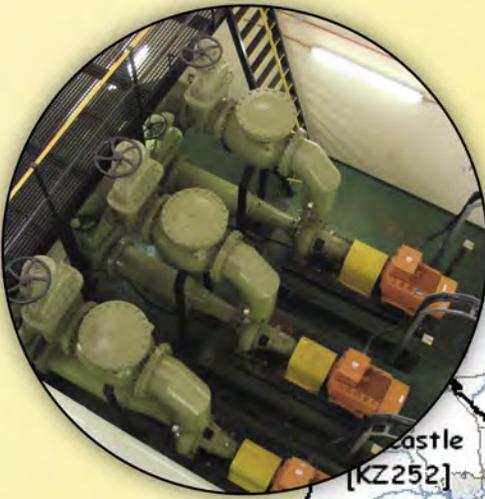


uThukela Water Infrastructure Refurbishment – A CASE STUDY

H du Preez, A Toerien
& P Dama-Fakir



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uThukela Water Infrastructure Refurbishment – A Case Study

Report to the
Water Research Commission
and
Department of Water Affairs

by

H du Preez, A Toerien, P Dama-Fakir
Golder Associates Africa (Pty) Ltd

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Water Research Commission
Private Bag X03
Gezina, 0031

orders@wrc.org.za or download from www.wrc.org.za

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The authors are grateful for the contribution of the following persons:

Mr H Basson uThukela Water

Mr M Cronwright uThukela Water

Project Team:

Mrs P Dama-Fakir Golder Associates Africa

Mr H du Preez Golder Associates Africa

Ms A Toerien Golder Associates Africa

EXECUTIVE SUMMARY

Objective

Significant improvements to existing waste water treatment plants (WWTP) were achieved by Uthukela Water. These improvements were achieved through a combination of refurbishment, retrofitting and replacement of equipment. The purpose of this study is to ensure that the experience gained by Uthukela Water during the refurbishment and upgrades at the WWTPs of the Amajuba and Umzinyathi Water Services Authorities, is documented and disseminated to other municipalities and people working in the water industry.

The objectives of this study were to:

- Investigate case studies on WWTP refurbishments in the uThukela Municipality;
- Investigate the financial implications of refurbishment;
- Investigate the technical implications; and
- Highlight lessons learnt.

Case Studies

In the course of the investigation the following plants were used as case studies:

- uThukela Water operate and maintain 24 pump stations spread across their service area which are used to pump sewage from distributed communities to central WWTPs. Many of these pump stations are isolated and difficult to reach, making it difficult to inspect and maintain;
- Madadeni WWTP uses an activated sludge process with extended aeration. It was built in the early 1990s with a design capacity of 12 ML/day. Through refurbishment and plant upgrade, it was extended to 18 ML/day in 2008;
- Osizweni WWTP uses both biofilter (8 ML/day) and activated sludge (7 ML/day) processes. It was built in the 1970s and has a combined design capacity of 15 ML/day;
- Durnacol WWTP utilises an activated sludge (Pasveer ditch) process followed by a clarifier and wetland. Formerly sludge was treated in a digester. The plant was built in the 1970s and has a design capacity of 2 ML/day;
- Dundee WWTP was built in the 1950s. Originally it utilised a biofiltration process (7 ML/day), which was augmented in the 1990s by two activated



sludge treatment modules (2 x 3 ML/day), of which one is currently operational. It has a combined operational design capacity of 10 ML/day;

- The initial Newcastle WWTP process consisted of a biofilter plant with an initial capacity of 10 ML/day. The plant was constructed in the 1970s. It was converted to a PETro system in 1994 with a design capacity of 25 ML/day.

Conclusions

The case studies confirm that refurbishment and upgrading work done at uThukela Water's WWTPs, has resulted in considerable cost savings when compared to replacement costs, while improving the effluent quality.

Refurbishment should be considered as an option before any treatment works is replaced. Plant audit and asset register decision matrices can be helpful when deciding whether replacement or refurbishment would be the most feasible option for a particular plant.

It is important to note that in the Infrastructure Asset Management, refurbishment is included in the asset life cycle.

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1.0 INTRODUCTION AND BACKGROUND

Local government in KwaZulu-Natal is organised into ten district municipalities (DM), including Amajuba and uMzinyathi. The local municipality of Newcastle is included in the Amajuba DM. Both the district and local municipalities are water service providers (WSPs), with the mandate of water and sanitation services delivery to their areas of responsibility.

uThukela Water was launched in April 2005, to provide support to its municipalities in terms of both water supply and sanitation/wastewater conveyance and treatment. This report focuses on the sanitation services provided.

The uThukela Water service area (see Figure 1) is mostly a rugged area that includes parts of the Drakensberg, with a dispersed rural population in small towns and villages. Wastewater treatment plants (WWTPs) are therefore scattered and small with limited access to funds, senior process and operating personnel and mechanical/maintenance support.

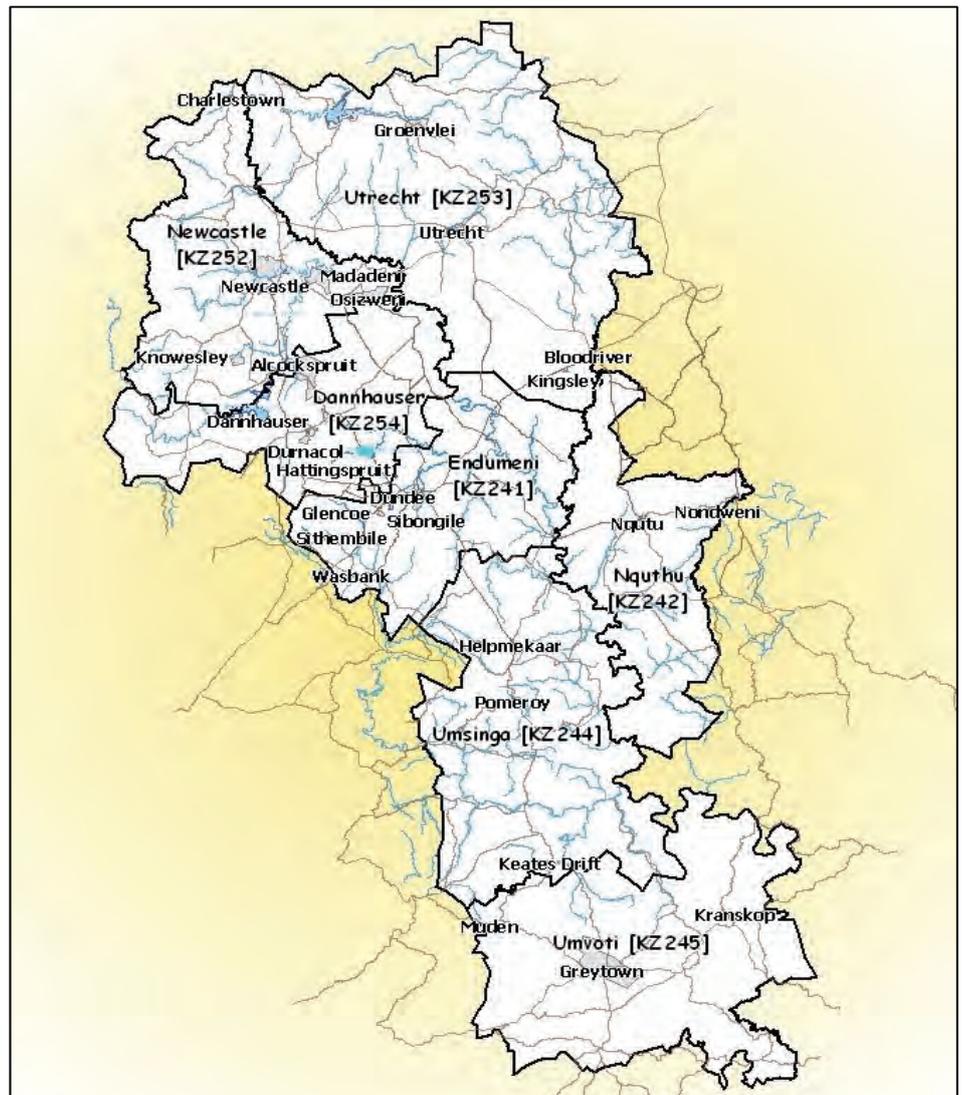


Figure 1: Area served by uThukela Water

1.1 Background to uThukela Water

The area of service that falls under the jurisdiction of uThukela Water covers a surface area in excess of 17,000 km² and includes 18 WWTPs that use a wide variety of treatment technology and treatment processes. Treatment technologies employed range from trenches and oxidation ponds to pond enhanced treatment and operation (PETrO), biological trickling filters and activated sludge reactors. Sludge is stabilised at some plants using anaerobic digesters before being disposed, while in others it is disposed directly in drying beds or 3 meter deep ponds.

For the last 15-20 years, prior to uThukela Water's involvement, very little or no maintenance was done on the majority of these plants. During this time the increases in hydraulic and chemical loading on the different plants varied from 90% to 400% of design capacity.

Currently there are 24 sewage pump stations that uThukela Water is responsible for.

The staff complement breakdown at the uThukela Water head office is as follows (Table 1):

Table 1: uThukela Water Staff Complement

Type	Number
Operations	17
Finance	22
Corporate Services	6
Human Resources	4
Customer Care	10
IT	3
Water Testing Laboratory	5

In addition to the above, there are superintendants, supervisors, operators, drivers and general workers employed at the various plants run by uThukela Water, numbering 100 in total. This falls far short of the staff requirement based on the plant classification as prescribed by the Department of Water Affairs and Environment (DWA), which should number 212 in total. However, a significant improvement in operation and maintenance of these plants has been achieved. uThukela also runs a Water Testing Laboratory that employs 5 full-time employees and 3 students.

1.2 Background to Study

South Africa has approximately 850 municipal treatment plants. In a recent Green Drop evaluation carried out, 55% of the treatment plants investigated scored below 50%, indicating that drastic improvements are required. This trend in many cases is due to minimal maintenance and replacement, causing infrastructure and equipment to deteriorate to the extent that replacement is considered. However, refurbishment is an option that should be considered as the uThukela Municipality has managed to achieve significant improvements at many of its treatment plants through improved management practices and refurbishments.



The study area selected includes 18 WWTPs, and covers an area of 17,000 km².

Treatment technologies employed at uThukela range from trenches and oxidation ponds to activated sludge reactors.



A recent green drop evaluation indicated that improvements are required in SA's wastewater treatment sector. uThukela have demonstrated that significant improvements can be achieved through improved management practices and refurbishments.

This report was commissioned by the Water Research Commission and SALGA in order to capture the lessons learnt at uThukela and make this information available to other municipalities.

1.3 Background to SALGA

SALGA, the South African Local Government Association plays a role in ensuring the creation of an enabling environment for free and basic services (FBS). They also play a role in monitoring the delivery of FBS and compiling reports on the status of implementation and support, mobilising municipalities, profiling lessons and good practice and commissioning research surveys on FBS.

1.4 Study Objectives

The objectives of this study are to:

- Investigate case studies on WWTW refurbishments in the uThukela Municipality;
- Investigate the financial implications of refurbishment;
- Investigate the technical implications; and
- Highlight lessons learnt



Years of inadequate investment on infrastructure expansion, maintenance and repairs leave plants being in a poor condition, not compliant in terms of effluent standards and often overloaded.



Progressive approach taken involves

- Clean-out tanks or basins
- Correct hydraulic bottlenecks
- Repair existing infrastructure
- Refurbish units that cannot be repaired



A decision was made to address the pump stations first as these feed into the WWTP. This ensured that the true load to the WWTPs could be evaluated.



In order to identify the location of remote pump stations, an aerial survey was carried out by means of a microlight aircraft during the winter months. The outfalls were identified by means of overgrown vegetation in the otherwise dry winter landscape. Points were recorded on a handheld GPS and records kept for future use.

2.0 UTHUKELA CASE STUDIES

In 2004 a survey of the uThukela Water plants was done. It was found that most of the plants were operating inefficiently, not compliant to effluent standards, in a poor condition and the majority were overloaded. This was as a result of the lack of adequate investment on infrastructure expansion, maintenance and repairs for between 15 and 20 years. Not only was additional treatment capacity required at most plants, but due to the lack of preventative maintenance, many of the treatment units were malfunctioning or totally dysfunctional. To add new capacity and to replace units/equipment, large investment was required. However, since uThukela Water is reliant on municipal funding, they could not afford the investment. Consequently, a new approach was developed whereby plants were assessed and the following interventions progressively applied as and where appropriate:

- Clean out existing tanks/basins to re-introduce capacity lost to silting;
- Correct hydrological bottle necks (e.g. bigger feed/discharge pipes);
- Repair existing or decommissioned infrastructure (e.g. trickling filters) to increase capacity;
- Refurbish/replace units that cannot be repaired.

By the end of 2010 most of the interventions were completed with the WWTPs consistently meeting effluent discharge standards.

To capture the lessons learnt from the interventions applied, six case studies are presented below.

2.1 Pump Stations

uThukela Water operate and maintain 24 pump stations spread across their service area which are used to pump sewage from distributed communities to central WWTPs. Many of these pump stations are isolated and difficult to reach, making it difficult to inspect and maintain. Since the pump stations pump sewage to some of the WWTPs, it was decided to first fix the problems at the pumps stations before tackling the WWTPs. This also ensured that the WWTPs would receive the full load and could be managed accordingly.

2.1.1 General Infrastructure Assessment

No records were kept of pump station locations and before the pump stations could be assessed, they had to be located and their positions logged. An aerial survey of the Buffels River from Newcastle towards Greytown was conducted in the winter of 2004 by means of a microlight aircraft. Since most pump stations were not in operation, not having been maintained, they could be found by following the sewage outfalls from the river back to the pump station. The outfalls were identified as being overgrown by green plants in the otherwise dry winter landscape. The position of each pump station was then logged by means of a handheld GPS unit.

Due to vandalism, theft and lack of repair/maintenance, most of the pump stations were not functioning. The condition of the pumps, pipes, electrical supply, civil structures and valves at each pump station was assessed and logged.



Figure 2: Nkandla Pump Station prior to refurbishment

2.1.2 Upgrade and Retrofit Options Implemented



Improvements to pumps stations included:

- Better secured buildings
- Standardising on equipment where possible
- Remote monitoring system using telemetry for flow data

To replace/rebuild the pump stations are very costly and it was therefore decided to rather refurbish the pump stations where possible. Depending on the condition of the equipment, it was either refurbished or replaced. Pump station buildings were better secured to prevent theft and vandalism. Where possible mechanical and electrical equipment were standardised to enable faster servicing and repair work. Concrete work was repaired, gas extraction systems repaired/replaced and standby equipment connected.



Figure 3: Refurbished Ayliff (Newcastle) Pump Station



Savings were realised as:

- Improved security resulted in reduced theft and vandalism
- Retrofitting rather than rebuilding
- Ability to monitor sites remotely.

For examples of typical refurbishment being performed, Figure 2 shows Nkandla pump station prior to refurbishment and the refurbished Ayliff and Newcastle Pump Station No 1 in Figure 3.

2.1.3 Innovative Solutions

Each pump station was fitted with a remote monitoring system that is operated via a cellular phone signal (GSM). Hourly flow rate data from each pump station is logged onto an internet based monitoring system at the cost of an SMS. This

data can be accessed and monitored through the internet, saving uThukela from having to visually monitor these remote sites. Pumping operation history can be evaluated and trends analysed that can help identify where maintenance is required.

Another unique solution employed was to fit pump stations with purpose built security doors that reduced vandalism and theft inside the pump station buildings.

2.1.4 Results

By refurbishing and replacing equipment at existing pump stations rather than rebuilding entire pump stations, significant cost savings were realised. Remote monitoring is also far more cost effective, limiting the need for conducting visual inspections on site. Remote pump flow rate analyses further reduce costs as preventative maintenance can be employed. Securing the access to the pump station buildings reduced vandalism and theft.

2.2 Madadeni WWTP

Madadeni is a township situated approximately 10 km east of Newcastle. The WWTP uses an activated sludge process with extended aeration. It was built in the early 1990s with a design capacity of 12 ML/day. Through refurbishment and plant upgrade, it was extended to 18 ML/day in 2008. However, it is still overloaded due to an increase in flow and load. With the government's drive to extend basic water and sanitation services to all communities, it is expected that a million people in the area will benefit from these services and consequently an upgrade is planned to increase the WWTP capacity to 35 ML/day.



The Madadeni plant was overloaded as the result of:

- Drive to extend basic water and sanitation services
- Poor water management practices in communities
- Increased Pit latrines serviced by mobile sewage collection vehicles. Further blockages occurred at the plant as the result of snuff boxes etc in the pit latrines.



Figure 4: Aerial Photograph of Madadeni WWTP

Due to a history of free water provision, there is no water conscious culture within this community and water supply points (see [Figure 5](#)) often are not closed when not in use. Leaks are not reported. Consequently, the WWTP inflow remains high at night, albeit with lower loading rates (diluted) and impacts on the plant's ability to manage and balance peak conditions.



Figure 6: VIP latrine



Figure 5: Communal water supply pump

With increased installation of ventilated improved pit (VIP) latrines (see Figure 6) that are serviced by mobile sewage collection vehicles, the disposal of snuff boxes and other large objects therein create blockages in the WWTP.

The main process unit components at Madadeni are the following:

- Inlet Works
- Primary Sedimentation Tanks
- Primary Sludge Pump Station
- Reactor
- Final Clarifiers
- RAS and WAS Pump Station
- Ferric Dosing
- Chlorination Contact Tank
- Chlorination Building and Pump Station
- Administration Building
- Sludge Screening & Building
- Sludge Drying Beds
- Workshop
- Minor MCC Buildings
- Emergency Ponds

2.2.1 Plant flows and qualities

The WWTP daily flow rates for 2009 are presented in Figure 7.



Although the COD and SS outflow concentrations have not shown a marked improvement, the COD inflow load shows a 3-fold increase and the SS inflow load a 4-fold increase, despite the fact that the plant flow rate has increased by only 60%.

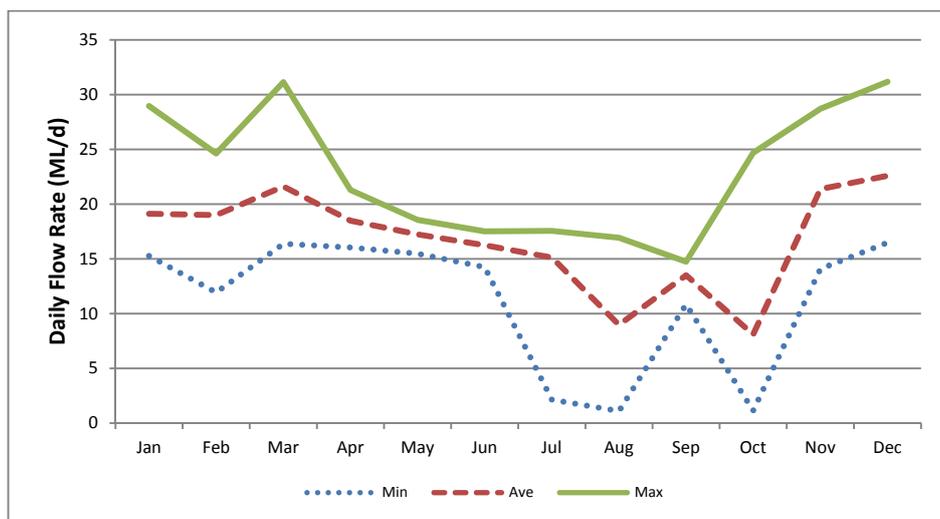


Figure 7: Madadeni WWTP daily flow rates (ML/day)

The daily average flow rate for 2009 was 16.8 ML/day. From Figure 7 it is evident that the flow ranged from a low of 1.1 ML/day to a maximum of 31.2 ML/day (see APPENDIX A for complete daily flow rates recorded in 2007, 2009 and 2010).

The water quality data for Madadeni WWTP is given in Table 2:

Table 2: Madadeni Water Quality Data

Parameter	Units	50 Percentile (2005)		50 Percentile (2009-2010)	
		Inflow	Outflow	Inflow	Outflow
pH		6.85	6.90	7.06	7.43
Conductivity	mS/m	49.6	43.7	61.8	53.6
COD	mg O ₂ /L	80	26	155	24
SS	mg/L	53.6	4.8	139	11.4
TDS	mg/L	426	389	315	271
Alkalinity	mg/L as CaCO ₃	204	80	226	152
Ammonia	mg/L as N	20.4	3.9	18.7	6.9
Nitrate	mg/L as N	2.2	7.1	1.3	1.5
Orthophosphate	mg/L as P	*NM	6.8	9.4	3.1
Faecal Coliforms	cfu/100 mL	*NM	*NM	*NM	20000
Flow (avg daily)	ML/d (Year)	9.8 (2007)		15.8 (2010)	
COD (load)	kg/d	784	255	2449	379
SS (load)	kg/d	525	47	2196	180
TDS (load)	kg/d	4175	3812	4977	4282
Ammonia (load)	kg/d as N	200	38.2	295	109

*NM = Not measured

The final effluent qualities (see Table 2) for all the measured parameters comply with the DWA general standards for final effluent, except for the Faecal Coliforms which is most likely due to ineffective disinfection.



Apart from overloading, a plant infrastructure audit revealed that equipment was not operational or damaged, some corroded, reactors silted up and no disinfection was taking place.



The accumulation of sand and silt in the reactor had a direct effect on the plant treatment capacity.

When the TDS and conductivity ratios for the two periods are compared, it is not constant as would be expected. This can be due to the measuring instruments not being regularly calibrated.

Although the COD and SS outflow concentrations have not shown a marked improvement, the COD inflow load shows a 3-fold increase and the SS inflow load a 4-fold increase, despite the fact that the plant flow rate has increased by only 60%.

2.2.2 Plant infrastructure assessment

During a plant infrastructure assessment in 2006, the following were observed:

- Clarifier overflow weirs corroded (see Figure 9);
- No stilling wells on clarifiers;
- Reactor filled with sand and silt;
- Only 4 out of 10 aerators in operation;
- Aerator draft tubes damaged;
- Not all RAS and WAS pumps working;
- Missing or broken sluice gates and penstocks;
- Perimeter fence not secure;
- No chlorine dosing resulting in algae growth in disinfection channels and no disinfection of discharged effluent.



Figure 8: Aeration basins at Madadeni WWTP



The following units will be added/replaced to upgrade the works to meet the increased loading:

- Head of works
- Additional clarifier – currently 3
- Additional aeration basin – currently 1.

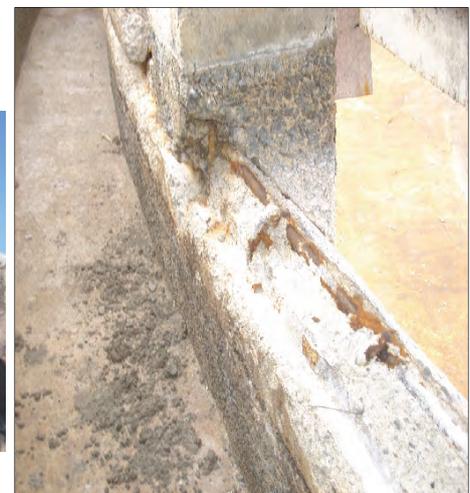


Figure 9: Clarifier weir deterioration as the result of corrosion

Over time sand and silt accumulated in the reactor, resulting in a loss of capacity. As indicated in Table 3, the loss in capacity was up to 20%.

Table 3: Silt volumes

Accumulation	Volume (m ³)
Sand Volume (2005)	3131
Sand Volume (2006)	2612
Reactor Volume	17197



The plant upgrade included the cleaning out of:

- clarifiers
- reactors

The following were refurbished:

- aerators
- clarifiers, including over flow weirs and bridges
- inlet channels, where eroded concrete was repaired

In addition to this, the following new pieces of equipment were installed:

- Inlet screens which needed to be replaced
- Stilling wells
- DO meters on reactors
- Chlorination unit

2.2.3 Plant upgrade/retrofit work

Refurbishment started in 2006 and the following work was undertaken:

- Inlet screens replaced (new);
- Eroded concrete repaired on inlet channels;
- Clarifier (including overflow weirs and bridges) refurbished (see Figure 10, Figure 11, and Figure 12);
- Clarifier cleaned out;
- Stilling wells installed on clarifiers;
- Sand and silt from reactor removed;
- DO meters in reactor installed (new);
- Aerators refurbished;
- Chlorination unit installed (new).

Future work envisaged to increase the capacity to 35 ML/day are:

- Head of works replacement (new);
- Fourth clarifier construction (new);
- Second aeration basin construction (new).



Figure 10: Refurbished clarifier weir and side wall



Figure 11: Clarifier refurbishment in progress



Figure 12: Refurbished clarifier centre well (left) and bridge (right)

2.2.4 Capital cost for upgrade/retrofit work

The expenditure breakdown is provided in Table 4.

Table 4: Madadeni Capital Cost Estimates

Item	Indicative cost
Refurbish 3 clarifiers	R 900 000
Remove sand from reactor	R 500 000
Install 3 RAS and 2 WAS pumps with pipework	R 500 000
Replace all missing or broken sluice gates and penstocks	R 95 000
Refurbish electrical system	R 200 000
Repair scum disposal system	R 50 000
Install 2 mechanical screens	R 200 000
Replace perimeter fence	R 1 000 000
Build new ablution block and store room	R 200 000
Repair office block and install security system	R 100 000
Overhaul 8 aerators	R 500 000

Item	Indicative cost
Replace tractor and accessories	R 350 000
Install 2 DO meters in reactor	R 120 000
Install new chlorinator	R 50 000
Install 2 flow meters	R 20 000
Repair irrigation system and potable water pipelines	R 30 000
Paint buildings, put up signage and install safety equipment	R 40 000
Site rehabilitation	R 30 000
Total	R 4 885 000

To compare the estimated capital costs of refurbishment/ upgrade/retrofitting given in Table 4 to that of replacement, two methods are used:

- Cost estimate based on the plant size as well as the inclusion of specific process units (see APPENDIX B); and
- Cost-size relationship chart for a complete plant based on historical data (see APPENDIX C).

A generic list of civil and mechanical structures associated with a WWTP is given in Table 5. The list is used to identify components

- Affected by refurbishment (upgrades or repairs);
- Included when the plant replacement cost estimates were calculated.

Table 5: Madadeni WWTP refurbishment vs. replacement

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Inlet Works	X	X
Primary Sedimentation Tanks		X
Primary Sludge Pump Station		X
Fermenters		
Fermenter Thickeners		
Fermenter Pump Station		
Equalisation Tank		
Reactor	X	X
Final Clarifiers	X	X
RAS and WAS Pump Station	X	X
Ferric Dosing		X

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Chlorination Contact Tank	X	X
Chlorination Building and Pump Station		X
Control Building (BNR)		
Administration Building		X
Sludge Screening & Building		X
GBT Feed Pump Station and Pumps		
Poly Dosing Building		
Linear Belt Thickener Building		
Digester Feed Pump Station and Pumps		
Filter Belt Pump Station and Pumps		
Sludge Belt Press Building		
Digesters (Mixing)		
Gas Collection and Gas Holder		
Boiler Room and Digester Heating		
Lime Silo and Dosing		
Lime Thickeners		
Sludge Drying Beds		X
Workshop	X	X
Minor MCC Buildings		X
Emergency Ponds		X

In addition to the items identified in Table 5, the component specific replacement cost calculations also allows for:

- Preliminary and general items;
- Interconnecting pipework;
- Mass earthworks and roads;
- Civil construction;
- Mechanical and electrical equipment;
- Engineering; and
- Disbursements.

The capital cost comparison for the 18 ML/day Madadeni WWTP is given in Table 6:

Table 6: Madadeni WWTP capital cost comparison

Capital cost description	Cost
Refurbishment of existing WWTP	R 4 885 000



It is estimated that a saving of approximately R 84 million was achieved by retrofitting the plant rather than replacing it.

Capital cost description	Cost
Component specific replacement	R 88 625 707
Generic new WWTP (chart)	R 149 200 000

Compared to the unit specific capital cost estimate (R 88 625 707) required for complete replacement rather than upgrade/retrofitting of the plant, a saving of approximately R 84 million was achieved.

2.2.5 Plant operational and management assessment



Skills shortages hamper efficient plant operation and maintenance.

The Madadeni plant is classified as a Type C Plant by DWA based on its size. For this classification the plant is required to employ staff of certain prescribed skills. In Table 7 the required staff versus the actual staff complement is indicated.

Table 7: Madadeni Staff

Type	Required Staff	Actual Staff
Superintendent	1 (shared)	1 (shared)
Plant Supervisor	1	1
Operator	4	1
Assistant Operator	10	8
Team leader	1	1
Driver	1	0
General worker	8	7
Total	25	18

Due to skill shortages and financial constraints imposed by the municipalities, most of the required posts are not filled and the actual staff numbers are less than required. To comply with the Department of Water Affairs (DWA) guidelines, the following workers are required:

- 3 skilled operators;
- 2 assistant operators;
- 1 driver; and
- 1 general worker.



Osizweni WWTP is experiencing an increasing flow and load – mainly due to expansion of basic services, poor water management practises and increased VIP latrines.

2.3 Osizweni WWTP

The Osizweni township is situated approximately 20 km east of Newcastle. The WWTP uses both biofilter (8 ML/day) and activated sludge (7 ML/day) processes. It was built in the 1970s and has a combined design capacity of 15 ML/day. However, the inflow load is rising at an increasing rate.

The plant is currently being refurbished and upgraded and the work will be completed during 2010.

Similar to Madadeni, VIP units are widely used and a water conscious culture has not been established in the community.

The main process unit components are the following:

- Inlet Works
- Primary Sedimentation Tanks
- Primary Sludge Pump Station
- Reactor
- Final Clarifiers
- RAS and WAS Pump Station
- Ferric Dosing
- Chlorination Contact Tank
- Chlorination Building and Pump Station
- Control Building
- Administration Building
- Sludge Screening and Building
- Digester Feed Pump Station and Pumps
- Sludge Drying Beds
- Workshop
- Minor MCC Buildings
- Emergency Ponds

2.3.1 Plant flows and qualities

The WWTP daily flow rates for 2009 are presented in [Figure 13](#).



Apart from overloading, a plant infrastructure audit revealed that equipment was not operational, some corroded, digesters and ponds silted up and equipment not used as per their design

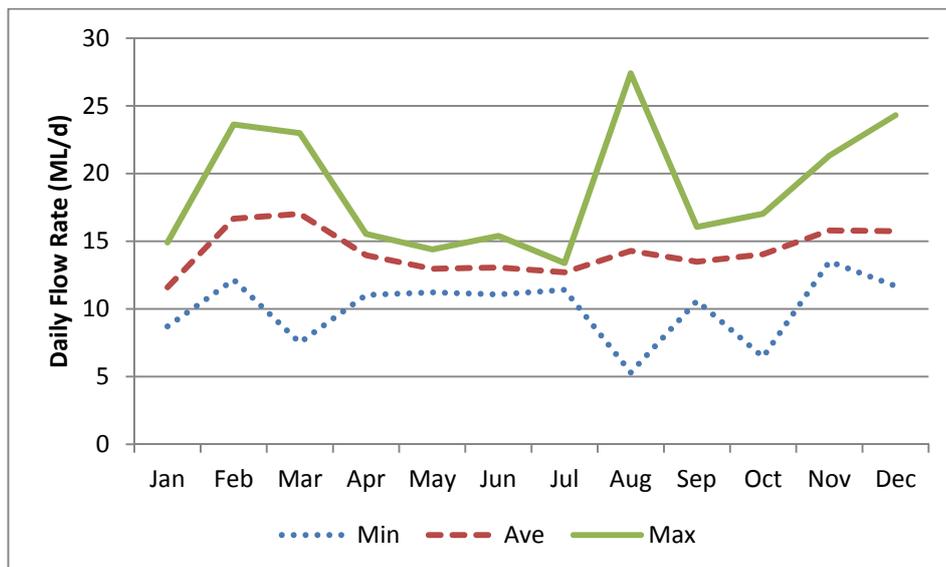


Figure 13: Osizweni WWTP daily flow rates (ML/day)

The daily average flow rate during 2009 was 14.3 ML/day, ranging from a low of 6.4 ML/day to a maximum of 24.3 ML/day (see APPENDIX A for complete daily flow rates recorded in 2007, 2009 and 2010).

The water quality data for Madadeni WWTP is given in Table 8:

Table 8: Osizweni Water Quality

Parameter	Units	50 Percentile (2005)		50 Percentile (2009-2010)	
		Inflow*	Outflow	Inflow*	Outflow
pH		7.3	6.8	7.5	7.2
Conductivity	mS/m	63.4	46.7	61.8	41.1
COD	mg O ₂ /L	147	35.5	138	19.5
SS	mg/L	100	6.4	134	8.6
TDS	mg/L	420	353	305	283
Alkalinity	mg/L as CaCO ₃	257	120	223	61
Ammonia	mg/L as N	32.0	11.1	30.3	1.8
Nitrate	mg/L as N	3.3	7.2	1.4	6
Orthophosphate	mg/L as P	4.4	4.1	8.6	3.4
Faecal Coliforms	cfu/100 mL	**NM	**NM	**NM	3654
Flow (avg daily)	ML/d (Year)	13.3 (2007)		19.1 (2010)	
COD (load)	kg/d	1955	472	2636	372
SS (load)	kg/d	1330	85	2559	164
TDS (load)	kg/d	5586	4695	5826	5405
Ammonia (load)	kg/d as N	426	148	579	34

*Average biofilter and activated sludge plant inflows

**NM = Not measured



The plant is nitrifying successfully, but only partially denitrifying in the activated sludge reactor.



The plant upgrade included the cleaning out of:

- clarifiers
- reactors
- digesters
- maturation ponds

The following were refurbished:

- aerators
- clarifiers, including over flow weirs and bridges
- biofilters
- settling tanks

In addition to this, the following new pieces of equipment were installed:

- Inlet works
- Chlorination unit
- Chlorine contact channel
- Additional clarifier

The old oxidation ponds were converted to an attenuation dam.

In 2005, the ammonia concentration value was above the DWA limit of 10 mg/L (see Table 8). This was reduced to 1.8 mg/L in 2009/2010. The final effluent qualities for all the other measured parameters comply with the DWA general standards for final effluent, except for the Faecal Coliforms which is most likely due to ineffective disinfection.

Although the SS outflow concentration has increased, the SS inflow load has doubled, despite the fact that the plant flow rate has increased by only 45%.

2.3.2 Plant infrastructure assessment

An infrastructure assessment was done in 2006 and the following were observed:

- Old oxidation ponds used as PSTs;
- PST filled with sand and sludge;
- 3 biofilters' centre bearings broken;
- 4 effluents recycle pumps with only 1 fully functional;
- 2 humus pumps with 1 working;
- 4 anaerobic digesters with reduced capacity due to sand build-up;
- Maturation pond filled with sludge (1.2 m) and only 300 mm water;
- 12 floating aerators – 3 working;
- 1 RAS pump working;
- 1 WAS pump working;
- Clarifier weirs corroded;
- Clarifier centre bearing worn through base plates.

2.3.3 Plant upgrade/retrofit work

Refurbishment started in 2009 and was completed in 2010. The following work was undertaken:

- Old oxidation ponds used as PSTs converted to attenuation dam;
- Installation of new inlet works with mechanical screen and compactor;
- Refurbish settling tanks (3);
- Refurbish biofilters (3);
- Refurbish clarifier (including overflow weirs and bridges);
- Clean out clarifier;
- Remove sand and silt from reactor;
- Remove sand from digesters;
- Clean out maturation and storm water ponds;



In order to increase the plant capacity, the addition of the following units is envisaged:

- Aeration basin
- 3 Secondary clarifiers
- Additional chlorine contact tank

As an efficiency and energy saving initiative, existing aerators will be replaced with bubble aeration

- Refurbish aerators;
- Installation of a new chlorination unit;
- Add one new clarifier for extra capacity.



Figure 14: Installation of new inlet works



Figure 16: Cleanup at Osizweni WWTP



Figure 15: Installation of automated classifier

Future process units envisaged to increase the capacity to 25 ML/day:

- One new aeration basin;
- Bubble aeration to replace aerators as an efficiency and energy saving initiative;
- Three new secondary clarifiers;
- One new chlorine contact tank.

2.3.4 Capital cost for upgrade/retrofit work

The estimated costs for retrofitting and refurbishment of the WWTP are listed in Table 9. In comparison, replacing the plant with a new WWTP of equal capacity and the following estimated capital budget would be required.

Table 9: Osizweni Capital Cost Estimates (budget estimation)

Item	Indicative cost
Refurbish 3 primary settling tanks	R 300 000
Refurbish 3 biofilters	R 500 000
Replace biofilter recirculation/humus pumps & electrical panel.	R 130 000
Construct new chlorine contact canal.	R 1 500 000
Replace 3 RAS and 2 WAS pumps and pipework.	R 270 000
Install automatic screen and compactor at Head of Works and refurbish civil structures.	R 750 000
Repair sludge drying beds.	R 50 000
Overhaul all electrical panels.	R 500 000
Replace perimeter fence.	R 1 000 000
Clean out maturation and storm water ponds.	R 600 000
Install 2 DO meters on aeration basin.	R 120 000
Install 2 flow meters.	R 30 000
Repair scum disposal system.	R 65 000
Replace tractor and accessories.	R 350 000
Remove sand from 4 digesters and repair pipework and valves.	R 500 000
Upgrade store room and ablution block.	R 250 000
Repair office block and install security system.	R 100 000
Paint buildings, put up signage and install safety equipment.	R 50 000
Total	R 7 065 000

A generic list of civil and mechanical structures associated with a WWTP is given in Table 10:

Table 10: Osizweni WWTP refurbishment vs. replacement

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Inlet Works	X	X
Primary Sedimentation Tanks	X	X
Primary Sludge Pump Station		X

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Fermenters		
Fermenter Thickeners		
Fermenter Pump Station		
Equalisation Tank		
Reactor	X	X
Final Clarifiers	X	X
RAS and WAS Pump Station	X	X
Ferric Dosing		X
Chlorination Contact Tank	X	X
Chlorination Building and Pump Station		X
Control Building (BNR)		X
Administration Building	X	X
Sludge Screening & Building		X
GBT Feed Pump Station and Pumps		
Poly Dosing Building		
Linear Belt Thickener Building		
Digester Feed Pump Station and Pumps		X
Filter Belt Pump Station and Pumps		
Sludge Belt Press Building		
Digesters (Mixing)	X	X
Gas Collection and Gas Holder		
Boiler Room and Digester Heating		
Lime Silo and Dosing		
Lime Thickeners		
Sludge Drying Beds	X	X
Workshop	X	X
Minor MCC Buildings	X	X
Emergency Ponds	X	X

The capital cost comparison (see APPENDIX B and APPENDIX C) for the 15 ML/day Osizweni WWTP is given in Table 11:

Table 11: Osizweni WWTP capital cost comparison

Capital cost description	Cost
Refurbishment of existing WWTP	R 7 065 000
Component specific replacement	R 85 151 419
Generic new WWTP (chart)	R 127 360 000

Compared to the unit specific capital cost estimate (R 85 151 419) required for complete replacement rather than upgrade/retrofitting of the plant, a saving of approximately R 78 million was achieved.

2.3.5 Plant operational and management assessment

The Osizweni plant is classified as a Type B by DWA based on the size of the plant. For this classification the plant is required to employ staff of certain prescribed skills. In Table 12 below the required staff versus actual staff complement are indicated.

Table 12: Osizweni Staff

Type	Required Staff	Actual Staff
Superintendent	1 (shared)	1 (shared)
Plant Supervisor	1	1
Operator	5	0
Assistant Operator	10	8
Team leader	1	0
Driver	1	0
General worker	8	6
Total	26	15



Having the correct number of trained plant operators is a key requirement.

Due to skill shortages and financial constraints imposed by the municipalities, most of the required posts are not filled and the actual staff numbers are lower than the required number. This places an extra burden on staff to adequately operate and maintain the works.

This plant was formerly run by Sediba and operators were not adequately trained prior to uThukela Water taking over the operation of the plant.

2.4 Durnacol WWTP

Durnacol is a mine village situated approximately 35 km south of Newcastle. The WWTP utilises an activated sludge (Pasveer ditch) process followed by a clarifier and wetland. Formerly sludge was treated in a digester. The plant was built in the 1970s and has a design capacity of 2 ML/day, but is currently processing around 0.6 ML/day due to the mine down-scaling its operation. The inflow load is not expected to increase in the short term.

Raw sewage enters the plant and with no screening taking place, flows directly to the Pasveer ditch. No aerators are operational and no waste sludge drawn off from the reactor. The reactor overflows via the final clarifier and is discharged without any chlorination to the reed beds downstream of the plant. Due to the condition of the plant, practically no treatment is imparted and therefore the ammonia, phosphate, COD and SS are high.

The plant is currently being refurbished and upgraded and the work is expected to be completed in November 2010.



Figure 17: Satellite picture of Durnacol WWTP

The main process unit components are the following:

- Inlet Works
- Pasveer Reactor
- Final Clarifiers
- RAS and WAS Pump Station
- Ferric Dosing
- Chlorination Contact Tank
- Chlorination Building and Pump Station
- Control Building
- Administration Building
- Sludge Drying Beds
- Workshop
- Minor MCC Buildings
- Emergency Ponds



Figure 18: Pasveer ditch at Durnacol WWTP – note no aerators operational



A plant infrastructure audit revealed that equipment had silted up, electrical cables were stripped or stolen, equipment corroded, damaged or not operational and structures cracked.

Table 13: Durnacol Water Quality

Parameter	Units	50 Percentile (2005)		50 Percentile (2009-2010)	
		Inflow	Outflow	Inflow	Outflow
pH		6.8	7.2	7.0	7.1
Conductivity	mS/m	58.9	57.4	60.8	55.1
COD	mg O ₂ /L	210	70	209	141
SS	mg/L	66	13.4	162	60
TDS	mg/L	414	443	302	294
Alkalinity	mg/L as CaCO ₃	223	195	224	226
Ammonia	mg/L as N	18.3	5.7	30.3	26.2
Nitrate	mg/L as N	3.3	5.2	1.8	1.5
Orthophosphate	mg/L as P	*NM	7.3	12.5	11.0
Faecal Coliforms	cfu/100 mL	*NM	*NM	*NM	241960
Flow (avg daily)	ML/d (Year)	0.6 (2006)		0.6 (2010)	
COD (load)	kg/d	126	42	125	85
SS (load)	kg/d	40	8	97	36
TDS (load)	kg/d	248	266	181	176
Ammonia (load)	kg/d as N	11	3	18	16

*NM = Not measured

2.4.1 Plant flows and qualities

The daily average flow rate data is limited and the flow is understood to remain constant at 0.64 ML/day, below the design capacity of 2 ML/day.

From the results in Table 13, it is evident that the final effluent quality has deteriorated from 2005 to 2010 with respect to COD, SS, alkalinity, ammonia, orthophosphate and Faecal Coliforms. The COD, SS, ammonia and orthophosphate are all above the DWA limits. The flow rate and loads remained constant over this period.

Apart from some COD and SS removal, the WWTP is ineffective in treating the raw influent. Due to the deterioration of the final effluent quality, an upgrade was required.

2.4.2 Plant infrastructure assessment

An infrastructure assessment was done in 2006 and the following were observed:

- Electrical cabling and many steel items were stripped and stolen;
- Pasveer ditch filled with sand;
- Pasveer ditch brush aerator shafts in disrepair;
- Brushes corroded;



Figure 19: Durnacol clarifier in state of disrepair



The plant upgrade included the cleaning out of the pasveer reactor and mechanical repairs on the unit in terms of adding an overflow weir and flow baffles.

Civil repairs carried out include:

- Pasveer ditch
- Head of works
- Operators house
- Sludge drying beds
- Reed bed structures

Brush aerators were repaired and four new aerators added

In addition to this, the following new pieces of equipment were installed:

- Office and store
- Telemetry system
- RAS pumps
- Palisade fence

It is envisaged that the aerators will be replaced by bubble aerators in the future.

- Clarifier filled with sand, weir corroded and centre bearing worn through base plate;
- Drying beds filled with sand/silt;
- Drying bed brickwork cracked and collapsing;
- Digester filler with sand.

2.4.3 Plant upgrade/retrofit work

Plant refurbishment started in March 2010 and is expected to be completed in November 2010. The following work is being undertaken:

- Complete overhaul of clarifier;
- Remove sand from Pasveer ditch;
- Civil repairs to Pasveer ditch and aerator structures;
- Mechanical and civil repairs to head of works;
- Repair and secure operators' house, erect office (new) and store (new);
- Replace electrical panel and secure outside electrical supply against theft;
- Install telemetry system (new);
- Refurbish and install 4 new brush aerators (including drives and motors);
- Replace 2 RAS pumps (new);
- Mechanical refurbishment of Pasveer ditch (e.g. overflow weir, flow baffles);
- Repair sludge drying beds;
- Repair reed beds and structures;
- Rehabilitate site;
- Secure the site by replacing fence with a palisade fence.



Figure 20: Pasveer ditch being refurbished



Figure 21: Clarifier being refurbished

Future work envisaged:

- Bubble aeration to replace aerators as an energy saving initiative and to optimise the process;

2.4.4 Capital cost for upgrade/retrofit work

The estimated costs for retrofitting and refurbishment of the WWTP are listed in Table 14. In comparison, replacing the plant with a new WWTP of equal capacity and the estimated capital budget would be required.

Table 14: Durnacol Capital Cost Estimates

Item	Indicative cost
Complete overhaul of clarifier	R 200 000
Remove sand from Pasveer ditch	R 50 000
Civil repairs to Pasveer ditch and aerator structures	R 500 000
Mechanical and civil repairs to head of works	R 100 000
Repair and secure house for occupation, erect office and store	R 350 000
Replace electrical panel and secure outside electrical supply against theft and install telemetry system	R 250 000
Install fine bubble aeration and construct blower room	R 3 900 000
Replace 2 RAS pumps	R 40 000
Mechanical refurbishments to Pasveer ditch (e.g. overflow weir, flow baffles)	R 50 000
Repair sludge drying beds	R 250 000
Repair reed beds and structures	R 250 000
Rehabilitate site	R 75 000
Secure site access by installing a palisade fence	R 450 000
Total	R 6 465 000

A generic list of civil and mechanical structures associated with a WWTP is given in Table 15:



A saving of approximately R 15 Million was achieved by repairing and refurbishing equipment was possible instead of replacing the plant.

Table 15: Durnacol WWTP refurbishment vs. replacement

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Inlet Works	X	X
Primary Sedimentation Tanks		
Primary Sludge Pump Station		
Fermenters		
Fermenter Thickeners		
Fermenter Pump Station		
Equalisation Tank		
Reactor	X	X
Final Clarifiers	X	X
RAS and WAS Pump Station	X	X
Ferric Dosing		X
Chlorination Contact Tank		X
Chlorination Building and Pump Station		X
Control Building (BNR)		
Administration Building	X	X
Sludge Screening & Building		
GBT Feed Pump Station and Pumps		
Poly Dosing Building		
Linear Belt Thickener Building		
Digester Feed Pump Station and Pumps		
Filter Belt Pump Station and Pumps		
Sludge Belt Press Building		
Digesters (Mixing)		
Gas Collection and Gas Holder		
Boiler Room and Digester Heating		
Lime Silo and Dosing		
Lime Thickeners		
Sludge Drying Beds	X	X
Workshop		X
Minor MCC Buildings		X
Emergency Ponds		X

The capital cost comparison (see APPENDIX B and APPENDIX C) for the 2 ML/day Durnacol WWTP is given in Table 16:



A saving of approximately R 15 Million was achieved by repairing and refurbishing equipment was possible instead of replacing the plant.

Table 16: Durnacol WWTP capital cost comparison

Capital cost description	Cost
Refurbishment of existing WWTP	R 6 465 000
Component specific WWTP	R 21 618 007
Generic new WWTP (chart)	R 29 770 000

Compared to the unit specific capital cost estimate (R 21 618 007) required for complete replacement rather than upgrade/retrofitting of the plant, a saving of approximately R 15 million was achieved.

2.4.5 Plant operational and management assessment

The plant is classified as a Type D sewage treatment plant by DWA based on the size of the plant. For this classification the plant is required to employ staff of certain prescribed skills. In Table 17 below the required staff versus actual staff complement are indicated.

Table 17: Durnacol Staff

Type	Required Staff	Actual Staff
Superintendant	1 (shared)	0
Plant Supervisor	0	0
Operator	3	0
Assistant Operator	2	0
Team leader	0	0
Driver	0	0
General worker	2	1
Total	8	1

Due to skill shortages and financial constraints imposed by the municipalities, most of the required posts are not filled and the actual number of staff employed is lower than the required posts. This is mainly due to skilled operators moving away for better remuneration.

2.5 Dundee WWTP

Dundee is situated approximately 55 km south west of Newcastle. The WWTP was built in the 1950s. Originally it utilised a biofiltration process (7 ML/day), which was augmented in the 1990s by two activated sludge treatment modules (2 x 3 ML/day), of which one is currently operational. It has a combined operational design capacity of 10 ML/day and is currently processing around 10.7 ML/day.

Blood from a local abattoir is also being treated by the WWTP.

Following an 18 month period of refurbishment and upgrades that ended in 2010, it is planned to increase the plant's capacity further by reinstating the second activated sludge module. This will require additional work to be done.



Figure 22: Satellite photograph of Dundee WWTP

The main process unit components are the following:

- Inlet Works;
- Primary Sedimentation Tanks;
- Primary Sludge Pump Station;
- Reactor;
- Final Clarifiers;
- RAS and WAS Pump Station;
- Ferric Dosing;
- Chlorination Contact Tank;
- Chlorination Building and Pump Station;
- Administration Building;
- Sludge Screening and Building;
- Digester Feed Pump Station and Pumps;
- Digesters (Mixing);
- Gas Collection and Gasholder;
- Boiler Room and Digester Heating;
- Sludge Drying Beds;
- Workshop;
- Minor MCC Buildings;
- Emergency Ponds;

2.5.1 Plant flows and qualities

In 2009 the daily average flow rate was 10.8 ML/day, ranging from a low of 6.1 ML/day to a maximum of 26.3 ML/day, as is evident from Figure 23. See APPENDIX A for complete daily flow rates recorded in 2007, 2009 and 2010. There seems to be a high stormwater infiltration rate during summer, causing excessively high plant flows.

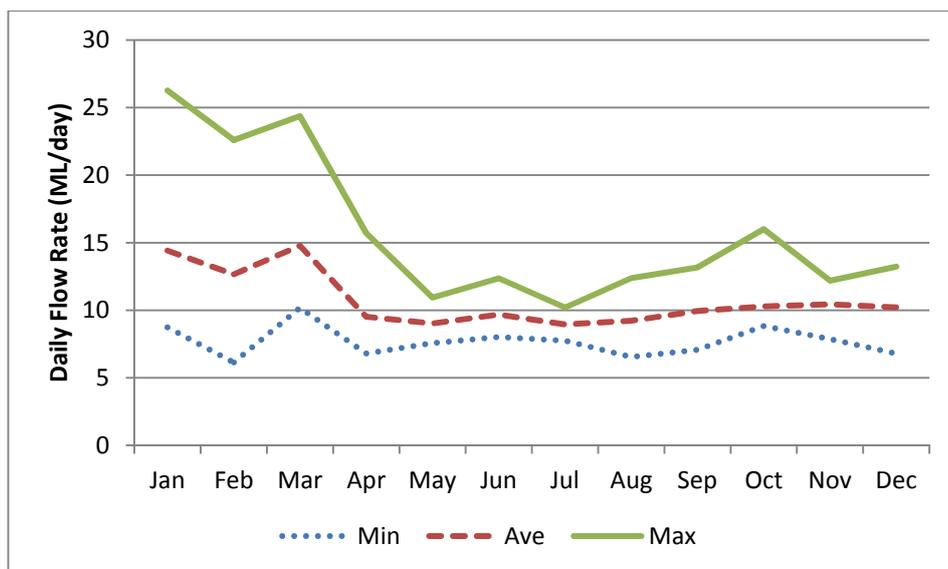


Figure 23: Dundee WWTP daily flow rates (ML/day)



Figure 24: Algae on clarifier

Table 18: Dundee Water Quality

Parameter	Units	50 Percentile (2005)		50 Percentile (2009-2010)	
		Inflow*	Outflow	Inflow*	Outflow
pH		6.9	7.3	6.9	7.1
Conductivity	mS/m	89	79	75	56
COD	mg O ₂ /L	370	43	339	32
SS	mg/L	240	7	232	14
TDS	mg/L	634	486	450	383
Alkalinity	mg/L as CaCO ₃	340	318	277	102
Ammonia	mg/L as N	33.1	27.0	25.3	3.2
Nitrate	mg/L as N	2.5	2.3	1.8	5.2
Orthophosphate	mg/L as P	**NM	5.6	17.0	4.7
Faecal Coliforms	cfu/100 mL	**NM	**NM	**NM	70000
Flow (avg daily)	ML/d (Year)	10.2 (2007)		10.2 (2010)	
COD (load)	kg/d	3774	439	3458	326
SS (load)	kg/d	2448	71	2366	143



Figure 25: Broken shaft components

Parameter	Units	50 Percentile (2005)		50 Percentile (2009-2010)	
TDS (load)	kg/d	6467	4957	4590	3907
Ammonia (load)	kg/d as N	338	275	258	33

*Average biofilter and activated sludge plant inflows

**NM = Not measured

From the results presented in

Table 18, it is evident that the final effluent quality has deteriorated from 2005 to 2010 with respect to SS and nitrate. The 2010 Faecal Coliforms value is above the DWA limit. In general there is a decrease in the load on the WWTP with respect to COD, SS, TDS and ammonia.

From the data presented, it is evident that although nitrification takes place, little denitrification occurs. A reasonable level of phosphate reduction is achieved, while COD removal is good.



An infrastructure assessment indicated that equipment had silted up and several critical unit processes were no longer operational.

2.5.2 Plant infrastructure assessment

An infrastructure assessment completed in 2006 showed that only one activated sludge plant was operational. Both the second activated sludge module and the biofiltration plants have fallen into disrepair. The following were observed:

- Sludge ponds filled with sand/sludge with their bypasses not operational;
- Primary clarifiers filled with sand;
- Biofilter pumps and level controllers not operational;
- Humus tanks and pump station not operational;
- Sludge thickening tanks and pumps not operational;
- The aerators and pumps on the second aeration basin was not functional;
- Primary digester filled with sand and mixers not operational;
- Secondary digester mixers not operational.
- Chlorination system not operational.



The plant upgrade included the cleaning out of the tanks.

The following equipment was repaired and recommissioned:

- Primary clarifiers
- Biofilter pumps
- Biofilters
- Humus tanks
- Sludge thickening tanks

The following equipment had to be replaced:

- Sludge pumps
- Sluice gates that were missing

The buildings were repaired, painted and secured.



Figure 26: Thickener not operational

2.5.3 Plant upgrade/retrofit work

Refurbishment started in 2008 and the following work was undertaken:

- Head of works: repair mechanical back raked and inclined bar screens and compactors.
- Repair and recommission 2 primary clarifiers.
- Repair 6 biofilter pumps and level controllers.
- Repair and recommission 6 biofilters.
- Repair and recommission 4 humus tanks and pump station.
- Repair sludge thickening tanks and replace pumps;
- Replace 2 x 6" Gorman Rupp sludge pumps;
- Refurbish all electrical panels and installations;
- 2nd aeration basin: overhaul 3 aerators and 2 axial flow pumps;
- Refurbish irrigation pump station building, electrical panel, pumps and pipeline;
- Digester blood decanting point: attach connection point on suction end of digester pump – for anaerobic digestion of blood;
- Replace various missing sluice gates;
- Repair, paint and secure buildings.



Figure 27: Refurbished biofilter



Figure 28: New and refurbished biofilter shafts

Future work required:

- Construct a second clarifier for the Activated Sludge plant.
- Clean out all sludge ponds.



The plant requires additional work, including:

- A new clarifier for the activated sludge plant
- Refurbishment of drying beds
- Replacement of digester mixers and pumps
- Replacement of biofilter delivery pumps
- Replacement of boundary fence
- Cleaning out of the maturation pond and sludge pond
- Installation of chlorination system, DO and MLSS meters and name plates and signage.

- Refurbish sludge drying beds.
- Replace 2 secondary digester mixers with mixer pumps.
- Repair 2 primary digester mixers and remove sand.
- Replace boundary fence.
- Replace 3 biofilter delivery pumps.
- Repair final effluent pipes.
- Clean maturation ponds.
- Install new chlorination system.
- Install D.O. and MLSS meters.
- Install name plates and signage.

2.5.4 Capital cost for upgrade/retrofit work

Table 19: Dundee Capital Cost Estimates

Item	Indicative cost
Head of works: Repair back raked and inclined bar screens and 2 compactors.	R 114 500
Repair and recommission 2 primary clarifiers.	R 255 000
Repair 6 biofilter pumps and level controllers.	R 182 000
Repair and recommission 6 biofilters.	R 390 000
Repair and recommission 4 humus tanks and pump station.	R 300 000
Repair sludge thickening tanks and replace pumps.	R 35 000
Replace 2 x 6" Gorman Rupp sludge pumps.	R 88 000
Refurbish all electrical panels and installations.	R 70 000
2nd aeration basin: Overhaul 3 aerators and 2 axial flow pumps.	R 60 000
Refurbish irrigation pump station building, electrical panel, pumps and pipeline.	R 55 000
Digester blood decanting point: Attach connection point on suction end of digester pump.	R 20 000
Replace missing sluice gates.	R 10 000
Repair, paint and secure buildings.	R 125 000
Total	R 1 704 500

In order to increase the plant capacity and restore the sludge digestion and handling facility, the following additional (Table 20) work is required.

Table 20: Dundee Future Capital Cost Estimates

Item	Indicative cost
Construct a second clarifier for the Activated Sludge plant	R 4 000 000
Clean out all sludge ponds	R 625 000
Refurbish sludge drying beds	R 500 000
Replace 2 secondary digester mixers with mixer pumps	R 150 000
Repair 2 primary digester mixers and remove sand	R 500 000
Replace boundary fence	R 400 000
Replace 3 biofilter delivery pumps	R 400 000
Repair final effluent pipes	R 50 000
Clean maturation system	R 30 000
Install chlorination system	R 35 000
Install D.O. and MLSS meters	R 7 500
Install name plates and signage	R 30 000
Total	R 6 727 500

A generic list of civil and mechanical structures associated with a WWTP is given in Table 15:

Table 21: Dundee WWTP refurbishment vs. replacement

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Inlet Works	X	X
Primary Sedimentation Tanks	X	X
Primary Sludge Pump Station	X	X
Fermenters		
Fermenter Thickeners		
Fermenter Pump Station		
Equalisation Tank		
Reactor	X	X
Final Clarifiers	X	X
RAS and WAS Pump Station		X
Ferric Dosing		X

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Chlorination Contact Tank	X	X
Chlorination Building and Pump Station		X
Control Building (BNR)		
Administration Building		
Sludge Screening & Building		X
GBT Feed Pump Station and Pumps		
Poly Dosing Building		
Linear Belt Thickener Building		
Digester Feed Pump Station and Pumps	X	X
Filter Belt Pump Station and Pumps		
Sludge Belt Press Building		
Digesters (Mixing)	X	X
Gas Collection and Gas Holder		X
Boiler Room and Digester Heating		X
Lime Silo and Dosing		
Lime Thickeners		
Sludge Drying Beds	X	X
Workshop		
Minor MCC Buildings		
Emergency Ponds		X

The capital cost comparison (see APPENDIX B and APPENDIX C) for the 10 ML/day Dundee WWTP is given in Table 22:

Table 22: Dundee WWTP capital cost comparison

Capital cost description	Cost
Refurbishment of existing WWTP	R 8 432 000
Component specific WWTP	R 63 229 229
Generic new WWTP (chart)	R 90 680 000

Compared to the unit specific capital cost estimate (R 63 229 229) required for complete replacement rather than upgrade/retrofitting of the plant, a saving of approximately R 55 million was achieved.

2.5.5 Plant operational and management assessment

The plant is classified as a Type B sewage treatment plant by DWA, based on its size. For this classification the plant is required to employ staff of certain prescribed skills. In Table 23 below the required staff versus actual staff complement is indicated.



It is estimated that a saving of approximately R 55 million will be achieved by retrofitting and refurbishing the current plant as opposed to building a new plant.

Table 23: Dundee Staff

Type	Required Staff	Actual Staff
Superintendent	1 (shared)	1 (shared)
Plant Supervisor	1	0
Operator	5	0
Assistant Operator	8	6
Team leader	1	0
Driver	1	0
General worker	6	3
Total	23	10



Plants in good repair, with dedicated management, are clean and neat and comply to discharge standards.

Due to skill shortages and financial constraints imposed by the municipalities, most of the required posts are not filled and the actual number of staff employed is lower than the required posts. However, the condition of this plant is good and all refurbished plant equipment in working order and very neat.

2.6 Newcastle WWTP

Newcastle is situated in northern KwaZulu-Natal. The initial WWTP process consisted of a biofilter plant with an initial capacity of 10 ML/day. The plant was constructed in the 1970s. It was converted to a PETro system in 1994 with a design capacity of 25 ML/day and it now operates at more than 90% of the design capacity. During the rainy season the plant capacity is exceeded for up to two weeks at a time due to high infiltration of storm water and ground water.

Refurbishment and upgrading work was done from 2009 to 2010 and future work is planned for the next financial year.



Figure 29: Satellite photograph of Newcastle WWTP

The main process unit components are the following:

- Inlet Works
- Primary Sedimentation Tanks
- Primary Sludge Pump Station

- Equalisation Ponds
- Humus Tanks
- Humus Tank Pump Stations
- Biofilters
- Reactor
- Final Clarifiers
- RAS and WAS Pump Station
- Ferric Dosing
- Chlorination Contact Tank
- Chlorination Building and Pump Station
- Control Building
- Administration Building
- Sludge Screening and Building
- Digester Feed Pump Station and Pumps
- Digesters (Mixing)
- Gas Collection and Gasholder
- Boiler Room and Digester Heating
- Sludge Drying Beds
- Workshop
- Minor MCC Buildings
- Emergency Ponds



Figure 30: Biofilter in operation

2.6.1 Plant flows and qualities

The daily 2009 average flow rate was 20 ML/day ranging from a low of 9.8 ML/day to a maximum of 56.8 ML/day as evidenced in Figure 30 (see APPENDIX A for complete daily flow rates recorded in 2007, 2009 and 2010).

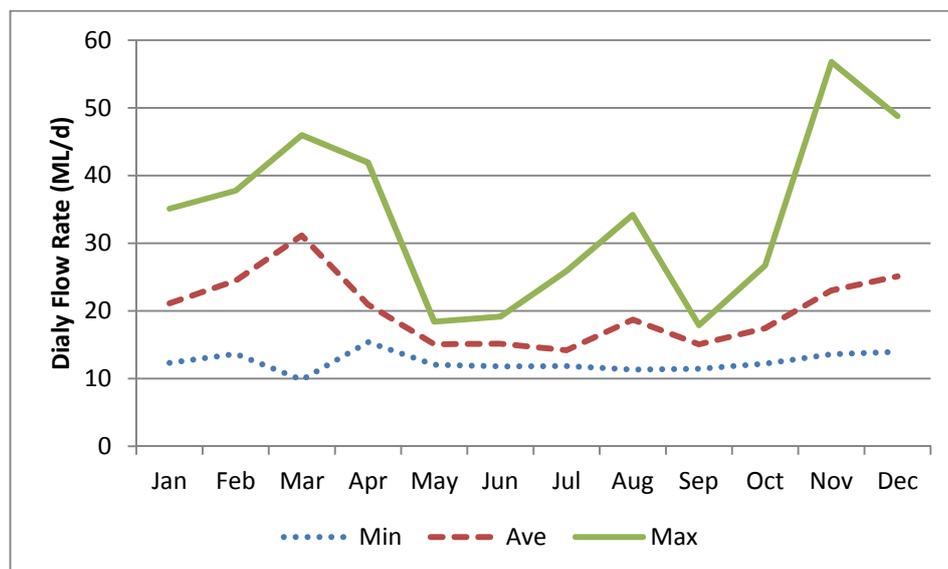


Figure 31: Newcastle WWTP daily flow rates (ML/day)



During the rainy season, the plant is overloaded as the result of high ingress of storm water and ground water.

An infrastructure assessment revealed that equipment was damaged or corroded, staff facilities did not comply with OHS Act requirements and improved security was required.

Table 24: Newcastle Water Quality

Parameter	Units	50 Percentile (2005)		50 Percentile (2009-2010)	
		Inflow	Outflow	Inflow	Outflow
pH		7.1	6.8	7.1	7.1
Conductivity	mS/m	71	60	59	52
COD	mg O ₂ /L	304	31	194	25
SS	mg/L	128	2.0	145	0.8
TDS	mg/L	465	505	328	380
Alkalinity	mg/L as CaCO ₃	257	78	217	69
Ammonia	mg/L as N	31	3.9	20.7	1.7
Nitrate	mg/L as N	2.3	11.6	1.6	5.9
Orthophosphate	mg/L as P	*NM	6.2	10.4	4.8
Faecal Coliforms	cfu/100 mL	*NM	*NM	*NM	300
Flow (avg daily)	ML/d (Year)	17.3 (2007)		19.3 (2010)	
COD (load)	kg/d	5259	536	3744	483
SS (load)	kg/d	2214	35	2799	15
TDS (load)	kg/d	8045	8737	6330	7334
Ammonia (load)	kg/d as N	536	67	400	33

*NM = Not measured

From the results in Table 24, it is evident that the final effluent quality has improved from 2005 to 2010 with respect to all parameters measured. No final effluent quality parameters are above the DWA limit

The COD, TDS and ammonia loads on the WWTP have decreased, while the SS has increased slightly.



uThukela is still in the process of repairing the plant. The following refurbishment work has been completed:

- Staff facilities comply with OSH Act
- Corroded concrete structures and pipelines repaired
- Clarifier repaired
- Feedpipe to digesters encased in concrete.
- Biofilter arms replaced.

It is planned that the following will be repaired in 2011:

- Corroded anaerobic digester manholes
- Area lighting
- Overflow at anaerobic pond distribution channel
- Broken manhole covers

The anaerobic pond outlet sluices will be replaced.

In addition, the following will be installed:

- New humus pumps
- Crawl beam in store room
- Potable water line in chlorinator room

Six vehicle garages will be built.

2.6.2 Plant infrastructure assessment

During infrastructure assessment conducted in 2006, the following were observed:

- Clarifier conical floor was cracked;
- Biofilter distribution arms were broken;
- Change rooms and dining room do not comply with OHS Act specifications;
- Some digester concrete structures were acid corroded due to incomplete digestion;
- Humus pumps in disrepair;
- Store room in disrepair and not secure;
- Need to secure vehicles in garages.

2.6.3 Plant upgrade/retrofit work

Refurbishment work done during 2006 to 2010 was as follows:

- The 800 mm feed pipe to the digesters was encased in concrete;
- Clarifier floor repaired;
- 4 sets of biofilter arms were replaced;
- Change rooms and dining room upgraded to comply with OHS Act specifications;
- Acid corroded concrete structures and pipe lines were repaired.

Refurbishment planned for the 2011 financial year is as follows:

- Repair and protect anaerobic digester manholes against acid corrosion;
- Repair broken manhole covers;
- Install new humus pumps;
- Repair overflow at anaerobic pond distribution channel;
- Repair all area lighting;
- Install a crawl beam in store room;
- Install potable water line to chlorinator room;
- Refurbish recycle pump station electrical panel;
- Replace anaerobic pond outlet sluices;
- Erect 6 vehicle garages.

2.6.4 Capital cost for upgrade/retrofit work

Table 25: Newcastle Capital Cost Estimates

Item	Indicative cost
Encase 800 mm feed pipe to digesters in concrete.	R 90 000
Repair clarifier conical floor.	R 250 000
Replace 4 sets of biofilter arms.	R 350 000
Upgrade change rooms and dining room to comply with OHS Act specifications	R 350 000
Repair acid corroded concrete structures and pipe lines.	R 200 000
Repair and protect anaerobic digester manholes against acid corrosion.	R 75 000
Repair broken manhole covers.	R 35 000
Install new humus pumps.	R 20 000
Repair overflow at anaerobic pond distribution channel.	R 30 000
Repair all area lighting.	R 20 000
Install crawl beam in store room.	R 35 000
Install potable water pipeline to chlorinator room.	R 40 000
Refurbish recycle pump station electrical panel.	R 50 000
Replace anaerobic pond outlet sluices.	R 30 000
Erect 6 vehicle garages.	R 250 000
Total	R 1 825 000

A generic list of civil and mechanical structures associated with a WWTP is given in Table 26:

Table 26: Newcastle WWTP refurbishment vs. replacement

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Inlet Works		
Primary Sedimentation Tanks	X	X
Primary Sludge Pump Station	X	X
Fermenters		
Fermenter Thickeners		

Typical WWTP civil and mechanical structures	Affected by upgrade or repair work	Included in plant replacement cost
Fermenter Pump Station		
Equalisation Tank		
Reactor		
Final Clarifiers	X	X
RAS and WAS Pump Station		
Ferric Dosing		
Chlorination Contact Tank		
Chlorination Building and Pump Station		
Control Building (BNR)		
Administration Building		
Sludge Screening & Building		
GBT Feed Pump Station and Pumps		
Poly Dosing Building		
Linear Belt Thickener Building		
Digester Feed Pump Station and Pumps	X	X
Filter Belt Pump Station and Pumps		
Sludge Belt Press Building		
Digesters (Mixing)		X
Gas Collection and Gas Holder		
Boiler Room and Digester Heating		
Lime Silo and Dosing		
Lime Thickeners		
Sludge Drying Beds		
Workshop	X	X
Minor MCC Buildings		
Emergency Ponds		



It is estimated that a saving of approximately R 45 million will be achieved once the planned repairs are completed.

The capital cost comparison (see APPENDIX B and APPENDIX C) for the 25 ML/day Newcastle WWTP is given in Table 27:

Table 27: Newcastle WWTP capital cost comparison

Capital cost description	Cost
Refurbishment of existing WWTP	R 1 825 000
Component specific WWTP	R 47 222 150
Generic new WWTP (chart)	R 199 910 000

Compared to the unit specific capital cost estimate (R 47 222 150) required for complete replacement rather than upgrade/retrofitting of the plant, a saving of approximately R 45 million was achieved.

2.6.5 Plant operational and management assessment

The WWTW is classified as a Type B by DWA based on its size. For this classification the plant is required to employ staff of certain prescribed skills. In Table 28 below the required staff versus actual staff complement are indicated.

Table 28: Newcastle Staff

Type	Required Staff	Actual Staff
Superintendent	1 (shared)	1 (shared)
Plant Supervisor	0	0
Operator	5	5
Assistant Operator	10	8
Team leader	1	1
Driver	1	1
General worker	15	8
Total	33	14

The plant staffing level is in a better position than other, due to its close proximity to Newcastle.

Due to skill shortages and financial constraints imposed by the municipalities, most of the required posts are not filled and the actual staff numbers are lower than the required posts.



The following process changes have proved to be successful in the region:

- Bubble aeration is more cost effective than the conventional and is easy to retrofit on existing systems.
- Controlling the MLSS in the activated sludge reactor at 6 500 mg/l worked on plants that were overloaded.
- The Pulsar chlorination units were found to be successful in smaller plants.
- Mechanical dewatering of sludge is preferred, due to the wet conditions and high humidity in the area.
- Adding a brick layer on top of the sand and stone when refurbishing drying beds, allowed for back-acting tractors to be used for cleaning out these beds.
- Sludge bags are being investigated as a technology for separating the solid and liquid components of sludge.

3.0 GENERAL MEASURES IMPLEMENTED

A number of general measures were effectively implemented across all the WWTPs within uThukela Water's jurisdiction.

3.1 Process upgrades

uThukela Water has identified a number of areas where existing processes can be retrofitted/upgraded by either using more effective technology or changing the operation:

Aeration

The use of bubble aeration as opposed to conventional aerators is an example of a technology that is more cost effective, has a lower energy cost and is easy to retrofit at existing WWTPs. Installation of systems that can be isolated and removed for maintenance or replacement of diffusers, is essential.

MLSS

Since many of the WWTPs were overloaded in 2006 when uThukela Water started with their refurbishment programme, a solution was to control the mixed liquor suspended solids (MLSS) in the activated sludge reactor at about 6500 mg/L, which is higher than the theoretically recommended range of 3500-4500 mg/L. Based on their experience, the effluent remained clear, the quality did not deteriorate and they therefore continue to operate these plants at high MLSS values.

Chlorination

Instead of using more sophisticated chlorine gas dosing systems, uThukela Water opted for proprietary Pulsar chlorination units at their smaller plants. Although these units have to be cleaned weekly with citric or hydrochloric acid (1:1 dilution) to remove scale, it is much cheaper to install at R6000 per unit compared to a chlorine installation. Potable water must be used to prevent clogging, rather than final effluent. The operational cost is also much lower. With traditional chlorine installations, the harmful Cl₂ gas is expensive and the handling of heavy cylinders difficult. In sophisticated control systems, safety precautions are also required.

Sludge dewatering

Due to wet conditions, high humidity and low evaporation rates, mechanical sludge dewatering is preferred on the smaller plants. Mechanical dewatering is less labour intensive than dewatering by means of sludge drying beds, but requires regular maintenance.

Sludge drying beds

When sludge drying beds are refurbished, the sand/stone are taken out and repacked. However, by putting a brick layer on top of the sand and stone, back-acting tractors can be used to clean out the beds mechanically, where this was previously done manually.

Sludge bags (new innovation)

uThukela Water is currently looking at using sludge bags to capture and dry the sludge. Using this technology, sludge/solids can be separated from the liquid when sludge is pumped into the bag and the liquid drained out. The sludge bag can then be easily stored, used as supporting material in earth works or, if the organic content is high enough, sold as compost bags. The technology is used



Downtime was reduced by implementing the following measures:

- uThukela standardised on pumps, electrical panels and painting of equipment as this allowed for swap outs when necessary, staff trained with limited equipment, having spares available and reduced repair times.
- Ideally, a WWTP should have a stores room on site
- Using local suppliers ensures quick delivery and availability of spares.
- uThukela partnered with a local BEE accredited workshop that trains and employs people with special needs in the community. They provide a 24 hour repair service when required
- Custom built emergency pump trailers have been built. These mobile units can be utilised as and when required at various sites.
- Proper planning upfront reduced downtime for

extensively in the Netherlands where sand/sludge are pumped into the sludge bags when desilting their harbours and water ways. uThukela Water sees this as an example where universities and industry can also be involvement in researching innovative ways in dealing with some of the challenges they face.

3.2 Reducing down time

In the wastewater treatment industry, down time has to be avoided at all cost to prevent untreated wastewater discharge. This is because the inflow of sewage cannot be stopped, which can quickly result in huge backlogs to deal with. Effluent spillages can result if there is not sufficient emergency storage to deal with the situation.

There are a number of ways in which down time can be managed:

Standardising on equipment

Through standardising on mechanical and electrical equipment, repair and replacement of equipment can be expedited due to:

- equipment in stock;
- equipment can be exchanged from non-critical processes;
- technical skills are improved in dealing with a limited, standardised variety of equipment; and
- less time is expended in repairs.

uThukela Water has standardised on

- electrical panels;
- pumps (self priming); and
- painting of equipment (using SABS specifications).

Compared to conventional pumps, self priming pumps are easier to use and maintain. uThukela Water has standardised on Gorman-Rupp and Mas for self-priming pumps. It takes only 30 min to remove rags, therefore downtime is minimised.

Spare parts

Ideally, every WWTP should have a stores room on site where spare parts are to be kept. When standardised equipment is used, standard spares can be kept in stock and the inventory optimised.

Local suppliers

To ensure quick deliveries and availability of spares, uThukela uses local suppliers as far as possible.

Engineering workshop

uThukela Water has partnered with a local BEE accredited engineering workshop that does *i.a.* pump refurbishments, general mechanical refurbishments, emergency piping connections, emergency pump trailers and security doors. Through uThukela Water's support, the workshop successfully trains and employs people with special needs, creating employment in the local community.



Figure 32: Standard electrical panel.

24 hour repair team

An essential requirement for successfully operating WWTPs in a large service area is to have emergency repair equipment and teams available 24 hours a day.

Emergency equipment

Custom built emergency pump mobile trailers (with all the necessary equipment on board) have been used very successfully by uThukela Water for cleaning and repairing pipe or pump breakages. In this way uncontrolled discharge can be prevented. They can also be used to empty structures to provide access for maintenance and cleaning.

uThukela Water currently has 6 emergency pumps available that can be utilised as and when required.



Figure 33: Mobile pump units used in emergencies

Planning

For refurbishment or upgrade work, down time is minimised by working in shifts around the clock. This requires proper planning and dedicated teams.

3.3 Electrical supply outages

Most of the plants' electricity is directly supplied by Eskom. In times of energy shortages, load shedding can be applied and the WWTPs need to be able to mitigate this. For backup power, generators can be installed. But these are expensive and need to be adequately secured and maintained. Attenuation dams can be used to bypass and temporarily store sewage feed to the plants. When the power supply is restored, the stored sewage can be re-introduced to the plant.



Other successful measures that have been implemented include:

- Attenuation dams can be used to successfully divert and temporarily store sewage during electricity outage.
- Alternative sources of funding are always being investigated.
- Smaller tenders are easier to manage and thus tenders are prepared to be discipline specific.
- Proper safe facilities are provided to staff to improve staff retentions. These include ablution facilities and dining facilities that comply with the OSH Act, keeping grounds tidy, regular training, and employing casual labour for jobs that do not require skilled staff.
- Automation has been used where possible to minimise the burden on available operators due to the shortage of employees on the plants.
- Security measures are constantly being improved to minimise losses as the result of theft and vandalism.

3.4 Energy cost control

Different technologies that use less electricity can be considered. For example, bubble aeration saves up to 70% in operating costs (mainly in electricity) when compared to conventional aerators.

uThukela Water is considering the installation of energy meters (kWh) at all major equipment in order to monitor and manage energy use. The energy consumption information can also be expressed in R/kgCOD removed, which can then be used to compare the energy efficiency of different treatment processes.

Biogas recovered from anaerobic digesters can be used to supply essential equipment with electricity during load shedding and augment electricity supply to the plant under normal conditions.

3.5 Alternative sources of funding

Most of the District Municipalities' funding is realised through service levies. Additional funding intended for water and wastewater treatment is also made available by DWA and other state agencies via the municipalities. However, there are not adequate controls in place to ensure that this funding is allocated towards wastewater treatment infrastructure. Funds can also be accessed through SALGA.

Another source of funding is through the national government's Municipal Infrastructure Grant (MIG) where infrastructure subsidies are provided to ensure that all households have access to a basic level of infrastructure services.

It is essential to do financial planning well in advance, as it can take up to 5 years for funding to be approved.

3.6 Tender size

The Public Financial Management Act prescribes specific rules for tenders. Generally, smaller tenders require fewer tenderers than larger tenders. The more tenderers required, the more time and effort is required to evaluate the tenders. By structuring tenders by discipline (e.g. electrical) instead of job (e.g. clarifier refurbishment), smaller tender values can be realised, avoiding the onerous tendering processes required for larger tenders.

3.7 Staff

Retaining trained staff is essential and therefore proper and safe facilities at the WWTPs should be provided, as well as staff training and skills development maintained.

Ablution facilities

At most WWTPs, the facilities available to employees were in a state of disrepair or non-existent. It is essential that ablution, change rooms and dining room facilities are upgraded to comply with the Occupation Health and Safety (OHS) Act. When staff is properly provided for, they perform better at work.

Keeping grounds tidy

It is often difficult to find trustworthy WWTP caretakers that can keep WWTP grounds tidy. In this area of KwaZulu-Natal, women older than 45 year of age are recommended. They can even be allowed to plant vegetable gardens and to keep farm animals at the plants as an added incentive.

Automation

Due to a chronic lack of skilled staff, automated screens, classifiers and compactors should be installed at the inlet works of the smaller WWTPs (1-2 ML/d). In this way up to 4 workers less are required.

Training

Past SETA accredited training initiatives were not successful. An option that uThukela pursues is to become involved with practical in-house training through the Kilbarchan Training Centre. The centre is located close to the Kilbarchan WWTP and students are afforded the opportunity to gain firsthand experience with the operation and equipment used at this plant. Through their contacts with equipment suppliers, uThukela can obtain training material (e.g. pump sections) to assist these students.

Casual labour

For digester cleaning, casual labour can be used as it does not require skilled labour.

Larger scale sand/silt clean out of tanks (more than R 200 000) can be outsourced to contractors.

3.8 Security

To secure equipment and property remains a big challenge. In uThukela Water's case, their plants and pump stations are often in remote areas that are not easily accessible and not continuously manned. To protect against sabotage and theft, it is essential to have adequate plant lighting. As the lights themselves are often first sabotaged, uThukela Water is busy installing high mast, cantilever lights. These lights are high enough to prevent access, while also allowing for easy maintenance through its cantilever action.

By utilising an engineering workshop, security doors can be custom made to prevent theft, for example:

- using stronger material;
- caging in locks to prevent access by tools used for sabotage; and
- making custom sized security doors and cages.



Figure 34: Discarded airbrushes



The following valuable lessons were learnt over the years:

- The brush aeration system is an expensive and high maintenance technology and alternatives should be investigated.
- Attenuation dams are useful to have at pumped processes to minimise spillage during power outages
- It is important to investigate and address the cause and not the symptom.

4.0 LESSONS LEARNT

Brush aerators

At one of uThukela Water's WWTPs, the Pasveer brush aerators were specified incorrectly with the wrong shaft size. Many replacements were made in the past, based on the incorrect specifications. uThukela Water investigated and corrected the specification and solved the problem, however the brush aeration system is still a very expensive technology due to high energy and maintenance costs. Furthermore, it has many components where breakages can occur (bearings, shafts and brushes), which make them difficult and expensive to maintain. The cost to refurbish and upgrade this particular brush aeration system was R 22 million, compared to a new bubble aeration system (which is much cheaper to operate and maintain) at about R 6 million.

Attenuation dams at pumped processes

At one of the WWTPs the inlet works is right at the river bank from where the wastewater is pumped from one unit process to the next. The plant is therefore vulnerable to power interruptions and pump stoppages, as untreated wastewater is directly spilled into the adjacent river. Although generators can be used as backup in the case of a power failure, generators also fail from time to time, are vulnerable to theft and require regular maintenance. A safer solution is to have sufficient attenuation dams in a safer location.

Address cause and not symptom

It is better to fix the cause of a problem than to merely address the symptoms. At one plant 14 broken Pasveer brush aerator shafts were found on site. Upon further investigation it was found that the shafts had broken due to a mechanical error on the shaft drive. Once the drive was fixed, the problem was solved.



Some of the challenges faced by uThukela include:

- Skills retention - training costs are incurred by the municipality and trained staff are drawn to larger towns/cities.
- New staff often have the wrong expectations for the job in hand and proper induction is crucial
- Political interference sometimes prevents the municipality from bringing in skilled persons.
- Conflicting instructions from authorities.

5.0 CHALLENGES

Despite making good progress in the operation and maintenance of the WWTPs, uThukela Water is faced with a number of challenges:

Skills retention

A plant supervisor or operator is required to be skilled, knowledgeable and good decision makers that are keen to learn from observations and take an interest in their work. When such individuals are found and trained, they tend to be drawn to bigger towns and cities where they are offered higher remuneration. A way needs to be found to retain these employees at the plants and for their skills and experience to remain there as well.

Training costs

Often when money is invested in training students, it is 'lost' when the students are drawn away to larger towns/cities. One way to mitigate this problem would be to have the new employer share responsibility for the student's training by compensating uThukela Water retrospectively for training afforded to a particular individual.

Wrong expectations

Another problem is that operators trained at post-matric learning institutions are often not interested in the jobs they were trained for, due to wrong impressions and expectations. It is crucial that proper inductions are done with new candidates/employees to expose them to all aspects of their future work so that they are prepared.

Political interference

In some cases skilled workers cannot be brought in from outside due to political reasons. Some rural chiefs insist that local people be employed, even if they do not have the required skills.

Theft and sabotage

Despite using innovative ways to prevent theft and sabotage, it is still a frequent occurrence at most WWTPs.

Conflicting instructions from authorities

Although the DWA have guidelines for the number of employees required at a WWTP, there often is a lot of pressure from cash strapped local authorities (municipalities) to reduce jobs or not to fill vacancies. Since WWTPs are mostly difficult to access and out of public sight, their budgets (and staff) are easily cut by municipalities. On the other hand, National Government is applying more pressure on Water Service Providers to comply with standards through their Blue and Green Drop initiatives, respectively. Government is also aiming to create jobs through various job creation initiatives – especially in rural areas.



Refurbish – state of being restored to its former good condition.

Replace – to substitute something that is broken, inefficient, no longer working or yielding what is expected with something new.

6.0 DECISION SUPPORT MODEL FOR WWTP UPGRADE

Refurbishment is included in the asset life cycle of Infrastructure Asset Management (IAM) and should be considered as an option before any treatment works is replaced, as this can often lead to cost savings and an extension of the useful life of a plant. Several criteria should be considered in order to make a decision of whether replacement or refurbishment would be the most feasible option.

6.1 Advantages of refurbishments

- 1) Environmental and cost – reduce the need to dispose of large quantities of equipment which may still be usable, as well as rubble from demolition of structures.
- 2) Reduced costs – refurbishments, if planned and designed correctly, result in reduced life cycle costs for the works, while ensuring that the most current discharge limits are being adhered to.
- 3) Land – can reduce or eliminate the need to acquire additional land.
- 4) Time – refurbishments can be completed within a shorter timeframe than building a new plant.

6.2 Advantages of replacement

- 1) New design – it is easier to design to meet specific discharge standards on a new design than to retrofit an existing process.
- 2) Less restrictions – with refurbishments, one has to utilise space available for retrofitting where necessary. There will be cases where equipment cannot be optimally placed due to space constraints.
- 3) Maintenance – Ageing equipment may require additional maintenance.
- 4) Efficiency – Refurbished equipment, such as pumps, can lose efficiency.
- 5) Funds – Funding for new projects are often more readily available than for repair or replacement projects.

The following decision trees were prepared to assist with making a decision on whether to refurbish or replace a wastewater treatment works.

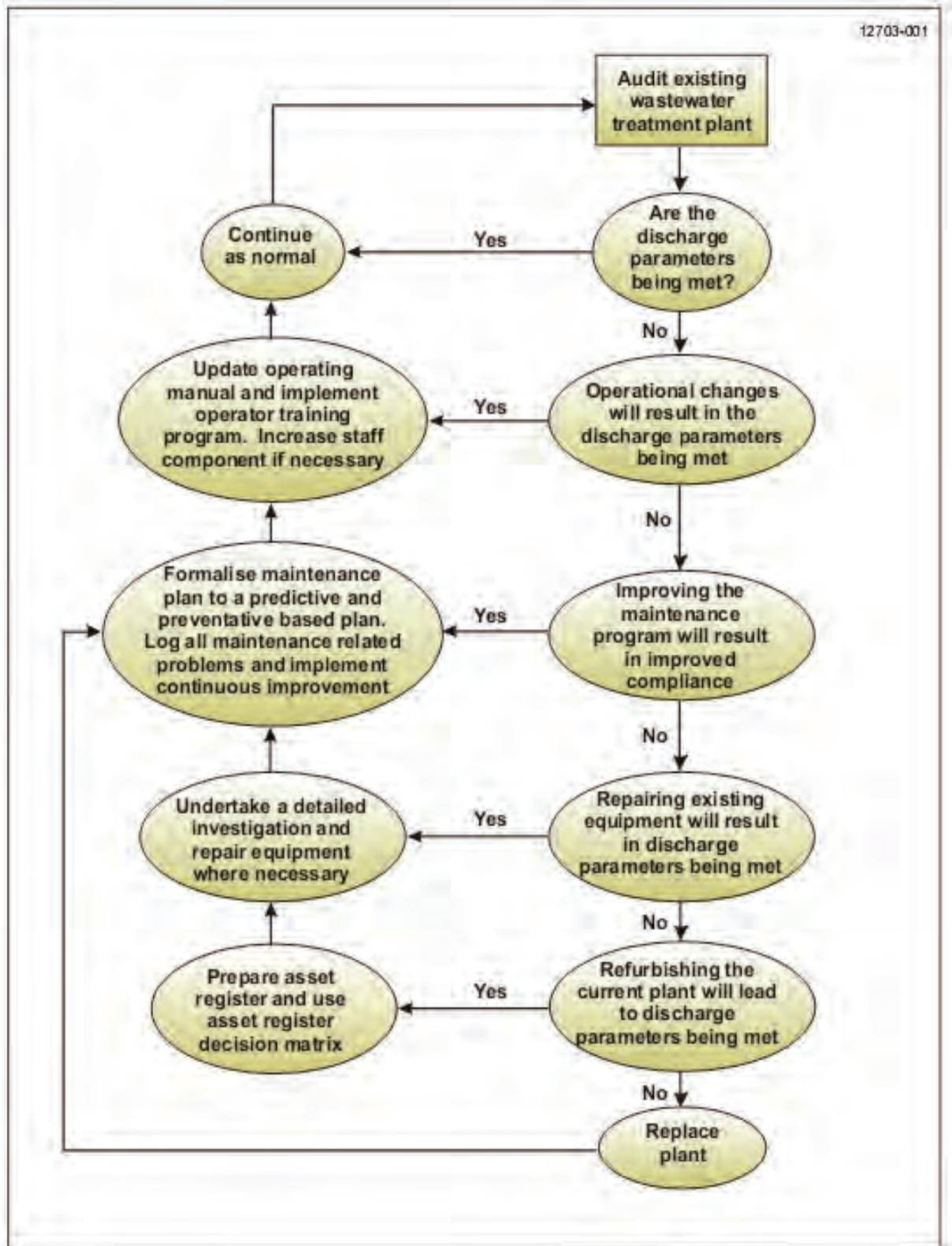


Figure 35: Plant audit decision matrix

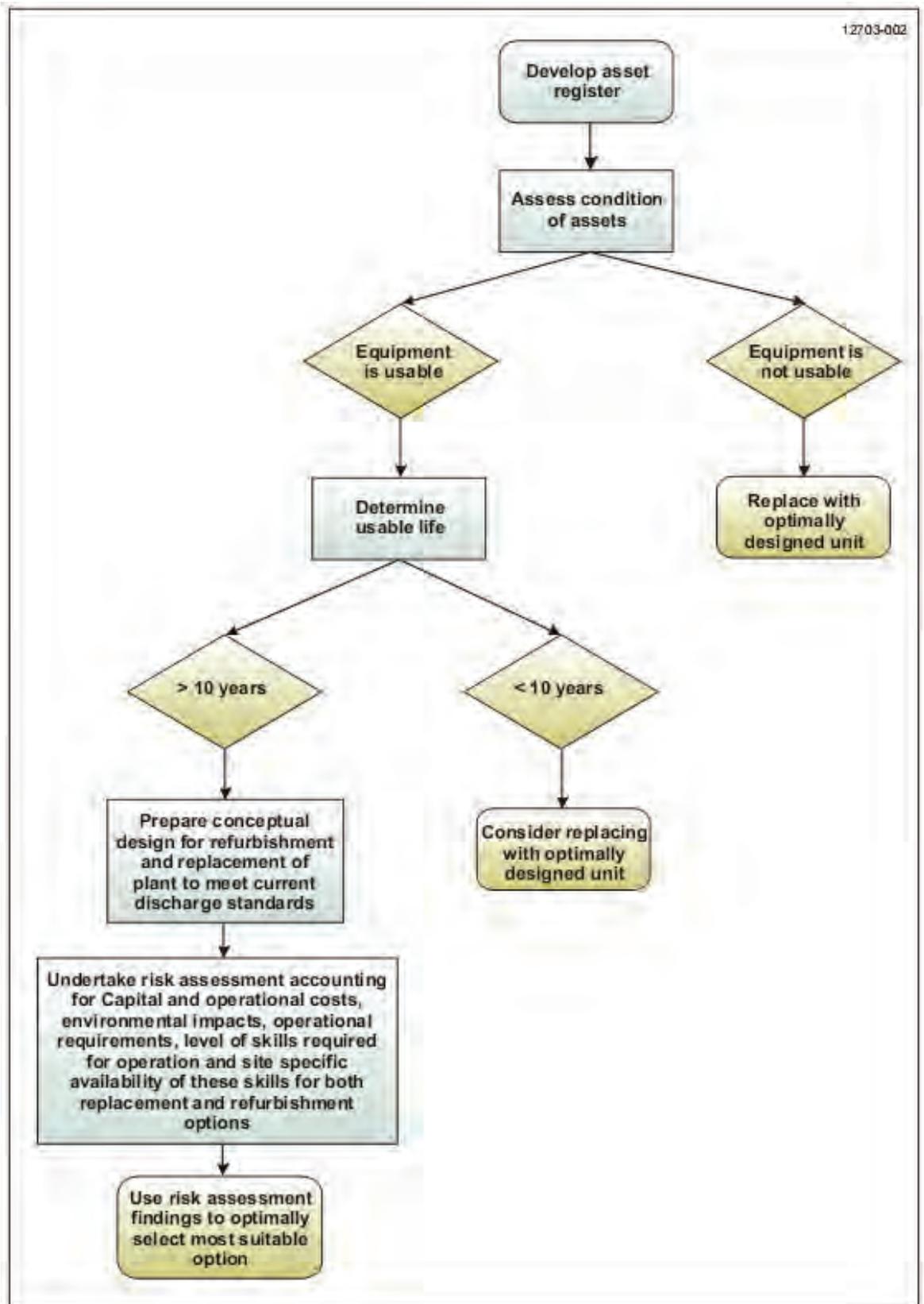


Figure 36: Asset register decision matrix

7.0 CONCLUSION

The case studies confirm that refurbishment and upgrading work done at uThukela Water's WWTPs has resulted in considerable cost savings when compared to replacement costs, while improving the effluent quality.

Specific upgrade/retrofit work comprised of:

- Installing monitoring telemetry at the pump stations;
- Repair eroded concrete;
- Refurbish Pasveer ditches, settling tanks, biofilters, clarifiers;
- Recommission humus tanks and biofilters;
- Refurbish pumps where possible;
- Clean out (remove sand from) Pasveer ditches, reactors, clarifiers, digesters;
- Refurbish aerators or retrofit with bubble aerations;
- Retrofit chlorination systems;
- Repair/refurbish concrete;
- Repair drying beds.

General changes made at the works included:

- upgrading/modifying existing processes;
- reducing down-time;
- mitigating electrical supply outages;
- finding alternative funding;
- raising staff morale; and
- improving security.

Historical effluent quality data for the WWTPs presented in the case studies showed overall improvements. It should be noted that the upgrade/retrofitting of works are not completed in all cases.

Some of the lessons learnt were that it is not always cost effective to refurbish aerators and that bubble aeration should be considered. Attenuation dams are crucial where plant flow is affected through pumping. Investigating and resolving causes and not only treat symptoms can be more cost effective.

Despite good progress, challenges like skills retention, training costs, wrong expectations, political interference, theft and sabotage and conflicting instructions from authorities remain.

Refurbishment should be considered as an option before any treatment works is replaced. Plant audit and asset register decision matrices can be helpful when deciding whether replacement or refurbishment would be the most feasible option for a particular plant. It is important to note that as part of Infrastructure Asset Management, refurbishment is included in the asset life cycle.

APPENDIX A

Daily Flow Rates for 2007, 2009 and 2010

Madadeni WWTTP - Daily In Flow in ML												2007		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Ave.	Est. ann. Total
1	5.683	5.489	5.590	6.283	5.429	4.063	8.241	14.544	14.252	15.710	15.277	16.787	298.345	3580.137
2	4.287	6.876	5.926	5.749	5.472	3.442	8.331	13.971	12.911	15.564	14.758	15.332		
3	3.961	6.283	3.961	3.540	5.457	7.064	8.049	14.530	13.963	13.929	16.113	15.426		
4	7.008	5.749	7.008	8.238	5.264	9.803	8.436	14.327	2.177	15.911	14.961	14.656		
5	5.789	3.540	5.789	6.336	5.722	8.799	8.303	12.800	1.619	20.259	17.630	5.384		
6	5.934	8.238	5.934	5.926	4.724	9.086	8.144	5.595	1.362	26.163	29.434	5.115		
7	5.489	6.336	5.655	5.894	5.176	8.549	8.123	1.639	11.757	20.897	23.010	3.584		
8	6.876	5.655	5.528	5.125	4.995	10.251	8.106	1.369	13.916	29.687	20.761	18.933		
9	6.283	5.528	5.590	4.823	5.300	8.795	7.709	1.728	13.469	32.886	20.361	18.005		
10	5.749	5.900	5.926	5.683	5.459	7.970	7.870	1.549	12.167	20.664	18.067	15.131		
11	3.540	5.926	5.894	4.287	5.194	8.905	7.928	1.628	13.133	22.331	17.387	15.253		
12	8.238	3.961	6.876	3.961	5.262	8.980	8.147	1.543	13.249	22.713	17.168	16.982		
13	6.336	7.008	6.283	7.008	5.442	6.628	8.147	3.490	12.595	19.573	16.166	19.522		
14	5.655	5.789	5.749	5.789	5.700	7.929	8.466	10.539	13.239	19.019	16.016	14.466		
15	5.528	5.934	3.540	5.934	5.425	7.677	8.715	13.227	12.626	17.755	16.485	15.664		
16	5.590	5.655	8.238	5.489	4.788	8.150	8.132	13.483	13.005	16.977	16.963	16.476		
17	5.926	5.528	6.336	6.876	3.642	8.238	8.306	13.192	12.426	16.986	16.625	22.723		
18	5.894	5.900	5.926	6.283	4.695	7.670	8.511	14.411	11.980	17.561	16.268	20.069		
19	5.125	5.926	5.894	5.749	5.687	8.526	12.917	14.148	12.601	17.731	16.122	18.843		
20	4.823	5.894	5.125	3.540	5.536	10.271	12.779	13.280	13.058	16.953	17.770	18.100		
21	5.225	5.125	4.823	8.238	4.428	8.334	14.107	13.348	12.658	16.206	4.692	17.488		
22	3.961	4.823	5.225	6.336	4.241	7.927	14.048	13.056	10.006	17.382	2.847	16.496		
23	7.008	5.225	5.194	5.655	4.365	8.169	13.650	13.309	11.249	17.126	2.589	16.084		
24	5.789	3.961	5.262	5.528	4.272	8.175	11.004	13.812	6.959	16.303	3.321	16.484		
25	5.934	7.008	5.442	5.590	4.406	8.142	13.463	13.682	9.695	14.861	2.568	15.808		
26	5.655	7.008	5.700	5.926	5.002	8.476	13.394	14.240	11.209	13.136	6.958	15.542		
27	5.528	5.789	5.425	5.894	4.943	8.715	13.692	13.218	12.302	14.206	14.323	15.362		
28	5.590	5.934	5.457	5.125	3.957	8.481	14.014	13.455	13.123	13.709	15.957	15.048		
29	5.926	X	5.264	4.823	6.428	8.484	14.593	13.677	13.204	13.975	16.094	14.633		
30	5.683	X	5.722	5.225	9.909	8.403	13.484	14.581	16.281	13.643	17.660	13.827		
31	4.287	X	4.724	X	13.223	X	15.131	14.380	X	14.630	X	14.272		
Total	174.300	161.368	175.006	170.853	169.543	244.102	323.940	331.942	342.791	564.446	444.351	477.495		
Max	8.238	8.238	8.238	8.238	13.223	10.271	15.131	14.581	16.281	32.886	29.434	22.723		
Min	3.540	3.540	3.540	3.540	3.642	3.442	7.709	1.543	1.362	13.136	2.568	3.584		
Ave	5.623	5.763	5.845	5.695	5.469	8.137	10.450	10.708	11.426	18.208	14.812	15.403		
% Loading	46.855	48.026	47.045	47.459	45.516	67.806	87.081	89.232	95.220	151.733	123.431	128.359		
Design Cap.	12. ML/Day													
													% Load	81.485
													Daily ave.	9.778

2007												
Osizweni WWTP - Daily In Flow in ML												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	14.980	21.533	18.188	13.831	10.865	9.225	12.087	11.381	11.230	12.123	17.352	12.695
2	13.875	20.395	17.852	12.419	11.424	10.850	11.866	11.421	11.488	13.226	16.983	11.678
3	15.124	20.074	16.263	12.149	10.483	11.052	11.303	11.368	11.011	12.372	16.177	11.399
4	15.203	19.719	19.279	9.307	11.595	9.809	11.482	11.342	9.581	15.518	16.623	12.706
5	14.863	21.596	17.513	10.541	12.050	9.702	11.447	11.672	9.314	17.295	16.051	13.621
6	14.102	18.119	17.066	11.724	11.815	12.254	11.436	11.755	9.599	17.608	18.463	12.547
7	14.157	21.050	18.819	11.785	11.396	6.075	11.316	11.316	10.985	16.553	18.574	11.595
8	13.863	20.492	17.328	11.015	10.731	6.885	12.127	11.310	11.551	18.828	18.096	11.847
9	13.134	20.547	19.619	11.609	10.579	11.247	11.352	11.759	11.926	18.390	14.472	15.423
10	13.306	20.013	15.953	12.254	11.046	10.741	11.483	9.856	11.030	15.580	13.118	16.431
11	12.872	19.568	13.993	11.756	10.510	10.506	11.319	11.878	10.940	14.147	14.897	13.431
12	13.229	17.517	16.255	12.177	10.801	11.782	11.342	11.551	10.892	16.271	13.017	12.599
13	13.296	16.679	16.129	12.311	11.012	12.039	11.220	11.408	10.825	16.454	10.925	12.993
14	13.646	18.750	17.459	11.863	10.850	11.305	11.485	11.516	11.022	15.299	11.614	13.157
15	13.552	14.330	18.007	11.880	11.051	11.084	11.620	11.255	11.428	13.896	10.567	13.087
16	13.495	11.260	15.554	11.605	10.093	11.230	11.206	11.128	11.159	12.629	11.529	13.646
17	13.345	14.863	16.611	12.938	10.144	11.214	11.119	11.350	10.394	13.465	11.971	15.874
18	13.516	13.526	14.611	12.778	11.152	11.102	5.409	10.972	10.154	14.160	13.716	18.227
19	14.256	14.326	17.699	12.401	11.298	11.067	6.611	12.347	10.363	14.358	13.161	17.685
20	13.210	14.162	24.989	12.586	11.358	11.555	5.679	11.184	9.371	14.958	14.856	17.003
21	14.923	14.738	37.754	12.542	11.039	11.406	11.203	11.374	10.769	14.474	14.230	11.301
22	13.200	14.389	16.921	13.160	11.352	11.255	11.535	11.036	11.264	13.355	15.015	9.585
23	12.488	15.600	15.500	12.083	11.462	11.279	11.389	10.908	10.669	14.573	13.758	8.878
24	12.762	13.046	15.643	12.179	9.546	11.261	11.674	11.660	11.136	14.491	15.789	8.881
25	13.681	14.007	17.475	10.817	9.186	11.024	11.412	11.563	10.725	14.316	13.546	13.353
26	13.384	13.996	15.276	10.367	10.693	10.544	10.657	11.950	11.698	13.591	13.751	13.032
27	12.929	13.450	22.196	12.379	10.317	11.048	10.837	11.894	10.729	14.952	12.645	12.716
28	17.325	12.407	18.564	11.678	9.877	10.950	11.492	11.932	11.355	14.711	11.762	12.999
29	22.008	X	34.953	10.847	9.186	11.425	11.631	10.644	11.330	14.168	12.215	12.298
30	23.859	X	19.754	10.967	12.805	12.029	11.279	11.136	14.995	13.626	12.225	12.084
31	23.093	X	18.058	X	9.997	X	11.271	11.234	X	15.394	X	12.145
Total	456.687	469.952	581.281	355.948	335.693	322.945	336.996	351.700	328.923	460.781	427.128	404.916
Max	23.859	21.596	37.754	13.831	12.805	12.254	12.127	12.347	14.995	18.828	18.574	18.227
Min	12.488	11.260	13.993	9.307	9.186	6.075	5.409	9.856	9.314	12.123	10.567	8.878
Ave	14.732	16.784	18.751	11.865	10.829	10.765	10.871	11.345	10.964	14.864	14.238	13.062
% Loading	98.212	111.893	125.007	79.100	72.192	71.766	72.472	75.634	73.094	99.093	94.917	87.079
Design Cap.	15 Ml/Day											
Monthly Ave.	402.746											
Est. ann. Total	4832.950											
% Load	88.372											
Daily ave.	13.256											

Durnacol WWTP - Daily In Flow in ML												2007		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Monthly Ave.	Est. ann. Total
1	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	19.588	235.060
2	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
3	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
4	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
5	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
6	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
7	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
8	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
9	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
10	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
11	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
12	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
13	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
14	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
15	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
16	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
17	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
18	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
19	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
20	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
21	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
22	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
23	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
24	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
25	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
26	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
27	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
28	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
29	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
30	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
31	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
Total	19.964	18.032	19.964	19.320	19.964	19.320	19.964	19.964	19.320	19.964	19.320	19.964	19.588	235.060
Max	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
Min	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
Ave	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644		
% Loading	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200
Design Cap	2 M/Day													
													% Load	Daily ave.
													32.200	0.644

<i>Dundee WWTP - Daily In Flow in ML</i>												<i>2007</i>
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	11.762	17.926	9.147	8.955	9.241	8.923	7.725	9.141	9.552	11.213	9.892	13.142
2	11.762	18.338	9.862	8.955	9.241	9.266	7.337	8.895	8.614	11.698	11.603	10.385
3	10.526	14.548	9.862	10.077	9.255	9.037	8.617	9.122	8.523	8.030	10.355	9.440
4	10.099	14.548	9.862	9.389	9.317	8.516	8.905	8.624	9.105	7.643	10.135	12.759
5	9.103	14.548	10.052	9.240	8.954	9.073	9.413	8.624	8.927	11.308	9.338	11.854
6	10.405	12.140	11.122	9.874	8.954	8.324	9.667	8.624	9.336	13.985	11.964	9.020
7	10.405	17.147	9.720	9.874	8.954	8.880	8.913	9.406	9.354	18.747	29.377	12.409
8	10.405	26.854	9.058	9.874	7.493	8.524	8.071	9.318	9.098	15.535	18.719	12.581
9	6.034	22.676	9.058	9.874	7.382	8.842	8.299	9.016	8.808	19.303	15.620	13.178
10	8.432	22.676	9.058	9.874	7.456	7.428	8.966	9.016	8.204	23.351	15.490	11.065
11	8.346	22.676	9.058	9.796	9.467	7.949	8.915	8.892	9.182	8.138	12.964	9.347
12	7.672	22.676	9.220	9.325	10.396	9.536	9.306	8.439	9.007	12.478	12.939	11.689
13	7.647	17.230	9.400	10.430	9.273	8.957	9.380	7.650	7.766	9.821	13.543	11.691
14	7.647	15.055	9.325	9.265	9.028	8.728	11.701	8.306	6.651	6.359	11.583	11.108
15	7.647	16.249	9.628	9.265	9.867	9.845	5.647	8.864	6.536	10.809	10.811	11.108
16	9.380	16.677	9.409	9.265	9.882	8.221	8.246	9.446	6.098	8.815	10.519	14.533
17	8.160	13.139	9.409	9.868	9.482	8.221	9.473	9.109	6.122	8.810	11.205	16.785
18	8.449	13.139	9.409	9.287	8.682	8.221	9.787	9.364	8.925	8.659	10.754	18.902
19	11.556	13.139	9.020	8.777	8.134	8.221	8.953	7.716	7.987	13.679	10.742	18.902
20	9.939	11.137	9.711	9.026	10.385	7.915	8.854	8.384	8.156	9.979	11.172	15.437
21	9.939	10.380	9.711	8.345	8.250	8.378	10.014	8.353	8.136	8.487	9.924	14.128
22	9.939	10.148	9.205	8.345	10.179	9.108	9.300	8.711	6.891	7.478	12.962	12.231
23	9.039	11.006	9.140	8.345	9.684	9.485	9.017	8.555	6.409	8.536	17.236	12.021
24	7.125	10.978	9.140	8.819	10.550	8.689	9.534	7.085	5.977	8.792	12.511	10.743
25	8.523	10.978	9.140	8.863	9.609	8.070	8.836	7.306	8.767	8.369	13.963	10.561
26	8.395	10.036	8.690	9.448	9.913	9.036	7.282	8.866	9.159	8.222	11.504	11.837
27	9.187	10.036	8.362	9.152	9.172	8.455	7.423	8.068	8.655	9.764	13.906	10.809
28	9.187	9.070	8.959	9.152	9.007	11.617	6.990	8.420	9.314	9.027	12.326	10.767
29	9.187	X	8.685	9.152	9.400	8.647	6.263	8.627	8.263	8.470	11.463	9.828
30	8.332	X	8.938	9.152	9.935	8.937	7.005	8.627	7.797	9.033	13.333	9.202
31	22.179	X	8.955	X	9.264	X	9.833	8.865	X	9.400	X	8.837
Total	296.408	425.150	290.315	279.063	276.565	263.049	268.672	268.240	245.319	333.938	367.853	376.299
Max	22.179	26.854	11.122	10.430	10.550	11.617	11.701	9.446	9.552	23.351	29.377	18.902
Min	6.034	9.070	8.362	8.345	7.382	7.428	5.647	7.085	5.977	6.359	9.338	8.837
Ave	9.562	15.184	9.365	9.302	9.219	8.768	8.667	8.653	8.177	10.772	12.928	12.139
% Loading	308.437	489.804	302.087	300.068	297.382	282.848	279.575	279.126	263.784	347.490	417.046	391.570
Design Cap.	3.1 Ml/Day (Additional capacity: Biofilter plant, 6 x filters, design capacity 6 Ml/d)											
Monthly Ave.												309.239
Est. ann. Total												3710.871
% Load												329.936
Daily ave.												10.228

Newcastle WWTP - Daily In Flow in ML												2007		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1	18,146	23,922	18,188	18,722	14,550	16,082	10,316	12,317	11,771	17,356	21,127	20,242		
2	18,071	16,491	17,852	19,724	10,388	10,605	14,552	18,111	13,406	18,606	15,645	19,429		
3	17,589	11,085	16,283	15,469	12,215	17,039	12,234	16,614	17,201	20,572	19,371	21,514		
4	15,804	24,370	19,279	20,065	14,918	9,553	13,127	16,021	12,130	17,604	18,023	22,443		
5	19,176	25,518	17,513	20,217	14,115	13,909	7,245	15,093	16,918	24,473	19,070	22,522		
6	16,219	28,691	17,066	21,377	12,649	16,108	12,063	16,075	16,514	30,426	23,548	24,170		
7	15,493	32,964	18,819	19,170	12,838	13,592	13,221	15,715	16,686	34,952	29,205	23,225		
8	17,576	31,795	17,328	16,767	12,968	15,200	11,638	16,532	13,326	27,514	23,628	20,633		
9	16,441	27,062	19,619	17,529	13,540	15,057	10,849	16,552	14,037	27,030	21,092	18,522		
10	18,162	22,401	15,953	17,529	15,110	9,542	13,265	16,417	13,920	32,854	19,525	18,251		
11	18,307	20,526	13,993	18,997	13,488	13,767	14,077	14,819	18,522	24,728	19,129	17,841		
12	14,492	20,038	16,255	17,046	14,954	15,998	18,355	13,374	12,667	25,713	24,462	16,878		
13	15,785	20,523	16,129	23,273	13,145	11,906	9,114	15,699	16,225	23,215	13,403	16,656		
14	16,270	19,923	17,459	17,280	12,005	13,859	13,735	15,804	16,795	21,358	20,361	19,789		
15	17,361	20,725	18,007	16,039	12,853	15,897	14,054	14,701	13,954	21,030	17,545	20,513		
16	17,377	19,574	15,554	19,909	12,340	11,541	12,624	17,069	14,294	17,417	18,070	16,482		
17	23,850	16,585	16,611	24,226	12,016	12,074	14,478	16,631	11,953	19,478	17,228	27,728		
18	11,064	19,566	14,611	22,709	14,847	16,481	11,263	15,363	16,735	20,920	16,634	27,494		
19	16,367	17,201	17,689	21,180	13,159	10,231	15,392	14,354	14,478	20,740	16,549	23,982		
20	15,249	19,356	24,989	20,625	13,733	15,220	18,745	15,201	13,967	19,438	18,215	22,711		
21	17,449	17,528	37,754	17,323	13,628	16,102	12,829	17,236	13,939	18,003	21,853	30,396		
22	15,149	19,006	16,921	16,781	14,060	12,455	12,455	12,948	15,497	21,768	19,917	21,076		
23	16,700	20,593	15,500	19,043	15,995	14,452	11,858	14,750	13,413	18,961	19,238	16,555		
24	16,222	17,132	15,643	19,846	10,959	11,039	12,329	17,044	11,867	20,419	22,411	19,634		
25	16,292	18,116	17,475	18,629	13,609	11,891	12,970	17,576	19,259	21,521	19,516	16,823		
26	15,336	16,713	15,276	16,839	14,983	15,596	12,255	15,449	11,791	21,312	18,629	16,824		
27	25,490	16,979	22,196	16,137	11,885	14,316	13,587	16,961	13,422	16,893	18,836	18,632		
28	21,962	17,172	18,564	16,482	13,628	15,737	11,303	15,051	14,354	12,373	18,071	15,936		
29	15,006	X	34,953	16,642	19,214	14,818	13,629	17,254	16,704	17,141	14,352	14,372		
30	23,494	X	19,754	17,813	14,506	10,316	8,743	16,771	17,704	17,745	15,375	12,710		
31	17,239	X	18,058	X	13,263	X	X	17,980	X	17,443	X	14,255		
Total	539,168	581,545	581,281	563,388	421,598	410,382	382,106	491,482	443,449	669,003	580,028	618,238		
Max	25,490	32,964	37,754	24,226	19,214	17,039	18,745	18,111	19,259	34,952	29,205	30,396		
Min	11,064	11,085	13,993	15,469	10,388	9,542	7,245	12,317	11,771	12,373	13,403	12,710		
Ave	17,363	20,769	18,751	18,780	13,600	13,679	12,737	15,854	14,782	21,581	19,334	19,943		
% Loading	69,570	83,078	75,004	75,118	54,400	54,718	50,947	63,417	59,127	86,323	77,337	79,773		
Design Cap	25 MIDay													
Monthly Ave.													523,472	
Est. ann. Total													6,281,668	
% Load													69,068	
Daily ave.													17,267	

2009												
Durnacol WWTP - Daily In Flow in ML												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
2	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
3	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
4	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
5	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
6	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
7	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
8	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
9	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
10	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
11	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
12	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
13	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
14	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
15	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
16	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
17	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
18	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
19	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
20	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
21	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
22	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
23	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
24	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
25	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
26	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
27	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
28	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
29	0.644	X	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
30	0.644	X	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
31	0.644	X	0.644	X	0.644	X	0.644	0.644	0.644	X	0.644	0.644
Total	19,964	18,032	19,964	19,320	19,964	19,320	19,964	19,964	19,320	19,964	19,320	19,964
Max	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
Min	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
Ave	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644
% Loading	32,200	32,200	32,200	32,200	32,200	32,200	32,200	32,200	32,200	32,200	32,200	32,200
Design Cap	2 Ml/Day											
Monthly Ave.	19,588											
Est. ann. Total	235,060											
% Load	32,200											
Daily ave.	0.644											

2009 Dundee WWTP - Daily In Flow in ML												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	9.817	15.643	24.369	11.019	8.429	9.119	9.087	9.396	9.003	10.135	10.573	11.280
2	10.634	13.663	20.593	8.473	8.429	9.452	9.059	12.378	9.905	11.109	8.867	8.109
3	14.120	11.285	20.276	9.784	8.429	9.303	10.205	9.999	10.421	10.207	11.055	13.234
4	10.925	9.542	17.278	10.742	8.429	9.421	9.071	9.579	10.689	9.547	11.107	12.875
5	8.740	9.131	17.175	9.283	8.429	9.636	8.440	10.717	10.254	9.211	11.141	10.215
6	9.614	7.780	12.300	9.479	8.429	9.871	8.204	9.409	10.727	10.305	11.815	9.725
7	11.669	7.618	12.300	8.212	9.749	9.207	9.656	9.260	10.098	9.309	10.596	10.626
8	11.553	7.931	14.556	9.544	10.935	12.366	8.738	8.458	10.048	9.962	11.120	11.689
9	12.296	6.890	15.587	11.791	9.024	8.941	8.867	8.439	9.940	10.005	12.052	10.945
10	9.553	6.139	15.058	15.711	9.166	10.743	9.080	7.820	10.136	10.150	11.161	11.884
11	20.511	11.838	16.893	9.251	8.736	9.450	9.095	8.212	10.677	10.100	10.726	12.368
12	12.922	9.165	14.271	8.899	9.562	9.945	8.974	8.432	7.074	9.668	10.679	11.777
13	25.984	12.492	15.154	8.602	8.840	10.755	8.445	9.916	9.247	10.543	10.038	11.499
14	20.661	16.193	10.640	9.221	9.194	9.821	9.255	8.974	8.072	10.332	9.957	10.696
15	26.266	13.313	13.847	9.396	10.321	8.096	8.884	7.928	8.596	10.342	9.927	11.705
16	15.709	15.852	14.976	10.794	8.890	8.633	9.063	7.543	9.252	10.156	9.797	10.825
17	12.345	17.316	14.583	9.368	8.775	8.022	9.011	6.540	10.310	10.030	10.188	10.114
18	16.620	15.803	15.352	9.162	7.570	9.342	8.799	9.469	13.176	9.934	10.005	10.095
19	16.214	17.372	13.728	9.294	9.115	9.942	7.744	9.636	10.981	9.578	11.173	10.810
20	12.293	12.300	14.872	10.629	8.782	10.109	8.394	9.887	10.346	10.147	10.629	10.494
21	11.950	9.243	14.382	10.915	9.457	9.971	8.563	10.009	9.676	9.952	12.189	9.580
22	11.066	15.969	15.930	8.936	10.388	9.953	8.437	9.957	10.433	9.886	11.811	9.063
23	11.333	14.191	15.097	8.868	8.907	10.245	8.568	9.641	10.487	10.376	10.383	8.002
24	10.579	12.416	10.183	8.350	8.604	10.163	8.807	9.230	9.933	9.737	10.730	8.340
25	11.799	13.086	14.686	8.770	8.948	10.080	9.058	9.666	9.963	9.405	10.193	6.786
26	10.416	14.284	13.391	8.169	9.029	10.102	9.079	9.509	10.218	8.834	8.414	8.893
27	11.311	15.382	12.855	8.324	8.516	9.873	9.052	10.027	9.380	10.585	7.864	9.845
28	24.544	X	11.901	8.773	9.371	9.052	9.221	9.290	10.167	11.496	8.389	8.329
29	23.417	X	12.004	6.799	9.296	9.492	9.609	8.595	9.818	16.002	10.667	8.765
30	21.420	X	12.238	X	9.239	X	9.717	8.896	X	12.033	X	9.235
Total	447.114	354.441	458.102	285.609	279.852	290.579	277.465	286.152	298.282	318.834	313.117	316.735
Max	26.266	22.604	24.369	15.711	10.935	12.366	10.205	12.378	13.176	16.002	12.189	13.234
Min	8.740	6.139	10.183	6.799	7.570	8.022	7.744	6.540	7.074	8.834	7.864	6.786
Ave	14.423	12.659	14.777	9.520	9.027	9.686	8.950	9.231	9.943	10.285	10.437	10.217
% Loading	144.230	126.586	147.775	95.203	90.275	96.860	89.505	92.307	99.427	102.850	104.372	102.173
Design Cap	10	MI/Day										
Monthly Ave.											327.190	
Est. ann. Total												3926.282
% Load											107.630	
Daily ave.												10.763

2010												
Madadeni WWTP Daily inflows in ML.												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	18.037	19.128	17.997	24.816	17.519	16.670	14.344	2.244	15.592	12.507	0.000	0.000
2	19.162	25.273	18.128	23.012	24.480	15.423	13.387	2.137	15.396	11.209		
3	19.072	21.955	18.147	21.211	19.063	8.352	14.314	2.161	16.791	9.654		
4	17.541	21.861	18.998	21.475	5.559	2.474	17.481	2.256	16.196	6.667		
5	17.952	21.519	19.241	20.491	14.778	2.513	16.022	2.192	16.164	7.167		
6	17.934	21.088	19.107	18.837	18.591	2.399	15.301	2.132	15.789	3.521		
7	17.041	19.590	19.626	21.129	20.725	2.383	13.114	2.138	17.338	1.962		
8	23.161	20.224	17.402	21.411	20.234	16.973	15.445	2.230	16.460	1.962		
9	20.637	20.243	16.843	20.806	20.676	18.288	14.807	2.366	15.768	10.049		
10	18.726	19.731	16.191	20.816	17.370	16.804	14.209	13.774	15.962	18.131		
11	20.419	20.041	16.963	20.424	16.119	14.516	15.037	16.860	16.709	14.288		
12	19.061	19.092	17.771	13.273	15.887	13.621	15.165	16.984	15.664	14.075		
13	18.265	18.855	18.421	16.436	17.641	12.666	16.421	18.130	15.407	7.385		
14	18.009	19.038	17.519	21.357	16.011	14.321	15.414	15.418	14.198	12.450		
15	19.078	18.074	17.428	18.880	21.090	15.254	14.489	18.280	17.185	14.181		
16	20.241	20.571	18.080	25.539	20.442	16.685	13.674	17.844	13.405	12.530		
17	19.513	20.036	21.610	31.724	18.350	12.900	12.486	22.039	15.119	10.387		
18	17.972	20.069	19.900	26.026	19.659	11.945	12.353	16.566	15.441	12.473		
19	18.180	19.996	19.110	26.452	19.770	10.961	6.722	15.507	15.188	16.767		
20	24.064	18.868	18.689	23.874	19.392	6.689	2.969	17.255	4.395	16.322		
21	21.659	18.792	19.808	23.417	18.578	2.487	11.706	18.089	4.313	12.296		
22	20.491	17.673	20.453	22.615	18.822	13.005	11.279	17.121	12.329	3.376		
23	24.370	18.802	17.484	24.393	18.754	16.711	8.813	17.262	14.030	2.699		
24	25.767	18.085	19.319	19.477	16.968	15.587	12.636	16.604	15.046	2.725		
25	26.046	18.822	19.068	22.484	16.863	13.206	11.115	17.090	14.055	2.560		
26	36.031	19.180	19.422	21.074	18.614	11.724	11.393	17.529	15.650	2.500		
27	38.873	19.593	18.798	29.027	17.038	5.999	9.688	17.166	15.599	2.692		
28	34.171	18.258	18.904	19.231	16.848	15.585	2.069	16.259	12.963	2.842		
29	27.364	X	19.419	19.200	6.893	16.798	2.053	16.198	13.954	2.257		
30	25.022	X	19.002	12.414	2.429	15.286	2.243	20.026	12.861	2.334		
31	13.699	X	27.858	X	13.454	X	2.272	15.952	4.128	X		
Total	677.558	554.457	586.706	651.320	528.417	358.225	358.401	397.809	434.967	254.096		
Max	38.873	25.273	27.858	31.724	24.480	18.288	17.481	22.039	17.338	18.131		
Min	13.699	17.673	16.191	12.414	2.429	2.383	2.053	2.132	4.313	1.962		
Ave	21.857	19.802	18.926	21.711	17.046	11.941	11.561	12.833	14.499	8.197		
% Loading	182.139	165.017	157.717	180.922	142.048	99.507	96.344	106.938	120.824	68.305		
Design Cap	12	MI/Day										
Monthly Ave.												
Est. ann. Total												
480,196												
5762.347												
% Load												
131.976												
Daily ave.												
15.837												

2010												
Durnacol WWTP Daily inflows in ML.												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
2	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
3	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
4	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
5	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
6	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
7	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
8	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
9	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
10	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
11	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
12	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
13	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
14	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
15	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
16	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
17	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
18	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
19	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
20	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
21	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
22	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
23	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
24	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
25	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
26	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
27	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
28	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
29	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
30	0.644	X	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.000	0.000	0.000
31	0.644	X	0.644	X	0.644	X	0.644	0.644	X	0.000	X	0.000
Total	19.964	18.676	19.964	19.320	19.964	19.320	19.964	19.964	19.320			
Monthly Ave.	19.606											Est. ann. Total 235.275
Max	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644			
Min	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644			
Ave	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644	0.644			
% Loading	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200	32.200			Daily ave. 0.644
Design Cap	2	MI/Day										

Dundee WWTP Total Daily Inflows in ML.												
2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	8.491	16.894	10.236	12.955	10.816	10.223	10.258	8.663	8.615	0.000	0.000	0.000
2	8.263	16.350	10.197	10.386	10.480	9.789	9.654	8.955	9.285	0.000	0.000	0.000
3	9.179	12.123	11.768	11.195	10.412	9.768	9.431	9.208	8.600	0.000	0.000	0.000
4	8.834	11.814	10.594	10.763	10.671	10.207	9.848	9.530	9.215	0.000	0.000	0.000
5	9.935	12.943	10.674	14.166	10.418	9.797	10.258	9.500	9.029	0.000	0.000	0.000
6	8.936	8.233	9.635	9.904	10.192	9.985	10.973	9.562	9.956	0.000	0.000	0.000
7	9.029	11.226	8.568	11.175	11.368	10.605	12.733	9.380	9.288	0.000	0.000	0.000
8	10.097	9.996	8.651	13.480	11.588	9.976	9.771	9.495	9.768	0.000	0.000	0.000
9	6.447	9.433	9.183	13.099	11.689	9.915	10.690	8.880	8.265	0.000	0.000	0.000
10	10.756	10.022	8.717	12.743	11.688	10.060	9.813	8.774	8.803	0.000	0.000	0.000
11	15.578	10.809	9.240	11.751	11.001	9.734	9.832	10.064	8.892	0.000	0.000	0.000
12	13.676	8.785	8.827	11.589	10.644	9.933	9.819	9.937	8.174	0.000	0.000	0.000
13	17.156	10.015	9.368	11.890	10.385	9.930	8.957	9.530	8.176	0.000	0.000	0.000
14	15.829	9.031	10.278	10.645	10.239	8.944	10.412	8.792	9.582	0.000	0.000	0.000
15	14.067	12.581	10.113	10.858	10.077	9.644	9.060	9.574	9.394	0.000	0.000	0.000
16	14.180	10.459	6.269	10.441	10.592	9.686	11.570	9.005	9.316	0.000	0.000	0.000
17	12.940	12.733	6.883	6.659	9.680	9.644	10.185	9.554	9.177	0.000	0.000	0.000
18	11.759	12.822	10.671	11.417	10.758	10.010	9.531	9.111	8.860	0.000	0.000	0.000
19	15.033	11.725	10.833	10.913	9.966	9.745	9.290	9.631	9.442	0.000	0.000	0.000
20	11.694	9.959	10.100	9.716	10.318	8.428	9.514	9.396	9.453	0.000	0.000	0.000
21	14.338	11.310	10.117	8.900	9.854	9.171	9.853	8.614	9.997	0.000	0.000	0.000
22	12.994	9.334	8.684	10.875	9.328	10.222	9.441	8.958	9.741	0.000	0.000	0.000
23	13.339	10.472	8.881	11.269	9.126	10.587	9.596	8.728	9.716	0.000	0.000	0.000
24	12.425	10.114	6.899	10.545	9.453	11.033	9.829	9.342	8.671	0.000	0.000	0.000
25	13.110	10.782	9.851	10.013	10.109	10.577	9.965	9.229	8.663	0.000	0.000	0.000
26	14.236	11.339	8.608	10.187	7.174	9.860	10.412	8.891	8.411	0.000	0.000	0.000
27	14.657	11.424	8.608	12.783	10.029	9.796	10.262	9.264	8.864	0.000	0.000	0.000
28	15.657	10.260	9.444	20.728	10.691	9.344	10.252	8.621	9.847	0.000	0.000	0.000
29	12.333	X	8.236	10.411	4.518	10.267	9.692	8.621	8.653	0.000	0.000	0.000
30	12.333	X	10.677	8.389	5.233	10.126	9.073	8.621	8.594	0.000	0.000	0.000
31	12.235	X	10.330	X	8.893	X	9.237	8.945	X	0.000	X	0.000
Total	379.536	312.988	291.140	339.845	307.390	297.006	309.211	284.375	273.447			
Max	17.156	16.894	11.768	20.728	11.689	11.033	12.733	10.064	9.997			
Min	6.447	8.233	6.269	6.659	4.518	8.428	8.957	8.614	8.174			
Ave	12.243	11.178	9.392	11.328	9.916	9.900	9.975	9.173	9.115			
% Loading	122.431	111.781	93.916	113.282	99.158	99.002	99.745	91.734	91.149			
Design Cap	10	MI/Day										
Monthly Ave.										310.549		
Est. ann. Total												3726.584
% Load												Daily ave.
												102.467
												10.247

2010 Newcastle WWTP Daily inflows in ML												
Date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	17.611	36.665	25.113	33.396	20.860	16.336	19.008	14.899	14.912	19.224	0.000	0.000
2	17.523	26.479	33.086	30.942	17.273	16.557	14.156	15.590	15.228	8.658		
3	19.606	27.208	27.313	22.907	19.215	15.588	15.029	17.815	13.163	14.446		
4	16.171	28.844	31.124	22.931	20.397	16.066	16.863	14.375	15.698	13.292		
5	18.479	20.364	24.693	28.842	16.559	14.850	15.795	15.392	12.696	17.022		
6	18.288	22.407	24.268	21.862	19.685	12.616	16.507	16.590	16.126	17.873		
7	17.861	21.993	26.314	26.653	17.230	17.312	17.208	14.470	17.484	16.774		
8	15.410	25.079	25.282	25.207	17.243	16.695	15.570	14.875	13.570	18.037		
9	13.676	19.009	18.687	23.135	16.418	12.990	16.618	12.192	16.186	16.165		
10	26.097	22.733	23.819	21.635	17.685	16.605	15.580	14.672	15.201	14.884		
11	25.045	20.974	21.906	20.454	17.691	16.742	14.552	14.159	15.344	19.049		
12	32.001	19.120	19.604	19.636	16.913	18.966	14.058	14.398	17.204	13.966		
13	23.381	18.738	21.210	22.994	18.202	13.340	15.646	15.253	16.263	19.785		
14	24.374	17.196	21.403	19.705	16.360	19.272	14.703	13.114	15.326	22.529		
15	19.555	17.218	16.485	20.808	17.245	15.989	14.761	12.658	16.613	25.216		
16	18.126	27.595	19.788	27.270	17.626	15.989	13.276	15.723	16.411	21.609		
17	17.907	31.981	24.713	23.705	18.670	16.640	15.069	14.102	16.544	13.749		
18	15.255	20.929	23.250	20.523	18.173	14.337	14.617	14.257	17.412	19.597		
19	14.703	21.759	22.185	22.234	18.173	15.858	16.183	14.402	13.047	17.417		
20	40.422	21.759	21.709	22.905	18.499	15.023	12.951	14.451	16.711	17.632		
21	35.261	22.917	17.464	21.739	15.544	16.727	14.312	13.538	16.916	17.092		
22	32.588	15.675	22.548	20.419	16.317	15.292	13.921	13.322	16.855	17.190		
23	27.106	22.384	21.689	19.842	16.775	17.083	14.077	14.637	16.207	16.925		
24	28.887	17.676	23.889	19.478	17.375	15.281	14.424	16.531	15.457	16.925		
25	36.247	20.022	20.730	19.044	15.193	15.067	14.080	15.948	15.714	16.633		
26	46.397	37.972	23.404	18.550	20.378	15.019	14.721	15.516	14.174	19.085		
27	56.721	33.983	15.149	20.030	16.718	13.915	16.420	15.725	16.469	16.466		
28	46.719	28.731	22.491	19.490	15.112	16.898	16.211	12.159	18.062	23.882		
29	51.915	X	17.836	16.711	16.541	15.777	16.301	15.777	14.934	18.981		
30	35.476	X	15.107	19.693	13.411	16.267	17.850	13.075	15.555	17.947		
31	33.419	X	40.992	X	16.662	X	14.860	14.508	X	19.146		
Total	842.227	667.410	712.251	671.740	540.133	475.097	475.327	454.123	471.482	547.096		
Max	56.721	37.972	40.992	33.396	20.860	19.272	19.008	17.815	18.062	25.216		
Min	13.676	15.675	15.107	16.711	13.411	12.616	12.951	12.159	12.696	8.658		
Ave	27.169	23.836	22.976	22.391	17.424	15.837	15.333	14.649	15.716	17.648		
% Loading	108.674	95.344	91.903	89.565	69.695	63.346	61.333	58.597	62.864	70.593		
Design Cap	25	MI/Day										
Monthly Ave.											585.689	
Est. ann. Total											7028.263	
% Load											77.191	
Daily ave.											19.298	

APPENDIX B

Component Specific New WWTP Capital Cost Estimates

Madadeni WWTP

CIVIL CONSTRUCTION AND
MECHANICAL EQUIPMENT(with Anaerobic Sludge)

	ADWF Catered For XM/d	Total Cost for Plant/Extensions			Total Cost
		Civil	Mechanical	Electrical	
Inlet Works	18	1 172 409	1 134 590	377 818	2 684 817
Primary Sedimentation Tanks	18	1 966 822	385 760	128 458	2 480 841
Primary Sludge P/S	18	416 018	226 918	75 564	718 498
Fermenters	0	0	0	0	0
Fermenter Thickeners	0	0	0	0	0
Fermenter P/S	0	0	0	0	0
Equalisation Tank	0	0	0	0	0
Reactor	18	6 209 987	3 191 979	1 062 929	10 464 895
Final Clarifiers	18	4 394 644	1 981 750	659 923	7 036 317
RAS and WAS P/S	18	805 114	1 361 508	453 382	2 420 004
Ferric Dosing	18	151 279	113 459	37 782	302 519
Chlorination Contact Tank	18	1 512 786	378 197	125 939	2 016 922
Chlorination Building and PS	18	431 144	336 595	112 096	879 825
Control Building (BNR)	0	0	0	0	0
Administration Building	18	1 512 786	0	0	1 512 786
Sludge Screening & Building	18	226 918	189 098	62 970	478 986
GBT Feed P/S and Pumps	0	0	0	0	0
Poly Dosing Building	0	0	0	0	0
Linear Belt Thickener Building	0	0	0	0	0
Digester Feed Pumpst. & Pumps	0	0	0	0	0
Filter Belt Pumpst. & Pumps	0	0	0	0	0
Sludge Belt Press Building	0	0	0	0	0
Digesters(Mixing)	0	0	0	0	0
Gas Collection & Gasholder	0	0	0	0	0
Boiler Room & Digester Heating	0	0	0	0	0
Lime Silo + Dosing	0	0	0	0	0
Lime Thickeners	0	0	0	0	0
Sludge Drying Beds	18	3 797 093	453 836	151 127	4 402 057
Workshop	18	453 836	0	0	453 836
Minor MCC Buildings (280 m2)	18	1 512 786	0	0	1 512 786
Emergency Ponds	18	1 512 786	378 197	125 939	2 016 922
Sub-Total		25 876 208			39 382 012
Interconnecting Pipework etc.		5 175 242	0	0	5 175 242
Mass Earthworks-Roads etc		7 762 862	0	0	7 762 862
Preliminary and General Items		11 644 294	1 013 189	337 392	12 994 874
Sub-Total		50 458 606	11 145 074	3 711 310	65 314 990
Add: 10% Cont + 5% CPA		7 568 791	1 671 761	556 696	9 797 248
Total Cost (excl. VAT)		58 027 397	12 816 835	4 268 006	75 112 238
Civil Construction					58 027 397
Mech. Equipment					12 816 835
Electr. Equipment					4 268 006
Sub Total					75 112 238
Engineering Cost					9 013 469
Supervision					3 000 000
Disbursements					1 500 000
TOTAL PROJECT COST(excl. VAT)					88 625 707

Osizweni WWTP

CIVIL CONSTRUCTION AND
MECHANICAL EQUIPMENT(with Anaerobic Sludge)

	ADWF Catered For XM/d	Total Cost for Plant/Extensions			Total Cost
		Civil	Mechanical	Electrical	
Inlet Works	15	1 007 616	975 112	324 712	2 307 441
Primary Sedimentation Tanks	15	1 890 195	331 538	110 402	2 132 135
Primary Sludge P/S	15	357 541	195 022	64 942	617 506
Fermenters	0	0	0	0	0
Fermenter Thickeners	0	0	0	0	0
Fermenter P/S	0	0	0	0	0
Equalisation Tank	0	0	0	0	0
Reactor	15	5 337 115	2 743 316	913 524	8 993 956
Final Clarifiers	15	3 776 936	1 703 196	567 164	6 047 296
RAS and WAS P/S	15	520 060	1 170 135	389 655	2 079 850
Ferric Dosing	15	130 015	97 511	32 471	259 997
Chlorination Contact Tank	15	1 300 150	325 037	108 237	1 733 425
Chlorination Building and PS	15	370 543	289 283	96 331	756 157
Control Building (BNR)	15	188 522	0	0	188 522
Administration Building	15	1 300 150	0	0	1 300 150
Sludge Screening & Building	15	195 022	162 519	54 119	411 660
GBT Feed P/S and Pumps	0	0	0	0	0
Poly Dosing Building	0	0	0	0	0
Linear Belt Thickener Building	0	0	0	0	0
Digester Feed Pumpst. & Pumps	15	260 030	195 022	64 942	519 995
Filter Belt Pumpst. & Pumps	0	0	0	0	0
Sludge Belt Press Building	0	0	0	0	0
Digesters(Mixing)	15	1 781 205	1 261 145	419 961	3 462 312
Gas Collection & Gasholder	0	0	0	0	0
Boiler Room & Digester Heating	0	0	0	0	0
Lime Silo + Dosing	0	0	0	0	0
Lime Thickeners	0	0	0	0	0
Sludge Drying Beds	15	3 283 376	390 045	129 885	3 783 306
Workshop	15	390 045	0	0	390 045
Minor MCC Buildings (280 m2)	15	1 300 150	0	0	1 300 150
Emergency Ponds	15	1 300 150	325 037	108 237	1 733 425
Sub-Total		24 468 822			38 017 330
Interconnecting Pipework etc.		4 893 764	0	0	4 893 764
Mass Earthworks-Roads etc		7 340 646	0	0	7 340 646
Preliminary and General Items		11 010 970	1 016 392	338 459	12 365 821
Sub-Total		47 714 202	11 180 314	3 723 045	62 617 561
Add: 10% Cont + 5% CPA		7 157 130	1 677 047	558 457	9 392 634
Total Cost (excl. VAT)		54 871 333	12 857 361	4 281 501	72 010 195
Civil Construction					54 871 333
Mech. Equipment					12 857 361
Electr. Equipment					4 281 501
Sub Total					72 010 195
Engineering Cost					9 641 223
Supervision					3 000 000
Disbursements					1 500 000
TOTAL PROJECT COST(excl. VAT)					85 151 419

Durnacol WWTP

CIVIL CONSTRUCTION AND
MECHANICAL EQUIPMENT(with Anaerobic Sludge)

	ADWF Catered For XMl/d	Total Cost for Plant/Extensions			
		Civil	Mechanical	Electrical	Total Cost
Inlet Works	2	263 871	255 359	85 035	604 264
Primary Sedimentation Tanks	0	0	0	0	0
Primary Sludge P/S	0	0	0	0	0
Fermenters	0	0	0	0	0
Fermenter Thickeners	0	0	0	0	0
Fermenter P/S	0	0	0	0	0
Equalisation Tank	0	0	0	0	0
Reactor	2	1 397 665	718 410	239 230	2 355 305
Final Clarifiers	2	989 090	446 027	148 527	1 583 644
RAS and WAS P/S	2	138 191	308 431	102 041	544 664
Ferric Dosing	2	34 048	25 536	8 503	68 087
Chlorination Contact Tank	2	340 479	85 120	28 345	453 943
Chlorination Building and PS	2	97 036	75 756	25 227	198 020
Control Building (BNR)	0	0	0	0	0
Administration Building	2	340 479	0	0	340 479
Sludge Screening & Building	0	0	0	0	0
GBT Feed P/S and Pumps	0	0	0	0	0
Poly Dosing Building	0	0	0	0	0
Linear Belt Thickener Building	0	0	0	0	0
Digester Feed Pumpst. & Pumps	0	0	0	0	0
Filter Belt Pumpst. & Pumps	0	0	0	0	0
Sludge Belt Press Building	0	0	0	0	0
Digesters(Mixing)	0	0	0	0	0
Gas Collection & Gasholder	0	0	0	0	0
Boiler Room & Digester Heating	0	0	0	0	0
Lime Silo + Dosing	0	0	0	0	0
Lime Thickeners	0	0	0	0	0
Sludge Drying Beds	2	854 601	102 144	34 014	990 759
Workshop	2	102 144	0	0	102 144
Minor MCC Buildings (280 m2)	2	340 479	0	0	340 479
Emergency Ponds	2	340 479	85 120	28 345	453 943
Sub-Total		5 236 560			8 035 729
Interconnecting Pipework etc.		1 047 312	0	0	1 047 312
Mass Earthworks-Roads etc		1 570 968	0	0	1 570 968
Preliminary and General Items		2 356 452	209 890	69 827	2 636 369
Sub-Total		10 211 293	2 309 892	769 194	13 290 378
Add: 10% Cont + 5% CPA		1 531 694	346 484	115 379	1 993 557
Total Cost (excl. VAT)		11 742 986	2 656 375	884 573	15 283 935
Civil Construction					11 742 986
Mech. Equipment					2 656 375
Electr. Equipment					884 573
Sub Total					15 283 935
Engineering Cost					1 834 072
Supervision					3 000 000
Disbursements					1 500 000
TOTAL PROJECT COST(excl. VAT)					21 618 007

Dundee WWTP

CIVIL CONSTRUCTION AND
MECHANICAL EQUIPMENT(with Anaerobic Sludge)

	ADWF Catered For XMl/d	Total Cost for Plant/Extensions			Total Cost
		Civil	Mechanical	Electrical	
Inlet Works	10	730 268	706 711	235 335	1 672 313
Primary Sedimentation Tanks	10	1 224 985	240 282	80 014	1 545 261
Primary Sludge P/S	10	259 127	141 342	47 067	447 536
Fermenters	0	0	0	0	0
Fermenter Thickeners	0	0	0	0	0
Fermenter P/S	0	0	0	0	0
Equalisation Tank	0	0	0	0	0
Reactor	10	3 888 064	1 988 213	862 075	6 518 352
Final Clarifiers	10	2 737 327	1 234 388	411 051	4 382 766
RAS and WAS P/S	10	376 912	848 053	282 402	1 507 367
Ferric Dosing	10	94 228	70 671	23 533	188 433
Chlorination Contact Tank	10	842 281	235 570	78 445	1 256 296
Chlorination Building and PS	10	268 550	209 858	69 816	548 024
Control Building (BNR)	0	0	0	0	0
Administration Building	0	0	0	0	0
Sludge Screening & Building	10	141 342	117 785	39 222	298 350
GBT Feed P/S and Pumps	0	0	0	0	0
Poly Dosing Building	0	0	0	0	0
Linear Belt Thickener Building	0	0	0	0	0
Digester Feed Pumpst. & Pumps	10	188 456	141 342	47 067	376 865
Filter Belt Pumpst. & Pumps	0	0	0	0	0
Sludge Belt Press Building	0	0	0	0	0
Digesters(Mixing)	10	1 290 925	914 013	304 366	2 509 304
Gas Collection & Gasholder	10	268 550	1 177 851	392 225	1 838 626
Boiler Room & Digester Heating	10	452 295	1 074 201	357 709	1 884 204
Lime Silo + Dosing	0	0	0	0	0
Lime Thickeners	0	0	0	0	0
Sludge Drying Beds	10	2 385 126	282 884	94 134	2 741 944
Workshop	0	0	0	0	0
Minor MCC Buildings (280 m2)	0	0	0	0	0
Emergency Ponds	10	842 281	235 570	78 445	1 256 296
Sub-Total		16 150 699			28 971 939
Interconnecting Pipework etc.		3 230 140	0	0	3 230 140
Mass Earthworks-Roads etc		4 845 210	0	0	4 845 210
Preliminary and General Items		7 267 814	961 833	320 291	8 549 939
Sub-Total		31 493 863	10 590 168	3 523 196	45 597 227
Add: 10% Cont + 5% CPA		4 724 079	1 587 025	528 479	6 839 584
Total Cost (excl. VAT)		36 217 942	12 167 194	4 051 675	52 436 811
Civil Construction					36 217 942
Mech. Equipment					12 167 194
Electr. Equipment					4 051 675
Sub Total					52 436 811
Engineering Cost					6 292 417
Supervision					3 000 000
Disbursements					1 500 000
TOTAL PROJECT COST(excl. VAT)					63 229 229

Newcastle WWTP

CIVIL CONSTRUCTION AND
MECHANICAL EQUIPMENT(with Anaerobic Sludge)

	ADWF Catered For XM/d	Total Cost for Plant/Extensions			
		Civil	Mechanical	Electrical	Total Cost
Inlet Works	0	0	0	0	0
Primary Sedimentation Tanks	25	2 807 109	511 395	170 294	3 288 798
Primary Sludge P/S	25	551 504	300 820	100 173	952 497
Fermenters	0	0	0	0	0
Fermenter Thickeners	0	0	0	0	0
Fermenter P/S	0	0	0	0	0
Equalisation Tank	0	0	0	0	0
Reactor	0	0	0	0	0
Final Clarifiers	25	5 825 887	2 627 164	874 846	9 327 896
RAS and WAS P/S	0	0	0	0	0
Ferric Dosing	0	0	0	0	0
Chlorination Contact Tank	0	0	0	0	0
Chlorination Building and PS	0	0	0	0	0
Control Building (BNR)	0	0	0	0	0
Administration Building	0	0	0	0	0
Sludge Screening & Building	0	0	0	0	0
GBT Feed P/S and Pumps	0	0	0	0	0
Poly Dosing Building	0	0	0	0	0
Linear Belt Thickener Building	0	0	0	0	0
Digester Feed Pumpst. & Pumps	25	401 094	300 820	100 173	802 087
Filter Belt Pumpst. & Pumps	0	0	0	0	0
Sludge Belt Press Building	0	0	0	0	0
Digesters(Mixing)	25	2 747 492	1 945 305	647 786	5 340 583
Gas Collection & Gasholder	0	0	0	0	0
Boiler Room & Digester Heating	0	0	0	0	0
Lime Silo + Dosing	0	0	0	0	0
Lime Thickeners	0	0	0	0	0
Sludge Drying Beds	0	0	0	0	0
Workshop	25	601 641	0	0	601 641
Minor MCC Buildings (280 m2)	0	0	0	0	0
Emergency Ponds	0	0	0	0	0
Sub-Total		12 734 727			20 313 503
Interconnecting Pipework etc.		2 546 945	0	0	2 546 945
Mass Earthworks-Roads etc		3 820 418	0	0	3 820 418
Preliminary and General Items		5 730 627	568 550	189 327	6 488 505
Sub-Total		24 832 717	6 254 054	2 082 600	33 169 371
Add: 10% Cont + 5% CPA		3 724 908	938 108	312 390	4 975 406
Total Cost (excl. VAT)		28 557 624	7 192 162	2 394 990	38 144 777
Civil Construction					28 557 624
Mech. Equipment					7 192 162
Electr. Equipment					2 394 990
Sub Total					38 144 777
Engineering Cost					4 577 373
Supervision					3 000 000
Disbursements					1 500 000
TOTAL PROJECT COST(excl. VAT)					47 222 150

APPENDIX C

Generic New WWTP Capital Cost Estimate Chart

TOTAL COST OF BNR WWTP (excl. VAT) (Nov 2010)

