20 year floodplain and an increase in developable area.

4.3.8 Flood Risk Mitigation

All finished floor levels of structures will be constructed above the 1:100 year flood level. Site egress during high order flood events will be via the proposed bridge across the M5 (Berkley Road) on the eastern portion of the site. Egress via the Observatory Road/Liesbeek Parkway intersection is not possible as the level of the bridge crossing the Liesbeek River is at the 1:20 year flood level.

4.3.9 Calculation of Stormwater Runoff

Based on the rainfall data provided in the Table 4-1 below the various design storms (South Africa, 24h SCS Type 1) will be created and simulated. The storm distributions are shown in figure 4-2 below. Rainfall data extracted from the SRK/Smithers Rainfall Database are used to create these storm events.

Table 4-1: 24hr Rainfall - SRK/Smithers Database 2011

Recurrence Interval	24hr Rainfall Depths
0.5yr	32.3
1yr	43.9
2yr	53.1
5yr	71.2
10yr	84.5
20yr	98.4
50yr	117.9
100yr	133.8
200yr	150.9

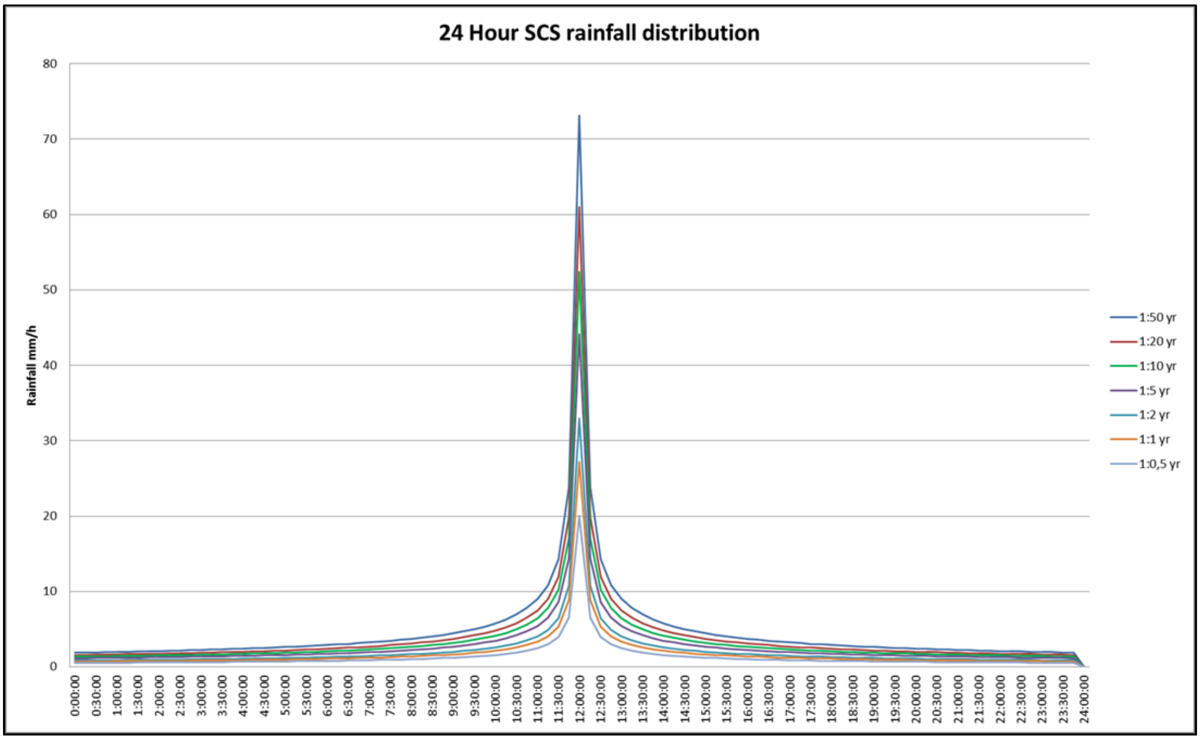


Figure 4-2: 24hr SCS Type 1 Storm Distribution

4.3.10 Proposed Infrastructure

A system of vegetated swales underlain by a formalised piped drainage network will convey stormwater from within the precinct to the various detention ponds.

Bioretention swales provide both stormwater treatment and conveyance functions, combining a bioretention system installed in the base of a swale that is designed to convey stormwater. The swale component provides pre-treatment of stormwater to remove coarse to medium sediments while the bioretention system removes finer particulates and associated contaminants. Bioretention swales provide flow retardation for frequent storm events and are particularly efficient at removing nutrients.

The bioretention swale treatment process operates by filtering stormwater runoff through surface vegetation associated with the swale and then percolating the runoff through a prescribed filter media, forming the bioretention component which provides treatment through fine filtration, extended detention treatment and some biological uptake. A typical cross section of a swale is shown in the figure below. Bioretention swales also act to disconnect impervious areas from downstream waterways and provide protection to natural receiving waterways from frequent storm events by reducing flow velocities compared to piped systems. The bioretention component is provided as a continuous “trench” along the full length of a swale.

It is important to ensure that velocities in the bioretention swale from both minor (2-10 year RI) and major (50-100 year RI) runoff events are kept sufficiently low (preferably below 0.5 m/s and not more than 2.0 m/s for major flood) to avoid scouring. This will be achieved by ensuring the slope and hydraulic roughness of the overlying swale reduce flow velocities by creating shallow temporary ponding (i.e. extended detention) over the surface of the bioretention filter media via the use of a check dams (only where required).

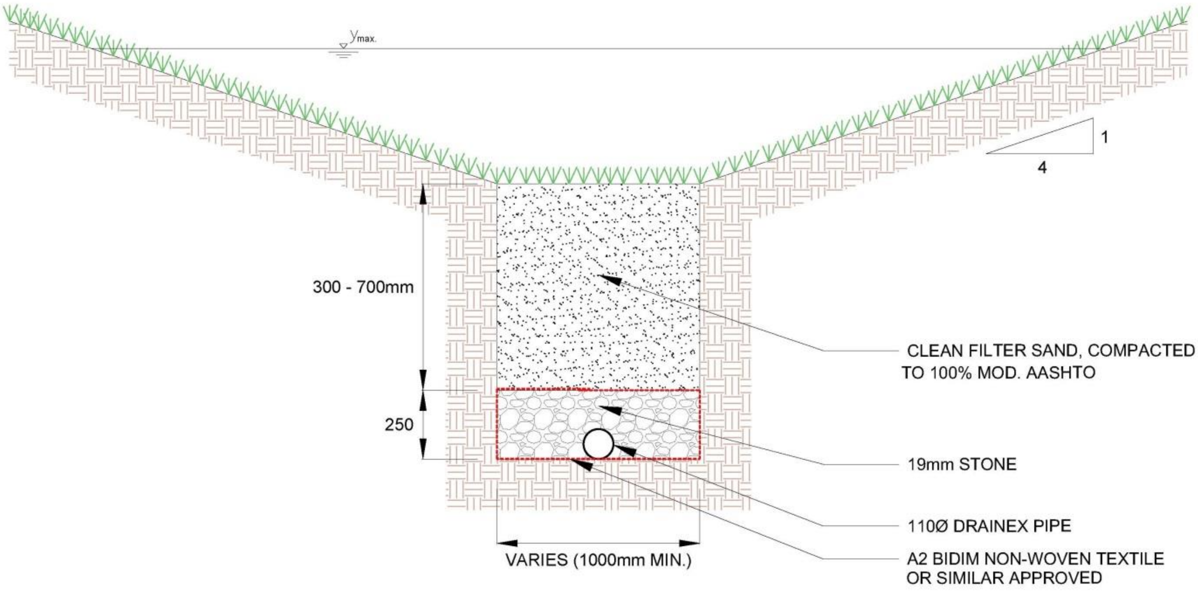


Figure 4-3: Swale – Typical Cross Section

4.3.11 Operation & Maintenance

Operation and maintenance procedures will be produced by Aurecon as part of the closeout procedures for the project. The maintenance agreement will require the owner of the property to periodically clean the structures, monitor the vegetation and sediment accumulation and provide occasional watering to preserve the vegetation during the dry season. Typical periodic maintenance activities for swales are provided in Municipal Stormwater Management, 2nd Edition, Debo TN, Reese AJ, 2003 (Table 13-20 and Table 13-38, Source: Georgia Stormwater Manual, 2001). The landowner will implement the most suitable of these activities for the specific site conditions or as required during the lifecycle of the swales.

4.4 Sustainable Urban Drainage

A **sustainable drainage system** (SuDS) or water urban sensitive design is designed to reduce the potential impact of new and existing developments with respect to surface water drainage discharges

SuDS use the following techniques:

- source control
- increasing permeable surfaces such as permeable paving
- storm water detention
- storm water infiltration
- evapo-transpiration (e.g. from a green roof)

Some interventions that are being considered for implementation include:

- Protecting and enhancing the Liesbeek Canal through rehabilitation of the bank on the River Club side.
- Protecting and improving the water quality of water draining from the proposed development through the use of bio swales
- Attempting to restore the urban water balance by maximising the reuse of stormwater, recycled water and grey water;
- Integrating stormwater treatment into the landscape so that it offers multiple beneficial uses such as water quality treatment, wildlife habitat for the WLT , recreation and open public space;
- Marginally reducing peak flows and runoff simultaneously providing for infiltration and groundwater recharge;
- Integrating water into the landscape to enhance urban design as well as social, visual, cultural and ecological values

5. Potable Water

5.1 Existing Infrastructure and Conditions

The site falls within the Molteno Reservoir area of supply. From this reservoir there is an existing 450mm dia. main located in Liesbeek Parkway which supplies water to the larger Observatory area and surrounds. The River Club, South African Astronomical Observatory (SAAO) and the Valkenberg Hospital Complex are all currently supplied by a 110mm dia. main which branches off from this 450mm dia. main.

The potable water demand of the current buildings that are located within the site is considered negligible in comparison to the proposed demand and thus has not been considered further in this report.

5.2 Permanent Water Demand

5.2.1 Unit Demands/Consumption Norms

The Guidelines for Human Settlement Planning and Design (Red Book) 2003 was used as the basis to calculate the potable water demands. The adopted unit demands are summarized in Table 5-1 below.

Table 5-1: Potable Water Unit Demands

Land Use	Unit	Rate
Retail	$l/m^2/day$	4
Residential – Conventional Apartments	l/unit/day	600
Residential – Inclusive Apartments	l/unit/day	600
Office	$l/m^2/day$	4
Hotel	$l/m^2/day$	4
Ancillary	$l/m^2/day$	4
Private School	l/pupil/day	20

A suitable allowance has been made for firefighting purposes. The development has been considered as a high risk area due to the fact that almost all buildings are four stories or more in height. Thus 25 l/s has been considered per hydrant and it is assumed that two hydrants will be discharging simultaneously during a single fire event.

The building specific firefighting requirements are not known and would have to be confirmed at a later date with the appointed fire engineers.

5.2.2 Proposed Demand

The AADD (Average Annual Daily Demand) for the development is estimated at 876 kl/day which equates to an instantaneous demand of 10.14 l/s. The peak instantaneous demand is 40.7 l/s and when considering the firefighting flow the total peak demand increases and is calculated as 90.7 l/s. The findings are summarized in Table 5-2 below whilst the detailed demand calculations appear in Annexure D.

Table 5-2: Potable Water Demand – Summary

Description	Unit	Amount
Annual Average Daily Demand(AADD)	kl/day	876
Instantaneous Demand	l/s	10.14
Peak Factor	-	4
Peak Instantaneous Demand (Q_p)	l/s	40.7
Allowance for Fire Flow (Q_f)	l/s	50
Peak Flow (Q_p +Q_f)		**90.7**

5.3 Temporary Demand - During Construction

Refer to the section on Non Potable Water Use for regarding water for construction.

5.4 Water for Fire-fighting

Potable water shall be used for fire-fighting as is the convention in the City of Cape Town. A firefighting scenario has been accounted for in the demand calculations and thus should not negatively impact on the municipal network's ability to supply surrounding areas should such an event arise. It should be noted that water for firefighting is a discreet event and is not part of the regular daily consumption of the development.

5.5 Confirmation of Capacity

The City of Cape Town has confirmed that they have sufficient capacity to supply the demand of the previous proposal of 120,000m^2 of bulk. We are awaiting a response on the confirmation of capacity to service 150,000m^2. (Refer to Annexure E).

5.6 Proposed Supply Infrastructure

5.6.1 Bulk Infrastructure

No bulk infrastructure upgrades inclusive of storage, treatment or conveyance are required to service the development and the potable water supply can be drawn from the existing 450mm dia. main located within Liesbeek Parkway.

5.6.2 Link Infrastructure

A new connection to the exiting bulk meter linking the potable municipal main to the site boundary shall be required and is illustrated in Drawing 112405-Temp-601 which is included in Annexure F. Based on the peak flow of 90.7 l/s a 200mm dia. connection is anticipated to be adequate to service the development. This indicative size assumes a minimum velocity of at least 0.7m/s being available at the point of connection. The size of the connection can only be confirmed once the flow and pressure at the tie in point can be ascertained and the remainder of the network modelled.

A bulk metered connection, in accordance with municipal standards is to be provided at a suitable point near the entrance to the development. Every development opportunity within the site could have a separate meter however these meters and the associating reading and billing will be the responsibility of the body corporate should this be desired. The cost of the link infrastructure will be borne by the developer.

5.6.3 Internal Infrastructure

Network Sizing

Preliminary estimates indicate that a network comprising of 200mm and 150mm dia. pipelines would be sufficient to service the development. However, this can only be confirmed upon detailed modelling and the confirmation of fire flow requirement to buildings. The network shall be designed to supply domestic and fire-fighting demand whilst maintaining the necessary pressures and velocities as prescribed by the CoCT.

Network Configuration

Due to the nature of the development which comprises of two precincts with super basements upon which multiple towers/buildings are located a large percentage of the water supply infrastructure will be installed within the basement structures.

Pipe Materials

Apart from where the pipes are installed in basements, pipe material will most likely be HDPE pipes to counter the predicted settlement due to the unfavourable in-situ soil conditions
The network design, pipe material and all fittings and specials will be in accordance with the municipal requirements and specifications.

Implementation Cost

The cost of the internal infrastructure will be borne by the developer.

5.7 Strategies for Reduction

5.7.1 Green Buildings

One of the strategies to reduce the demand for potable water is to implement a Green Star rating for specific building types. Office buildings have been potentially earmarked and will as far as possible be earmarked for 4 or 5 star ratings.

In addition, efficient water fixtures will be utilized in line with the CoCT bylaws and requirements and alternatives sources to potable water will be used for uses like irrigation.

5.7.2 Water Re-use

In terms of the water reuse and conservation of non-renewable, the following has relevance:

- The abstraction of surface and/or groundwater to reduce the demand for potable water is being considered.
- As per correspondence received from CoCT Water Demand Management & Strategy Department dated 01 September 2016 – no onsite treatment of wastewater will be permitted and thus treatment of wastewater is not being pursued, however smaller scale opportunities for greywater recycling will be considered. Given the current water scarcity this recommendation however might be reviewed by the CoCT and then could be considered by the development.
- The possibility of supply from the CoCT's Treated Sewer Effluent Network (which is currently being expanded) was explored. There are however concerns that using treated effluent for irrigation may compromise river health due to the close proximity to the water courses.

5.7.3 Alternative Technologies

Opportunities for alternative technologies are limited with respect to water supply. However, emphasis will be placed on demand management within the development and there is a desire to leverage on BMS (Building Management Systems) to track and manage water demand more efficiently.

6. Non-Potable Water

6.1 Water for Irrigation

Although high quality landscaping will be a feature throughout the development it is the intention that the landscaping palette comprise as far as possible of indigenous and other water wise species.

An estimated water demand for the establishment period of the proposed landscaping which represents a more conservative scenario has been determined. As the plants establish over a few seasons the demand will likely reduce by up to 50%.

To project the annual water demand for this scenario, the establishing scenario is 80,025m^3 for the establishment year. This equates to an average application rate of 2.36mm/m^2 which translates to a daily consumption of 220m^3/day. The detailed summary is included in Figure 6-1.

THE RIVERCLUB MOWBRAY - ET Based Schedule (9,273ha)

Projected Annual Water Demand for Indigenous Vegetation

Month	Area (m^2)	Seasonal Adjustment	*Daily Appl. Rate (mm/month)*	Monthly Appl. Rate (mm/month)	Projected. Monthly Water Demand (m^3)
January	92,730	**100%**	*5.35 mm/day*	165.75 mm/mth	15,370
February	92,730	**90%**	*4.81 mm/day*	139.55 mm/mth	12,941
March	92,730	**70%**	*3.74 mm/day*	116.03 mm/mth	10,759
April	92,730	**20%**	*1.07 mm/day*	32.08 mm/mth	2,975
May	92,730	**10%**	*.53 mm/day*	16.58 mm/mth	1,537
June	92,730	**0%**	*.00 mm/day*	.00 mm/mth	0
July	92,730	**0%**	*.00 mm/day*	.00 mm/mth	0
August	92,730	**0%**	*.00 mm/day*	.00 mm/mth	0
September	92,730	**10%**	*.53 mm/day*	16.04 mm/mth	1,487
October	92,730	**50%**	*2.67 mm/day*	82.88 mm/mth	7,685
November	92,730	**80%**	*4.28 mm/day*	128.33 mm/mth	11,900
December	92,730	**100%**	*5.35 mm/day*	165.75 mm/mth	15,370
Total Projected Annual Water Demand					**80,025**

Figure 6-1: Irrigation Demand

The probable sources of water for irrigation could include a blend of:

- Boreholes
- Supply from treated effluent lines (blended with other sources to mitigate against leachate)
- Water from dewatering and other subsurface water control operations

Treatment will most likely be required for some for the above source depending on the water quality.

6.2 Water for Construction

Minimal information or research exists surrounding water consumption and demand on mixed-use, complex construction sites such as this one.

From the high level review literature conducted (presented in Annexure G) it was determined that the total water demand for a building residential type project, expressed as total water consumed per gross floor area (m^3/m^2) ranges between 1.97 m^3/m^2 and 3.14 m^3/m^2. There are various factors which can influence this consumption rate including type of materials required and the construction methods etc. A conservative value of 3.14 m^3/m^2 was selected order to calculate a notional construction water demand.

6.2.1 Total Consumption

Given the total bulk of the development is 150,000 m^2, it is reasonable albeit a conservative estimate that a total of 471,000 m^3 of water will be used to construct the building components of the project over its entire construction period.

It is expected that civil engineering construction will account for an equivalent 140,000 m^2 during the construction period and hence requiring 1 m^3/m^2 water per constructed area.

Considering both civil construction and building construction a total of 611,000 m^3 of water could be used over the entire construction period

6.2.2 Notional annual consumption

In developing a model to estimate the annual consumption the following assumptions were made with respect to phasing:

- It is assumed that enabling works such as civil engineering and infrastructure works would be completed during the first 2 years of construction,
- Precinct 1 would require 2 years for construction. It is assumed that half of the required floor area would be constructed per year.
- Precinct 2 would require 9 years of construction with 1 tower requiring 1 year to complete.

It is thus assumed that the total period of construction could be up to 13 years and this has been used to provide a notional annual consumption. It is important to note that the actual implementation duration will depend on numerous factors and is difficult to estimate at this time. The projected annual water demand for the river club can be seen in Figure 6-2.

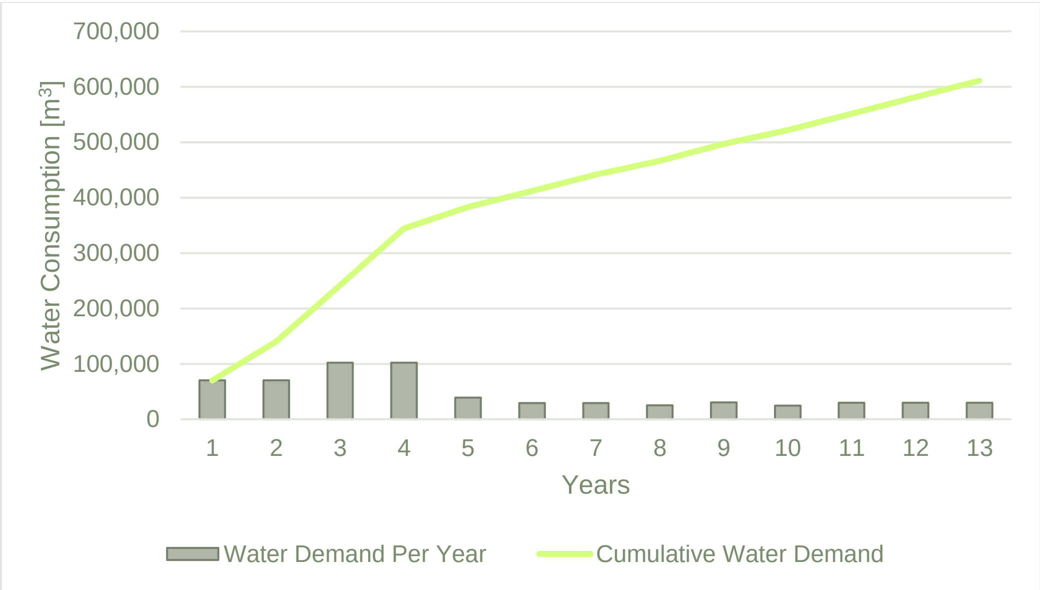


Figure 6-2: Projected Annual and Cumulative Construction Water Demand

It is also important to note that not all the water will be consumed at the Riverclub site and that water can be consumed at other locations such as in the supply of ready mix concrete.

7. Sewage Disposal

7.1 Existing Infrastructure and Conditions

The proposed development falls within the Athlone Waste Water Treatment Works (WWTW) catchment area and within a sub catchment that drains to the Raapenberg Pump Station which pumps the sewage to the Athlone WWTW.

Currently a 225mm dia. pipe to the south of the River Club located in Observatory Road services the River Club as well as the SAAO and Valkenberg Hospital Complexes. This 225mm dia. main crosses into Station Road before changing course into Ossian Road. The existing services are reflected in 112405-TEMP-501A which is included in Annexure H. In addition, a large diameter bulk sewer ranging in size from 900mm to 1050 mm dia. is found to the west of the River Club. In Annexure H the extent of the main can be seen in Fir Street before changing course into Station Road and then continuing on in Florence Avenue. This main eventually discharges into the Raapenburg Pump Station.

Given the additional flows that are expected it is anticipated that the 225mm dia. main will not have sufficient spare capacity to serve the development and it is likely that a more direct connection to the bulk main is required. It is also reported by the CoCT that the Raapenburg Pump Station experiences challenges during peak times and is at capacity during these times.

7.2 Permanent Sewage Flows

7.2.1 Unit Flows and Peak Factors

The unit flows are based on a percentage of the water demand and are indicated in Table 7-1 below.

Table 7-1: Sewage Flows Unit Demands

Land Use	Water Demand		Sewer Yield	Sewer Flows	
	Unit	Rate		Unit	Rate
Retail	l/m²/day	4	95%	l/m²/day	3.8
Residential	l/unit/day	600	90%	l/unit/day	540
Office	l/m²/day	4	95%	l/m²/day	3.8
Hotel	l/m²/day	4	95%	l/m²/day	3.8
Private School	l/pupil/day	20	95%	l/pupil/day	19
Ancillary	l/m²/day	4	95%	l/m²/day	3.8

The peak factor was calculated using the Harmon Formula where

PF = 18+ SQRT (EP) / 4 + SQRT (EP)
Where
PF = Peak Factor
EP = Equivalent Population
SQRT = square root

The ADWF (Average Dry Weather Flow) for the development is estimated at 866 kl/day which equates to an instantaneous flow of 10.02 l/s. The PDWF (Peak Dry Weather Flow) is estimated at 35.37 l/s and when considering an infiltration rate of 15% the PWWF (Peak Wet Weather Flow) is estimated at 40.68 l/s. The findings are summarized in Table 7-2 below whilst the detailed flow calculations appear in Annexure I.

Table 7-2: Sewage Flows –Proposed Development

Description	Unit	Amount
Average Dry Weather Flow (ADWF)	kl/day	866
Instantaneous Flow	l/s	10.02
Peak Dry Weather Flow (PDWF)	l/s	35.37
Infiltration @ 15%	l/s	5.31
Peak Wet Weather Flow (PWWF)	**l/s**	**40.68**

7.3 Temporary Flows - During Construction

The temporary sewage flow will be handled by the contractor through temporary ablution facilities to accommodate workers on site. It is reasonable that the sewage flows will be negligible. These facilities will be maintained in conjunction and be compliant with the environmental management plan for the development.

7.4 Nature & Composition of sewage

The development is a mixed used development and will contain residential, office, retail and restaurant land uses. No industrial activity or land use is planned. Industrial effluent often has a distinct nature and composition which requires further consideration.

Retail and restaurant effluent which typically contains significantly more oils and fats will require the employment of grease traps as per building code regulations to remove such content prior to discharging into the reticulation network.

The wastewater characteristics for domestic sewage have been deemed to be reflective of the mixed-use development envisaged for the River Club and has been adopted for design purposes. These values which are shown in Table 7-3 below are consistent with that which is typically found in the effluent emanating from residential, retail, offices and restaurants establishments.

The parameters anticipated for the typical composition of the sewage are summarized in Table 7-3.

Table 7-3: Sewage Composition

Parameter	Adopted for Design	Typical SA Domestic*
pH	7.2	5.5 - 9.0
Chemical Oxygen Demand (COD) (mg/l)	800	500 - 1000
Total Kjedahl Nitrogen (TKN) (mg/l)	70	40 - 80
Ammonia (NH3) (mg/l)	50	30 - 60
Total Phosphorous (TP) (mg/l)	12	8 - 20
Total Suspended Solids (TSS) (mg/l)	260	250 - 500

* Average values for Domestic wastewater in South Africa was obtained from WRC (1994), Theory, Design and Operation of Nutrient Removal Activated Sludge Processes

7.5 Confirmation of capacity

The City of Cape Town has confirmed that they have sufficient capacity to accept the flows emanating from the previous proposal of 120,000m^2 of bulk. We are awaiting a response on the confirmation of capacity to service 150,000m^2 of bulk. (Refer to Annexure E).

7.6 Proposed Drainage Infrastructure

7.6.1 Bulk Infrastructure

No bulk collection, pumping or conveyance infrastructure upgrades are required to service the River Club development. In terms of wastewater treatment the City of Cape Town is currently installing a 3rd diversion main from the Athlone WWTW to the Cape Flats WWTW so that flows during peak times can be diverted to Cape Flats WWTW thus creating additional capacity.

Although the River Club Development will benefit from this bulk infrastructure upgrade, it was part of COCT infrastructure upgrade prior to the River Club Development and will benefit other developments within the catchment.

7.6.2 Link Infrastructure

Link Infrastructure will be required as it is unlikely that the exiting sewer pipe that services the River Club currently will be sufficient for the increased flows.

The link infrastructure will consist of:

- Two pump stations, PS 1 located in Precinct 1 and PS 2 located in Precinct 2
- PS2 is a satellite pump station i.e. it pumps sewage to PS1 from where it is pumped towards the municipal discharge point in Station Road. A bypass arrangement is provided at PS1 so that PS 2 can still pump sewage towards the municipal discharge point if PS1 is experiencing technical difficulties.

- The two HDPE sewage rising mains of approximately 160mm dia. will be installed within the basement for most of their routes whilst reticulated within the development and installed in trench for a shorter distance.
- The infrastructure that will be required outside of the development boundary entails a section of 160mm dia. HDPE rising main crossing Liesbeek Parkway and discharging into a break pressure manhole. From the break pressure man hole the sewage will gravitate in 200mm dia. uPVC of approximately 40m until it discharges into an existing 900mm dia. sewer main. The Liesbeek Parkway crossing will most likely be installed using directional drilling to avoid disruption to road users.

The proposed link infrastructure is illustrated in Drawing 112405-TEMP-501A which is included in Annexure H. The cost of the link infrastructure will be borne by the developer.

7.6.3 Internal Infrastructure

Network Sizing

Preliminary estimates indicate that for the gravity component of the network sizes ranging from 160mm to 250mm diameter would be sufficient to service the development. However, this can only be confirmed upon detailed sewer modelling. The network shall be designed to maintain the minimum velocities and other requirements as prescribed by the CoCT.

Network Configuration

Due to the nature of the development which comprises two precincts with super basements upon which multiple towers/buildings will be constructed as well as the fact that settlement is predicted due to poor in-situ soil conditions a large percentage of the internal sewer network will be installed within the basement structures.

Pipe Materials

Apart from where pipes are installed in the basement, pipe material will most likely be HDPE pipes to counter the predicted settlement due to the unfavourable in-situ soil conditions.
The network design, pipe material and all fittings and specials will be in accordance with the municipal requirements and specifications.

Implementation Cost

The internal infrastructure will be borne by the developer. The proposed internal infrastructure is illustrated in Drawing 112405-TEMP 501A which is included in Annexure J.

7.6.4 Pump station Layout & Details

The sewage pump station will include a holding tank so that sewage can be temporarily sored and pumped during off peak times thus mitigating against the capacity constraints faced at Raapenburg pump station during peak times.

Concept Layout

Since ground settlement is expected to be significant it is considered more efficient to leverage on the piled structures of the building and locate both sewage pump stations within the building basement. Adopting this approach has the following benefits:

- Safeguard the pump station installation from vandalism

- Allows for 24hrs access
- Containment of spillages within the basement structure

A general arrangement sketch which illustrates the proposed concept of the pump station are is shown in Figure 7-1 below.

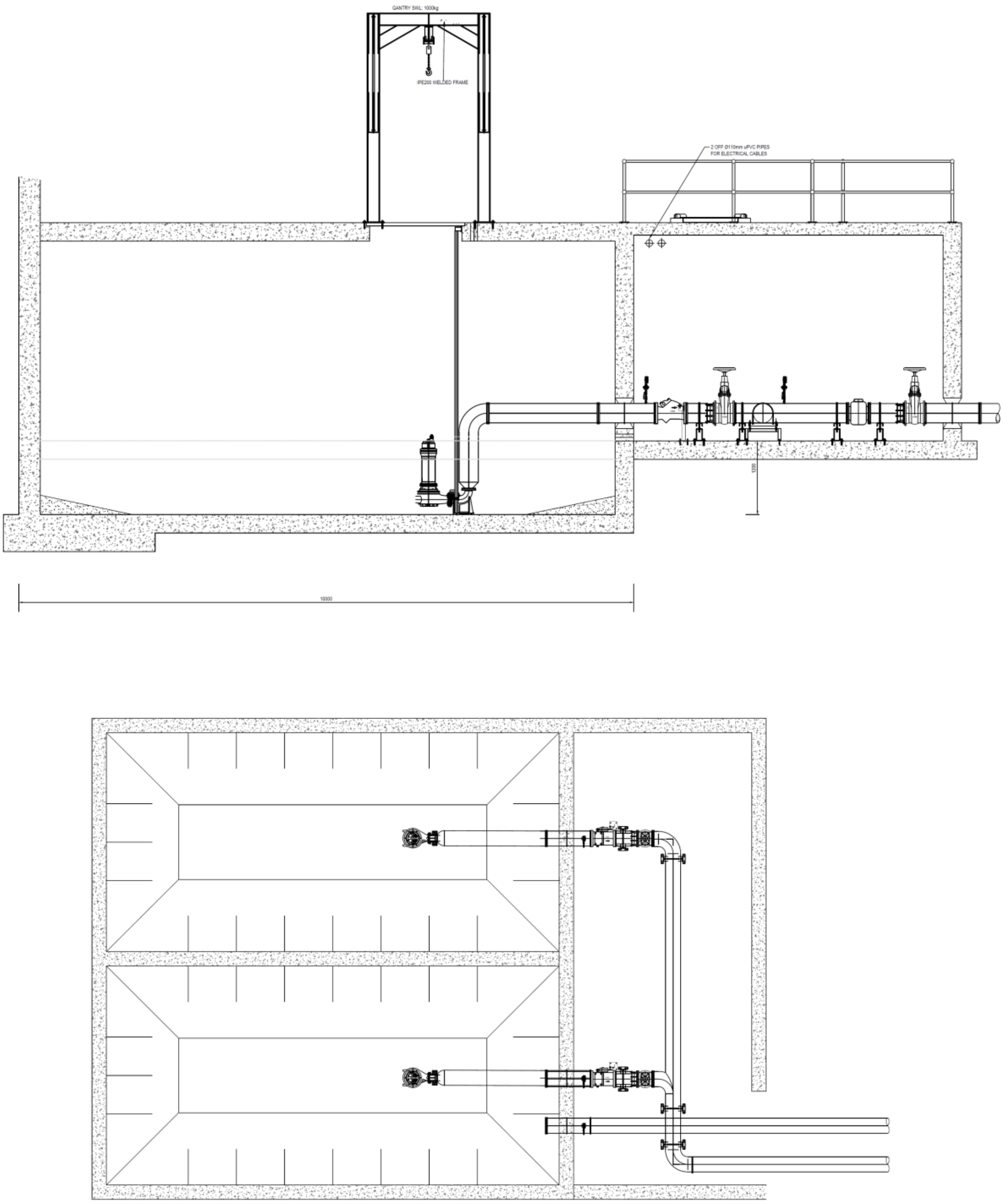


Figure 7-1: Sewer Pump Station General Arrangement

The pump station will be designed in accordance with the CoCT specifications however will be operated and maintained by the developer.

Alternatives

It should be noted that if upgrades are undertaken to relieve the capacity constraints at Raapenberg pump station the development will look to gravitate the sewer to the municipal bulk main as opposed to pumping.

7.7 Pollution Prevention Interventions

Since the development is situated alongside the Liesbeek River and Black River and near of the Raapenberg wetlands, spillage of sewage can have a detrimental effect on the surrounding environment.

To mitigate against events that could result in spillage the following strategies will be integrated into the design of the sewage network and included in Table 7-4.

Table 7-4: Sewage Pollution Prevention Strategy

Activity	Description	Resp.	Risk	Impact	Mitigation
Collect	Building Sewer System → Gravity Network	Developer	1.) Pipe failure/break	Splliage into watercourse - river & public health	Use of HDPE Pipe - more resilient joints, less susceptable to failure due to settlement
					Collection mains located within within basement - redeces chance of spillage into river
				Spillage into basement - public health	Collection mains located within within plenum in basement - redeces chances of basment spillage
			2.) Blockage	Spillage into watercourse - river & public health	As above for pipe failure
				Spillage into basement - public health	As above for pipe failure
Detention +Pump	Pump Station – Sump	Developer	1.) Pump failure	Spillage into basement - public health	Duty and standby pump configuration
					Pumps are submersable type - easy removal and replacement
					Emergency storage capacity of 6 hrs available within sump + additional sotrage in plenum
					Facility for removal of contents via sewage tanker in case of complete pump failure
			2.) Power outage	Spillage into basement - public health	Backup generator provision
					Emergency storage capacity of 6 hrs available within sump + additional storage in plenum
					Facility for removal of contents via sewage tanker in case of complete power failure
			3.) Structural failure	Spillage into basement - public health Ground contamination - river health	Bunded area around tank
					Emergency storage capacity of 6 hrs available within sump + additional storage in plenum
					Facility for removal of contents via sewage tanker in case of complete structural failure
			4.) Noxious gases	Public health	Ventilation shaft to outside of basment
					Monitoring devices inside basment to minotr noxious gas - linked to alarm and BMS
Convey	Sewage Rising Main	Developer /Council	1.) Pipe failure/break	Spillage into watercourse - river & public health	Use of HDPE Pipe - more resilient joints, less susceptable to failure due to settlement
					Large % of rising mains located within basement - reduces chance of spillage into river
				Spillage into basement - public health	Rising mains located within within plenum in basement - redeces chances of basment spillage
			2.) Damage to pipe where int trench	Spillage into watercourse - river & public health	Clearly mark pipe with identification tape in trench
					In high risk areas concrete encase pipe
Discharge	Discharge manhole → Municipal Network	Developer /Council	1.) Blockage	Splliage into road/watercourse - river & public health	Ensure proper maintenace and regular cleaning of manhole/downstream pipe
					Automatic shutdown of pipe if flow below threshold

A framework process flow that illustrates the protocol that should be implemented in the case of pump station failure is shown Figure 7-2and Figure 7-3 and should be incorporated in the building operating procedures.

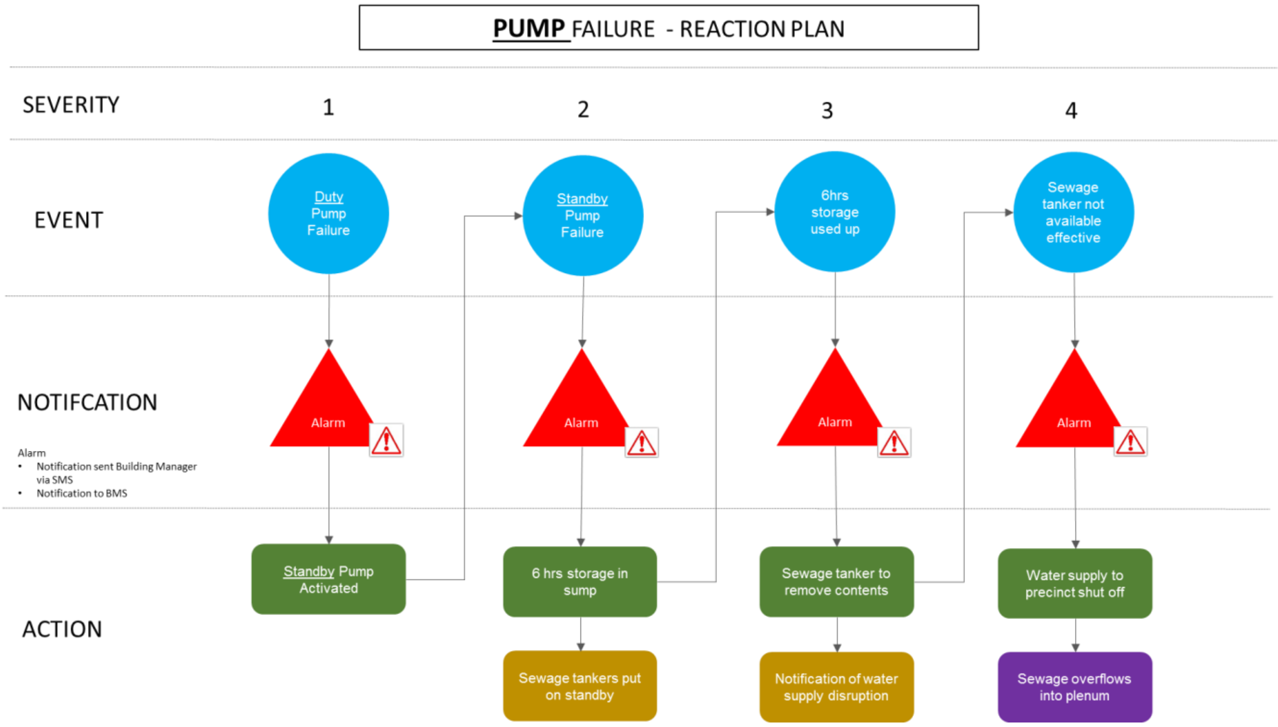


Figure 7-2 : Pump Failure – Framework Reaction Plan

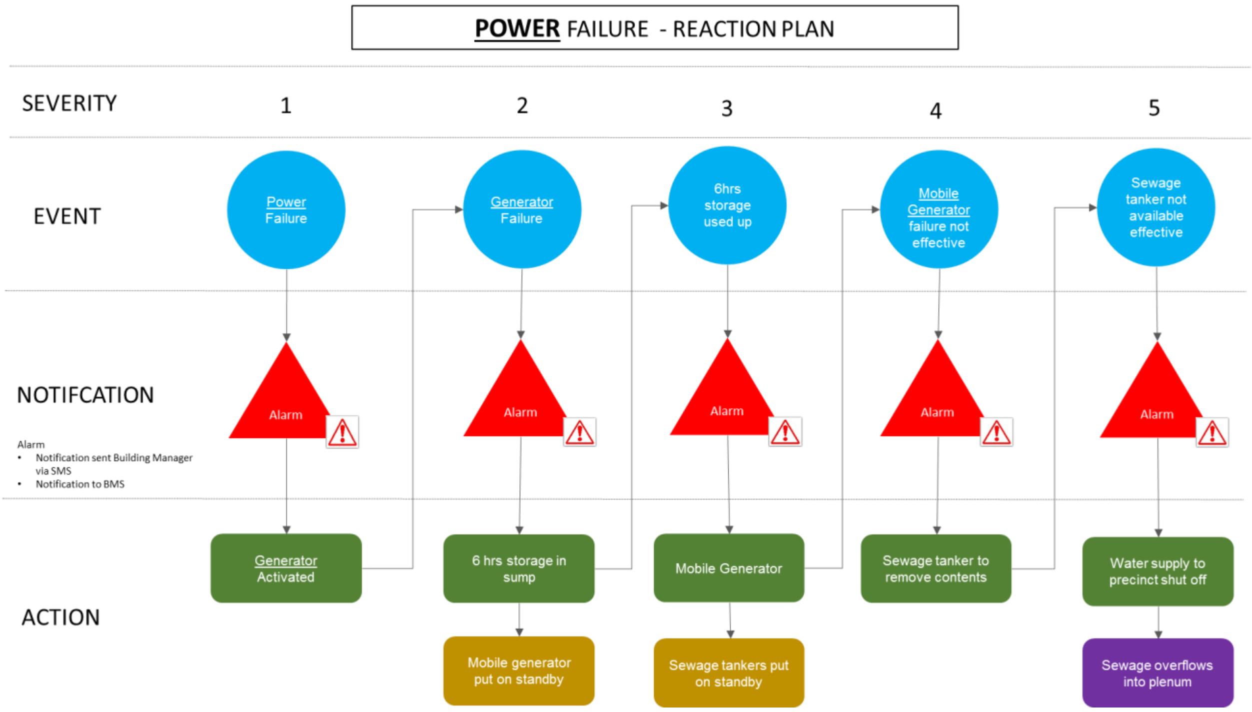


Figure 7-3 : Power Failure – Framework Reaction Plan

7.8 Strategies for Reduction

Strategies for reduction of sewage are closely aligned with the strategies for the reduction in water use. In general the less water that is consumed the less wastewater that is also produced. The strategies to be implemented for water reduction are discussed in Section 5.7.

8. Construction

8.1 Dewatering

Due to the construction of a low level basement structure for Precinct 1 dewatering during construction will be required as well as localized dewatering for Precinct 2. Dewatering will be carefully managed and entail the use of silt removal traps to prevent siltation of the adjacent water courses. Consideration will also be given to harvesting the ground water extracted from dewatering for use during construction,

For the permanent buildings, due to the high water table sub-surface drainage below the lower basement slabs are not considered feasible and “tanked” basements are being considered thus no subsurface drainage and associated removal of subsurface water is anticipated.

8.2 Filling of Site

8.2.1 General

Substantial fill material will be required to raise the site above the 1:100 flood level. Initial estimates indicate that approximately 200,000m^3 of fill material will be required. Although there are opportunities for cut to fill to raise the site a large portion will be imported material.

The fill will be placed predominantly on the perimeter of the site as the central parts of the site will consist of a basement structure. Substantial fill will also be required for the Berkley Road Extension as well as the filling of the Old Liesbeek River.

8.2.2 Source of Fill

The strategy with respect of sourcing the large quantity of fill required will entail targeting the following three sources:

- Spoil - Excavations from other building sites
- Recycled building material
- Commercial sources - quarries

Spoil - excavations from other building sites

It is the intention of the development to explore the possibility of importing the fill material to elevate the site from other constructions sites within close proximity where large excavations are required i.e. excavating of a basement in the CBD.

There are benefits to this approach which includes

- the positive impact as result of diversion of excavated material from designated waste sites,
- less travelled distance by haul trucks thus easing congestion
- and reducing the carbon footprint.

Recycled Building Material

Similar to using excavated material from construction sites, building waste/rubble for fill is also being considered which will have similar positive impacts on the environment. However, cognisance needs to be taken that this type of material could possibly contaminate the ground as thus stricter controls would need to be put in place.

Commercial sources

This is material sourced from licenced commercial quarries in Cape Town and surrounds.

8.2.3 Contamination Prevention

Strict protocols will be put into place to prevent contamination of the ground with imported material as well as construction materials, fuels and oils. These will be implemented as part of the EMP.

8.2.4 Erosion and Silting

During construction stormwater management will be undertaken in accordance with the Environmental Management Plan. Cognisance should be taken of the statement with regards to attenuation.

Control of Silt

With respect to dewatering silt traps will be used. Siltation will be managed during construction through a combination of silt fences and berms. Surface runoff, where practical long term stockpiles and or embankments will be either grassed, straw stabilized or compacted in such a manner will be used as to reduce the silt.

Temp Run Off

Temporary detention facilities will be excavated to trap stormwater as far as possible to remove silt and improve the quality of the stormwater prior to discharge into adjacent water courses.

8.3 Details of Excavations and Foundations

Due to the shallow groundwater table and poor founding conditions on the site, deep excavations will be avoided where the underlying bedrock is deep below the existing ground level and the water table.

Where the bedrock is at relatively shallow depth (on the southern portion of the site) it may be feasible to excavate down to the bedrock and install one basement level below the existing ground level. Therefore, where the rock is deep, basement structures would be constructed on grade with fill placed around them. Bulk excavation would be limited in most cases to the excavation of 300 to 500 mm of loose topsoil and rubble to be replaced with a 300 mm thick end tipped crushed rock pioneer to create a stable working platform for construction. Where the rock is shallower (at the southern end of the site) consideration will be given to constructing one of the basements level below the existing ground level. This would entail taking foundations and perimeter walls down to the underlying rock levels. Alternatively, the same procedure can be followed as for basements where the underlying bedrock is deep.

8.3.1 Precinct 1

Here perimeter diaphragm walls/sheet piling are/is taken down to and into rock and provided with temporary tie-back anchors. The walls and the toe are sealed (with grouting and other measures) to limit water ingress through and under .the side walls.

The basement is excavated down to competent rock and sealed with grout in fissures/faults to limit water ingress from below.

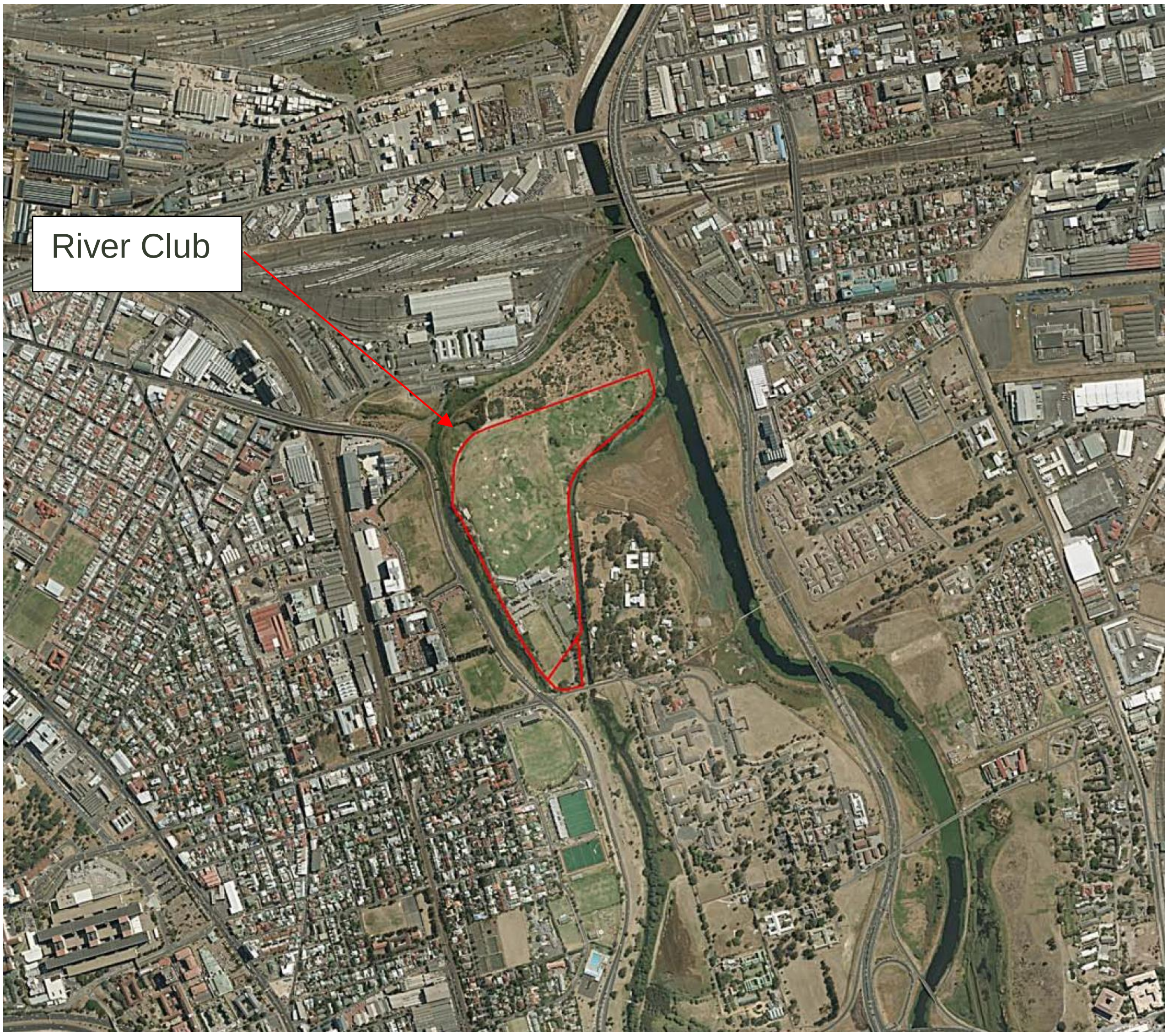
The P2 floor slab is suspended over to create a drained (and pumped cavity). The alternative of designing a structure to resist the hydrostatic uplift forces under flood conditions (7,5 m of water) would require a very robust structure and extensive anchoring into the rock below).

8.3.2 Precinct 2

Here the basements are built in the dry, with the lower (P2) basement being tanked. In times of flood, the basement structure will exclude the water (with some leaks). The hydrostatic pressure (which would cause the basement to float up) is resisted by the weight of the structure and the tensile capacity of the piles (where the structure is not by itself heavy enough to prevent flotation).

ANNEXURES

ANNEXURE A – LOCALITY PLAN


River Club

ANNEXURE B – GEOTECHNICAL INVESTIGATION

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ANNEXURE C – PROPOSED STORMWATER CONCEPT

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ANNEXURE D – DETAILED WATER DEMAND CALCULATION

River Club

3/1/2018

Water Demand Model

Precinct	Land Use	Area (m^2)	No of Residential Units	Pupils	Unit Demand		Average Daily Demand (kl/d)	Instantaneous Demand (l/s)	Peak Factor	Instantaneous Peak Flow (l/s)
Precinct 1 Mixed Use	Retail	24,900			4	l/m²/d	100	1.15	4	4.61
	Residential	8,400	200		600	l/unit/day	120	1.39	4	5.56
	Office	15,100			4	l/m²/d	60	0.70	4	2.80
	Gym	4,100			4	l/m²/d	16	0.19	4	0.76
	Hotel	10,400			4	l/m²/d	42	0.48	4	1.93
	Ancilliary	2,100			4	l/m²/d	8	0.10	5	0.49
	Sub Total	65,000	200				346	4.01		16.13
Precinct 2 Mixed Use	Retail	5,000			4	l/m²/d	20	0.23	4	0.93
	Residential	23,500	500		600	l/unit	300	3.47	4	13.89
	Office	44,500			4	l/m²/d	178	2.06	4	8.24
	Private School	10,000		1200	20	l/pupil/d	24	0.28	4	1.11
	Ancilliary	2,000			4	l/m²/d	8	0.09	4	0.37
	Sub Total	85,000	500				530	6.13		24.54
	TOTAL	**150,000**	**700**				**876**	**10.14**		**40.7**

ANNEXURE E – LETTERS FROM CITY OF CAPE TOWN INDICATING CAPACITY

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ANNEXURE F – PROPOSED WATER LAYOUT

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ANNEXURE G - LITERATURE REVIEW - WATER FOR CONSTRUCTION

Unit of Measurement

While some research has provided units of measurement for water consumption on construction sites as kL per currency, relating water consumption to the cost of the project, m^3 total water used over duration of construction /m^2 gross floor area (m^3/m^2) was decided to be used as a baseline unit of measurement, as the water consumption is directly related to the product rather than the worth of the product as discrepancies in costing will influence the indicator.

Contributing factors

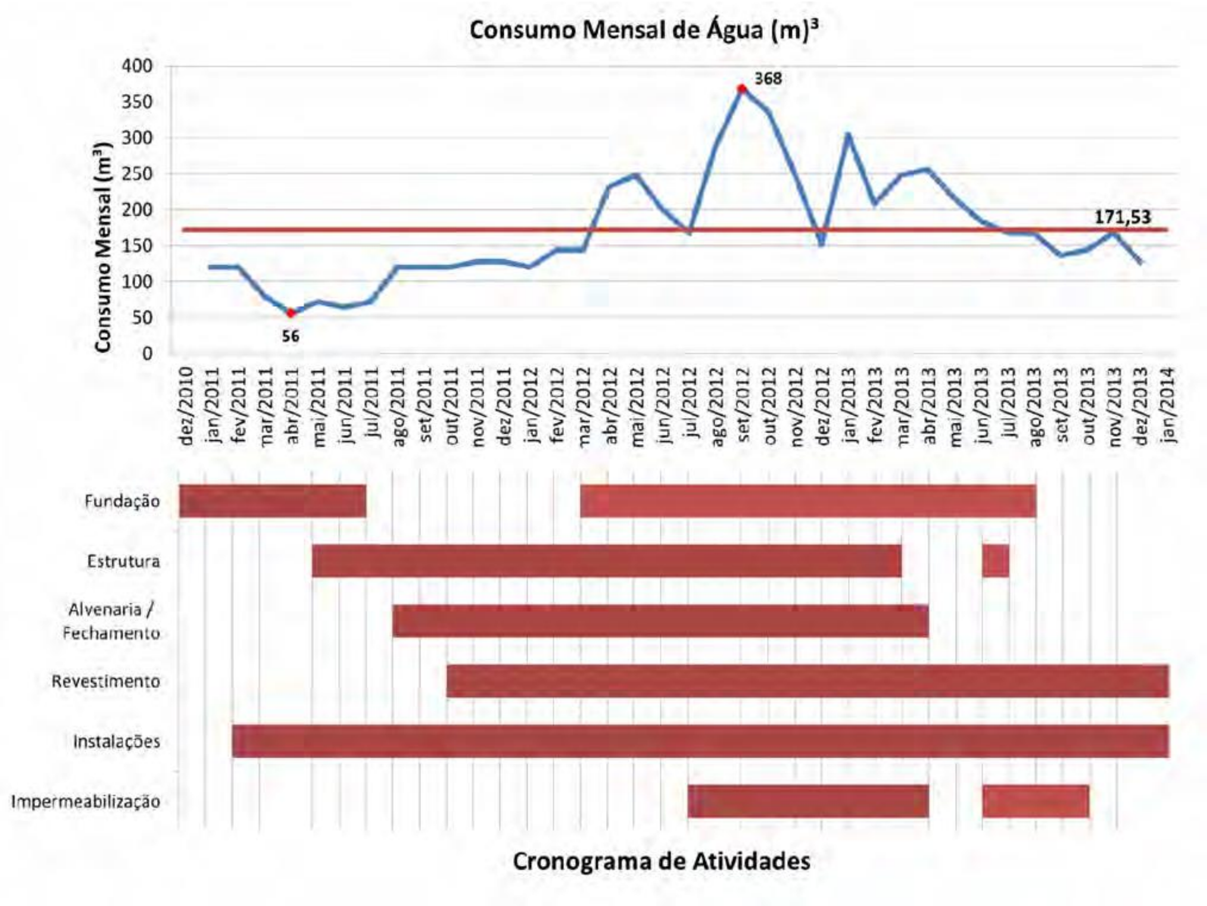
Various factors can affect the water demand and consumption on a construction site. This is mainly due to the various activities that are performed on site and the work performed by the contractor. Some of these activities include landfill compression, concrete manufacture, concrete curing, testing of waterproofing, finishing, cleaning and dust suppression. (Cerqueira, da Silva, & dos Santos, 2015)

Building type and building design will also influence the water demand of a construction site as it will directly influence what sort of structures will need to be constructed. Similarly, the building process i.e. precast vs in situ and on-site vs off-site concrete mixing will also influence the water demand of a construction site.

Temporary Demand in Existing Literature

In a study performed by Cerqueira et. al. (2015) in Brazil, it was found that the construction site for a 17-story residential building with a total floor space of 7467,66 m^2, a total of 6175 m^3 (6.175 million litres) of water was used for the construction period. Figure 5-1 shows the monthly water consumption of the site along with the phases of construction over the construction period. Table 5-3 'Actual' values shows the distribution of the water consumption across all the activities as measured that took place during construction. It should be noted that a considerable portion (57.9 %) was consumed for human use on the construction site. This is due to temporary campsites being provided on site for the construction workers and providing them with amenities such as washing areas and ablution facilities. Water for food and consumption is also included in the 'Human Use' category. It should also be noted that foundation elements and structural elements were machined outside of the construction side and only thin concrete was prepared in situ. Table 5-3 'Hypothetical' values displays a hypothetical distribution should the concrete for the foundation and the structure be produced on site.

Considering that South Africa does not provide temporary campsites for their construction workers like Brazil does in urban environments, it would be accurate to disregard 'Human Use' in order to calculate the water consumption for construction purposes. In doing so, it can be seen that total water used for construction purposes and 'other' (unspecified) would amount to 2599.4 m^3 (2.599 million litres) of water. Considering the total constructed area, the water consumption per constructed area over the lifespan of the project amounts to 0.35 m^3/m^2.



Monthly Water Consumption and Activity Schedule

Distribution of Total Water Consumption

Water Consumption [m³]	Foundations	Structure	Masonry	Coating	Water-proofing	Human Use	Other
Actual	6.69	418.19	14.86	123.58	480.74	3575.6	1555.34
Hypothetical	104.28	795.78	14.86	123.58	480.74	3575.6	1080.16

In a study conducted by S, Bardhan (2011) which examined the total embodied water of a structure it was found that the total water used during the construction period amounted to 2Kl/m^2 (Bardhan, 2011) which equates to 2 m^3/m^2. This study was similarly performed for a multi-storied residential building built in Calcutta, India. The building was intended for a high-income group and thus high-quality materials were used during construction.

Another study conducted by S Bardhan (2016) which examined the embodied (virtual water) of similar high-rise residential building in two different cities in India, it was concluded that water consumption during construction could be as high as 7.46 m^3/m^2 in Calcutta or as low as 2.93 m^3/m^2 in Pune (Bardhan & Chouduri, 2016). The significant difference in water consumption over the construction was mainly attributed to human consumption on site in Calcutta, as an average of 100 workers were staying on site per day, while the construction site in Pune had an average of 5 security guards on site per day. There was no indication of water consumption values which exclude human consumption within the article. Humidity of the location of the construction site was also considered to contribute to the water consumption on site.

Other articles found have concluded water consumption values of 7.90 m^3/m^2 for Australian suburban residential housing (Crawford, 2011) and 1.97 m^3/m^2 for a 4-star hotel in India (Choudhuri, 2015).

Temporary Demand for South Africa

From the examined literature, it can be seen that the temporary water demand for a construction site may vary from 0.35 m^3/m^2 to 7.9 m^3/m^2 dependant on the type, location and working conditions of the project. To identify an indication of the temporary water demand for the River Club development, it was decided that only data from buildings similar to the River Club's residential development in the examined literature will be considered. Hence temporary water demand for the Australian suburban house (7.9 m^3/m^2) will be disregarded. To determine upper and lower limits of temporary demand, similarities in economies and working conditions between South Africa and the other countries examined in the research provided will be used. Data taken from 2012 shows that industry value added (including construction) as % of gross GDP for South Africa and India are 25.53% and 24.31% respectively while industry value added for Brazil is 22.34%. The indicators for South Africa and India are close enough to regard temporary water demand for Indian construction sites from literature examined as representative of South African temporary water demand for construction sites, while indicators for Brazil are less so. It can therefore be said that temporary water demand for South Africa may range from 1.97 m^3/m^2 to 7.46 m^3/m^2. It should be noted that the value of 7.462 m^3/m^2 includes consumption of workers on site as there was temporary accommodation provided for them. As this is not common practice in South Africa, specifically in urban construction sites, this value should be reduced or otherwise used as a highly conservative value. Given that in cases where temporary accommodation is provided, human consumption accounts for 57.9% of total water use (Cerqueira, et al., 2015), the limits of temporary water demand for South Africa may be adjusted to between 1.97 m^3/m^2 and 3.14 m^3/m^2 for the entirety of the project.

year		gross floor area.	cum gross floor area	Wdbulk per year	cum Wdbulk
1	civil works	70000	70000	70000	70000
2		70000	140000	70000	140000
3	phase 1	32500	32500	102050	242050
4		32500	65000	102050	344100
5	phase 2	12360	77360	38810.4	382910.4
6		9280	86640	29139.2	412049.6
7		9280	95920	29139.2	441188.8
8		8000	103920	25120	466308.8
9		9692	113612	30432.88	496741.68
10		7900	121512	24806	521547.68
11		9496	131008	29817.44	551365.12
12		9496	140504	29817.44	581182.56
13		9496	150000	29817.44	611000

Figure: Detailed Calculation of Annual and Cumulative Construction Water Demand

ANNEXURE H – PROPOSED SEWER LAYOUT

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ANNEXURE I – DETAILED SEWER FLOW CALCULATION

River Club

3/1/2018

Sewer Flow Model

Precinct	Land Use	Area (m^2)	No of Residential Units	Pupils	Unit Flows		Average Dry Weather Flow (kl/d)	Instantaneous Flow (l/s)	Peak Factor	Peak Dry Weather Flow (l/s)
Precinct 1 Mixed Use	Retail	24900			3.8	$l/m^2/d$	95	1.095	3.66	4.01
	Residential	8,400	300		540	l/unit/d	162	1.875	3.48	6.53
	Office	15,100			3.8	$l/m^2/d$	57	0.664	3.81	2.53
	Gym	4,100			3.8	$l/m^2/d$	16	0.180	4.10	0.74
	Hotel	10,400			3.8	$l/m^2/d$	40	0.457	3.91	1.79
	Ancilliary	2100			3.8	$l/m^2/d$	8	0.092	4.21	0.39
	Sub Total	65,000	300				377	4.364		15.99
Precinct 2 Mixed Use	Retail	5,000			3.8	$l/m^2/d$	19	0.220	4.07	0.89
	Residential	23,500	500		540	l/unit/d	270	3.125	3.29	10.27
	Office	44,500			3.8	$l/m^2/d$	169	1.957	3.47	6.78
	Private School	10,000		1200	19	l/pupil/d	23	0.264	4.03	1.06
	Ancilliary	2,000			3.8	$l/m^2/d$	8	0.088	4.21	0.37
	Sub Total	85,000	500				489	5.654		19.38
	TOTAL	150,000	800				866	10.02		35.37

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