Department of Water Affairs and Forestry

INTEGRATED WATER RESOURCES MANAGEMENT
TRIAL IMPLEMENTATION – TESTING

LOCAL SERVICE PROVIDERS
WORK PACKAGE 3: WC/WDM MVOTI – UMZIMKULU
UGU DISTRICT MUNICIPALITY
STAGE 1 REPORT
FINAL

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Engineering & Management

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UGU DISTRICT MUNICIPALITY
STAGE 1 REPORT

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Abbreviations

CMA	catchment management agency
conn	connection (of pipe from water main or sewer to building)
DWAF	Department of Water Affairs and Forestry
DANCED	Danish Cooperation for Environment and Development
IRP	integrated resource planning
IWRM	integrated water resource management
kl	kilolitre (= one cubic metre)
km	kilometre
l	litre
m	metre
M&E	monitoring and evaluation
NWCDMS	national water conservation and demand management strategy
SABS	South African Bureau of Standards
UAW	unaccounted for water
WDM	water demand management
WMA	water management area
WSI	water services institution
STW	sewage treatment works
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand

Glossary of Terms

assurance factor (or return period)	is the statistical probability of a particular water abstraction rate being sustained – e.g. a 1:50 assurance factor means that that on a long-term average basis the water available will be less than the specified abstraction rate only once in 50 years, it is equivalent to a 98% probability of supply.
exfiltration (from sewers)	is wastewater that escapes from the sewer network due to defects in pipes etc. and which pollutes sub-soil and groundwater, where the infrastructure is above the water table.
infiltration (of groundwater)	is groundwater that enters a sewerage network due to defects in pipes, chambers etc., where the infrastructure is below the water table
inflow (of surface water)	is drainage water from a rainfall event, or from connections to springs or groundwater sources such as foundation drains, that enters a sanitary sewerage system which is conveying polluted wastewater to treatment / disposal locations
integrated resource planning	a holistic way of analysing the change in demand and operation of water institutions that evaluates a variety of supply side and demand side management measures to determine the optimal way of providing water services (DWAF National Strategy for Water Conservation and Demand Management, draft Aug 2001)
integrated water resource management	a philosophy, a process and an implementation strategy to achieve equitable access to and sustainable use of **water resources** by all stakeholders at catchment, regional, national and international levels, while maintaining the characteristics and integrity of water resources at the catchment scale within agreed limits.
unaccounted for water (NWCDMS and SABS 0306 definition)	the difference between the measured volume of water put into the supply and distribution system and the total volume of water measured to authorised consumers whose fixed property address appears on the official list of the water service authority *(but see section 3.2 of guideline)*
water conservation	the minimisation of loss or waste, care and protection of water resources and the efficient and effective use of water (national WC/WDM strategy definition)
water demand management	the adaptation and implementation of a strategy to influence water demand and usage in order to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, political acceptability (national WC/WDM strategy definition)
Water Services Institution	is a body that has responsibility in whole or in part for delivery of public water services to the community. WSIs include Water Services Authorities, municipalities, water boards, Water Services Providers, Water Services Committees and Water Services Intermediaries.
yield (of a water source)	is the steady supply of water that could just be maintained through a drought of specified severity; **gross yield** is the total available resource; **net yield** is the water remaining for supply after any compensation water or residual water has been left and losses have been deducted.

UGU DISTRICT MUNICIPALITY
STAGE 1 REPORT

1. INTRODUCTION

The Department of Water Affairs and Forestry (DWAF), in association with the Danish Co-operation for Environment and Development (DANCED) have initiated a number of studies to develop Integrated Water Resource Management (IWRM) strategies for specified Water Management Areas (WMA). The Mvoti-Mzimkhulu WMA is the subject of this study. Thelani Consulting in association with Stewart Scott Consulting Engineers have been appointed to undertake the Trial Assessment - Testing phase of this study (i.e. Work Package 3).

The development of an IWRM strategy requires attention to be given to all aspects of the water resource, supply and demand in the study area. This report addresses just one element, that of the return water flow to the sewerage treatment works at Margate. The study area therefore focuses on the sewage catchment area of the wastewater works, but a broad assessment of the surrounding area in terms of groundwater levels and rainfall is also carried out.

The Margate Sewerage Treatment Works is the only facility in the catchment area to treat sewage. The design capacity of the works is constantly exceeded, during dry and wet weather. Since the design capacity is significantly greater than the theoretical contribution from the existing sewer catchment, inflow and infiltration was found to be a major contributor to clear water influent at the sewerage treatment works.

This report (Stage 1) presents results on the return flow audit and the condition of the infrastructure, and deals with short term remediation that would result in immediate benefits to the District Municipality. The benefits to the District Municipality are both financial and environmental improvement.

2. AIM OF THIS REPORT

The Margate Sewerage Treatment Works was previously owned and operated by the Hibiscus Coast Municipality. The Section 84 Notice, together with the Section 12 Notices, published in 2000, provided a basis for District Municipalities to proceed with implementation of the following functions in relation water and sanitation:

- Transfer of staff;
- Transfer of assets, rights, liabilities and obligations;

With effect from 01 July 2003, the Margate Sewerage Treatment Works has effectively become the responsibility of the Ugu District Municipality.

In a study undertaken by Stewart Scott in 2002, the Margate Sewerage Treatment Works was identified as being hydraulically overloaded. High consumer usage, groundwater infiltration and stormwater inflow into the sewers were all contributing factors.

At present, there is scope for improving efficiencies of the sewerage infrastructure, reducing the amount of overloading at the sewerage treatment works and correcting some of the negative impacts. The first step in determining the action plans is to undertake a situation assessment, which is the focus of this. This report deals with some of the short term remedial actions that have been identified by the investigation to date. The remedial actions proposed in this report will result in immediate benefits to the DM.

3. APPROACH TO THE ASSESSMENT

Although the DWAF/DANCED initiative have employed consultants to undertake this situation assessment, it is important to note that the technical staff of Ugu District Municipality has adopted a partnership approach to the assessment. Without the commitment, support and insight from the municipality, it would not be possible to table a reasonably accurate situation assessment.

It is also important to note that an attempt has been made not to go into too much detail on specific aspects of the assessment since this is deemed to be the purpose of follow up studies. Furthermore, much of the requisite data and many of the facts are just not available and will require additional investigation.

4. OVERVIEW OF STUDY AREA

The study area is limited to the sewage catchment area of the Margate Sewerage Treatment Works. Margate is situated approximately 20 km south of Port Shepstone. The area is bounded by the Indian Ocean on the east and extends to just beyond the Nation Route N2 on the west.

The study area is depicted on the following locality diagram.

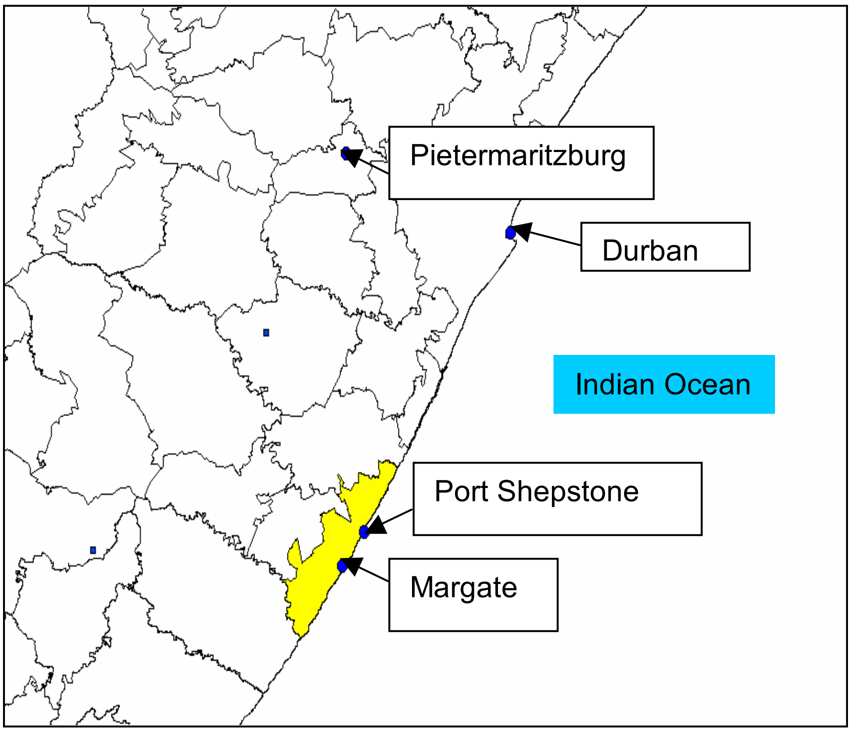


Figure 4.1: Locality Plan

The catchment area consists largely of residential units, holiday apartments and homes and commercial enterprises. There are very few manufacturing industries in Margate.

The pilot project area is located in the centre of Margate on the South Coast of KwaZulu Natal. The area is divided into several catchment areas as shown in Annexure 1. Pump Station 1 pumps into Pump Station 3. Pump Station 3 bypasses Pump Station 4 and pumps directly into Pump Station 4A situated at the Margate Sewer Treatment Works. The catchment draining to Pump Station 4 is also pumped directly to Pump Station 4A. Pump Station 4A also receives sewage from gravity pipelines. Pump Station 4A pumps the sewage to the head of the works. A gravity sewer also enters the head of the works. After treatment at the Works the final effluent is piped into the sea.

This is shown diagrammatically as follows:

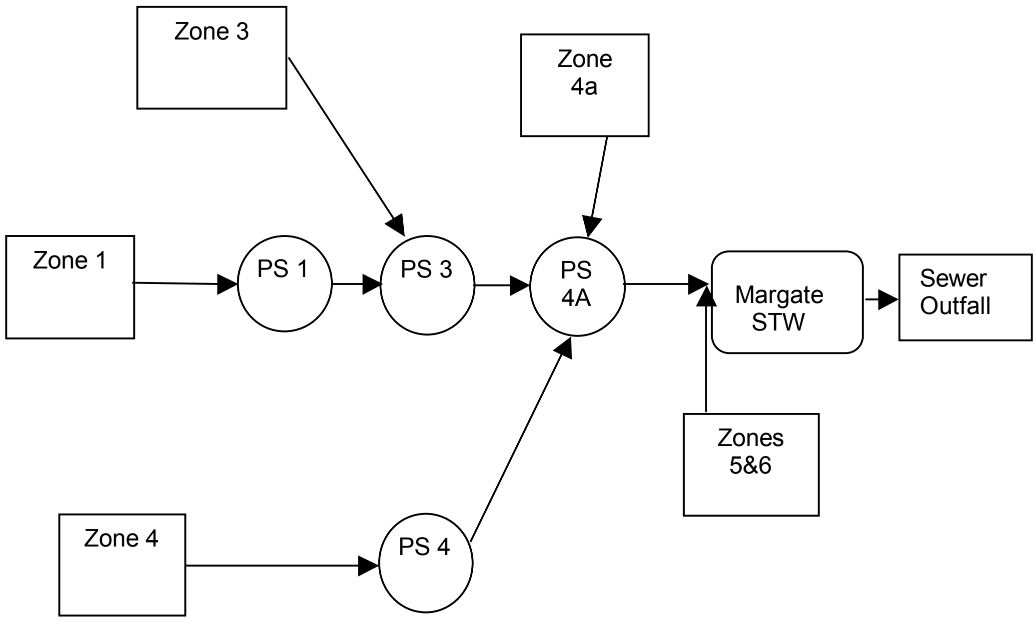


Figure 4.2: Sewer Flow Diagram

This report makes reference to manhole numbers, and must therefore be read in conjunction with Drawing No. O/S 172 C, (Annexure 1).

Table 4.1 summarises the catchment and pump station parameters for each of the pump stations.

Table 4.1 – Catchment and Pump Station Parameters

Parameter	Unit	Zone 1	Zone 3	Zone 4	Zone 4a	Gravity to Head of Works	Totals
Catchment Area	km^2	0.273	0.556	1.132	0.502	1.5	3.963
Length of sewers	m	2,773	7,273	13,560	8,171	15,000	46777
Average Sewer Diameter	mm	0.100	0.250	0.200	0.150	0.150	0.177
Number of Manholes	No	67	171	300	210	620	1368
Number of Connections	No	89	231	472	254	1345	2391
Manhole Density	No/km	24.2	23.5	22.1	25.7	41.3	29.2
Connection Density	No/km	32.1	31.8	34.8	31.1	89.7	51.1
%age of manholes in high WT zone	%	20%	60%	30%	30%	15%	26%

The relevant parameters for Margate Sewage Treatment Works are tabulated below.

Table 4.2 – Sewage Treatment Works Parameters

Parameter	**Unit**	**Value**
Wet Weather Flow Capacity	l/s	200
Wet weather flow capacity	m^3/h	720
Wet weather flow capacity	m^3/day	17280
Average dry weather flow capacity	m^3/day	6250
Peak dry weather flow capacity		Not Given
COD Dry weather	mg/l	440
COD Rating - Estimated continuous (annual average)	kg/day	2750

*Source: Report on Integration of Sewerage Services in Coastal Areas for Margate TLC, Stewart Scott, 3 June 1997

5. THE RETURN WATER FLOW AUDIT

The Return Water Flow Audit consists of the collation of available data and the collection of new data through fieldwork with regard to the water use and sewer flows in the Margate catchment area. In case of unavailable or unreliable data, reasonable assumptions had to be made. The assumptions were based on the knowledge of Stewart Scott of the Margate Sewerage system, and experience in their involvement on similar facilities. Although the assumptions needed to be tested from time to time, they were considered to be reasonable for the scope of this project. The assumptions used are stated in the report, wherever necessary.

The aim of the Return Water Flow Audit is to produce a Return Water Flow Balance. In order to set up this balance, consumer use, waste, infiltration and exfiltration had to be quantified.

As a means to achieve the above, a 24 hour flow and COD or BOD pattern had to be determined at the inlet of the works, at the sewer pump stations and at key points in the sewer reticulation to provide an indication of the indicators which are difficult to measure in practice. The BOD and COD samples taken at the inlet sump did not yield reasonable results because of the effect of stagnation and settling of the sewage in the sump.

Water demand figures for the area were quantified per catchment area, so the net groundwater infiltration could be quantified. The amount of net groundwater infiltration (i.e. after allowing for exfiltration) was determined by subtraction of estimated wastewater from total dry weather flows, correlated against night flow sewage strength data.

In the absence of historical sewer / treatment works flow data, the quantitative assessment of storm water inflows should ideally have been limited to the analysis of monthly electrical consumptions at pumping stations from Eskom accounts, correlated against rainfall statistics. However, at this stage there is no information available at the Ugu District Municipality nor the Hibiscus Coast Municipality (formerly Margate TLC) about the breakdown of electricity costs per Pump Station. This is a serious shortcoming, as the Municipality has no way of determining its true cost of its operation or efficiency.

5.1 Working method

5.1.1 Existing data

Available data was collected and collated for rainfall in Margate from January 2001 to May 2003. These monthly figures where correlated against the monthly outfall figures of the Margate Sewer Treatment Works (STW) over the same period. The rainfall data is shown in Annexure 9.

Water sales data for the Margate area over the period 1 January to 30 April 2003 was obtained from Ugu District Municipality. Over the same period the unaccounted for water was calculated for the Margate area, to determine the nett total water demand. The total number of consumers per catchment was calculated and the consumption of the big consumers (> 10 m^3/month) was excluded to determine the average demand per consumer. These calculations are shown in Annexure 4.

5.1.2 Fieldwork

Flow measurements and samples where taken at the inlet of the Margate STW in order to determine 24 hour flow and COD or BOD load patterns, as shown in Annexure 3.

At the pumping stations the inflow rates were determined at night by means of wet well level monitoring under pump off conditions. Due to the time constraints and in order to set up a realistic water balance, focus was on certain defined sections in the sewer network where the flow was measured at key points by means of sewer flow measurement equipment. The defined sections are the catchments running to pump station 1, 3 and 4 as shown in Annexure 1.

There exists a flume at the end of the works before the sewer leaves the sewage treatment works. The flow is measured at the flume, and these are included in Annexure 7.

Photo 1: Measurement Flume at STW (outfall)

The catchment areas were divided into dry and wet sub-catchment areas. The catchment areas consisted of areas of high water table, and these were identified by visual inspections. The flows in each of the sewers were then measured using the ultrasonic flow measurement instruments.

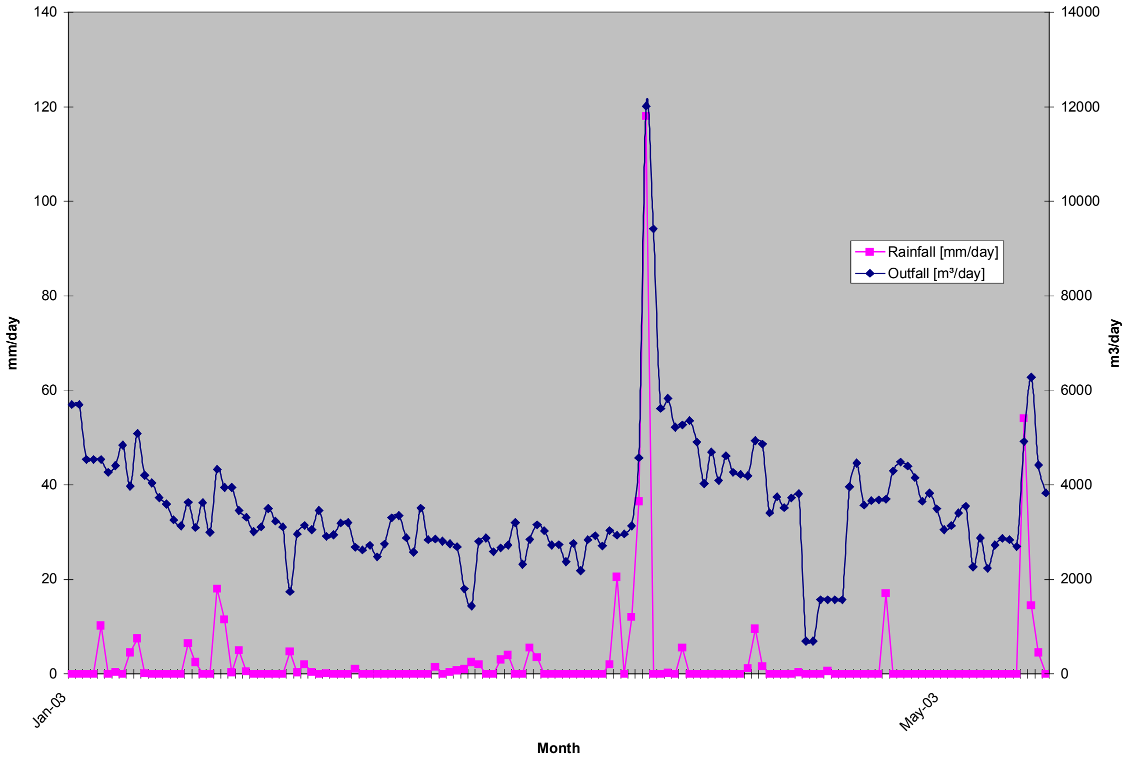
Photo 2: Ultrasonic Flow Measurement and Data Logging at Manhole

Over a period of several weeks the pump running hours of the pump stations were recorded three times a day (at 5:00, 14:00 and 22:00) to determine the night and day flow. These figures were compared and correlated against the calculated water demand figures per catchment. The results are shown in Annexure 6.

5.1.3 Results

5.1.3.1 Desktop Study/Analysis of Existing Data

The monthly rainfall figures at Margate Airport for 2001, 2002 and the first half of 2003 are shown below. These figures are compared with the monthly final effluent flow figures at the outfall of the Margate Sewer Treatment Works.



Graph 1: Correlation between Rainfal(mm)l and Outfall(m^3/day)

The graph shows a distinct relationship between the rainfall in the area and the flow into the Margate STW as measured by monitoring the final effluent flows at the Works. It must however be noted that the relatively wet months of December and January are also the peak holiday period in the Margate area when water consumption and sewage return flows to the works are higher than normal. However, it is clear that the rainfall in the area has a distinct impact on the flow into the STW.

To quantify the impact, certain specific areas in the Margate area were studied, especially the catchments running to pump station 1, 3 and 4.

The water demand per household was obtained from the monthly sales figures over the first four months of 2003. These sales are based on the consumer meter readings. In the analysis, all big consumers (more than 10 m^3/day) in the Margate area were excluded to determine a more accurate average use per connection per day. The average unaccounted for water in the Margate System for the four months is 21.41%. The total water demand per household consists of the metered sales figures plus the average losses in the Margate Water System. These figures are shown in Annexure 4.

It was assumed that 80% of the total water demand will find its way into the sewer. The other 20% is assumed to be used for gardening, pools, (car) washing and consumption. The Ugu District Municipality intends linking the billing of sewerage rates to the water consumption. The guidelines will be used to determine the percentage of water purchased that is discharged into the sewers. Once the process is initiated, more accurate flow measurement will take place in sample areas, so that the values could be refined.

As confirmed by the Ugu District Municipality, all plots in the investigated catchment areas are connected to the sewer system, so no provision has been made for on site sanitation. The sanitation drawings prepared by the Municipality also indicates that all plots are connected to the sewer reticulation system.

Results of the aforementioned calculations were used to determine the expected flow from households into the sewer system.

5.1.3.2 Analysis of Fieldwork Results

In order to determine the actual duty of the pumps at the Sewage pump stations, drop tests were performed at Pump Stations 1, 3, 4 and 4A. The detailed results of the drop tests where compared against the theoretical pump duty, as supplied by the manufacturer. It shows that the theoretical pump duties are not accurate, due to maintenance and adjustments to the pumps or pipelines. It is therefore wise to use the pump duties according to the drop test, as shown in Annexure 5 and summarised hereunder:

Table 5.1 – Theoretical and actual pump duties

Pump station	Theoretical Pump duty from operating manuals [ℓ/s]	Theoretical Pumping Head (m)	Pump Operation	Pump duty according to drop test (one pump running) [ℓ/s]
1	15	25	1 duty	9.41
3	70	37	1 duty (upgraded 1986)	42.13
4	75	36	1 duty (upgraded 1986)	81.38
4A	180	30.5	2 duty	160

The pump duties as recorded by the drop tests were multiplied by the pump running hours to provide an indication of the total flows in the period 17-23 February 2003, 19-25 May 2003 and 9-18 June 2003. The total flows calculated as described are shown in Annexure 6 (page 1 and 2). The graphs attached as Annexure 6 (page 3 to 5) show the flow pattern for the four pump stations at three different points. Upon correlation with the rainfall figures in the same period, it is clear that there is a direct relationship between the rainfall and the flows in the sewers. The short time duration between the rainfall event and the rise of the flow levels indicates that a significant amount of the infiltration in wet weather situations is caused by surface or storm water infiltration.

The average flow determined from pump running hours at the pump stations over the 3 measured periods (as shown in Annexure 6) is compared to the flow which could be expected, based on the average use per consumer and the number of plots discharging to the specific Pump Station. These figures are shown and compared in Table 5.2 and it is clear that the flow determined from pump running hours is significantly higher than the flows which could be expected, based on the sales figures for the Margate area.

Table 5.2 – Expected flow per catchment compared with the measured flow

Catchment	No of Connections [no]	Length of Sewers metres	Expected flow [m³/day]	Flow Determined from Pump Running Hours [m³/day]	Difference [m³/day]
to P/S 1	102	2773	120	175	55
to P/S 3	322 (incl 102 of P/S 1)	7273	400	1050	650
to P/S 4	716	13560	540	350	-190
TOTAL			1060	1575	

Note that the number of connections differ from the number of plots.

Note that the number of consumers is significantly different from the number of connections, because of multiple water connections to commercial and industrial sites. The calculated difference between the expected flow and the measured flow at the pump stations indicates a high level of infiltration into the sewer from sources outside domestic use, such as streams and ground water.

Ingress into the sewer could be affected by:

- Defects in the sewer pipes (broken pipes)
- Poor joint interface (sewer pipes)
- Poor joint interface (manhole rings)
- Poor joint interface (manhole rings to manhole base)
- Damage due to root penetration into manholes and sewer pipes
- Deterioration of cement mortar
- Human factors (connecting of stormwater into sewer network)

The high level of infiltration into the sewer is especially so for the catchment to Pump Station 3 which has a significantly higher flow into the sewer, than the normal flow which can be expected from that catchment.

The exception is Pump Station 4 where the measured flow is 350 m³/day, according to the pump hour-meter. This is lower than the expected flow which is obviously a doubtful situation. Measurements at manhole B48B and M44 show that there is a flow from these relative catchments into pump station 4 of at least 502 + 208 = 710 m³/day (see Annexure 8). It is expected that the pump hour meter is not recording correctly. This is confirmed by calculations, based on the filling and pump times at the sump of pump station 4 as shown in Annexure 5.2. On site control measurements of the pump hour meter bear testimony to this statement.

Measurements at several manholes in the catchments confirm the infiltration of storm and ground water into the sewers and also show a big difference between the expected theoretical flow and the measured flow in the system. It also shows, as confirmed by the measurements at the pump stations, that the main infiltration seems to take place in the catchment to Pump Station 3. At manhole 2B, just before Pump Station 3, the nightflow is very high (40-50 m³/day) and the measured flow well above the expected flow, as per Table 5.3 below.

Table 5.3 - Expected flow per catchment compared with the measured flow

Manhole	No of connections	Expected flow	Measured flow	Percentage Difference
B78	200	160 m³/ day	322 m³/ day	201%
B48A	275	220 m³/ day	502 m³/ day	228%
M44	115	92 + 19 (big consumers) = 111 m³/ day	208 m³/day	187%
2B	306	245 + 198 (big consumers) = 443 m³/ day	1986 m³/ day	448%

In order to check for correlation between inflow volumes and pollutant loading at the Margate Sewage Treatment Works, the incoming flow was logged for 3 days and a 24 hour sampling of the BOD and COD was taken at the inlet flume. The BOD and COD sampling took place on Friday, 6 June 2003 during dry weather. The samples were taken at four hour intervals, commencing at 01:00.

The flow pattern depicted in Annexure 2 shows a clear peak and trough pattern in the incoming flow at the Works. As shown in Table 5.4 and Annexure 3, the BOD and COD is fairly constant throughout the day, with a clear peak at 09h00 in the morning and a drastic decrease of the pollutant loading at night. The BOD/COD of the influent at night is even lower than the required 75mg/ℓ for WWTW final effluent. Since these night flows were recorded during dry weather conditions it is clear that the majority of the night flow consists of infiltrated ground or surface water. The investigated catchments in Margate are characterised by a significant amount of little streams running close to the sections of the sewerage system. Leaks in manholes and pipes, close to these streams are suspected to contribute significantly to the inflow into the sewerage system, even in dry weather periods. A clear distinction between inflow from storm water (in wet weather periods) and inflow from running streams or springs is therefore recommended.

Table 5.4 – BOD and COD and incoming flow at the inlet flume of the Margate STW

Time	**Flow**	**COD**	**BOD**	**COD**	**BOD**
	m³/h	**mg/ℓ**	**mg/ℓ**	**Kg**	**Kg**
01:00	54	62	19	80	25
05:00	50	625	200	750	240
09:00	277	1308	440	8696	2925
13:00	108	494	233	1280	604
17:00	84	444	195	895	393
21:00	95	426	280	971	638

The equivalent daily effluent inflow at the STW was 2672 m3 over the measurement period. The Biological loading over the same 24 hour measurement period was 2112 kg COD and 804 kg BOD.

The above deductions have been confirmed by the visual inspections in the sewer manholes, which show infiltrating ground and surface water (refer to Annexure 10 for visual assessment at manholes). If the quality conditions of the sewers are similar to the manholes, further infiltration and exfiltration can be expected.

5.2 Return Flow Water Balances

The above findings can be presented in the Return Flow Water Balance as shown on the following template. The calculations are contained in Table 7.1.

Table 5.5: Return Flow Water Balance Template:

<table>
<tr><td rowspan="6">water drawn by consumers from mains water or other supply sources</td><td>consumptive use</td><td rowspan="2" colspan="3">water not returned to local aquatic environment</td></tr>
<tr><td>evaporation & transpiration from irrigation and other external water use</td></tr>
<tr><td></td><td colspan="2">irrigation water returned to aquifer (percolation)</td><td rowspan="4">Total return flow to ground</td></tr>
<tr><td></td><td colspan="2">wastewater disposed to ground, on site sanitation</td></tr>
<tr><td>wastewater into sewers</td><td rowspan="4">Total wastewater diluted with infiltration and inflow</td><td>exfiltration from sewers</td></tr>
<tr><td>wastewater removed by tanker</td><td>wastewater disposed to ground after treatment</td></tr>
<tr><td rowspan="2">other sources of water (non potable)</td><td>surface water inflow to sanitation or combined sewers</td><td>overflows from sewers</td><td rowspan="2">total return flow to surface water via sewers & treatment plants</td></tr>
<tr><td>groundwater infiltration to sewers</td><td>discharges from treatment plants and sewer outfalls</td></tr>
</table>

The balance for Pump Station 4 is not done because the pump running hour meter is highly inaccurate. However, for the purposes of completion of calculations, reasonable estimates were made for various values of the flow balance, assuming that the values would be proportional to the catchment areas or sewer lengths wherever applicable.

Comments:

1. Ongoing flow measurement by the District Municipality will ensure optimum and meaningful usage of the equipment purchased under this project.

5.3 Conclusions on Return Flow Water Audit

The investigations for the Return Water Flow Audit show clear signs of infiltration into the sewer system in Margate.

The dry weather night flow at the STW shows a constant nightflow (baseline flow) with a very low COD and BOD levels, which indicates a significant amount of infiltration or clear-water into the sewer system or wastage of potable water due to leaking taps and cisterns.

Checks on certain catchment areas in the Margate area confirm a significant amount of infiltration into the sewer system and show a higher sewer flow than can be expected, based on the sales figures for these catchment areas. This is shown in the Return Flow Water Balance for these catchments.

Visual inspections at peak daylight hours and off-peak hours at night confirm the above findings.

6 SEWER RETICULATION INFRASTRUCTURE

6.1 Groundwater Levels

Margate lies at the base of the greater Umzimkulu catchment area. The topography of the area indicates approximately 50% of the area lies above the mean height of Margate. The high lying areas were found to have a water table below the average sewer invert level of 2.5m. The effect of prolonged rainfall on the level of the weather table could not be analysed, due to the study being undertaken in the drier season of the year.

The water table in the lower areas of the CBD, particularly the areas adjacent to Valley Road (Pump Stations 1, 3 and 4) is very high. At the lowest point in Hunter Street, groundwater was found to be seeping out of the ground and flowing over the kerb and into the stormwater inlet.

6.2 Infiltration

Visual inspections were carried out on a sample of sewer manholes throughout the catchment area. The infrastructure was found to be old, and in poor condition. The sewerage system was originally designed as a separate system, to take foul flows only. The amount of surface water inflow in Catchment 1 is not excessive in volumetric terms, but nevertheless unsatisfactory in environmental impact terms.

In all areas where the groundwater level was found to be high, clear water was found to seep through the precast manhole rings. Approximately 75% of the manholes adjacent to Valley Street were found to have groundwater seeping through the manhole ring joints. Clear water was also found to seep into the manholes through the benching.

Photo 3: Groundwater Infiltration in Manholes through Benching

Based on the field survey carried out during the study, approximately 250 out of a total of 748 manholes or 34% have water seeping into the sewer through the joints between the precast manhole rings.

Some manholes are in the vicinity of wild fig or rubber trees and have been infiltrated by their root system.

Photo 4: Penetration of roots into Manholes

Field surveys have shown that approximately 35 manholes or 9% have roots penetrating the manhole joints.

Infiltration from defects in the sewer pipes are also evident. Between manholes C29C and 7F a manhole exists, which drains fresh water from the water feature in the Boulevard property. Manholes B49A & B57 had a very strong clear water flow. The gravity main from P/S 4A down to P/S 4 had a very strong flow at MH B3A (greater than 1 l/s). Most of this line is running along a drainage line and some 30% of it is below the stream level.

It has been reported by the District Municipality that the new residential area known as Extension 3 was found to have high infiltration and inflow. This is exacerbated by the high water table in the area. The Municipality spent substantial resources in rectifying some of the problem contributing to infiltration and inflow. However, the contributions of clear water from private properties persist, thus contributing to higher inflow during the wet seasons. This area is connected to the sewerage works via a 225 mm diameter gravity line.

Comments:

1. The record drawings of the sewer reticulation are inaccurate, and out of date.
2. Not all of the manholes are accessible for inspections.

A full list of the findings during the visual assessments is attached as Annexure 10.

Infiltration per unit length is bound to be significantly greater than exfiltration, because as the sewer pipes gets deeper it is subject to external hydrostatic pressures that may be as much as 2 to 3 metres.

6.3 Exfiltration

Exfiltration (sewage seeping out of the sewer pipes) is also evident in Margate. At the S/W exit point at the Margate main beach (Kids swimming pool), the water flowing from the culvert was clean except for the smell of sewage. This point is about 100m away from the nearest sewer intersectional inspections. This indicates that the sewer pipes or joints could be leaking, and the raw sewage seeping into the stormwater culvert.

Exfiltration occurs mainly in areas where the water table is low, and the sewer pipes are found to be in a poor condition. It has not been possible to estimate this with any degree of accuracy, but given the high amount of net infiltration, it is expected that there is a corresponding and significant amount of exfiltration, since there is unlikely to be any difference in the quality of the sewers above and below the water table. Reduction of exfiltration will have an effect of increasing overloading. However, reduction of exfiltration requires serious consideration from an environmental and health perspective.

6.4 Inflow

During a heavy downpour, the sewer lines furthest away from the sewerage treatment works begin to flow full. The situation worsens progressively closer to the works. As a result, the pumps at the pump stations operate continuously to cope with the extraordinarily high flows.

Inspection Eyes (IEs) installed on the sewer lines in private properties are made of PVC. These IEs are not designed for vehicular traffic. Over time the covers become brittle and crack. As the IEs are installed at ground levels, they are a source of inflow during a heavy downpour.

During 1999-2000, the District Municipality sent a number of its field staff on a Peace Officer training course. The Peace Officers, once qualified were tasked with inspecting private properties for stormwater connections into the sewer reticulation. In many instances, the occupants that were issued with notices rectified the problems. The benefit of the exercise was immediately felt at the sewerage treatment works. However, the Peace Officers were not authorised to issue summons to defaulters, and the lack of suitable resources resulted in cancellation of this initiative.

6.5 Pump Failures

On 26 June 2003, the pumps at PS3 failed to turn on. The standby pump was also not in operation. The diesel pump ran through the night, until it ran out of fuel. Unfortunately, this occurred during heavy rainfall, and the sewage overflowed through the steel vent into the estuary. The following two photographs show the overflow weir and the estuary the raw sewage flows into in the event of pump failure. The pumps at Pump Station 3 fails on average five times a year.

Photo 5: Overflow weir at PS3 into estuary

Photo 6: Another view showing recreation estuary adjacent to PS3

PS 4 has also failed on a number of occasions. Failure of the pumps results in the raw sewage venting through a blow-manhole adjacent to pump station. The area adjacent to PS4 shows evidence of raw sewage flowing into the stream, and this poses serious environmental and health risks. This is shown in Photo 7 below.

Photo 7: Blow Manhole at PS4

As the electricity supply to the pump stations cannot be guaranteed, failure of the pumps to turn on coupled with high infiltration and inflows can be catastrophic. Reduction of infiltration and inflow rates could ensure minimum environmental damage if the standby diesel generators fail.

Whilst overflows of raw waste water occur mainly during wet weather conditions (i.e. apart from mechanical failure at pumping stations), their severity is aggravated by the presence of infiltration water which utilises part of the spare hydraulic capacity that is designed into sewerage system.

In a fully combined or partially separate sewerage system that is designed to receive storm water, "regulated" overflows are provided that at least minimise the environmental impact, in terms of both quantity and sensitivity of the point of discharge. In a system such as Margate that is not so designed, the negative impact of excessive surface water inflow is lower, since overflows are unregulated. These are sometimes found in areas of high sensitivity, eg. PS 3 and PS4.

The following table summarises impacts of unregulated overflows, and the respective priority for action.

Table 6.1: Impacts of Unregulated Overflows and Priority of Action

Pump Station Number or Zone	Estimated Volume of Overflow, m3/yr/mm of rainfall	Locations of unregulated overflows and receptors, frequencies and consequences of overflow events	Priority for action
1	7300 / 27	Overflow into recreation beach that is also used for fishing. *Frequency: 10 times / year	Very high
3	65700 / 118	1 High level overflow at PS3 discharges into estuary of Inkongweni River, which is used for recreational/touristic purpose *Frequency: 8 times / year	High
4	38544 / 96	1 Manhole upstream of PS4, sewage runs overland and then in to the of Inkongweni River. The open field is highly accessible by people visiting the river or estuary for fishing or recreational purposes. *Frequency: 10 times / year	High
4a	20732 / 68	Overflow into forest and stream. No public access and immediate public health risk. Continued flow will contaminate the stream, and hence the river. *Frequency: 5 times / year	Medium
5 & 6	101376 / 101	Overflow adjacent to Freeway (N2), and into open fields. No public access and no water course in close proximity.	Low
Total	242652 / 93		

* Frequency estimated after discussions with Operations staff.

6.6 Sewage Treatment Works

Margate Sewage Treatment Works has a nominal design capacity of 6 250 m^3/day dry weather flow and 720 m^3/hour equivalent to 17 280 m^3/day peak flow, as per Table 4.2. Reference to Annexure 7 shows that the average DWF was around 3 500 m^3/day and that the peak DWF was 8 211 m^3/day (during December 2001 following four days with no rainfall), but in the corresponding period 02/03, the highest DWF was only 5 700 m3/day. There was only one day in the 2.5 year data, around November 2001, when the design peak flow was exceeded (21 669 m^3/day). On that occasion, 350mm of rain fell in a week, and 165mm on the maximum day, which was en extreme event, considering that the average annual rainfall for 2000 to 2002 has been 1378mm.

Further examination of Annexure 9 and the effluent COD data shows that there was no correlation between the failures to meet effluent standards and rainfall. In fact the peak flow through the works should be limited by (i) the capacity of the pumps at PS4a and (ii) the capacity of the gravity sewers draining catchments 5 and 6. The hydraulic capacity of the gravity sewer is estimated at 54 l/s, giving a combined peak flow to the STW of 234 l/s or 20 218 m^3/day which is greater than the peak flow of 17 280 m^3/day. This is assuming that the pumps at PS4a operates for 24hours/day, which is an unlikely scenario. If the sewer pipes flow under peak conditions for

16 hours per day for the PS4a and under peak conditions for 8 hours for the gravity main, and average flow for the balance of the day, then the maximum flow into the STW is expected to be 13 478 m^3/day. As these flow rates are more initiative of actual flows, then the sewage treatment works does not seem to be overloaded under dry or normal wet weather conditions, and failures of effluent quality do not appear to be caused by high flows in wet weather conditions. In very heavy rainfall events, overloading of the sewage treatment works is alleviatd by the existence of unregulated overflows on the sewage network.

The main impact of the high amounts of infiltration and, to a lesser extent storm water, is in utilising spare hydraulic capacity that would otherwise be available to treat additional flows from new developments.

7 SITUATION AND IMPACT ASSESSMENT

The study was carried out during a relatively dry season of the year. It has, nevertheless shown that more than 50% of the sewage treated at the Margate Sewage Treatment Plant is made up of infiltration and inflow. The graph of presented under the return flow audit also indicates an obvious direct relationship between sewage treated and rainfall.

7.1 Quantification of Problem

A full return flow audit at Pump Station 4 is not possible, due to the faulty hour meter at the pump station. An attempt to determine a correlation between the actual flow rate and the hours pumped proved to be futile as the hour meter changed erratically. The amount of groundwater infiltration and surface water inflow for Pump Station 4 was therefore estimated, based on the results obtained for Pump Stations 1 and 3, and the number of households in each catchment.

The dry-weather infiltration and inflow for the Margate Sewage Treatment Works is tabulated overpage.

Table 7.1: Calculation of infiltration and inflow

Catchment / PS		catchmnt 1 & PS1	catchmnt 3	PS 3 (1+3)	catchmnt 4 & PS4	4a	PS4a(1+3 +4+4a)	5, 6	Total to STW	Remarks
Infrastructure Data:										
Catchment area	km2	0.273	0.556		1.132	0.502		1.500	3.963	
Connections / properties	no	89	231		472	254		1345	2,391	
Sewer length	m	2,773	7,273		13,560	8,171		15,000	46,777	
Estimated percent sewer below WT	%	20%	60%		30%	30%		15%		
Length below WT	m	555	4,364		4,068	2,451		2,250	13,688	
Mean diameter	m	0.1	0.25		0.2	0.15		0.15		
Conn density by sewer length	no/km	32.1	31.8		34.8	31.1		89.7		*not used in calculation, but useful indicator >*
Property density	no/km2	326	415		417	506		897		
No of manholes	no	67	171		300	210		620	1368	
Manhole density	no/km	24.2	23.5		22.1	25.7		41.3		
Flow Mass Balance:										
Wastewater from connections	**m3/yr**	**43,800**	**102,200**	**146,000**	**137,824**	**74,168**	**357,992**	**392,740**	**750,732**	*800l/household/day*
Annual average, per day	m3/d	120	280	400	378	203	981	1,076	2,057	
Peak day wastewater	m3/d	216	504	720	680	366	1,765	1,937	3,702	
Peak factor		1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	
Average wastewater per connection	l/d	1,348	1,212		800	800		800		
Net infiltration less exfiltration	**m3/yr**	**10,950**	**116,800**	**127,750**	**147,904**	**39,420**	**315,074**	**216,968**	**532,042**	
Ditto	m3/d	30	320	350	405	108	863	594	1,458	
Storm water inflow	**m3/yr**	**9,125**	**155,125**	**164,250**	**48,180**	**25,915**	**238,345**	**137,970**	**376,315**	
Storm overflow	m3/yr	7,300	65,700	73,000	38,544	20,732	132,276	110,376	242,652	
Storm water retained within system	m3/yr	1,825	89,425	91,250	9,636	5,183	106,069	27,594	133,663	
Total flows retained within system	m3/yr	56,575	308,425	365,000	295,364	118,771	779,135	637,302	1,416,437	- storm o'flow & exfiltration
Infiltration & Exfiltration Analysis:										
Permitted in&exfiltration SABS	m3/d.km.m	15	15		15	15		15		
Ditto	m3/d	1	16		12	6		5		
Assume exfiltration as % SABS limit	%	200%	200%		200%	200%		200%		
Exfiltration sewer length above GWT	m3/d	7	22		57	26		57	169	
Ditto	m3/yr								61,517	
Infiltration sewer length below GWT	m3/d	37	342		462	134		652	1,626	
Ditto	m3/yr								593,559	

Specific infiltration, below WT	m3/d.km.m	661	313		568	364		1931		
Specific infiltration, x SABS limit	ratio	44.1	20.9		37.9	24.2		128.8		
Excess infiltration (SABS 15)	**m3/yr**	**13,076**	**118,791**		**164,237**	**46,801**		**236,062**	**578,967**	
Ditto	m3/d	36	325		450	128		647	1,586	
Ditto if 2 x SABS 15	m3/d	28	287		381	97		584	1,378	
Estimated % of badly defective* MHs	%	49%	52%		55%	55%		52%		* visible flow
Estimated no below WT	no	7	53		50	35		48	193	
If average infiltrn per MH =	m3/d	3	3		3	3		3		critical figure
Total infiltrn at bad MHs below WT	m3/d	21	159		150	105		144	579	
Remaining in sewers	m3/d	16	183		312	29		508	1047	
Ditto per metre length below WT	m3/d.m	0.03	0.04		0.08	0.01		0.23		
Ditto specific infiltration	m3/d.km.m	282	168		384	78		1,505		
Amount to achieve SABS if MH repaired	m3/d	15	166		300	23		503	1007	
Ditto to achieve 2*SABS if MH repaired	m3/d	7	128		231	-8		440	799	
Surface Water Inflow Analysis:										
Specific sw inflow, by sewer length	m3/yr.km	3,291	21,329		3,553	3,172		9,198		
Specific sw inflow, by area	m3/yr.km2	33,425	279,002		42,562	51,624		91,980		
Target max sw inflow by sewer length	m3/yr.km	5,000	5,000		5,000	5,000		5,000		see note 1
Ratio storm overflow: storm retained		400%	73%		400%	400%		400%	182%	
Specific sw overflow, equiv mm of rain	mm	27	118		34	41		74	61	
Inflow as proportion of wastewater	%	21%	152%		35%	35%		35%		
Excess sw inflow	**m3/yr**	**0**	**118,760**		**0**	**0**		**62,970**	**181,730**	
Pumping Stations:										
Original design capacity	l/s	15		70	75		180			
Present as tested	l/s	9.4		42.1	81.4		160			
Multiple of existing DWF		5.4		4.9	9.0		7.5			

***: 5&6 are gravity inflows to head of works

Note1: Notional / provisional target pending further appraisal of causes of surface water ingress and praticalities of their elimination

7.2 Financial Appraisal

The greatest variable costs associated with sewage treatment are electricity consumption and purification costs. The variable electricity costs relate to pumping costs and are applicable if sewage or mixed liquor is returned to the head of the works for treatment. This was found not to be the case at the Margate Sewage Treatment Works.

Purification costs include chemical costs, which could go up to R6.00/kl, depending on the facility and the treatment process. As no chlorination or chemical dosing takes place at the STW, chemical costs are not directly proportional to the treated volume.

A further cost associated with high infiltration and inflow is the electricity costs associated with pumping. The calculated cost of pumping sewage at each of the pump stations are as follows:

- Pump Station 1 6.1c/kl
- Pump Station 3 8.1c/kl
- Pump Station 4 7.6c/kl
- Pump Station 4 7.4c/kl

The above costs were calculated, based on the respective pumping heads at each of the pump stations, assumed pump efficiency of 0.5, and an average electricity charge of 45c/kWh.

The financial implications of pumping clear water to Margate Sewage Treatment Works are tabulated overpage.

Table 7.2: Financial benefits of remediation

Catchment / PS	Unit	catchmnt 1 & PS1	catchmnt 3	PS 3 (1+3)	catchmnt 4 & PS4	4a	PS4a (1+3+4+4a)	5, 6***	Total to STW	Remarks
Financial Analysis:										
Pumping head	m	25		33	31		30		5	see note 2
Elec cost per m3 at PS	c	6.1		8.1	7.6		7.4		1.0	see note 3
Elec cost per m3 thro to STW	c	30.2	24.1		16.0	8.4		1		
Cost of pumping infiltr'n to STW	R/yr	3,307	28,149		23,665	3,311		2,170	60,601	
Cost per m of sewer below WT	R/yr.m	5.96	6.45		5.82	1.35		0.96		
Cost per property sewer below WT	R/yr.prop	186	203		167	43		11		
Cost savings if infiltration = SABS	R/yr	3,949	28,629		26,278	3,931		2,361	65,147	
Ditto if = 2xSABS	R/yr	3,123	25,270		22,239	2,973		2,133	55,738	
Cost savings bad MHs only	R/yr	2,315	13,986		8,760	3,219		526	28,806	
Unit cost savings per bad MH	R/yr.MH	331	264		175	92		11		
Cost savings, sewers to SABS	R/yr	1,634	14,642		17,518	712		1,835	36,341	
*Cost savings, sewers to 2*SABS*	R/yr	809	11,283		13,479	-246		1,607	26,932	
Unit cost savings per m of sewer repair	R/yr.m	1.5	2.6		3.3	-0.1		0.7		assuming 2*SABS
Cost of pumping s/w inflow to STW	R/yr	551	21,551		1,542	435		276	24,356	
Cost savings if sw inflow at target	Ryr	0	28,621		0	0		630	29,251	
Total Excess Pumping Costs	R/yr	3,858	49,700		25,206	3,747		2,446	84,957	
Total potential cost savings (SABS)	R/yr	3,949	57,250		26,278	3,931		2,990	94,398	

Note 2: At STW allows for RAS recirculation at 1*DWF

There are two basic scenarios in which measures to reduce infiltration and inflow can be assessed:

a) short run marginal cost benefit in terms of savings in annual operating costs, and

b) long run marginal cost benefit that includes also the savings made by reduction in the capacity of capital assets, which may be their renewal / refurbishment or in extensions to accommodate future urban developments.

Scenario 1 can for most practical purposes be dealt with as a simple "payback" calculation. Taking a discount rate of 7% and a 20 year accounting period, the DCF multiplier is 10.594. Therefore any measure that has better than a 10 year payback in running cost savings is financially viable on those criteria. All measures should therefore be screened using this simple method, before developing any future scenarios of type b), if this is required.

7.2.1 Marginal Operating Costs

The marginal operating costs within the network, which are basically the electrical power costs at the pumping stations have been estimated as given Table 7.2 above. As shown in Fig. 4.2, sewage from Zone 1 is pumped at PS 1, 3 and 4a, i.e. a total of three times. Similarly sewage from Zone 2 id pumped twice, and sewage from Zone 4 is pumped twice. The flows from catchments 5 & 6 are not pumped at all (except for within the STW in the form of return activated sludge that is set typically at 1 x the dry weather flow. The vital point to appreciate is that a kilolitre of infiltration or inflow that is prevented from entering the network in catchment 1 saves 30 cents of electrical power cost, whereas a kilolitre in catchments 5 & 6 saves only 1 cent. Thus apart from environmental and public health considerations, the highest priority should go to reducing inflow and infiltration in catchment 1, followed by catchment 3, 4 and 4a in that order. Of course each measure must be considered on its own merits.

7.2.2 Manholes

The average cost of rehabilitation of a manhole to eliminate infiltration is nearly R7 400.00 compared to the cost of replacing the manhole at R 10 500.00. Other alternative would be to seal the manhole from the inside, therefore limiting the need to excavate around the manhole for all but the worst cases.

Another option in straight through manholes would be to "pipe through" the manhole and provide a hatch box. The manhole would fill with water to the water table level, but none should get into the sewer. On the rare occasions that access was required, the water would have to be pumped out.

However, if we take for figure of R7,400, in catchment 1, the amount of infiltration that would justify taking action for running cost savings would be:

$$7400/10/(0.3*365) = 6.8 \text{ m}^3 \text{ per day per manhole.}$$

In the other catchments the severity of infiltration would have to be greater, in inverse proportion to the lower running cost savings per m^3.

Rehabilitation of manholes should therefore be undertaken selectively, based on an inspection and assessment of the amount of infiltration against the break-even benchmark figure for each catchment.

7.2.3 Sewers

If the cost of rehabilitation of sewers is R500 per metre (no-dig technology), then in catchment 1, the amount of infiltration that would justify taking action for running cost savings would be:

$$500/10/(0.3*365) = 0.45 \text{ m}^3 \text{ per day per metre of sewer.}$$

To justify sewer rehabilitation, there is a need to conduct further investigations that will narrow the search to pinpoint the worst sections and determine which sections, if any exceed the break-even benchmark figures.

7.2.4 Long run marginal cost analysis – integrated least cost planning

Some measures cannot be justified financially on the basis of savings only in running cost, but may become viable when they also contribute to reducing and/or deferring the capital cost of extending the infrastructure.

Note also that, although this study has focused on the infiltration and inflow components of return flow, in an integrated approach to water conservation and demand management, any decrease (or increase) in potable water use by consumers is reflected in the return flow audit.

On environmental and public health grounds, the planning objective should be to minimise, (ideally eliminate except in cases of mechanical failure) overflows of wastewater onto lands and into the aquatic environment. In a fully rigorous analysis there would be a range of options and an optimised solution would almost certainly comprise a mix of measures. But notwithstanding the limitations of this study, since we are testing and illustrating the use of the guidelines, there is a need to demonstrate by worked example in the return flow component of water utilisation, the integrated least cost planning approach.

The result of this financial analysis (see spreadsheet attached as Annexure 12) is as follows:

Table 7.3: Financial Analysis

Option	Capacity or volume saved, m^3/d	Average incremental cost R/m^3
1 No WC/WDM actions, increase STW capacity by 20%	1,176	1.84
2a Rehabilitate 255 manholes in all catchments	765	1.16
2b Rehabilitate 555 m sewer in catchment 1	7	51.54
2c Rehabilitate 4,364 m sewer in catchment 3	128	6.28
2d Rehabilitate 6,780 m sewer in catchment 4	679	1.78
2e Rehabilitate 4,494 m sewer in catchment 4a	47	17.27
2f Rehabilitate 2,250 m sewer in catchments 5 & 6	1,265	0.78
2 Consolidated rehabilitation plan: rehab sewers in catchments 5 & 6 + 125 manholes in catchments 1, 3 & 4	1,637	0.77

8 REHABILITATION STRATEGY AND SHORT TERM MEASURES

The short term recommendations for remediation are based on the return flow audit and the assessment of the infrastructure. The main objective behind the short term remedial plans is **“minimum effort – maximum benefit”**.

The following action plans are recommended for the short term:

1. Lack of sufficient information poses a serious problem for the study as well as for the District Municipality charged with the responsibility of operating and maintaining the infrastructure system. The District Municipality should therefore investigate options of collating and updating its information database of the sewer reticulation network.
2. The section between B3A and B15A needs to be cleared of overgrowth so that access could be gained to the service manholes.
3. Annexure10 highlights manholes that are filled with soil. These restrictions should be removed in order that the sewer lines function properly.
4. Section N22 to N27 – the manholes in the road must be located and investigated for the possible link between sewer and S/W at N27.
5. At Section C29C to 8E, the connection between the Boulevard’s water feature and the sewer line must be removed.
6. At Section 9A to C97, any possible interconnections or possible leaks on both S/W and sewer systems needs to be investigated further.
7. The overflow vent at PS3 allows for the high flood waters from the estuary to flow into the sump. A non-return valve at the pump station, allowing the sump to drain freely into the estuary in the event of pump failure will help alleviate the problem.
8. The manholes listed in Annexure 10 that were found to have joint leaks must be repaired to minimise the effect of infiltration at the manholes. The cost of repairing the joint leaks in 317 manholes is included as Annexure 11.
9. Further investigation of fractured sewer pipes needs to be carried out at the positions identified by the field surveys. Any fractured sewer pipes should be repaired or replaced by the Municipality.
10. The reliability of the pumps at the pump stations needs improving.

11. Inspection of private properties for illegal connections of stormwater drains to sewer pipelines should continue, and enforcement of by-laws should follow the warnings to defaulters.
12. The Short Run Marginal Cost Benefit and Long Run Marginal Cost Benefit calculations and spreadsheet presented in this report must be used by the District Municipality as a decision making tool to prioritise the work that is not immediately affordable, but for which funding may be obtained through funding mechanisms not linked to the DM.

It is envisaged that Items 1-9 and 11 can be carried out by the District Municipality, or a number of SMME contractors. Item 10 can be funded by CMIP or a Municipal Infrastructure Grant (MIG). The business plan and application process will help quantify the cost of the bulk infrastructure improvement.

Comments:

1. Notwithstanding the above, the Ugu District Municipality has appointed Stewart Scott to investigate the feasibility of decommissioning PS3 and PS4, and replacing with a single pump station.

9 BENEFITS OF REMEDIATION

The obvious benefit of the short term remediation is a cost saving on energy input on the pumping of excess sewerage. This includes the savings on pumping costs, whereby the amount of clear water pumped will be minimised.

Overloading at the Sewerage Treatment Works gives a false impression of exceedence of hydraulic design capacity. Reduction of overloading at the works will result in a greater catchment area being served by the works. The rapid growth of the residential sector along the South Coast indicates that bulk infrastructure will require some sort of upgrade to meet the higher water demands and subsequent effluent discharges. The increase in hydraulic demand could be taken up by the reduction in overloading at the works.

Margate has an environmentally sensitive eco-system, which includes the estuary and the marina. Some local fishermen fish out of the stream. Contamination of the fish by e-coli could pose health risks to the local people.

The stream along PS3 is also used for recreational sport, and contamination of the water course could lead to the demise of water sport in the area. The small towns along the South Coast depend on the area's functionality as tourists' destinations, and any negativity associated with the waterways would adversely affect the economy of the tourism industry.

Constant failure of the pumps at PS4 results in the discharge of raw sewage on the open fields before it flows into the stream. This can present serious health problems, particularly to the children who use the area for recreational purposes.

Although groundwater is not abstracted for human consumptive use, groundwater contamination on a large scale will alter the system aquifer and its characteristics. Although the system may cope with the changes in the groundwater regime, immediate degradation followed by a long term recovery will be experienced, which will create a short term unbalance in the eco-system.

Sewer and manhole rehabilitation would therefore provide greater benefits for environmental and health preservation.

The benefit of system knowledge cannot be underestimated, as it adds tremendous value to the information database. This helps reduce operational inefficiencies, and the down-time to carry out repairs to the infrastructure.

10 RECOMMENDATIONS AND CONCLUSIONS

The Stage 1 report makes recommendations for the Municipality to improve the operations, maintenance and functionality of the sewer reticulation system.

- It is recommended that the Municipality gives consideration to the action plans and determine a procedure and programme for carrying out some of the action plans.
- It is noted that access to information is a serious impediment to a study of this nature, and information needs to be collated and disseminated in a co-ordinated manner for effective usage.
- The Municipality also needs to develop a routine maintenance programme for inspection and repair of damaged sewer infrastructure.
- Enforcement for illegal connection of stormwater into the sewer reticulation system must be an ongoing activity, and the by-laws of the Municipality must empower the Peace Officers in the execution of their duties.
- The quality of work accepted by the District Municipality must be reviewed, to ensure that work of the highest quality is handed over to the DM. A quality checklist should be included with the handover certificate, which must also include the appropriate pressure test of the sewer infrastructure.

The benefits of remediation, both financial and improvement to the environment will only be noted if there is a concerted and dedicated input from all the role players. The lack of funds is seen as a serious limiting factor to the success of a project of this nature, and innovative ways of securing funds should be investigated by the Municipality to ensure long term success and sustainability of this project.

The problems experienced by the District Municipality are commonly experienced by other District and Local Municipalities along the South Coast. Therefore, the knowledge gained from this exercise, should be used for the benefit of similar Municipalities.

ANNEXURES

ANNEXURE 1

Catchment boundaries and pump station locations in Margate

Margate Return Flow Analysis

5&6 are gravity inflows to head of works

Catchment / PS		catchmnt 1 & PS1	catchmnt 3	PS 3 (1+3)	catchmnt 4 & PS4	4a	PS4a(1+3+ 4+4a)	5, 6	Total to STW	Remarks
Infrastructure Data:										
Catchment area	km2	0.273	0.556		1.132	0.502		1.500	3.963	
Connections / properties	no	89	231		472	254		1345	2,391	
Sewer length	m	2,773	7,273		13,560	8,171		15,000	46,777	
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Length below WT	m	555	4,364		4,068	2,451		2,250	13,688	
Mean diameter	m	0.1	0.25		0.2	0.15		0.15		
Conn density by sewer length	no/km	32.1	31.8		34.8	31.1		89.7		*not used in calculation,*
Property density	no/km2	326	415		417	506		897		*but useful indicator >*
No of manholes	no	67	171		300	210		620	1368	
Manhole density	no/km	24.2	23.5		22.1	25.7		41.3		
Flow Mass Balance:										
Wastewater from connections	**m3/yr**	**43,800**	**102,200**	**146,000**	**137,824**	**74,168**	**357,992**	**392,740**	**750,732**	*800l/household/day*
Annual average, per day	m3/d	120	280	400	378	203	981	1,076	2,057	
Peak day wastewater	m3/d	216	504	720	680	366	1,765	1,937	3,702	
Peak factor		1.80	1.80	1.80	1.80	1.80	1.80	1.80	1.80	
Average wastewater per connection	l/d	1,348	1,212		800	800		800		
Net infiltration less exfiltration	**m3/yr**	**10,950**	**116,800**	**127,750**	**147,904**	**39,420**	**315,074**	**216,968**	**532,042**	
Ditto	m3/d	30	320	350	405	108	863	594	1,458	
Storm water inflow	**m3/yr**	**9,125**	**155,125**	**164,250**	**48,180**	**25,915**	**238,345**	**137,970**	**376,315**	
Storm overflow	m3/yr	7,300	65,700	73,000	38,544	20,732	132,276	110,376	242,652	
Storm water retained within system	m3/yr	1,825	89,425	91,250	9,636	5,183	106,069	27,594	133,663	
Total flows retained within system	m3/yr	56,575	308,425	365,000	295,364	118,771	779,135	637,302	1,416,437	- storm o'flow & exfiltration
Infiltration & Exfiltration Analysis:										
Permitted in&exfiltration SABS	m3/d.km.m	15	15		15	15		15		
Ditto	m3/d	1	16		12	6		5		
Assume exfiltration as % SABS limit	%	200%	200%		200%	200%		200%		
Exfiltration sewer length above GWT	m3/d	7	22		57	26		57	169	
Ditto	m3/yr								61,517	
Infiltration sewer length below GWT	m3/d	37	342		462	134		652	1,626	
Ditto	m3/yr								593,559	
Specific infiltration, below WT	m3/d.km.m	661	313		568	364		1931		
Specific infiltration, x SABS limit	ratio	44.1	20.9		37.9	24.2		128.8		
Excess infiltration (SABS 15)	**m3/yr**	**13,076**	**118,791**		**164,237**	**46,801**		**236,062**	**578,967**	
Ditto	m3/d	36	325		450	128		647	1,586	
Ditto if 2 x SABS 15	m3/d	28	287		381	97		584	1,378	

Estimated % of badly defective* MHs	%	49%	52%		55%	55%		52%		* visible flow
Estimated no below WT	no	7	53		50	35		48	193	
If average infiltrn per MH =	m3/d	3	3		3	3		3		critical figure
Total infiltrn at bad MHs below WT	m3/d	21	159		150	105		144	579	
Remaining in sewers	m3/d	16	183		312	29		508	1047	
Ditto per metre length below WT	m3/d.m	0.03	0.04		0.08	0.01		0.23		
Ditto specific infiltration	m3/d.km.m	282	168		384	78		1,505		
Amount to achieve SABS if MH repaired	m3/d	15	166		300	23		503	1007	
Ditto to achieve 2*SABS if MH repaired	m3/d	7	128		231	-8		440	799	
Surface Water Inflow Analysis:										
Specific sw inflow, by sewer length	m3/yr.km	3,291	21,329		3,553	3,172		9,198		
Specific sw inflow, by area	m3/yr.km2	33,425	279,002		42,562	51,624		91,980		
Target max sw inflow by sewer length	m3/yr.km	5,000	5,000		5,000	5,000		5,000		see note 1
Ratio storm overflow: storm retained		400%	73%		400%	400%		400%	182%	
Specific sw overflow, equiv mm of rain	mm	27	118		34	41		74	61	
Inflow as proportion of wastewater	%	21%	152%		35%	35%		35%		
Excess sw inflow	**m3/yr**	**0**	**118,760**		**0**	**0**		**62,970**	**181,730**	
Pumping Stations:										
Original design capacity	l/s	15		70	75		180			
Present as tested	l/s	9.4		42.1	81.4		160			
Multiple of existing DWF		5.4		4.9	9.0		7.5			
Financial Analysis:										
Pumping head	m	25		33	31		30		5	see note 2
Elec cost per m3 at PS	c	6.1		8.1	7.6		7.4		1.0	see note 3
Elec cost per m3 thro to STW	c	30.2	24.1		16.0	8.4		1		
Cost of pumping infiltr'n to STW	**R/yr**	**3,307**	**28,149**		**23,665**	**3,311**		**2,170**	**60,601**	
Cost per m of sewer below WT	R/yr.m	5.96	6.45		5.82	1.35		0.96		
Cost per property sewer below WT	R/yr.prop	186	203		167	43		11		
Cost savings if infiltration = SABS	R/yr	3,949	28,629		26,278	3,931		2,361	65,147	
Ditto if = 2xSABS	R/yr	3,123	25,270		22,239	2,973		2,133	55,738	
Cost savings bad MHs only	R/yr	2,315	13,986		8,760	3,219		526	28,806	
Unit cost savings per bad MH	R/yr.MH	331	264		175	92		11		
Cost savings, sewers to SABS	R/yr	1,634	14,642		17,518	712		1,835	**36,341**	
Cost savings, sewers to 2*SABS	R/yr	809	11,283		13,479	-246		1,607	**26,932**	
Unit cost savings per m of sewer repair	R/yr.m	1.5	2.6		3.3	-0.1		0.7		assuming 2*SABS
Cost of pumping s/w inflow to STW	**R/yr**	**551**	**21,551**		**1,542**	**435**		**276**	**24,356**	
Cost savings if sw inflow at target	Ryr	0	28,621		0	0		630	29,251	
Total Excess Pumping Costs	**R/yr**	**3,858**	**49,700**		**25,206**	**3,747**		**2,446**	**84,957**	
Total potential cost savings (SABS)	**R/yr**	**3,949**	**57,250**		**26,278**	**3,931**		**2,990**	**94,398**	

Notes:

1 Notional / provisional target pending further appraisal of causes of surface water ingress and praticalities of their elimination
2 At STW allows for RAS recirculation at 1*DWF
3 different figures in draft report and s/sheet

Balance Summary and Sewage Treatment Works Inflows:		
Wastewater generated from properties, annual average	2,057	m3/d
Wastewater from properties, reaching STW, annual average	1,888	m3/d
Ditto peak day	3,534	m3/d
Infiltration, groundwater and streams	1,626	m3/d
Dry Weather Flow, annual average	**3,514**	**m3/d**
DWF, peak day	**5,160**	**m3/d**
Storm water retained within system and passed through STW	133,663	m3/yr
Ditto average per day	366	m3/d
Annual average total inflow to STW	**3,881**	**m3/d**
Storm water overflowed within network	242,652	m3/yr

366.2
0.0709705

6250
2281250
0.058592

ANNEXURE 2

24 Hour Flow Pattern at Margate STW Inlet Flume (10 – 14 July 2003)

ANNEXURE 3

24 Hour COD/BOD load pattern at Margate STW (6 June 2003)

Margate

incl big consumers	consumers	sales [m³/month]	Ave Loss % over 4 months [%]	Demand [m³/month]	Ave Demand/ Consumer [m³/month]	Ave Demand/ Consumer [m³/day]	
Jan-03	2668	137,564	21.41%	167,016			
Feb-03	2632	105,482	21.41%	128,066			
Mar-03	2581	81,596	21.41%	99,066			
Apr-03	2560	101,908	21.41%	123,727			
Ave	**2610**	**106,638**	**21.41%**	**129,469**	**49.60**	**1.65**	532.37

excl big consumers	consumers	sales [m³/month]	Ave Loss % over 4 months [%]	Demand [m³/month]	Ave Demand/ Consumer [m³/month]	Ave Demand/ Consumer [m³/day]	
Jan-03	2591	87,127	21.41%	105,781			
Feb-03	2555	59,926	21.41%	72,756			
Mar-03	2504	31,159	21.41%	37,830			
Apr-03	2483	53,098	21.41%	64,466			
Ave	**2533**	**57,828**	**21.41%**	**70,208**	**27.71**	**0.92**	297.37

Over Jan - Apr 2003:

total consumption	860771
margate/uvongo sales	676442
unaccounted for water	184329
% Loss	**0.2141**

Big consumers (more than 10m3/day): Total m3/day for 77 properties 1627

in m³/day:	no of consumers	total consumtion excl big cons	big cons.	total consumtion incl big cons	
P/S 1	102	94	68	162	
P/S 3	322	297	120	417	83.49
P/S 4	716	661	19	680	

0.82
342
858
600.6

ANNEXURE 4

Water sales and demand figures (January 2003 to April 2003)

Sales figures, including big consumers

	consumers	sales [m³/month]	Ave Loss % over 4 months [%]	Demand [m³/month]	Ave Demand/ Consumer [m³/month]	Ave Demand/ Consumer [m³/day]
Jan-03	2668	137,564	21.41%	167,016		
Feb-03	2632	105,482	21.41%	128,066		
Mar-03	2581	81,596	21.41%	99,066		
Apr-03	2560	101,908	21.41%	123,727		
Ave	**2610**	**106,638**	**21.41%**	**129,469**	**49.60**	**1.65**

Sales figures, excluding big consumers

	consumers	sales [m³/month]	Ave Loss % over 4 months [%]	Demand [m³/month]	Ave Demand/ Consumer [m³/month]	Ave Demand/ Consumer [m³/day]
Jan-03	2591	87,127	21.41%	105,781		
Feb-03	2555	59,926	21.41%	72,756		
Mar-03	2504	31,159	21.41%	37,830		
Apr-03	2483	53,098	21.41%	64,466		
Ave	**2533**	**57,828**	**21.41%**	**70,208**	**27.71**	**0.92**

Big consumers (more than 10m3/day):

No of properties	m3/day
77	1627

Average Loss Over Jan - Apr 2003:

total consumption	860771
margate/uvongo sales	676442
unaccounted for water	184329
% Loss	**0.2141**

Demand per catchment
in m³/day:

	no of consumers	consumption in m3/day: excl. big consumers	big consumers per catchment	incl big consumers	Flow into Sewerage by 80% drainage into sewer
P/S 1	102	94	51	**145**	**120**
P/S 3	322	297	198	**495**	**400**
P/S 4	716	661	19	**680**	**540**

ANNEXURE 5.1

Pump Duty Calculations

Pump duty calculations

Pump station 1

Day flow

Measured volume of the sump:	10.1031	m^3			
Sump fill rate with pumps off:	2284	sec	=	0.00442	m^3/s
Average Pump Rate:	2913	sec	=	0.00347	m^3/s
+ Ave. Fill Rate:				0.00442	m^3/s
Pump measured duty [m^3/s]				0.00789	m^3/s
Pump Measured Duty in m^3/h:				**28.41**	**m^3/h**

Night flow

Measured volume of the sump:	10.1031	m^3			
Sump fill rate with pumps off:	14248	sec	=	0.00071	m^3/s
Average Pump Rate:	1161	sec	=	0.0087	m^3/s
+ Ave. Fill Rate:				0.00071	m^3/s
Pump measured duty [m^3/s]				0.00941	m^3/s
Pump Measured Duty in m^3/h:				**33.88**	**m^3/h**

Pump station 3

Day flow

Measured volume of the sump:	4.59446	m^3			
Sump fill rate with pumps off:	141	sec	=	0.03258	m^3/s
Average Pump Rate:	218.75	sec	=	0.021	m^3/s
+ Ave. Fill Rate:				0.03258	m^3/s
Pump measured duty [m^3/s]				0.05359	m^3/s
Pump Measured Duty in m^3/h:				**192.92**	**m^3/h**

Night flow

Measured volume of the sump:	4.59446	m^3			
Sump fill rate with pumps off:	712.5	sec	=	0.00645	m^3/s
Average Pump Rate:	128.75	sec	=	0.03569	m^3/s
+ Ave. Fill Rate:				0.00645	m^3/s
Pump measured duty [m^3/s]				0.04213	m^3/s
Pump Measured Duty in m^3/h:				**151.68**	**m^3/h**

Pump station 4

Day flow

Measured volume of the sump:	5.63257	m^3		
Sump fill rate with pumps off:	231.33	sec	=	0.02435 m^3/s
Average Pump Rate:	98.75	sec	=	0.05704 m^3/s
+ Ave. Fill Rate:				0.02435 m^3/s
Pump measured duty [m^3/s]				0.08139 m^3/s
Pump Measured Duty in m^3/h:				**292.99 m^3/h**

Night flow

Measured volume of the sump:	5.63257	m^3		
Sump fill rate with pumps off:	1502	sec	=	0.00375 m^3/s
Average Pump Rate:	74	sec	=	0.07612 m^3/s
+ Ave. Fill Rate:				0.00375 m^3/s
Pump measured duty [m^3/s]				0.07987 m^3/s
Pump Measured Duty in m^3/h:				**287.52 m^3/h**

Note:
The night flow duty is used for the calculations of pumped volumes by the pump stations because the inflow at night is more consistent and the calculation therefor more reliable

ANNEXURE 5.2

Check on Pump Hour Meters

Check on pump running hours:

Pump station 1

Peak	Filling time of sump:	2284	*(1*
	Time for pumping the sump	2913	*(2*
	Total cycle time:	5197	*(3*
Low	Filling time of sump:	14248	*(4*
	Time for pumping the sump	1161	*(5*
	Total cycle time:	15409	*(6*
Assumed time of peakflow (h):		6	*(7*
Assumed time of low flow (h):		18	*(8*
Pumps on during peak flow: *(= 7 / 3)*		4	*(9*
Duration (h): *(= 9 x 2)*		3.36	*(10*
Pumps on during low flow: *(= 8 / 6)*		4	*(11*
Duration (h): *(= 11 x 5)*		1.36	*(12*
Total pump running hours: *(= 10 + 12)*		**4.72**	**hour**

Check on pump running hours:

Pump station 3

Peak	Filling time of sump:	141	*(1*
	Time for pumping the sump	218.75	*(2*
	Total cycle time:	359.75	*(3*
Low	Filling time of sump:	712.5	*(4*
	Time for pumping the sump	128.75	*(5*
	Total cycle time:	841.25	*(6*
Assumed time of peakflow (h):		6	*(7*
Assumed time of low flow (h):		18	*(8*
Pumps on during peak flow: *(= 7 / 3)*		60	*(9*
Duration (h): *(= 9 x 2)*		3.65	*(10*
Pumps on during low flow: *(= 8 / 6)*		77	*(11*
Duration (h): *(= 11 x 5)*		2.75	*(12*
Total pump running hours: *(= 10 + 12)*		**6.40**	**hour**

Check on pump running hours:

Pump station 4

Peak	Filling time of sump:	231.33	*(1*
	Time for pumping the sump	98.75	*(2*
	Total cycle time:	330.08	*(3*
Low	Filling time of sump:	1502	*(4*
	Time for pumping the sump	74	*(5*
	Total cycle time:	1576	*(6*

Assumed time of peakflow (h):	6	*(7*
Assumed time of low flow (h):	18	*(8*
Pumps on during peak flow: *(= 7 / 3)*	65	*(9*
Duration (h): *(= 9 x 2)*	1.80	*(10*
Pumps on during low flow: *(= 8 / 6)*	41	*(11*
Duration (h): *(= 11 x 5)*	0.85	*(12*
Total pump running hours: *(= 10 + 12)*	**2.64**	**hour**

ANNEXURE 6.1

Pump running hours Pump Station 1, 3, 4 and 4A – Tabular

Margate Pump Running Hours

			P/S 1	Pump Duty:	9.41	l/sec		P/S 3	Pump Duty:	42.13	l/sec		P/S 4	Pump Duty:	79.87	l/sec		P/S 4A	Pump Duty:	160.56	l/sec		
		rainfall [mm]	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Pump No 3 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*
17 Feb 2003	5:00	-	930.30	5,653.30				23,002.00	12,634.81				-	1,354.98				20,946.40	21,233.00	2,590.42			
	14:00	-	932.50	5,653.80	2.70	91.48	10.16	23,005.00	12,635.58	3.77	571.84	63.54	-	1,359.31	4.33	1,244.95	138.33	20,946.40	21,235.00	2,590.42	2.00	1,156.06	128.45
	22:00	-	933.90	5,653.80	1.40	47.43	5.93	23,007.00	12,635.58	2.00	303.36	37.92	-	1,360.00	0.69	198.39	24.80	20,946.40	21,238.00	2,590.42	3.00	1,734.08	216.76
18 Feb 2003	5:00	-	934.50	5,653.80	0.60	20.33	2.90	23,008.00	12,635.58	1.00	151.68	21.67	-	1,360.38	0.38	109.26	15.61	20,946.40	21,239.00	2,590.42	1.00	578.03	82.58
	14:00	-	935.10	5,655.30	2.10	71.15	7.91	23,009.60	12,635.59	1.61	244.21	27.13	-	1,361.65	1.27	365.15	40.57	20,946.40	21,244.00	2,590.42	5.00	2,890.14	321.13
	22:00	-	935.10	5,656.90	1.60	54.21	6.78	23,009.60	12,639.90	4.31	653.74	81.72	-	1,362.55	0.90	258.77	32.35	20,946.40	21,247.20	2,590.42	3.20	1,849.69	231.21
19 Feb 2003	5:00	-	935.10	5,657.00	0.10	3.39	0.48	23,009.60	12,640.00	0.10	15.17	2.17	-	1,362.90	0.35	100.63	14.38	20,946.40	21,248.00	2,590.42	0.80	462.42	66.06
	14:00	-	936.90	5,658.10	2.90	98.25	10.92	23,011.00	12,641.45	2.85	432.29	48.03	-	1,364.13	1.23	353.65	39.29	20,946.40	21,250.00	2,591.20	2.78	1,606.92	178.55
	22:00	-	938.40	5,658.10	1.50	50.82	6.35	23,014.40	12,641.45	3.40	515.71	64.46	-	1,364.99	0.86	247.26	30.91	20,946.40	21,250.00	2,591.94	0.74	427.74	53.47
20 Feb 2003	5:00	-	939.10	5,658.10	0.70	23.72	3.39	23,015.00	12,641.45	0.60	91.01	13.00	-	1,365.30	0.31	89.13	12.73	20,946.40	21,250.00	2,592.94	1.00	578.03	82.58
	14:00	-	939.70	5,659.60	2.10	71.15	7.91	23,016.50	12,643.87	3.92	594.59	66.07	-	1,366.50	1.20	345.02	38.34	20,946.40	21,250.00	2,594.41	1.47	849.70	94.41
	22:00	-	939.70	5,660.80	1.20	40.66	5.08	23,016.50	12,645.97	2.10	318.53	39.82	-	1,367.28	0.78	224.26	28.03	20,946.40	21,250.00	2,595.50	1.09	630.05	78.76
21 Feb 2003	5:00	-	939.70	5,662.40	1.60	54.21	7.74	23,016.60	12,647.03	1.16	175.95	25.14	-	1,367.57	0.29	83.38	11.91	20,946.40	21,250.00	2,595.93	0.43	248.55	35.51
	14:00	-	941.40	5,662.40	1.70	57.60	6.40	23,019.12	12,647.90	3.39	514.20	57.13	-	1,368.89	1.32	379.52	42.17	20,946.40	21,250.00	2,597.59	1.66	959.53	106.61
	22:00	-	943.50	5,662.40	2.10	71.15	8.89	23,021.85	12,647.90	2.73	414.09	51.76	-	1,369.74	0.85	244.39	30.55	20,946.40	21,250.00	2,598.78	1.19	687.85	85.98
22 Feb 2003	5:00	-	943.80	5,662.40	0.30	10.16	1.45	23,022.90	12,647.90	1.05	159.26	22.75	-	1,370.02	0.28	80.50	11.50	20,946.40	21,250.00	2,599.17	0.39	225.43	32.20
	14:00	-	946.00	5,662.40	2.20	74.54	8.28	23,026.00	12,647.90	3.10	470.21	52.25	-	1,371.09	1.07	307.64	34.18	20,946.40	21,250.60	2,600.25	1.68	971.09	107.90
	22:00	-	947.50	5,662.40	1.50	50.82	6.35	23,028.45	12,647.90	2.45	371.62	46.45	-	1,371.80	0.71	204.14	25.52	20,946.40	21,253.50	2,600.25	2.90	1,676.28	209.54
23 Feb 2003	5:00	0.70	948.20	5,662.40	0.70	23.72	3.39	23,029.50	12,647.90	1.05	159.26	22.75	-	1,372.08	0.28	80.50	11.50	20,946.40	21,254.50	2,600.25	1.00	578.03	82.58
	14:00	0.70	950.20	5,662.40	2.00	67.76	7.53	23,032.30	12,647.90	2.80	424.71	47.19	-	1,373.07	0.99	284.64	31.63	20,946.40	21,257.70	2,600.25	3.20	1,849.69	205.52
	22:00	0.70	951.60	5,662.40	1.40	47.43	5.93	23,034.40	12,647.90	2.10	318.53	39.82	-	1,373.88	0.81	232.89	29.11	20,946.40	21,258.80	2,600.25	1.10	635.83	79.48

			P/S 1	Pump Duty:	9.41	l/sec		P/S 3	Pump Duty:	42.13	l/sec		P/S 4	Pump Duty:	79.87	l/sec		P/S 4A	Pump Duty:	160.56	l/sec		
		rainfall [mm]	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Pump No 3 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*
19 May 2003	5:00	-	1,048.90	6,025.20				23,586.80	12,862.60				14.77	1,616.47				20,972.20	21,433.60	2,837.26			
	14:00	0.70	1,048.90	6,027.40	2.20	74.54	9.32	23,589.90	12,862.60	3.10	470.21	58.78	14.77	1,617.22	0.75	215.64	26.95	20,972.70	21,433.60	2,838.43	1.67	965.31	120.66
	22:00	0.70	1,048.90	6,029.70	2.30	77.92	9.74	23,592.80	12,862.60	2.90	439.87	54.98	14.77	1,617.94	0.72	207.01	25.88	20,972.70	21,437.00	2,838.51	3.48	2,011.54	251.44
20 May 2003	5:00	-	1,048.90	6,030.10	0.40	13.55	1.69	23,593.80	12,862.60	1.00	151.68	18.96	14.77	1,618.13	0.19	54.63	6.83	20,972.70	21,438.30	2,838.51	1.30	751.44	93.93
	14:00	-	1,048.90	6,032.80	2.70	91.48	11.43	23,597.00	12,862.62	3.22	488.41	61.05	14.77	1,619.16	1.03	296.14	37.02	20,974.00	21,439.50	2,838.51	2.50	1,445.07	180.63
	22:00	-	1,048.90	6,034.70	1.90	64.37	8.05	23,599.70	12,862.62	2.70	409.54	51.19	14.77	1,619.93	0.77	221.39	27.67	20,974.10	21,442.30	2,838.51	2.90	1,676.28	209.54
21 May 2003	5:00	-	1,048.90	6,035.00	0.30	10.16	1.27	23,600.80	12,862.62	1.10	166.85	20.86	14.77	1,620.13	0.20	57.50	7.19	20,974.10	21,443.80	2,838.51	1.50	867.04	108.38
	14:00	-	1,048.90	6,037.60	2.60	88.09	11.01	23,603.90	12,862.62	3.10	470.21	58.78	14.77	1,620.97	0.84	241.51	30.19	20,974.10	21,444.90	2,839.60	2.19	1,265.88	158.24
	22:00	-	1,048.90	6,039.00	1.40	47.43	5.93	23,606.60	12,862.62	2.70	409.54	51.19	14.77	1,621.81	0.84	241.51	30.19	20,974.10	21,444.90	2,840.89	1.29	745.66	93.21
22 May 2003	5:00	-	1,048.90	6,039.40	0.40	13.55	1.69	23,607.80	12,862.62	1.20	182.02	22.75	14.77	1,621.96	0.15	43.13	5.39	20,974.10	21,444.90	2,841.30	0.41	236.99	29.62
	14:00	-	1,048.90	6,041.50	2.10	71.15	8.89	23,610.70	12,862.62	2.90	439.87	54.98	14.77	1,622.82	0.86	247.26	30.91	20,974.10	21,447.70	2,841.83	3.33	1,924.83	240.60
	22:00	-	1,048.90	6,042.80	1.30	44.04	5.51	23,613.70	12,862.62	3.00	455.04	56.88	14.77	1,623.39	0.57	163.88	20.49	20,974.10	21,451.30	2,841.83	3.60	2,080.90	260.11
23 May 2003	5:00	-	1,048.90	6,043.20	0.40	13.55	1.69	23,614.70	12,862.62	1.00	151.68	18.96	14.77	1,623.57	0.18	51.75	6.47	20,974.10	21,452.50	2,841.83	1.20	693.63	86.70
	14:00	-	1,048.90	6,045.40	2.20	74.54	9.32	23,618.40	12,862.62	3.70	561.22	70.15	14.77	1,624.28	0.71	204.14	25.52	20,975.50	21,453.80	2,841.83	2.70	1,560.68	195.08
	22:00	-	1,048.90	6,046.20	0.80	27.10	3.39	23,620.40	12,862.62	2.00	303.36	37.92	14.77	1,624.77	0.49	140.88	17.61	20,976.60	21,453.80	2,841.83	1.10	635.83	79.48
24 May 2003	5:00	-	1,048.90	6,046.90	0.70	23.72	2.96	23,622.00	12,862.62	1.60	242.69	30.34	14.77	1,625.06	0.29	83.38	10.42	20,977.30	21,453.80	2,841.83	0.70	404.62	50.58
	14:00	-	1,048.90	6,049.00	2.10	71.15	8.89	23,625.10	12,862.62	3.10	470.21	58.78	14.77	1,625.26	0.20	57.50	7.19	20,977.90	21,455.90	2,841.83	2.70	1,560.68	195.08
	22:00	-	1,048.90	6,049.90	0.90	30.49	3.81	23,627.30	12,862.62	2.20	333.70	41.71	14.77	1,625.42	0.16	46.00	5.75	20,977.90	21,459.00	2,841.83	3.10	1,791.89	223.99
25 May 2003	5:00	-	1,048.90	6,050.20	0.30	10.16	1.27	23,628.50	12,862.62	1.20	182.02	22.75	14.77	1,625.52	0.10	28.75	3.59	20,977.90	21,460.60	2,841.83	1.60	924.85	115.61
	14:00	-	1,048.90	6,052.10	1.90	64.37	8.05	23,631.20	12,862.62	2.70	409.54	51.19	14.77	1,626.11	0.59	169.64	21.20	20,977.90	21,463.80	2,841.83	3.20	1,849.69	231.21
	22:00	-	1,048.90	6,053.00	0.90	30.49	3.81	23,633.30	12,862.62	2.10	318.53	39.82	14.77	1,626.32	0.21	60.38	7.55	20,977.90	21,466.30	2,841.83	2.50	1,445.07	180.63

			P/S 1	Pump Duty:	9.41	l/sec		P/S 3	Pump Duty:	42.13	l/sec		P/S 4	Pump Duty:	79.87	l/sec		P/S 4A	Pump Duty:	160.56	l/sec		
		rainfall [mm]	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*	*Pump No 1 reading*	*Pump No 2 reading*	*Pump No 3 reading*	*Total pump hours*	*Flow (m³)*	*Flow (m³/h)*
	5:00	-	1,048.90	6,115.10				23,714.80	12,884.33				14.77	1,645.63				20,988.40	21,466.80	2,880.80			
09 Jun 2003	14:00	-	1,048.90	6,117.80	2.70	91.48	11.43	23,718.40	12,884.33	3.60	546.05	68.26	14.77	1,646.41	0.78	224.26	28.03	20,988.40	21,466.80	2,882.39	1.59	919.06	114.88
	22:00	-	1,048.90	6,119.60	1.80	60.98	7.62	23,720.80	12,884.33	2.40	364.03	45.50	14.77	1,646.98	0.57	163.88	20.49	20,988.40	21,466.80	2,883.47	1.08	624.27	78.03
	5:00	-	1,048.90	6,120.00	0.40	13.55	1.69	23,722.10	12,884.33	1.30	197.18	24.65	14.77	1,647.17	0.19	54.63	6.83	20,988.40	21,466.80	2,883.97	0.50	289.01	36.13
10 Jun 2003	14:00	-	1,048.90	6,122.40	2.40	81.31	10.16	23,725.80	12,884.33	3.70	561.22	70.15	14.77	1,647.90	0.73	209.89	26.24	20,988.40	21,466.80	2,885.36	1.39	803.46	100.43
	22:00	-	1,048.90	6,124.50	2.10	71.15	8.89	23,728.40	12,884.33	2.60	394.37	49.30	14.77	1,648.50	0.60	172.51	21.56	20,988.40	21,466.80	2,886.63	1.27	734.10	91.76
	5:00	-	1,048.90	6,124.90	0.40	13.55	1.69	23,729.50	12,884.33	1.10	166.85	20.86	14.77	1,648.71	0.21	60.38	7.55	20,988.40	21,466.80	2,887.00	0.37	213.87	26.73
11 Jun 2003	14:00	-	1,048.90	6,126.30	1.40	47.43	5.93	23,732.00	12,884.33	2.50	379.20	47.40	14.77	1,649.40	0.69	198.39	24.80	20,988.40	21,466.80	2,888.30	1.30	751.44	93.93
	22:00	-	1,048.90	6,128.90	2.60	88.09	11.01	23,735.80	12,884.33	3.80	576.39	72.05	14.77	1,649.74	0.34	97.76	12.22	20,988.40	21,466.80	2,889.63	1.33	768.78	96.10
	5:00	-	1,048.90	6,129.30	0.40	13.55	1.69	23,738.90	12,884.33	3.10	470.21	58.78	14.77	1,649.96	0.22	63.25	7.91	20,988.40	21,466.80	2,890.10	0.47	271.67	33.96
12 Jun 2003	14:00	-	1,048.90	6,130.30	1.00	33.88	4.24	23,741.20	12,884.33	2.30	348.87	43.61	14.77	1,650.40	0.44	126.51	15.81	20,988.40	21,466.80	2,891.50	1.40	809.24	101.15
	22:00	-	1,048.90	6,130.90	0.60	20.33	2.54	23,742.80	12,884.33	1.60	242.69	30.34	14.77	1,650.62	0.22	63.25	7.91	20,988.40	21,466.80	2,892.72	1.22	705.19	88.15
	5:00	-	1,048.90	6,130.90	-	-	-	23,743.00	12,884.33	0.20	30.34	3.79	14.77	1,650.82	0.20	57.50	7.19	20,988.40	21,466.80	2,893.13	0.41	236.99	29.62
13 Jun 2003	14:00	-	1,048.90	6,130.90	-	-	-	23,746.50	12,884.33	3.50	530.88	66.36	14.77	1,651.10	0.28	80.50	10.06	20,988.40	21,466.80	2,894.50	1.37	791.90	98.99
	22:00	-	1,048.90	6,130.90	-	-	-	23,749.20	12,884.33	2.70	409.54	51.19	14.77	1,651.40	0.30	86.26	10.78	20,988.40	21,466.80	2,895.64	1.14	658.95	82.37
	5:00	-	1,048.90	6,132.50	1.60	54.21	6.78	23,750.80	12,884.33	1.60	242.69	30.34	14.77	1,651.53	0.13	37.38	4.67	20,988.40	21,466.80	2,896.19	0.55	317.92	39.74
14 Jun 2003	14:00	-	1,048.90	6,135.20	2.70	91.48	11.43	23,754.10	12,884.33	3.30	500.55	62.57	14.77	1,651.98	0.45	129.38	16.17	20,988.40	21,466.80	2,897.60	1.41	815.02	101.88
	22:00	-	1,048.90	6,137.60	2.40	81.31	10.16	23,757.30	12,884.33	3.20	485.38	60.67	14.77	1,652.32	0.34	97.76	12.22	20,988.40	21,466.80	2,898.97	1.37	791.90	98.99
	5:00	-	1,048.90	6,138.60	1.00	33.88	4.24	23,758.00	12,884.33	0.70	106.18	13.27	14.77	1,652.44	0.12	34.50	4.31	20,988.40	21,466.80	2,899.50	0.53	306.35	38.29
15 Jun 2003	14:00	-	1,048.90	6,141.70	3.10	105.03	13.13	23,762.60	12,884.33	4.60	697.73	87.22	14.77	1,652.73	0.29	83.38	10.42	20,988.40	21,466.80	2,901.30	1.80	1,040.45	130.06
	22:00	6.00	1,048.90	6,144.40	2.70	91.48	11.43	23,765.90	12,884.33	3.30	500.55	62.57	14.77	1,653.04	0.31	89.13	11.14	20,988.40	21,466.80	2,902.43	1.13	653.17	81.65
	5:00	6.00	1,048.90	6,144.90	0.50	16.94	2.12	23,767.10	12,884.33	1.20	182.02	22.75	14.77	1,653.12	0.08	23.00	2.88	20,988.40	21,466.80	2,902.81	0.38	219.65	27.46
16 Jun 2003	14:00	6.00	1,048.90	6,147.30	2.40	81.31	10.16	23,770.80	12,884.33	3.70	561.22	70.15	14.77	1,653.33	0.21	60.38	7.55	20,988.40	21,466.80	2,904.30	1.49	861.26	107.66
	22:00	0.10	1,048.90	6,149.80	2.50	84.70	10.59	23,773.20	12,884.33	2.40	364.03	45.50	14.77	1,653.48	0.15	43.13	5.39	20,988.40	21,466.80	2,905.56	1.26	728.32	91.04
	5:00	0.10	1,048.90	6,150.10	0.30	10.16	1.27	23,773.40	12,884.33	0.20	30.34	3.79	14.77	1,653.52	0.04	11.50	1.44	20,988.40	21,466.80	2,905.90	0.34	196.53	24.57
17 Jun 2003	14:00	0.10	1,049.00	6,152.80	2.80	94.86	11.86	23,775.90	12,884.33	2.50	379.20	47.40	14.77	1,653.68	0.16	46.00	5.75	20,988.40	21,468.40	2,906.36	2.06	1,190.74	148.84
	22:00	1.80	1,049.00	6,154.70	1.90	64.37	8.05	23,778.70	12,884.33	2.80	424.71	53.09	14.77	1,653.76	0.08	23.00	2.88	20,989.40	21,469.40	2,906.36	2.00	1,156.06	144.51
	5:00	1.80	1,049.00	6,155.40	0.70	23.72	2.96	23,779.80	12,884.33	1.10	166.85	20.86	14.77	1,653.82	0.06	17.25	2.16	20,989.40	21,470.60	2,906.36	1.20	693.63	86.70
18 Jun 2003	14:00	1.80	1,049.00	6,157.60	2.20	74.54	9.32	23,783.10	12,884.33	3.30	500.55	62.57	14.77	1,653.94	0.12	34.50	4.31	20,990.30	21,471.70	2,906.36	2.00	1,156.06	144.51
	22:00	1.80	1,049.00	6,159.50	1.90	64.37	8.05	23,786.10	12,884.33	3.00	455.04	56.88	14.77	1,654.04	0.10	28.75	3.59	20,992.00	21,471.80	2,906.36	1.80	1,040.45	130.06
	5:00	-	1,049.00	6,159.90	0.40	13.55	1.69	23,787.20	12,884.33	1.10	166.85	20.86	14.77	1,654.04	-	-	-	20,992.40	21,471.80	2,906.36	0.40	231.21	28.90
19 Jun 2003	14:00	-	1,049.00	6,162.40	2.50	84.70	10.59	23,790.60	12,884.33	3.40	515.71	64.46	14.77	1,654.07	0.03	8.63	1.08	20,992.80	21,471.80	2,907.50	1.54	890.16	111.27
	22:00	-	1,049.00	6,163.70	1.30	44.04	5.51	23,793.30	12,884.33	2.70	409.54	51.19	14.77	1,654.12	0.05	14.38	1.80	20,992.80	21,471.80	2,908.75	1.25	722.54	90.32
	5:00	-	1,049.00	6,164.00	0.30	10.16	1.27	23,794.30	12,884.33	1.00	151.68	18.96	14.77	1,654.14	0.02	5.75	0.72	20,992.80	21,471.80	2,909.12	0.37	213.87	26.73
20 Jun 2003	14:00	-	1,049.00	6,167.00	3.00	101.64	12.71	23,796.70	12,884.33	2.40	364.03	45.50	14.85	1,654.27	0.21	60.38	7.55	20,992.80	21,471.80	2,910.97	1.85	1,069.35	133.67
	22:00	-	1,049.00	6,167.60	0.60	20.33	2.54	23,796.70	12,884.33	-	-	-	14.85	1,654.32	0.05	14.38	1.80	20,992.80	21,471.80	2,911.70	0.73	421.96	52.75
	5:00	-	1,049.00	6,168.50	0.90	30.49	3.81	23,796.70	12,884.33	-	-	-	14.85	1,654.36	0.04	11.50	1.44	20,992.80	21,471.80	2,912.22	0.52	300.57	37.57
21 Jun 2003	14:00	-	1,049.00	6,171.00	2.50	84.70	10.59	23,799.80	12,884.33	3.10	470.21	58.78	14.85	1,654.51	0.15	43.13	5.39	20,992.80	21,471.80	2,913.60	1.38	797.68	99.71
	22:00	-	1,049.00	6,172.80	1.80	60.98	7.62	23,803.20	12,884.33	3.40	515.71	64.46	14.85	1,654.70	0.19	54.63	6.83	20,992.80	21,471.80	2,915.20	1.60	924.85	115.61
	5:00	-	1,049.00	6,173.40	0.60	20.33	2.54	23,804.10	12,884.33	0.90	136.51	17.06	14.85	1,654.72	0.02	5.75	0.72	20,992.80	21,471.80	2,915.59	0.39	225.43	28.18
22 Jun 2003	14:00	-	1,049.00	6,176.10	2.70	91.48	11.43	23,807.20	12,884.33	3.10	470.21	58.78	14.85	1,654.88	0.16	46.00	5.75	20,992.80	21,471.80	2,916.99	1.40	809.24	101.15
	22:00	-	1,049.00	6,177.60	1.50	50.82	6.35	23,809.70	12,884.33	2.50	379.20	47.40	14.85	1,654.93	0.05	14.38	1.80	20,992.80	21,471.80	2,918.02	1.03	595.37	74.42
	5:00	-	1,049.00	6,178.30	0.70	23.72	2.96	23,810.80	12,884.33	1.10	166.85	20.86	14.85	1,654.96	0.03	8.63	1.08	20,992.80	21,471.80	2,918.42	0.40	231.21	28.90
23 Jun 2003	14:00	-	1,049.00	6,182.20	3.90	132.13	16.52	23,816.00	12,884.33	5.20	788.74	98.59	14.85	1,655.14	0.18	51.75	6.47	20,992.80	21,471.80	2,920.67	2.25	1,300.56	162.57
	22:00	-	1,049.00	6,183.60	1.40	47.43	5.93	23,817.50	12,884.33	1.50	227.52	28.44	14.85	1,655.24	0.10	28.75	3.59	20,992.80	21,471.80	2,921.45	0.78	450.86	56.36
	5:00	-	1,049.00	6,184.40	0.80	27.10	3.39	23,819.10	12,884.33	1.60	242.69	30.34	14.85	1,655.29	0.05	14.38	1.80	20,992.80	21,471.80	2,921.96	0.51	294.79	36.85
24 Jun 2003	14:00	-	1,049.00	6,187.80	3.40	115.19	14.40	23,823.40	12,884.33	4.30	652.23	81.53	14.85	1,655.71	0.42	120.76	15.09	20,992.90	21,475.80	2,922.28	4.42	2,554.88	319.36
	22:00	-	1,049.00	6,191.90	4.10	138.91	17.36	23,826.10	12,884.33	2.70	409.54	51.19	14.85	1,656.40	0.69	198.39	24.80	20,992.90	21,480.10	2,922.28	4.30	2,485.52	310.69
	5:00	16.50	1,049.00	6,193.40	1.50	50.82	6.35	23,826.10	12,884.33	-	-	-	14.85	1,656.65	0.25	71.88	8.98	20,992.90	21,482.00	2,922.28	1.90	1,098.25	137.28
25 Jun 2003	14:00	16.50	1,049.20	6,196.90	3.70	125.36	15.67	23,830.00	12,884.33	3.90	591.55	73.94	14.85	1,657.13	0.48	138.01	17.25	20,994.70	21,483.10	2,922.28	2.90	1,676.28	209.54
	22:00	16.50	1,049.20	6,198.60	1.70	57.60	7.20	23,833.90	12,884.33	3.90	591.55	73.94	14.85	1,657.64	0.51	146.63	18.33	20,996.00	21,483.10	2,922.28	1.30	751.44	93.93
	5:00	0.20	1,049.20	6,199.40	0.80	27.10	3.39	23,835.50	12,884.33	1.60	242.69	30.34	14.85	1,657.69	0.05	14.38	1.80	20,996.80	21,483.10	2,922.28	0.80	462.42	57.80
26 Jun 2003	14:00	0.20	1,050.00	6,201.30	2.70	91.48	11.43	23,839.60	12,884.33	4.10	621.89	77.74	14.85	1,657.86	0.17	48.88	6.11	20,998.00	21,483.70	2,922.75	2.27	1,312.12	164.02
	22:00	0.20	1,051.80	6,201.30	1.80	60.98	7.62	23,843.10	12,884.33	3.50	530.88	66.36	14.85	1,658.05	0.19	54.63	6.83	20,998.00	21,483.70	2,923.90	1.15	664.73	83.09
27 Jun 2003	5:00	-	1,052.40	6,201.30	0.60	20.33	2.54	23,844.50	12,884.33	1.40	212.35	26.54	14.85	1,658.11	0.06	17.25	2.16	20,998.00	21,483.70	2,924.78	0.88	508.66	63.58

Note: 24/6/2003 Pump station No.3: The electric pumps tripped with no indication on the panel. The diesel pump was running continuously for most of the night untill the diesel ran out and the sump overflowed. 16mm rain recorded for this night.

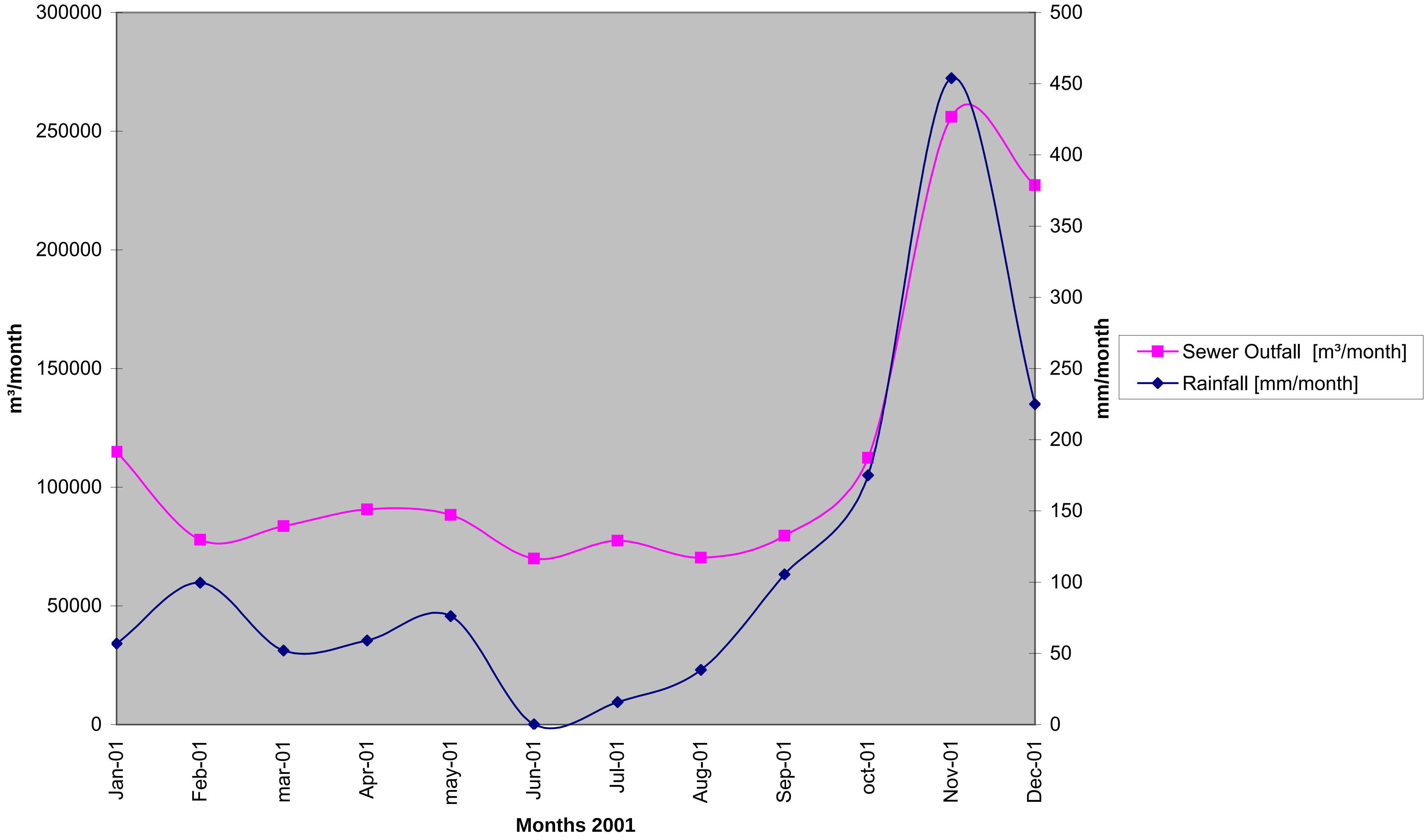
ANNEXURE 6.2

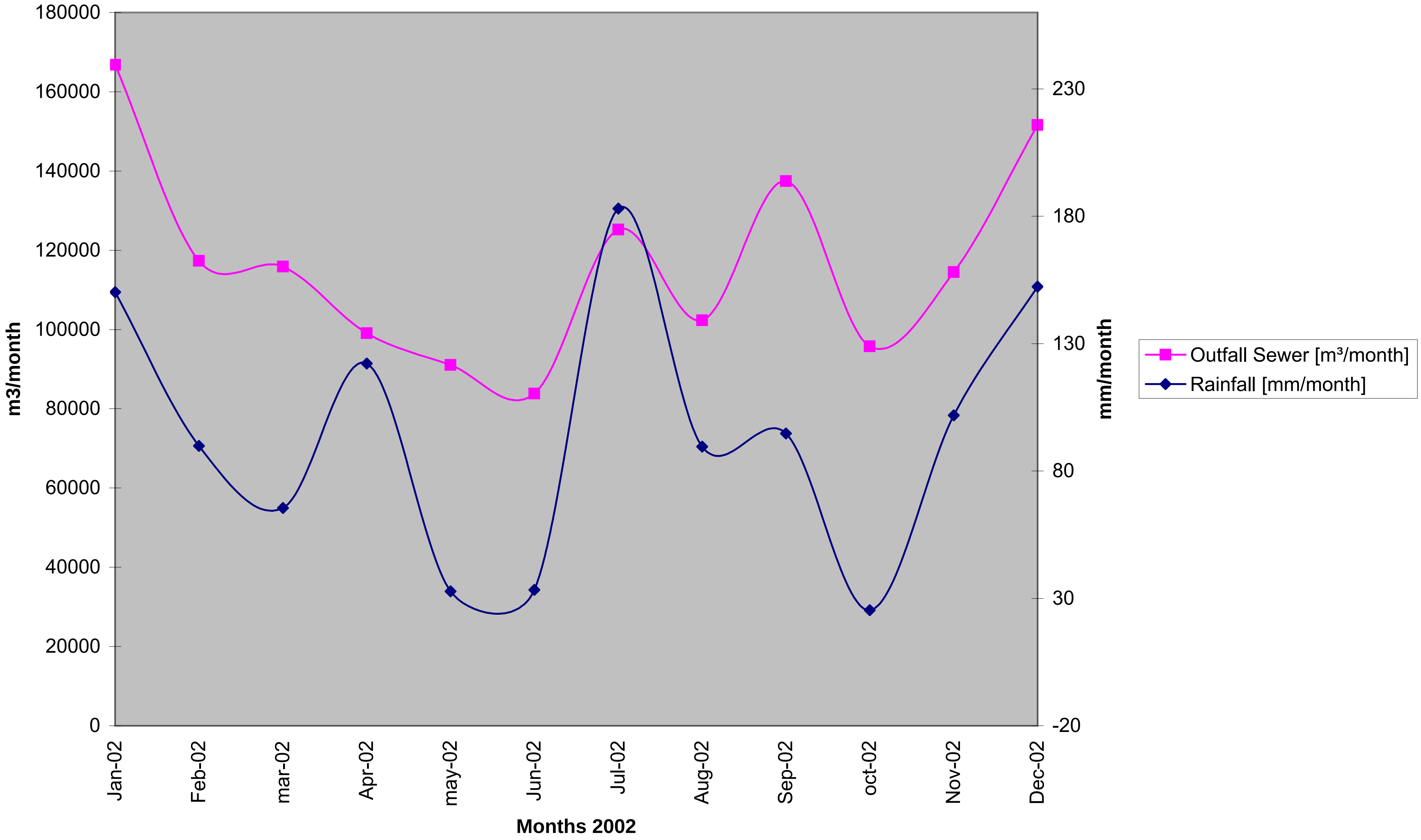
Pump running hours Pump Station 1, 3, 4 and 4A – Graphic

ANNEXURE 7

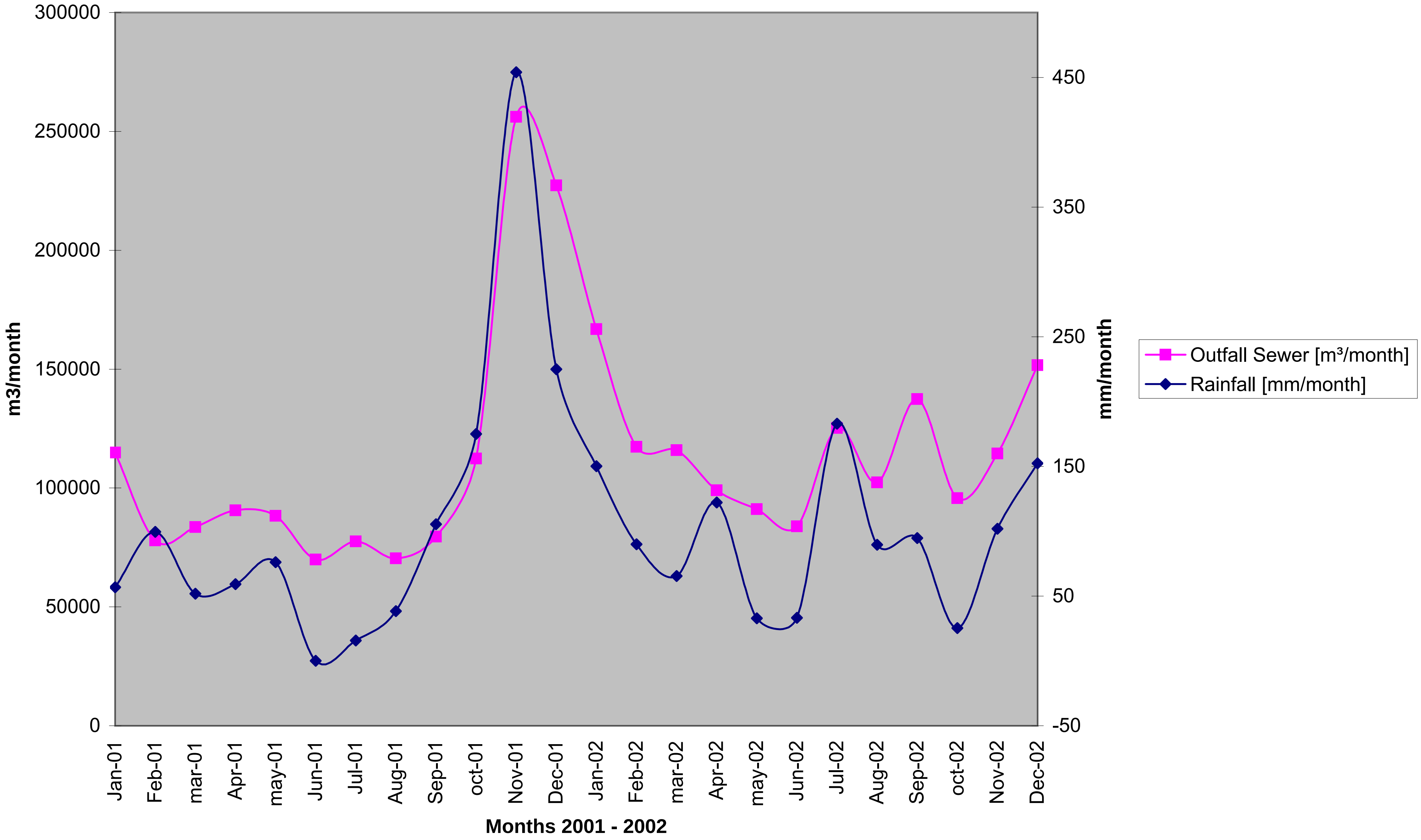
Final Effluent Flow versus Rainfall Correlation 2001 and 2002

Annexure 7
Final Effluent Flow versus Rainfall Correlation
2001




180000
160000
140000
120000
100000
80000
60000
40000
20000
0
m3/month
230
180
130
80
30
-20
mm/month
Outfall Sewer [m³/month]
Rainfall [mm/month]
Jan-02
Feb-02
mar-02
Apr-02
may-02
Jun-02
Jul-02
Aug-02
Sep-02
oct-02
Nov-02
Dec-02
Months 2002

Annexure 7
Final Effluent Flow versus Rainfall Correlation
2001-2002



Margate WWTW Out-Flow

Date	Total Outfall Cummulative	**Outfall [m3/day]**	Outfall [m3/month]	Rainfall [mm/month]
Jan-01	1964455	2257	114884	56.8
Feb-01	2042370	2489	77915	99.6
mar-01	2125926	2427	83556	51.9
Apr-01	2216553	2565	90627	59.1
may-01	2304836	2339	88283	76.1
Jun-01	2374781	2375	69945	0.1
Jul-01	2452295	2231	77514	15.8
Aug-01	2522661	3762	70366	38.4
Sep-01	2602250	2536	79589	105.4
oct-01	2714618	3885	112368	175.1
Nov-01	2970697	6943	256079	453.9
Dec-01	3197941	8211	227244	225
Jan-02	3364749	4549	166808	150.2
Feb-02	3482070	4158	117321	89.9
mar-02	3597930	3206	115860	65.5
Apr-02	3697003	3550	99073	122.2
may-02	3788068	2100	91065	32.8
Jun-02	3871892	3300	83824	33.3
Jul-02	3997144	5195	125252	183
Aug-02	4099440	0	102296	89.6
Sep-02	4236883	4279	137443	94.7
oct-02	4332622	2717	95739	25.4
Nov-02	4447121	3325	114499	101.9
Dec-02	4598735	0	151614	152.4

ANNEXURE 8

Flows at manholes 2B, M44, B48A and B78

Margate Pump Station 4 Catchment
Manhole No. M44 Levels in a 200mm Channel
Max. Distance to Invert 415mm

	Date / Time	**Recorded Depth in (mm)**	**Height of flow in channel in (mm)**	**Surface width of flow in channel in (mm)**	**Sectional Area in (m2)**	**Degrees**	**Wetted Perimeter in (m)**	**Velocity (Manning) in (m/s)**	**Flow rate in m3/s**	**Volume in (m3) for 2min.**	**Volume in (litres) for 2min.**	Volume [m³/h]	Volume cumm [m³]
10:00	6/27/2003 10:00	380.80	34.200	150.603585615	0.0035665663	97.7050	0.17052733	0.89306956	3.1852E-03	0.382223	382.223	14.62	14.62
11:00	6/27/2003 11:00	383.33	31.670	146.027546716	0.0031918908	93.7959	0.16370470	0.85226044	2.7203E-03	0.326439	326.439	10.51	25.13
12:00	6/27/2003 12:00	384.13	30.870	144.513571681	0.0030758714	92.5338	0.16150194	0.83902461	2.5807E-03	0.309688	309.688	9.72	34.85
13:00	6/27/2003 13:00	384.00	31.000	144.761873434	0.0030946420	92.7398	0.16186145	0.84118668	2.6032E-03	0.312381	312.381	9.24	44.09
14:00	6/27/2003 14:00	389.40	25.600	133.635923314	0.0023434919	83.8534	0.14635187	0.74740820	1.7515E-03	0.210185	210.185	8.40	52.49
15:00	6/27/2003 15:00	384.47	30.530	143.859919366	0.0030269322	91.9934	0.16055872	0.83334904	2.5225E-03	0.302699	302.699	7.24	59.73
16:00	6/27/2003 16:00	384.27	30.730	144.245167683	0.0030556930	92.3116	0.16111407	0.83669129	2.5567E-03	0.306801	306.801	7.21	66.93
17:00	6/27/2003 17:00	384.00	31.000	144.761873434	0.0030946420	92.7398	0.16186145	0.84118668	2.6032E-03	0.312381	312.381	8.74	75.67
18:00	6/27/2003 18:00	387.00	28.000	138.794812583	0.0026699173	87.8910	0.15339880	0.79012954	2.1096E-03	0.253150	253.150	7.87	83.55
19:00	6/27/2003 19:00	386.87	28.130	139.064058620	0.0026879468	88.1055	0.15377309	0.79239419	2.1299E-03	0.255590	255.590	8.77	92.31
20:00	6/27/2003 20:00	385.20	29.800	142.435388861	0.0029226132	90.8246	0.15851888	0.82105951	2.3996E-03	0.287957	287.957	8.83	101.14
21:00	6/27/2003 21:00	384.67	30.330	143.472521411	0.0029982485	91.6743	0.16000187	0.82999622	2.4885E-03	0.298624	298.624	9.16	110.31
22:00	6/27/2003 22:00	385.07	29.930	142.691206456	0.0029411144	91.0336	0.15888363	0.82325854	2.4213E-03	0.290556	290.556	9.31	119.62
23:00	6/27/2003 23:00	384.33	30.670	144.129817873	0.0030470567	92.2162	0.16094762	0.83568972	2.5464E-03	0.305567	305.567	9.31	128.92
0:00	6/28/2003 0:00	384.13	30.870	144.513571681	0.0030758714	92.5338	0.16150194	0.83902461	2.5807E-03	0.309688	309.688	9.33	138.26
1:00	6/28/2003 1:00	390.27	24.730	131.672732181	0.0022282755	82.3504	0.14372855	0.73147301	1.6299E-03	0.195591	195.591	7.93	146.18
2:00	6/28/2003 2:00	389.73	25.270	132.897360395	0.0022995888	83.2859	0.14536137	0.74139306	1.7049E-03	0.204588	204.588	6.33	152.52
3:00	6/28/2003 3:00	389.40	25.600	133.635923314	0.0023434919	83.8534	0.14635187	0.74740820	1.7515E-03	0.210185	210.185	5.99	158.50
4:00	6/28/2003 4:00	389.47	25.530	133.479872640	0.0023341588	83.7333	0.14614222	0.74613522	1.7416E-03	0.208992	208.992	6.27	164.77
5:00	6/28/2003 5:00	390.60	24.400	130.914323128	0.0021850217	81.7744	0.14272317	0.72536277	1.5849E-03	0.190192	190.192	6.48	171.25
6:00	6/28/2003 6:00	382.80	32.200	147.012380431	0.0032694149	94.6249	0.16515160	0.86093940	2.8148E-03	0.337772	337.772	9.50	180.75
7:00	6/28/2003 6:54	382.13	32.870	148.237149190	0.0033681577	95.6650	0.16696700	0.87181084	2.9364E-03	0.352368	352.368	10.12	190.87
						Over 21 hours and 44 minutes				**187.4202**	**187420.17**		208.22
													1.55

Margate PS 4 Catchment
Manhole No. B48A Levels in a 300mm Channel
Max. distance to Invert 1710mm

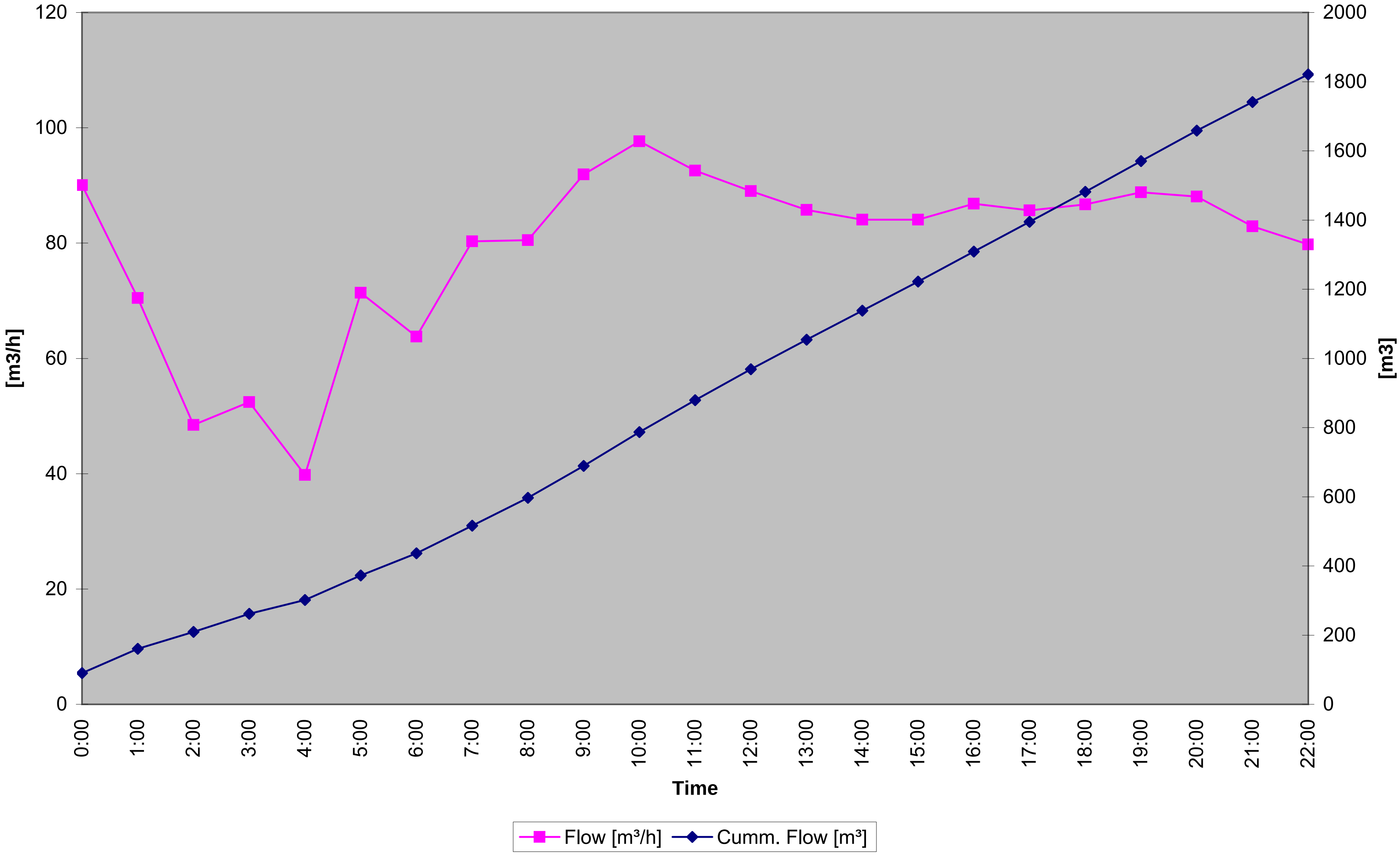
	Date / Time	Recorded Depth in (mm)	Height of flow in channel in (mm)	Surface width of flow in channel in (mm)	Sectional Area in (m2)	Degrees	Wetted Perimeter in (m)	Velocity (Manning) in (m/s)	Flow rate in m3/s	Volume in (m3) for 2min.	Volume in (litres) for 2min.	Volume in (m^3) for 1 hr.	Cumm Vol [m^3]
9:00	7/17/2003 9:00	1629.67	80.330	265.677180804	0.0152034475	124.6486	0.32632921	1.02913052	1.5646E-02	1.877560	1877.560	56.86	56.86
10:00	7/17/2003 10:00	1626.47	83.530	268.936714489	0.0160597352	127.3921	0.33351162	1.05203772	1.6895E-02	2.027454	2027.454	61.15	118.01
11:00	7/17/2003 11:00	1643.13	66.870	249.715062421	0.0117310112	112.6887	0.29501843	0.92598491	1.0863E-02	1.303529	1303.529	44.66	162.67
12:00	7/17/2003 12:00	1657.60	52.400	227.809042841	0.0082739153	98.8162	0.25870029	0.80085854	6.6262E-03	0.795148	795.148	33.78	196.45
13:00	7/17/2003 13:00	1655.33	54.670	231.622029177	0.0087945768	101.0809	0.26462917	0.82160776	7.2257E-03	0.867083	867.083	28.90	225.35
14:00	7/17/2003 14:00	1657.47	52.530	228.031568867	0.0083034973	98.9470	0.25904251	0.80205911	6.6599E-03	0.799187	799.187	23.75	249.10
15:00	7/17/2003 15:00	1658.27	51.730	226.653983861	0.0081219158	98.1405	0.25693117	0.79464685	6.4541E-03	0.774487	774.487	19.99	269.09
16:00	7/17/2003 16:00	1661.47	48.530	220.941975188	0.0074068654	94.8637	0.24835259	0.76440505	5.6618E-03	0.679421	679.421	16.60	285.69
17:00	7/17/2003 17:00	1665.53	44.470	213.198678232	0.0065268768	90.5776	0.23713173	0.72458645	4.7293E-03	0.567514	567.514	18.28	303.97
18:00	7/17/2003 18:00	1667.87	42.130	208.461632921	0.0060343494	88.0341	0.23047261	0.70084254	4.2291E-03	0.507495	507.495	18.72	322.69
19:00	7/17/2003 19:00	1671.00	39.000	201.782060650	0.0053933214	84.5372	0.22131779	0.66809726	3.6033E-03	0.432392	432.392	15.95	338.64
20:00	7/17/2003 20:00	1670.00	40.000	203.960780544	0.0055958471	85.6669	0.22427530	0.67868663	3.7978E-03	0.455739	455.739	12.18	350.82
21:00	7/17/2003 21:00	1663.60	46.400	216.951976253	0.0069412770	92.6342	0.24251574	0.74372549	5.1624E-03	0.619489	619.489	14.89	365.70
22:00	7/17/2003 22:00	1670.47	39.530	202.942150378	0.0055003894	85.1374	0.22288923	0.67372492	3.7057E-03	0.444690	444.690	12.99	378.69
23:00	7/17/2003 23:00	1677.27	32.730	187.058783274	0.0041753421	77.1486	0.20197468	0.59870076	2.4998E-03	0.299974	299.974	11.12	389.81
0:00	7/18/2003 0:00	1674.87	35.130	192.923643963	0.0046306336	80.0436	0.20955357	0.62590720	2.8983E-03	0.347802	347.802	10.85	400.66
1:00	7/18/2003 1:00	1673.00	37.000	197.291662267	0.0049948985	82.2401	0.21530407	0.64654090	3.2294E-03	0.387529	387.529	10.22	410.87
2:00	7/18/2003 2:00	1672.13	37.870	199.267288836	0.0051671110	83.2457	0.21793670	0.65598110	3.3895E-03	0.406743	406.743	11.41	422.28
3:00	7/18/2003 3:00	1674.53	35.470	193.730525215	0.0046962554	80.4466	0.21060878	0.62969446	2.9572E-03	0.354865	354.865	11.70	433.98
4:00	7/18/2003 4:00	1672.00	38.000	199.559514932	0.0051929905	83.3951	0.21832784	0.65738326	3.4138E-03	0.409654	409.654	12.18	446.16
5:00	7/18/2003 5:00	1671.20	38.800	201.341103603	0.0053530782	84.3098	0.22072244	0.66596455	3.5650E-03	0.427795	427.795	12.11	458.26
6:00	7/18/2003 6:00	1656.07	53.930	230.395790760	0.0086238944	100.3467	0.26270717	0.81489324	7.0276E-03	0.843306	843.306	16.64	474.90
7:00	7/18/2003 7:00	1647.87	62.130	243.136694886	0.0105639225	108.2809	0.28347886	0.88678035	9.3679E-03	1.124145	1124.145	26.98	501.88
						Over 23 hours and 18 minutes				**512.9272**	**512927.21**		523.70
													1.90

Margate PS 4 Catchment
Manhole No. B78 Levels in a 200mm Channel
Max. distance to Invert 2150mm

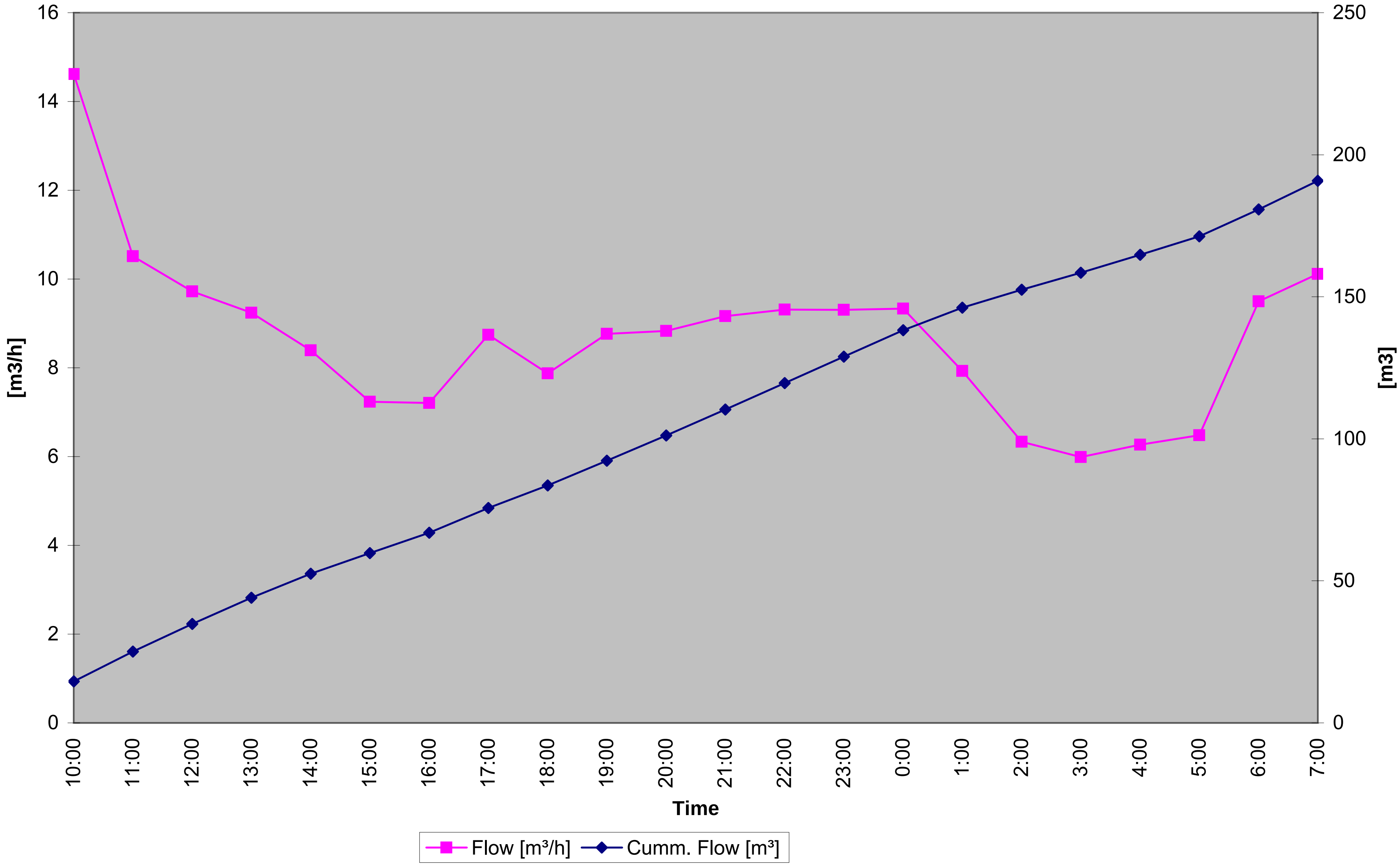
	Date / Time	Recorded Depth in (mm)	Height of flow in channel in (mm)	Surface width of flow in channel in (mm)	Sectional Area in (m2)	Degrees	Wetted Perimeter in (m)	Velocity (Manning) in (m/s)	Flow rate in m3/s	Volume in (m3) for 2min.	Volume in (litres) for 2min.	Vol [m³/h]	Cumm Volume [m³]
9:00	7/17/2003 9:01	2074.93	75.070	193.685261184	0.0107854275	151.1278	0.26376779	0.81436258	8.7832E-03	1.053990	1053.990	42.18	42.18
10:00	7/17/2003 10:01	2081.60	68.400	189.751837936	0.0094959260	143.1576	0.24985717	0.77559990	7.3650E-03	0.883805	883.805	27.15	69.33
11:00	7/17/2003 11:01	2087.60	62.400	185.323932615	0.0083650051	135.8277	0.23706412	0.73814384	6.1746E-03	0.740949	740.949	23.98	93.31
12:00	7/17/2003 12:01	2092.33	57.670	181.197914999	0.0074957129	129.9138	0.22674233	0.70674210	5.2975E-03	0.635704	635.704	21.76	115.07
13:00	7/17/2003 13:01	2092.80	57.200	180.755746797	0.0074105046	129.3186	0.22570353	0.70352634	5.2135E-03	0.625618	625.618	17.44	132.51
14:00	7/17/2003 14:01	2096.00	54.000	177.583783043	0.0068363675	125.2258	0.21856023	0.68115130	4.6566E-03	0.558792	558.792	16.68	149.20
15:00	7/17/2003 15:01	2096.00	54.000	177.583783043	0.0068363675	125.2258	0.21856023	0.68115130	4.6566E-03	0.558792	558.792	16.76	165.96
16:00	7/17/2003 16:01	2096.00	54.000	177.583783043	0.0068363675	125.2258	0.21856023	0.68115130	4.6566E-03	0.558792	558.792	16.67	182.62
17:00	7/17/2003 17:01	2095.87	54.130	177.718238794	0.0068594820	125.3935	0.21885293	0.68207695	4.6787E-03	0.561443	561.443	17.03	199.66
18:00	7/17/2003 18:01	2099.13	50.870	174.198083801	0.0062854811	121.1479	0.21144293	0.65842197	4.1385E-03	0.496620	496.620	17.16	216.82
19:00	7/17/2003 19:01	2095.27	54.730	178.332578067	0.0069663991	126.1659	0.22020105	0.68633063	4.7813E-03	0.573750	573.750	17.10	233.92
20:00	7/17/2003 20:01	2099.33	50.670	173.971849447	0.0062506590	120.8846	0.21098338	0.65694011	4.1063E-03	0.492757	492.757	15.78	249.69
21:00	7/17/2003 21:01	2096.53	53.470	177.030608653	0.0067423208	124.5407	0.21736456	0.67736256	4.5670E-03	0.548039	548.039	13.21	262.91
22:00	7/17/2003 22:01	2114.73	35.270	152.447067535	0.0037284409	99.3233	0.17335189	0.53064799	1.9785E-03	0.237419	237.419	12.45	275.36
23:00	7/17/2003 23:01	2130.27	19.730	119.276604579	0.0016010805	73.2226	0.12779750	0.37011323	5.9258E-04	0.071110	71.110	5.87	281.23
0:00	7/18/2003 0:01	2104.13	45.870	168.165907365	0.0054294714	114.4556	0.19976278	0.62025375	3.3676E-03	0.404118	404.118	5.87	287.11
1:00	7/18/2003 1:01	2133.67	16.330	109.532298433	0.0012123202	66.4135	0.11591335	0.32814315	3.9781E-04	0.047738	47.738	4.78	291.89
2:00	7/18/2003 2:01	2133.67	16.330	109.532298433	0.0012123202	66.4135	0.11591335	0.32814315	3.9781E-04	0.047738	47.738	2.00	293.89
3:00	7/18/2003 3:01	2113.60	36.400	154.337811310	0.0039015077	101.0116	0.17629853	0.54083310	2.1101E-03	0.253208	253.208	4.37	298.27
4:00	7/18/2003 4:01	2131.93	18.070	114.673015134	0.0014071542	69.9704	0.12212145	0.35003160	4.9255E-04	0.059106	59.106	2.54	300.81
5:00	7/18/2003 5:01	2130.60	19.400	118.383106903	0.0015619261	72.5861	0.12668667	0.36617929	5.7195E-04	0.068633	68.633	2.11	302.91
6:00	7/18/2003 6:01	2130.60	19.400	118.383106903	0.0015619261	72.5861	0.12668667	0.36617929	5.7195E-04	0.068633	68.633	2.20	305.12
7:00	7/18/2003 7:01	2118.73	31.270	145.274734211	0.0031337298	93.1665	0.16260619	0.49320075	1.5456E-03	0.185467	185.467	3.09	308.20
8:00	7/18/2003 7:03	2130.60	19.400	118.383106903	0.0015619261	72.5861	0.12668667	0.36617929	5.7195E-04	0.068633	68.633		321.60
9:00	7/18/2003 7:05	2120.13	29.870	142.573252751	0.0029325713	90.9372	0.15871537	0.47954254	1.4063E-03	0.168755	168.755		1.61
	7/18/2003 7:07	2120.40	29.600	142.039994368	0.0028942149	90.5024	0.15795644	0.47687333	1.3802E-03	0.165621	165.621		
	7/18/2003 7:09	2118.67	31.330	145.388185215	0.0031424347	93.2611	0.16277133	0.49377942	1.5517E-03	0.186200	186.200		
	7/18/2003 7:11	2129.33	20.670	121.766187425	0.0017142011	75.0100	0.13091722	0.38116887	6.5340E-04	0.078408	78.408		
	7/18/2003 7:13	2129.60	20.400	121.059324300	0.0016814709	74.5004	0.13002769	0.37801562	6.3562E-04	0.076275	76.275		
	7/18/2003 7:15	2123.93	26.070	134.675240486	0.0024064374	84.6564	0.14775322	0.44085843	1.0609E-03	0.127308	127.308		
	7/18/2003 7:17	2130.60	19.400	118.383106903	0.0015619261	72.5861	0.12668667	0.36617929	5.7195E-04	0.068633	68.633		
	7/18/2003 7:19	2116.40	33.600	149.546514503	0.0034766689	96.7887	0.16892814	0.51528595	1.7915E-03	0.214977	214.977		
	7/18/2003 7:21	2118.00	32.000	146.642422239	0.0032400992	94.3127	0.16460674	0.50020483	1.6207E-03	0.194486	194.486		
	7/18/2003 7:23	2130.60	19.400	118.383106903	0.0015619261	72.5861	0.12668667	0.36617929	5.7195E-04	0.068633	68.633		
						Over 22 hours and 48 minutes				**285.0178**	**285017.8**		

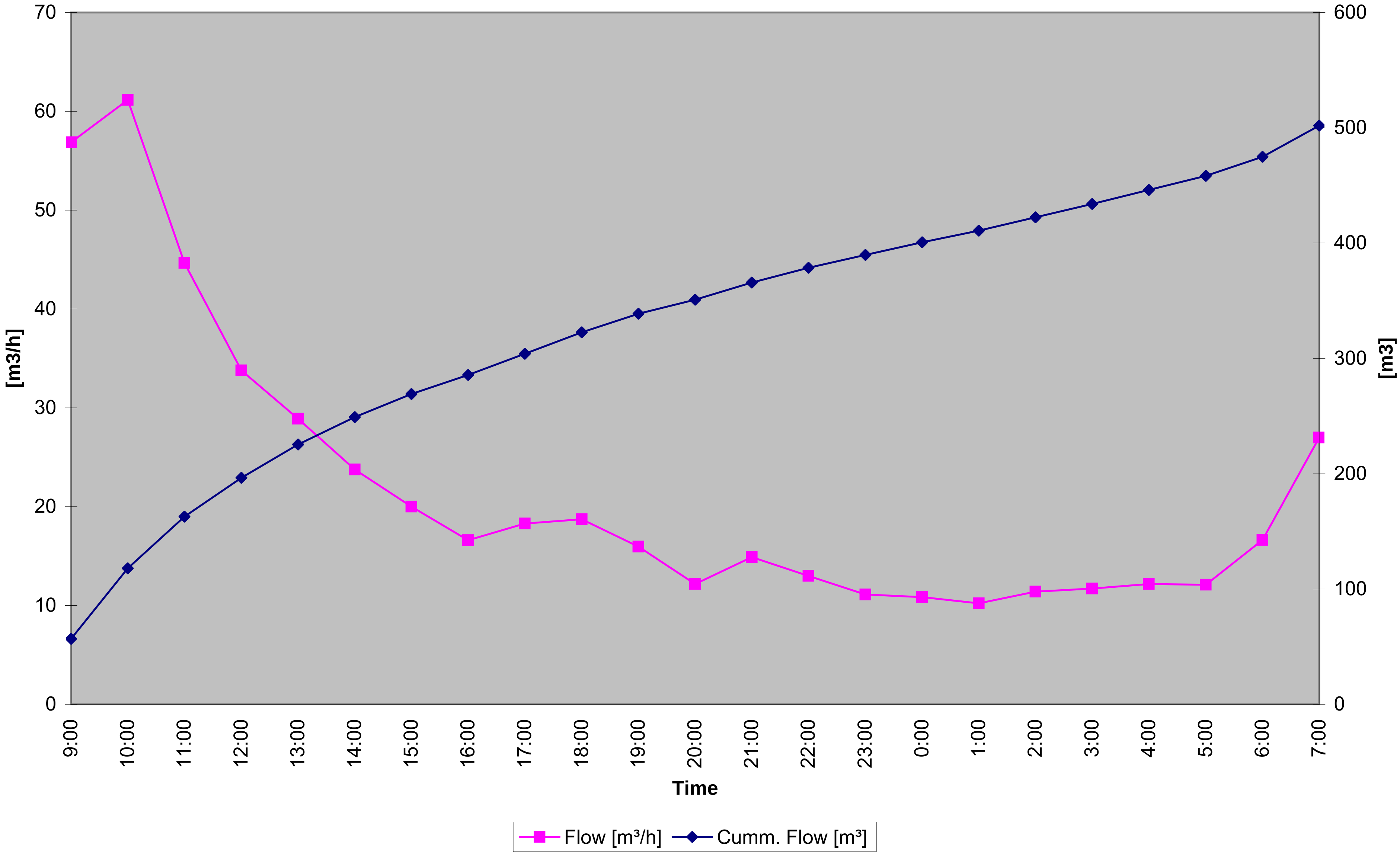
Return Flow Water Audit

Annexure 8
Flows measured at manholes
Manhole 2B

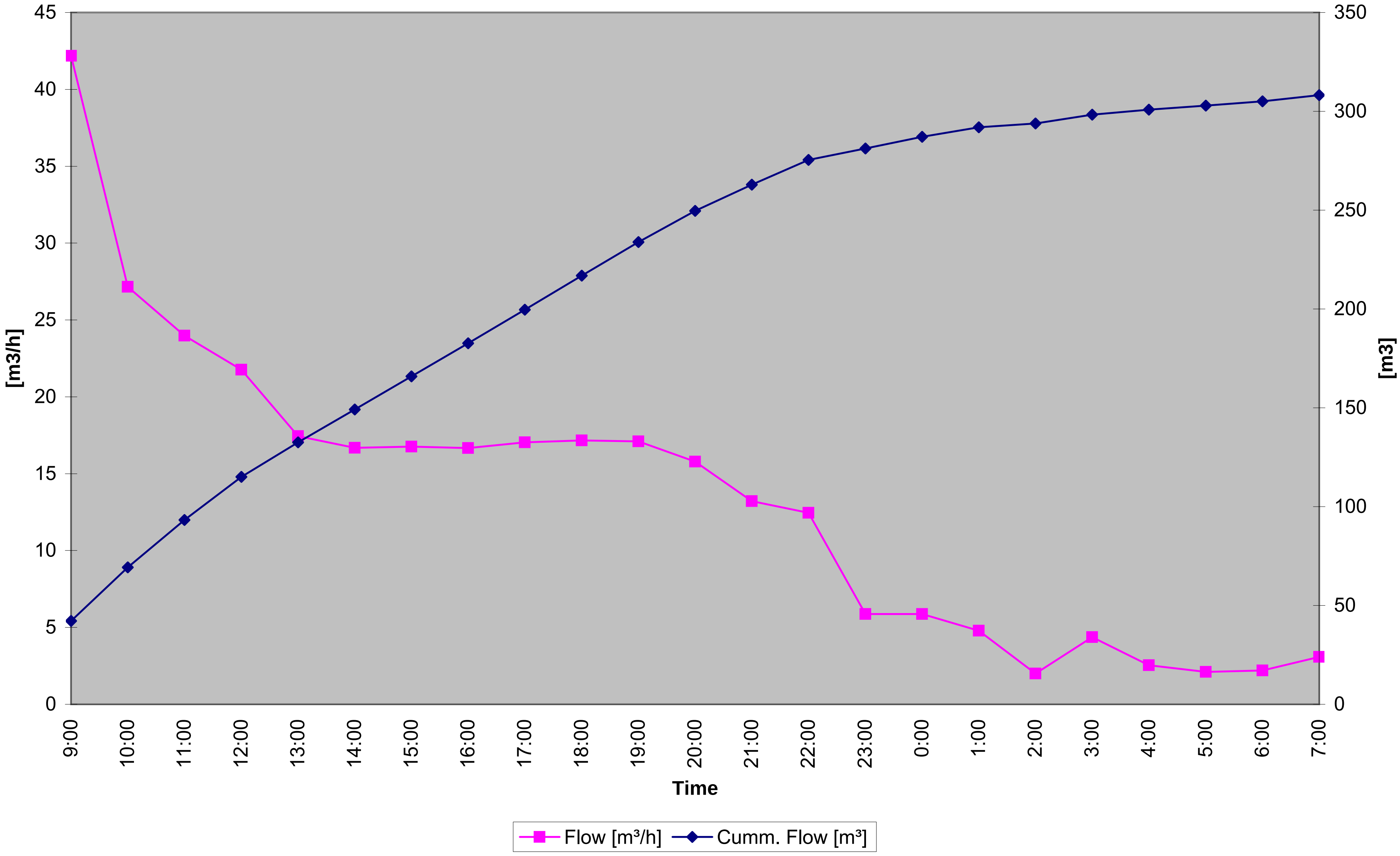


Return Flow Water Audit




70
60
50
40
30
20
10
0
[m3/h]
600
500
400
300
200
100
0
[m3]
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
Time
Flow [m³/h]
Cumm. Flow [m³]

Return Flow Water Audit



ANNEXURE 9

Rainfall Records Margate Airport

Oct-01	Rainfall measured	Nov-01	Rainfall measured	Dec-01	Rainfall measured	Jan-02	Rainfall measured	Feb-02	Rainfall measured	Mar-02	Rainfall measured	Apr-02	Rainfall measured	May-02	Rainfall measured
1	**0**	1	**0**	1	**7.5**	1	**0**	1	**0**	1	**2**	1	**0**	1	**1.8**
2	**0**	2	**0**	2	**1.8**	2	**1.5.**	2	**0**	2	**0**	2	**0**	2	**0**
3	**0.2**	3	**0**	3	**0**	3	**27.5**	3	**0**	3	**0**	3	**0**	3	**0**
4	**0**	4	**0**	4	**0**	4	**0**	4	**0**	4	**0**	4	**0**	4	**2**
5	**0**	5	**1.5**	5	**0.4**	5	**0**	5	**0**	5	**0**	5	**0**	5	**0**
6	**1.8**	6	**0**	6	**0**	6	**0**	6	**0**	6	**0**	6	**0.2**	6	**3**
7	**0**	7	**0**	7	**0**	7	**1.4**	7	**15**	7	**27**	7	**0**	7	**3.5**
8	**4.5**	8	**0.4**	8	**0.5**	8	**0.5**	8	**7**	8	**31**	8	**0**	8	**0**
9	**5.5**	9	**145**	9	**0**	9	**0**	9	**0.3**	9	**0**	9	**0**	9	**0**
10	**0**	10	**14.8**	10	**0**	10	**0**	10	**0**	10	**0**	10	**0.5**	10	**0**
11	**0**	11	**0.4**	11	**11.9**	11	**0**	11	**0**	11	**0**	11	**19.5**	11	**0**
12	**0**	12	**3**	12	**0**	12	**0**	12	**0**	12	**0**	12	**0**	12	**0**
13	**9**	13	**14.9**	13	**1.5**	13	**0**	13	**25**	13	**0**	13	**0**	13	**0**
14	**3**	14	**1.9**	14	**92**	14	**0**	14	**0**	14	**0**	14	**0**	14	**0**
15	**0**	15	**0**	15	**0**	15	**0**	15	**0**	15	**0**	15	**66.8**	15	**0.2**
16	**2**	16	**165**	16	**0**	16	**2.6**	16	**0**	16	**0**	16	**34**	16	**0.2**
17	**4**	17	**26.5**	17	**1**	17	**0**	17	**3.5**	17	**0**	17	**1.2**	17	**0**
18	**3**	18	**1.8**	18	**0.6**	18	**5**	18	**0**	18	**0**	18	**0**	18	**0**
19	**4.1**	19	**1.1**	19	**7**	19	**0**	19	**0.3**	19	**0.5**	19	**0**	19	**0**
20	**15.8**	20	**1.5**	20	**33.8**	20	**0**	20	**0**	20	**0**	20	**0**	20	**0**
21	**45.5**	21	**35**	21	**0**	21	**0**	21	**0**	21	**0**	21	**0**	21	**0**
22	**39**	22	**7.5**	22	**0**	22	**0**	22	**0**	22	**0**	22	**0**	22	**0**
23	**3**	23	**0**	23	**54**	23	**0.4**	23	**0**	23	**2**	23	**0**	23	**1.6**
24	**7**	24	**6**	24	**3**	24	**37**	24	**0**	24	**0**	24	**0**	24	**0**
25	**15.5**	25	**7.5**	25	**0**	25	**56**	25	**0**	25	**0**	25	**0**	25	**0**
26	**2.2**	26	**11.6**	26	**10**	26	**3.5**	26	**38.2**	26	**0**	26	**0**	26	**5.5**
27	**0**	27	**0**	27	**0**	27	**5**	27	**0.6**	27	**0**	27	**0**	27	**0**
28	**5.8**	28	**4.5**	28	**0**	28	**10**	28	**0**	28	**3**	28	**0**	28	**0**
29	**0.2**	29	**0**	29	**0**	29	**0**			29	**0**	29	**0**	29	**0**
30	**4**	30	**4**	30	**0**	30	**1.3**			30	**0**	30	**0**	30	**0**
31	**0**			31	**0**	31	**0**			31	**0**		**0**	31	**15**

ANNEXURE 10

Summary assessment of manholes and sewers

Annexure 10: Summary assessment of manholes and Sewers

Manhole No	Description
A16	Good structural condition, walls are dry.
A17	Good structural condition, walls are dry.
A18	Good structural condition, walls are dry.
A19	Good structural condition, walls are dry.
A20	Good structural condition, walls are dry.
A21	Dry, full of sand which can cause blockage, constructed from face brick.
A22	Good structural condition, walls are dry.
A23	The walls of the manhole are very wet.
A24	The walls of the manhole are very wet.
A25	The walls of the manhole are very wet.
A26	Good structural condition, walls are dry.
A27	Good structural condition, walls are dry.
A28	Good structural condition, walls are dry.
A29	The walls of the manhole are very wet.
A30	The walls of the manhole are very wet.
A31	The walls of the manhole are very wet, looks like there had been a blockage.
G4	The walls of the manhole are very wet.
G8	The walls of the manhole are very wet.
G12	The walls of the manhole are damp; the manhole is full of roots they have gone inside the sewer pipe.
F28	The walls of the manhole are very wet.
F25	The manhole is constructed from bricks, walls are wet and rusted.
F19	The manhole is constructed from facebrick and the walls are dry.
F18	The walls of the manhole are very wet, looks like there had been a blockage.
F16	The manhole is constructed from facebrick and the walls are wet.
C55	Good structural condition, walls are dry.
C58	Good structural condition, walls are dry.
C61	Good structural condition, walls are dry.
C7	Walls of the manhole are damp.
C5	Walls of the manhole are damp.
C8	Walls of the manhole are damp.
C90	Walls of the manhole are very wet.
F16	The manhole is constructed from facebrick and the walls are damp.
F11	Good structural condition, walls are dry.
F8	The manhole is dry but the walls are damaged.
F7	The manhole is full of roots.
F5	The manhole is full of roots.
C94	Walls of the manhole are damp.
C98	Walls of the manhole are damp.
C99	Good structural condition, walls are dry.
J	Good structural condition, walls are dry.
7F	Good structural condition, walls are dry.
3A	Walls of the manhole are damp.
1B	Good structural condition, walls are dry.
B232B	Walls of the manhole are damp.
B223D	Good structural condition, walls are dry but it looks like there is a blockage.
B223C	Walls of the manhole are damp.
C29B	The manhole is constructed from facebrick, walls are wet.
C29A	The walls of the manhole are damp.
C29E	The walls of the manhole are damp.

Manhole No	Description
C29C	The walls of the manhole are very wet.
C29	The walls of the manhole are damp.
C31	The manhole is constructed from facebrick, walls are damp.
C48	The manhole is constructed from facebrick, walls are damp.
C49	The walls of the manhole are damp.
C47	The walls of the manhole are damp.
F40	The manhole is constructed from facebrick, walls are dry.
F39	The manhole is constructed from facebrick, walls are damp.
F37	The manhole is constructed from facebrick, walls are damp.
C11	The manhole is constructed from facebrick, walls are damp.
F33	The manhole is constructed from facebrick, walls are damp.
F41	The manhole is constructed from facebrick, walls are damp.
C83	The walls of the manhole are damp.
C85	Good structural condition, walls are dry.
C87	The walls of the manhole are damp.
C21A	Good structural condition, walls are dry.
C53A	The walls of the manhole are damp.
B84A	The walls of the manhole are dry.
B83B	Good Structural condition, walls of manhole are damp.
B78	The manhole is full of roots.
B77	Manhole has a little bit of roots.
B74	Good Structural condition, walls are dry.
B73	Walls of the manhole are very wet.
B57	The manhole walls are damp and full of roots.
B69	The manhole walls are damp with a bit of roots.
B70	Good structural condition, walls of manhole are dry.
B215	Good structural condition, walls of manhole are dry.
B213	The manhole walls are damp with a bit of roots.
B212	The walls of the manhole are wet with little bit of roots.
B211	The walls of the manhole are wet with little bit of roots.
B133	Good structural condition, walls are dry.
B138	Good structural condition, walls are dry.
B137D	Good structural condition, walls are dry.
B137E	The manhole walls are damp and full of roots.
B137G	Good structural conditions, walls are dry.
B1446	Good structural conditions, walls are dry.
B144B	Good structural conditions, walls are dry.
B144	Good structural conditions, walls are dry.
B142	Good structural conditions, walls are damp.
B141	Good structural condition, walls are dry.
B140	Good structural condition, walls are dry.
B137A	Good structural condition, walls are dry
B121K	The walls of the manhole are wet.
B124	Good structural condition, walls are dry.
B151A	Good structural condition, walls are dry.
B151	Good structural condition, walls are dry.
B148	Good structural condition, walls are damp.
Y10B	Good structural condition, walls are damp.
Y4	Good structural condition, walls are dry.
Y9A	Good structural condition, walls are dry.
M25	Good structural condition, walls are damp.

Manhole No	Description
M24A	The walls of the manhole are wet with little bit of roots
M24	Good structural condition, walls are damp
M21	Good structural condition, walls are dry.
M27	Good structural condition, walls are dry.
M26A	Good structural condition, walls are damp.
E6	Good structural condition, walls are damp.
E8	Good structural condition, walls are dry.
E3	Good structural condition, walls are damp and water is seeping between rings.
	Good structural condition, walls are damp and water is seeping between rings.
B10D	Good structural condition, walls are dry.
B103B	Good structural condition, walls slightly damp.
B112D	Good structural condition, walls are dry.
B114	Roots from the surrounding trees have worked their way between rings. Walls are wet.
	Only one house is connected to this manhole. Manhole is fairly dry.
B114A	Roots from the surrounding trees have worked their way between rings. Walls are wet.
B99	Walls in the manhole are very wet.
B94	Good structural condition, walls are dry.
B96A	Walls of the manhole are damp and the water is seeping between the rings.
	Roots are growing in the pipe and this is creating a blockage in the pipe.
	The sewer pipe is blocked by sand.
	Walls of the manhole are wet and the water is seeping between the rings.
B126	The walls of the manhole are very wet.
B123B	The walls of the manhole are very wet.
B131	Walls of the manhole are wet and the water is seeping between the rings.
	Walls of the manhole are wet and the water is seeping between the rings.
B1C	Weeping during heavy rain.
C29C	High flows recorded till 02h00. Manholes are dry.
9B	Manholes in that area are sealed.
C99 & C100	Strong flow of clear water recorded. Stormwater may be connected to sewer or leak may exist.
7A	Hot sulphur and chlorine smell detected.
9A	Channel is almost blocked. Flow of water restricted.
C96	Flow is very strong.
C94	Flow is very strong. Jet of water could be heard upstream.
C93	Small amount of flow at this manhole.
C53A	Small amount of flow at this manhole.
F32	Line was dry.
C2	Manhole was dry.
F16	Same as C94.
F17	Covered by asphalt
F18	Not accessible at night.
F22	Less flow than F16, shows infiltration in the stream.
F16	Stormwater flow in area not as strong as in C99 & C100.
E4	Manholes in area dry. Sand in manholes indicate that there is infiltration between rings. Infiltration of roots.
766	Manholes in area dry. Sand in manholes indicate that there is infiltration between rings.

Manhole No	Description
Pump Station 1	Small amount of flow at this manhole.
M44	Moderate flow.
B147	Small amount of flow at this manhole.
B3A	Strong flow from B48B and weaker flow from B4A side.
C55	Small amount of flow at this manhole.
F26-F28	Unable to locate manholes. Other manholes in area are dry.
F27	Water table is very high. Meets “F” line at F23. Area very wet.
B3A	Strong flow recorded between P/S4A to P/S4.
B11d	Manhole was dry.
B28 B	Very weak flow.
N22	Moderate flow noted.
N24	Small amount of flow at this manhole. Less that at N22. May be a seepage into the line.
N27	Covered by asphalt.
B3A – B14	Bulk of flow to B3A is picked up from B3A & B14.
B49A B57	Strong flow of clear water.
B76	Covered by asphalt.
B76A	Moderate flow noted from both lines B133 & B209.
B213	Manhole was dry. This indicates that there may be a problem in
	the mid block section.
B137	Moderate flow from B140 side. B137 benching is leaking.
B140	Strong flow from B144 side. Benching is leaking.
B77	Audible inflow into sewer line upstream of manhole.
B78	Less flow than B77. Audible inflow into sewer line upstream of manhole.
B121A	High water table. Large amounts of seepage. Indication of problem with B121D, B121C, B86 & B76.
B122A	Could not be found.
B82	Moderate flow.
B84A	Small amount of flow at this manhole. Other manholes shown on drawing could not be found.
2A	Small amount of flow at this manhole.
1A	Small amount of flow at this manhole from M47 side.
M47	Flow recorded from Kingfisher side.
Y0	Very little flow.

ANNEXURE 11

Cost of Manhole Rehabilitation

ANNEXURE 11

MARGATE WASTE WATER MANAGEMENT						
Cost Model for Manhole Rehabilitation						
Item No	Payment Refers	DESCRIPTION	Unit	Quantity	Rate	Amount
	SABS 1200					
1.0		**PRELIMINARY AND GENERAL**				
1.1	AA 8.1.2	Preliminary and General	Sum			R 125,000.00
2.0		**EARTHWORKS(Small works)**				
2.1	C 2.3	Site Clearance: Removal of branches and cutting of vegetation to all pedestrian access to manholes (Provisional)	m^2	5000	R 5.00	R 25,000.00
2.2	DA 3.1.2	Excavation around manhole rings and backfilling upon completion. (Provisional)	m^3	10090.00	R 50.00	R 504,500.00
2.3	DA 5.1.4	Allow for keeping excavations free of water by hand or by machine	Sum	1	R 10,000.00	R 10,000.00
3.0		**MANHOLE REHABILITATION**				
3.1		Cutting and preparation of 10mm joints between manhole rings.	m	14124	R 20.00	R 282,480.00
3.2		Installation of 10mm X 10mm Sika Flex 11FC for the following size manhole rings (Rate to include for labour):				
3.2.1		1000mm (Provisional)	m	5649	R 13.64	R 77,038.24
3.2.2		1250mm (Provisional)	m	1412	R 13.64	R 19,256.15
3.3.3		1500mm (Provisional)	m	5085	R 13.64	R 69,346.69
3.3.3		1750mm (Provisional)	m	1977	R 13.64	R 26,961.34
4.0		**MANHOLE REHABILITATION**				
4.1		Replace precast manhole rings where necessary				
4.1.1		1000mm (Provisional)	No	40	R 4,800.00	R 192,000.00
4.1.2		1250mm (Provisional)	No	30	R 6,000.00	R 180,000.00
4.1.3		1500mm (Provisional)	No	25	R 7,200.00	R 180,000.00
4.1.4		1750mm (Provisional)	No	10	R 9,600.00	R 96,000.00

MARGATE WASTE WATER MANAGEMENT						
Cost Model for Manhole Rehabilitation						
Item No	Payment Refers	DESCRIPTION	Unit	Quantity	Rate	Amount
Subtotal						R 1,787,582.41
Contingencies			%	1,787,582	15%	R 268,137.36
Subtotal including Contingencies						R 2,055,719.77
Profession Fees			%	2,055,720	15%	R 308,357.97
Subtotal including Contingencies & Proffessional Fees						R 2,364,077.74
VAT			%	2,364,078	14%	R 330,970.88
Total						R 2,695,048.62