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CONSTRUCTION ENVIRONMENTAL MANAGEMENT PROGRAMME

FOR THE

PROPOSED UPGRADE OF THE GWAING WASTEWATER TREATMENT WORKS ON ERF RE/464, GEORGE.

APPLICATION IN TERMS OF THE NATIONAL ENVIRONMENTAL MANAGEMENT ACT, 1998
(ACT NO. 107 OF 1998), AS AMENDED, AND THE ENVIRONMENTAL IMPACT ASSESSMENT REGULATIONS, 2014

PREPARED FOR: George Municipality
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DATE: 14 July 2025

DEADP REF NO: 16/3/3/6/7/1/D2/19/0141/24
SES REF NO: 464/UGR/GWWTW/01/24

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Appendix 4 of the EIA Regulations 2014 (as amended 2017).

This Environmental Management Programme has been drafted in accordance with Appendix 4 of the Environmental Impact Assessment Regulations 2014 (as amended 2017). The table below shows how the requirements of Appendix 4 have been included within this Environmental Management Programme.

(1) An EMPr must comply with section 24N of the Act and include— (a)details of– (i)the EAP who prepared the EMPr; and (ii)the expertise of that EAP to prepare an EMPr, including a curriculum vitae;	Appendix D- EAP CV
(b)a detailed description of the aspects of the activity that are covered by the EMPr as identified by the project description;	Section 4 – Description of the Activity
(c)a map at an appropriate scale which superimposes the proposed activity, its associated structures, and infrastructure on the environmental sensitivities of the preferred site, indicating any areas that should be avoided, including buffers;	Section 4 - Description of the Activity
(d)a description of the impact management outcomes, including management statements, identifying the impacts and risks that need to be avoided, managed and mitigated as identified through the environmental impact assessment process for all phases of the development including— (i)planning and design; (ii)pre-construction activities; (iii)construction activities; (iv)rehabilitation of the environment after construction and where applicable post closure; and (v)where relevant, operation activities;	Section 8 - Environmental Impact Management: Planning and Design Phase Section 9 - Environmental Impact Management: Pre-construction Phase Section 10 - Environmental Impact Management : Construction Phase Section 11 - Environmental Impact Management : Post Construction Rehabilitation Phase
(f)a description of proposed impact management actions, identifying the manner in which the impact management outcomes contemplated in paragraph (d) will be achieved, and must, where applicable, include actions to — (i)avoid, modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation; (ii)comply with any prescribed environmental management standards or practices; (iii)comply with any applicable provisions of the Act regarding closure, where applicable; and (iv)comply with any provisions of the Act regarding financial provision for rehabilitation, where applicable;	Section 8 - Environmental Impact Management: Planning and Design Phase Section 9 - Environmental Impact Management: Pre-construction Phase Section 10 - Environmental Impact Management : Construction Phase Section 11 - Environmental Impact Management : Post Construction Rehabilitation Phase
(g)the method of monitoring the implementation of the impact management actions contemplated in paragraph (f);	Section 14 - Roles and Responsibilities Section 16 - Monitoring, Record Keeping and Reporting
(h)the frequency of monitoring the implementation of the impact management actions contemplated in paragraph (f);	Section 14 - Roles and Responsibilities Section 16 - Monitoring, Record Keeping and Reporting
(i)an indication of the persons who will be responsible for the implementation of the impact management actions;	Section 8 - Environmental Impact Management: Planning and Design Phase Section 9 - Environmental Impact Management: Pre-construction Phase Section 10 - Environmental Impact Management : Construction Phase Section 11 - Environmental Impact Management : Post Construction Rehabilitation Phase
(j)the time periods within which the impact management actions contemplated in paragraph (f) must be implemented;	Section 8 - Environmental Impact Management: Planning and Design Phase Section 9 - Environmental Impact Management: Pre-construction Phase

	Section 10 - Environmental Impact Management : Construction Phase Section 11 - Environmental Impact Management : Post Construction Rehabilitation Phase
(k)the mechanism for monitoring compliance with the impact management actions contemplated in paragraph (f);	Section 14 - Roles and Responsibilities Section 16 - Monitoring, Record Keeping and Reporting
(l)a program for reporting on compliance, taking into account the requirements as prescribed by the Regulations;	Section 8 - Environmental Impact Management: Planning and Design Phase Section 9 - Environmental Impact Management: Pre-construction Phase Section 10 - Environmental Impact Management : Construction Phase Section 11 - Environmental Impact Management : Post Construction Rehabilitation Phase Section 14 - Roles and Responsibilities Section 16 - Monitoring, Record Keeping and Reporting
(m)an environmental awareness plan describing the manner in which— (i)the applicant intends to inform his or her employees of any environmental risk which may result from their work; and (ii)risks must be dealt with in order to avoid pollution or the degradation of the environment; and	Section 14 - Roles and Responsibilities
(n)any specific information that may be required by the competent authority.	

DOCUMENT DETAILS

Project Ref. No:	464/UGR/GWWTW/01/24
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Sharples Environmental Services cc (SES) has been actively engaged since 1998 in the fields of environmental planning, assessment and management. Clients include private, corporate and public enterprises on a variety of differing land use applications ranging from large-scale residential estates and resorts to golf courses, municipal service infrastructure installations and the planning of major arterials. The consultants have over 40+ years of combined experience and operate in the Southern, Eastern and Western Cape regions.

MICHAEL BENNETT (**Environmental Assessment Practitioner, Report Writer):**
Michael studied at the University of Cape Town completing a Bachelor of Science degree majoring in Environmental and Geographic Science and Ocean and Atmospheric Science. Michael joined SES in 2014 and has extensive experience in assessments and monitoring and has worked on a variety of technical projects. See Appendix G for his curriculum vitae. Michael is registered with EAPASA as a certified Environmental Practitioner (EAPASA # 2021/3163).

LU-ANNE DE WAAL (**Candidate Environmental Assessment Practitioner, Report Co-Writer**):
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1. Introduction

Sharples Environmental Services cc (SES) has been appointed by *Lukhozi,*on behalf of the *George Municipality* (applicant) to complete the Environmental Management Programme (EMPr) as part of the Basic Assessment Process for the Proposed upgrade of the Gwaing Wastewater Treatment Works on Erf RE/464, George.

The proposed development will trigger listed activities in terms of the Amended Environmental Impact Assessment Regulations of 2014 (GN No. R.324 - 327 of 7 April 2017). Environmental Authorisation is therefore required from the competent authority (Western Cape Department of Environmental Affairs & Development Planning) before construction can commence.

2. About this EMPr

This document is intended to serve as a guideline to be used by *The George Municipality (*as the Implementing Agent) and any person/s acting on behalf of *The George Municipality,* during the pre-construction, construction, post-construction, and rehabilitation phases of the proposed upgrade and development. This document provides measures that must (where practical and feasible) be implemented to ensure that any environmental degradation that may be associated with the development is avoided, or where such impacts cannot be avoided entirely, are minimised, and mitigated appropriately.

This EMPr has been prepared in accordance with the requirements of an EMPr as specified in the Amended Environmental Impact Assessment Regulations, 2014 (GN No. R. 326 of 7 April 2017), and with reference to the "Guidelines for Environmental Management Programmes" published by the Department of Environmental Affairs and Development Planning (2005).

It is important to note that the EMPr is not designed to manage the physical establishment of the upgrade and development *per se* but should rather be seen as a tool which can be used to manage the environmental impacts of the development.

The rehabilitation, mitigation, management, and monitoring measures prescribed in this EMPr must be seen as binding to the George Municipality, and any person acting on its behalf, including but not limited to agents, employees, associates, guests, or any person rendering a service to the development site.

2.1 Important caveat to the report

In the past, some developments have had a devastating impact on the environment even though they have had Environmental Management Programmes in place, while other developments have had a low impact even though no management plans have been compiled.

The Implementing Agent and the attitude of the construction team play an integral role in determining the impact that the development will have on the environment. The ECO (see Chapter 15) needs to ensure that all role-players are "on board" with regard to the constraints that the EMPr places on the development and construction team. The end result relies on cooperation and mutual respect and understanding of all parties involved.

3. How to use this document

It is essential that this EMPr be carefully studied, understood, implemented, and adhered to as far as reasonably possible, throughout all phases of the proposed development. *The George Municipality* must retain a copy of this EMPr, and another copy of this EMPr must be kept on site at all times during the pre-construction, construction, and post-construction rehabilitation phases of the development.

This EMPr must be included in all contracts compiled for contractors and subcontractors employed by *The George Municipality* as this EMPr identifies and specifies the procedures to be followed by engineers and other contractors to ensure that the adverse impacts of construction activities are either avoided or reduced. *The George Municipality* and any appointed contractors must make adequate financial provision to implement the environmental management measures specified in this document.

This EMPr must be seen as a working document, which may be amended from time to time as needed, in order to accommodate changing circumstances on site or in the surrounding environment, or in order to accommodate requests/ conditions issued by the competent authority, the Department of Environmental Affairs & Development Planning. Amendments to this EMPr must first be approved by the competent authority, in writing.

4. Background and Location of the activity

4.1 Background and description

The George Municipality (GM) wishes to upgrade the WWTW an ultimate capacity of 50 MLD (UCT) and 68 MLD (MLE). The phases proposed, with the relevant processes and capacities are summaries below. The commissioning dates for each phase were selected based on a population growth of 4%. The exact dates of implementation will be determined as time progresses and as the demand increase becomes more apparent with actual figures. The 4% growth selected is the worst-case scenario and is used for illustration purposes.

Table 1: Summary of phasing capacities

Phase	Date of commissioning based on 4% population growth	Additional Capacity (MLD)	Total Capacity UCT (MLD)	Total Capacity MLE (MLD)
Existing Plant			8.6	10.4
Phase A	2026	4.6	13.2	17
Phase B	2029	8.8	22	28
Phase C	2041	11	33	42
Phase D	2051	17	50	68

PHASE A

This phase includes:

- 2 additional SSTs for Module A
- 4 SSTs for Module B (can operate with Reactor A)
- New RAS Pumpstation
- New Substation building
- Replacement of the DN450 with a DN950 pipe from the existing chlorine contact channel to the river outlet.
- Electrical Equipment
- Associated road and stormwater infrastructure

Capacity achieved:

- 13.2 MLD ADWF as a Raw UCT process
- 17 MLD ADWF as Raw MLE process

PHASE B

Phase B includes:

- New Inlet Works Train 1
- Regional Grit and Screenings Facility (Construction may be in a later phase or on a separate contract depending on funding availability)
- New biological reactor (Module B)
- New Blower House and aeration system
- Service corridor for air header
- New WAS pumpstation
- Chlorine tank upgrade
- Extension to WAS Dewatering Facility
- New Process Control including Admin Building (Construction of Admin Building may be in a later phase or on a separate contract depending on funding availability)
- Electrical Equipment
- Potentially sludge storage bunds and/or sludge drying facility
- Demolition of sludge drying beds
- Associated roads and stormwater infrastructure

Capacity achieved:

- 28 MLD ADWF as MLE
- 22 MLD ADWF as UCT

PHASE C

This phase includes:

- 1 New biological reactor (Module C)
- Extension of Blower House and aeration system
- 4 new SSTs (Module C)
- Chlorine contact tank upgrade
- New Inlet Works Train 2
- Additional DN950 outlet pipe from existing chlorine contact channel to the river outlet
- Electrical Equipment
- Associated roads and stormwater infrastructure

Capacity achieved:

- 42 MLD ADWF as MLE
- 33 MLD ADWF as UCT

PHASE D

This phase includes:

- 4 New PSTs
- Primary Sludge Pump Station
- 2 Gravity Thickeners (repurpose old PSTs)
- 4 Anaerobic Digesters
- Primary Sludge Dewatering Facility
- Electrical Equipment
- Associated roads and stormwater infrastructure

Capacity achieved:

- 68 MLD ADWF as MLE
- 50 MLD ADWF as UCT

BBF INFRASTRUCTURE LAYOUT

The BBF process comprises primarily of the following infrastructure:

- Guard House
- Perimeter fencing and access gate
- Approximately 30 000 m² of concrete slabs for the various stages of sludge stockpiling, solar drying, composing and sludge handling. This includes the areas under translucent roof sheeting for solar drying.
- Approximately 13 000 m² in plain view of translucent roof sheeting ('greenhouse') structures.
- One 18m x 36m shed with a clear height of 4.5m and without any columns inside the building for the sludge granulation plant.
- A second building of similar footprint for the packaging plant and distribution depot. This building is to include offices, ablution and a canteen for the operating staff of approximately 6 people.
- Movable precast concrete walls placed on slabs to demarcate separated process areas and to prevent contamination of treated sludge by raw sludge.
- Access Roads
- Rainwater collection and storage from all roof structures
- Stormwater collection and drainage from concrete slabs with pipeline to Gwaing WWTW inlet works.

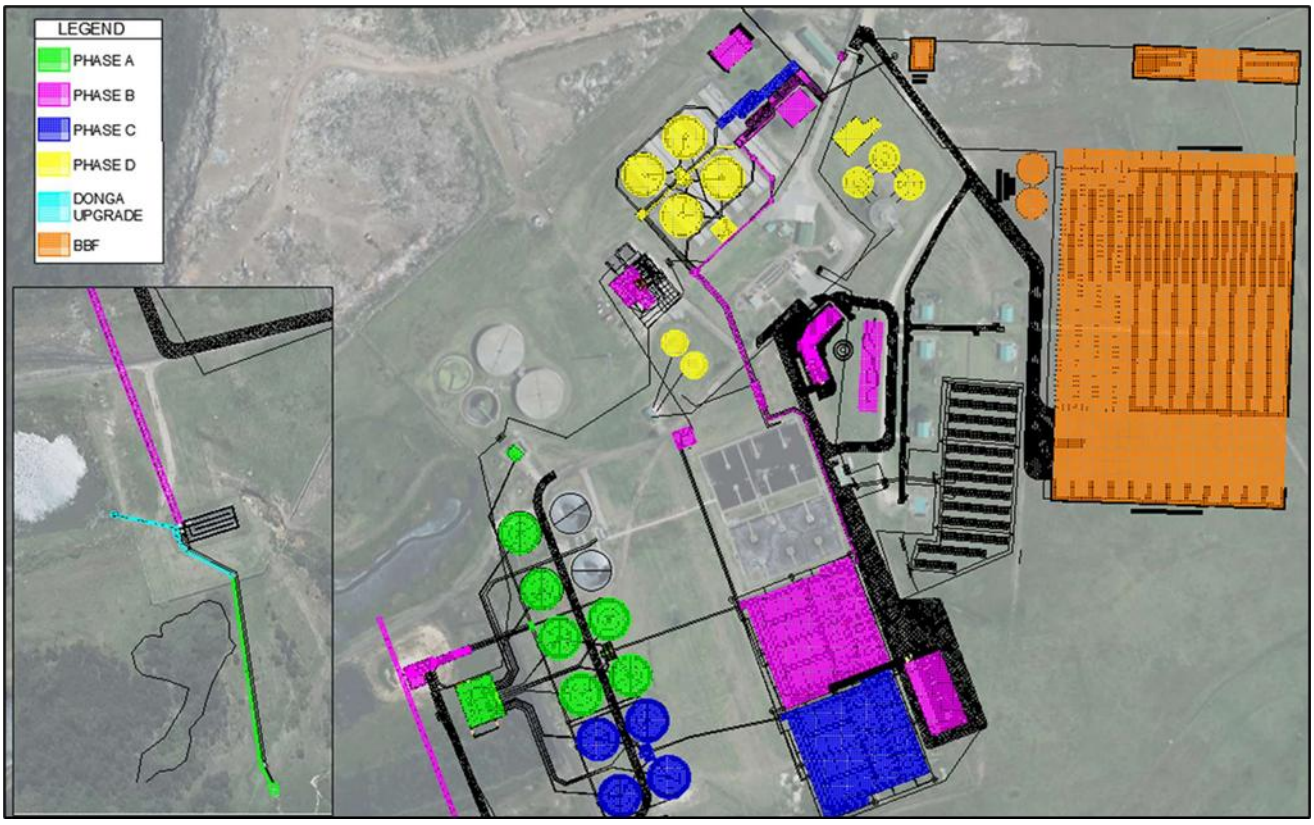


Figure 1: Phased Implementation Site Layout (Donga upgrades excluded from this project)

4.2 Locality

The proposed upgrade of the Gwaing Wastewater Treatment Works will be located on Erf RE/464, George, Western Cape.

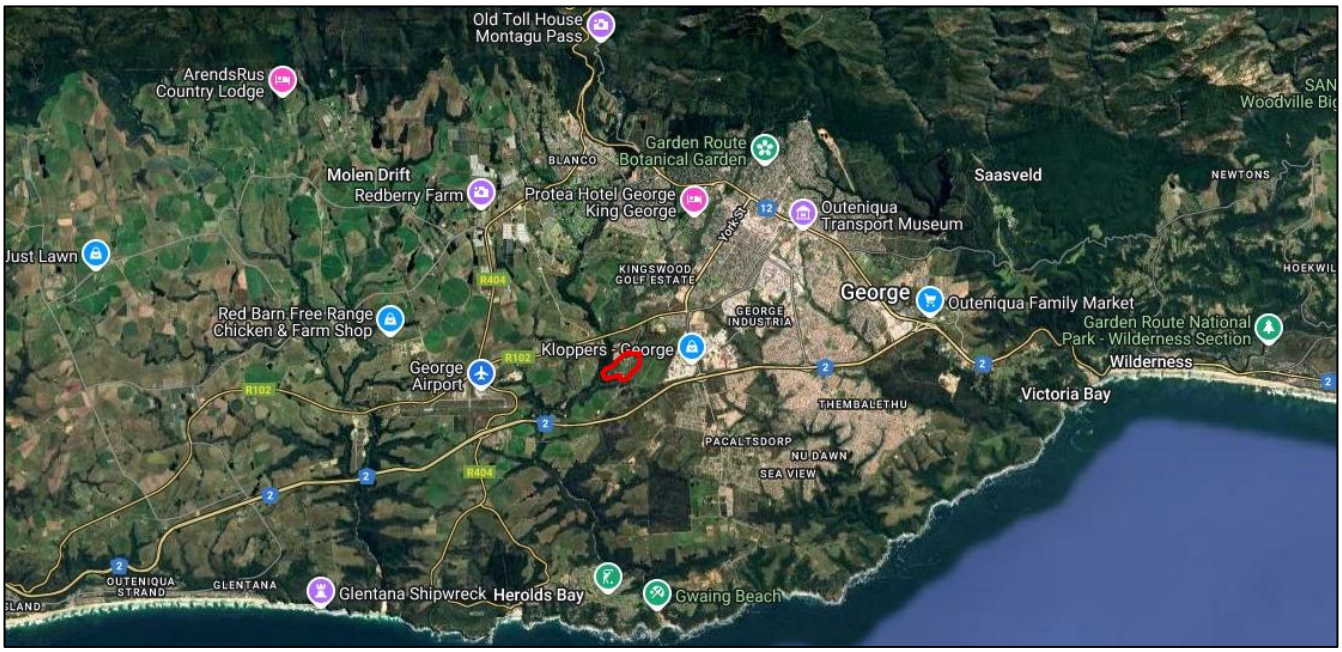


Figure 2: Locality of the Gwaing WWTW and BBF site

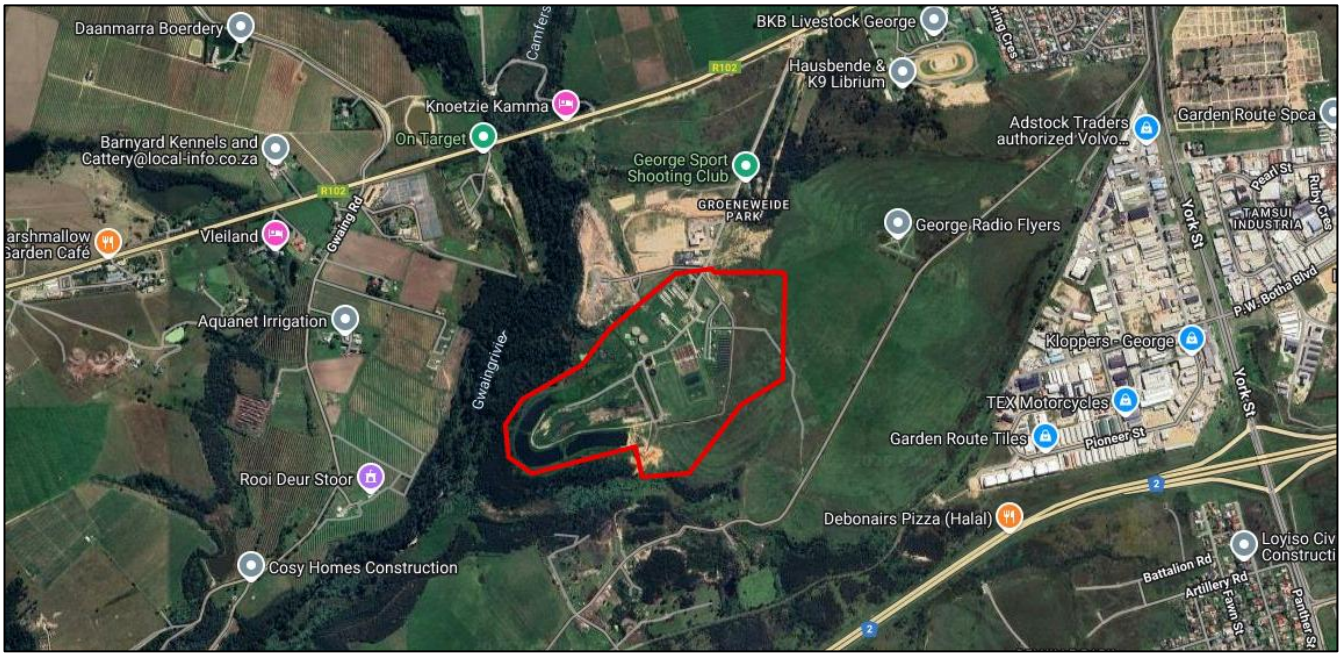


Figure 3: Closer view - Locality of the Gwaing WWTW and BBF site

Table 2: Summary Table: Site and Property Details

Province	Western Cape
District Municipality	Garden Route District Municipality
Local Municipality	George Municipality
Ward number	Ward 23
Erf name	RE/464

Figure 4: Approx GPS coordinates of the site

5. Legal Framework

5.1 Environmental Impact Assessment Regulations (2017)

The following listed activities, in terms of the amended Environmental Impact Assessment Regulations, 2017 (GN No. R. 324 – 327) will be triggered by the proposed development:

Table 3: Listed activities in terms of the amended Environmental Impact Assessment Regulations (2017)

Listed Activity No(s):	Describe the relevant Basic Assessment Activity(ies) in writing as per Listing Notice 1 (GN No. R. 983)
12	The development of— (ii) infrastructure or structures with a physical footprint of 100 square metres or more; where such development occurs— (a) within a watercourse; (c) if no development setback exists, within 32 metres of a watercourse, measured from the edge of a watercourse
19	The infilling or depositing of any material of more than 10 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than 10 cubic metres from a watercourse;
46	The expansion and related operation of infrastructure for the bulk transportation of sewage, effluent, process water, wastewater, return water, industrial discharge or slimes where the existing infrastructure— i) has an internal diameter of 0,36 metres or more; or ii) has a peak throughput of 120 litres per second or more; and (b) where the throughput capacity of the facility or infrastructure will be increased by 10% or more; excluding where such expansion
48	The expansion of—

	(i) infrastructure or structures where the physical footprint is expanded by 100 square metres or more; or (c) if no development setback exists, within 32 metres of a watercourse, measured from the edge of a watercourse;
57	The expansion and related operation of facilities or infrastructure for the treatment of effluent, wastewater or sewage where the capacity will be increased by 15 000 cubic metres or more per day and the development footprint will increase by 1 000 square meters or more.
Listed Activity No(s):	Describe the relevant Basic Assessment Activity(ies) in writing as per Listing Notice 3 (GN No. R. 985)
14	The development of— (ii) infrastructure or structures with a physical footprint of 10 square metres or more;
23	The expansion of— (ii) infrastructure or structures where the physical footprint is expanded by 10 square metres or more, where such expansion occurs (c) if no development setback has been adopted, within 32 metres of a watercourse

5.2 Other applicable legislation

The George Municipality, is responsible for ensuring that all contractors, labourers and any other appointed person/entity acting on their behalf, remain compliant with the conditions of the received environmental authorisation and water-use authorisations, as well as the provisions of all other applicable legislation, including *inter alia*:

- National Environmental Management Act (NEMA) (Act No 107 of 1998, as amended);
- National Environmental Management: Waste Act (Act 59 of 2008);
- Occupational Health and Safety Act (Act 85 of 1993);
- Amended Environmental Impact Assessment Regulations, GN No. R. 324 – 327 (7 April 2017)
- The Constitution of the Republic of South Africa, 1996 (Act 108 of 1996)
- Spatial Planning and Land Use Management Act, No. 16 of 2013 (SPLUMA)
- Infrastructure Development Act, 2014 (Act No. 23 of 2014)
- The National Environmental Management Laws Amendment Act, 2022

The above listed legislation has general applicability to most development applications, and it is *The George Municipality* responsibility to ensure that all contractors and employees are aware of their obligations in terms of these Acts. This EMPr does not detract from any other legal requirements.

6. Scope of this EMPr

This EMPr describes the measures that must be implemented in order to avoid, minimise, manage and monitor the potential environmental impacts of the development, during all phases of the project life cycle, namely:

- Planning and Design Phase
- Pre-construction Phase
- Construction Phase
- Post Construction Rehabilitation Phase

General environmental management measures that must be applied throughout the project lifecycle (as and where applicable) are described in Chapter 7. Additional management measures that must be implemented to address specific impacts that may arise during each phase are provided in **Chapters 8-12** of this EMPr.

7. General Environmental Management

The following general management measures are intended to protect environmental resources from pollution and degradation during all phases of the project life cycle. These measures must be implemented as and where applicable, reasonable and practicable during the pre-construction, construction and post-construction and rehabilitation phases of the proposed development.

7.1 Site access and traffic management
The site is directly accessed from the R102, George.

In general, all construction vehicles need to adhere to traffic laws. The speed of construction vehicles and other heavy vehicles must be strictly controlled to avoid dangerous conditions for other road users. As far as possible care must be taken to ensure that the local traffic flow pattern is not too significantly disrupted, and all vehicle operators therefore need to be educated in terms of "best-practice" operation to minimise unnecessary traffic congestion or dangers. Construction vehicles must therefore not unnecessarily obstruct the access point or traffic lanes used to access the site. Construction vehicles also need to consider the load carrying capacity of road surfaces and adhere to all other prescriptive regulations regarding the use of public roads by construction vehicles. Adequate signage that is both informative and cautionary to passing traffic (motorists and pedestrians) warning them of the construction activities. Signage would need to be clearly visible and need to include, among others, the following: (only where necessary)

- Identifying working area as a construction site;
- Cautioning against relevant construction activities;
- Prohibiting access to construction site;
- Clearly specifying possible detour routes and / or delay periods;
- Possible indications of time frames attached to the construction activities, and;
- Listings of which contractors are working on the site.

Other mitigation measures include:

- ECO to do awareness training with the contractor and labourers before construction commences.
- Ensure appropriate behaviour of operators of construction vehicles.

7.2 Site demarcation
The following areas must be clearly demarcated on site during the pre-construction or construction phases of the development, as appropriate.

7.2.1 Construction working area

Prior to the commencement of any construction activities, the outer boundary of the development area must be surveyed and pegged. The demarcation boundary must be tight around the site, typically allowing a working area of no more than 2.5 m around the development footprint. This demarcation boundary is to ensure that construction activities are restricted to only that area strictly required for the proposed development, and to prevent unnecessary disturbance of soil surfaces and vegetation outside of the development footprint.

7.2.2 No-go areas

Prior to the commencement of any construction activities, all No-Go areas, must be demarcated and must not be disturbed during the construction phase. The construction activities a required to upgrade the outlet structure may result in a disturbance or loss of aquatic vegetation and habitat due to the

proximity of the HGM 2 wetland. For this reason, the HGM 2 Wetland is considered a No-Go area when upgrading the outlet structure. Please note that the No-Go area, as indicated below, will be altered due to the compensation work to be implemented.

No-go areas must be off-limits to all construction workers, vehicles, and machinery during all phases of the development. No vegetation may be cleared from within the no-go areas, and no dumping of any material (waste, topsoil, subsoil etc.) may occur in these areas. Construction workers must be informed of the no-go areas, and if necessary appropriate signage and/or temporary fencing (e.g., droppers with danger tape) can be used to enforce the no-go areas.

Please refer to Figure 5 for the suggested No-Go area of the site. Please note that the No-Go area, as indicated below, will be altered due to the compensation work to be implemented.

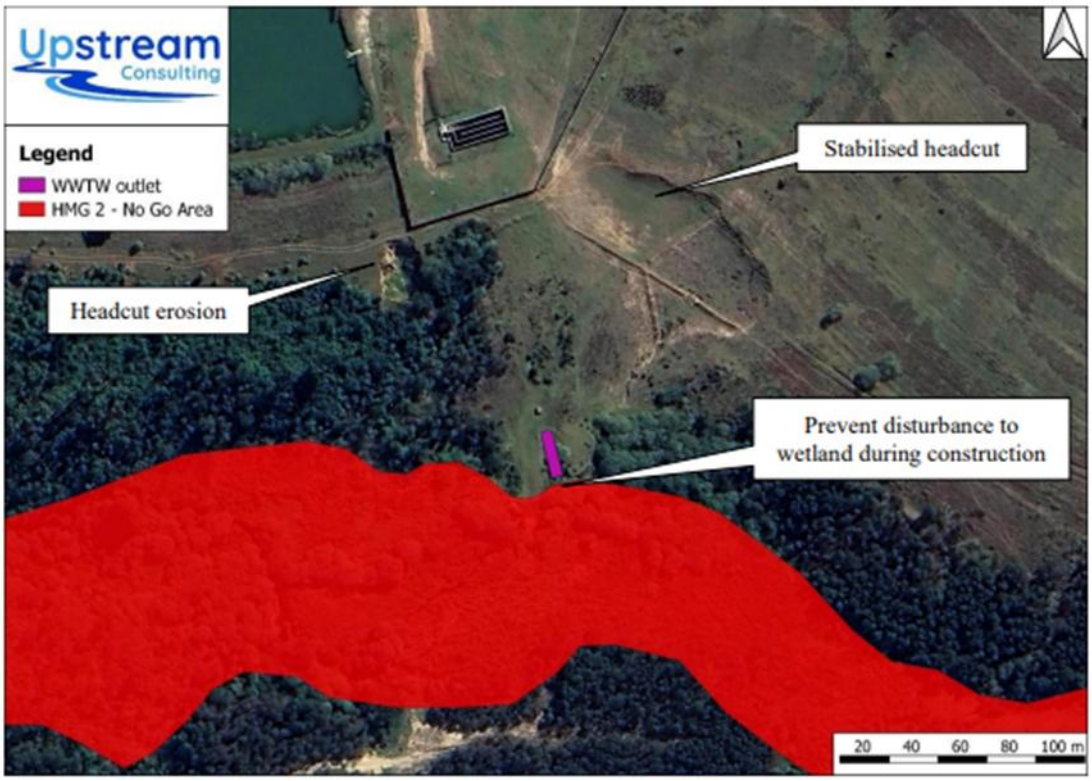


Figure 5: Suggested No-Go areas in red.

7.2.3 Demarcation of the site camp

The area chosen for the site camp and associated facilities must be the minimum area reasonably required to accommodate the site camp facilities, and which will involve the least disturbance to the environment. It is recommended that easily accessible, transformed areas are used for the site camp. Site selection must be done in consultation with the ECO.

7.3 Site camp and associated facilities

The following general management measures pertaining to the set-up, operation and closure of a site camp must be applied where appropriate, reasonable and practicable:

7.3.1 Fencing & Security

The site camp area must be secured to prevent any un-authorised individuals from entering the site camp and possibly getting injured or posing a safety and/or security risk. Adequate signage must be displayed, designating the site office / camp as a restricted area to non-personnel. If required, the site

camp and associated areas may be fenced off along the demarcated boundaries of these areas, preferably with 2 m high fence and shade netting or similar.

7.3.2 Fire Fighting Equipment

No less than 2 fire extinguishers must be present in the site camp. The extinguishers must be in a working condition and within their service period. A fire extinguisher must always be present wherever any "hot works" (e.g., welding, grinding etc.) are taking place. It is recommended that all construction workers receive basic training in fire prevention and basic fire-fighting techniques and are informed of the emergency procedure to follow in the event of accidental fires. No open fires may be made on the construction site during any phase of the project. Construction workers may make small, contained fires (e.g., for warming or cooking purposes), within the site camp provided the small fire is encircled by a corrugated iron structure, drum or similar, to prevent wind-blown cinders from causing fires elsewhere. Such fires may not be left unattended and must be thoroughly extinguished after use. No smoking must be allowed on the construction site. In the case of accidental fires, the contractor must (if required) alert the Local Authority's Fire Department as soon as a fire starts prior to the fire becoming uncontrollable.

7.3.3 Waste Storage Area

Sufficient bins for the temporary storage of construction related waste must be provided inside the site camp and/or at the working area and should be located in such a way that they will present as little visual impact to surrounding residents and road users as possible. Label each waste receptacle for waste separation, and ensure waste is contained either by use of lids or by ensuring waste receptacles are emptied prior to filling up, making them susceptible to wind dispersion. Sufficient signage and awareness should be created to ensure that these bins are properly used.

7.3.4 Hazardous Substances Storage Area

Fuels, chemicals, lubricants and other hazardous substances must be stored in a demarcated, secured and clearly sign-posted area within the site camp away from the watercourses on site. Sufficient signage and awareness should be created to ensure that these bins are properly used. Ensure that when substances are transferred, this is done on an impermeable and/or bunded surface, to contain any spillage. Spillage, should it occur, should be disposed of appropriately.

7.3.5 Potable Water

An adequate supply of potable water must be provided to construction workers at the site camp. It is the Contractors duty to ensure that the labour has adequate access to potable water throughout construction phase, and to monitor weather conditions, to ensure that labour has enough drinking water on hotter days, or construction activity must cease, until conditions are safe to continue.

7.3.6 Ablution Facilities

Chemical toilets should be maintained on the site camp for the duration of the construction phase and rehabilitation, on a level surface and secured from blowing over and located in such a way that the toilets will not cause any form of pollution. As per the SANS10400 requirement, one ablution facility for every 8 male workers and 2 ablution facilities for every 8 female workers will be provided. The contractor must ensure that no spillage occurs when the toilets are cleaned, serviced or moved. The toilet facilities should be emptied on a weekly basis, by an appropriately registered service provider. Proof of this weekly servicing must be obtained and filed in the Environmental File on site. Performing ablutions outside of the provided toilet facilities is strictly prohibited

7.3.7 Eating Area & Rest Area

A dedicated area within which construction site where workers can rest and eat during breaks should be provided within the site camp. Seating and shade should be provided.

7.3.8 Vehicle & Equipment Maintenance Yard

Where possible, construction vehicles and equipment that require repair must be removed from site and taken to a workshop for servicing. If emergency repairs and/or basic maintenance of construction vehicles or equipment are necessary on site, such repair work must be undertaken within the designated maintenance yard area away from any watercourses. Repairs must be conducted on an impermeable surface, and/or a tarpaulin and/or drip trays must be laid down prior to emergency repairs taking place,

in order to prevent any fuel, oil, lubricant or other spillages from contaminating the surrounding environment.

7.3.9 Housekeeping

The site camp and related site camp facilities must be kept neat and orderly at all times, in order to prevent potential safety risks and to reduce the visual impact of the site during construction.

7.4 Vegetation clearing

Where vegetation must be cleared the following measures must be implemented where applicable, reasonable and practical:

- Where feasible vegetation must simply be trimmed to facilitate access/ construction, rather than being completely cleared or removed.
- Vegetation clearing/trimming must be cleared by hand (i.e., brush cut) and stockpiled for use as mulch/ brush-packing during rehabilitation of the site. Any alien vegetation that is cleared must be disposed of in consultation with the ECO, unless the cleared alien vegetation does not contain seeds in which case it may be retained for use in site rehabilitation.
- No bulldozing must be undertaken for the purpose of vegetation clearing.
- Only the areas required to accommodate the construction activities and access to the construction site must be cleared/trimmed of vegetation.
- Vegetation outside of the construction footprint and beyond any No-Go areas must not be cleared.

7.5 Topsoil and subsoil management

It is recommended that topsoil be removed from any area where physical disturbance of the surface will occur, including within the footprint of the development site (working area) and possibly within the site camp, ablution area, vehicle maintenance yard, refuelling area and temporary waste storage area. Topsoil removal and stockpiling must be undertaken only after consultation with the ECO.

- Removed topsoil and subsoil must be stockpiled for the duration of the active construction period and utilised for the final landscaping and rehabilitation of disturbed areas on site.
- The removed topsoil must be stockpiled in a berm, in a demarcated area as agreed with the ECO.
- Removed subsoil must be stockpiled separately from topsoil.
- The topsoil & subsoil storage area must be located on a level area outside of any surface drainage channels and at a location where it can be protected from disturbance during construction and where it will not interfere with construction activities.
- Where applicable topsoil and subsoil stockpiles must be adequately protected from being blown away or eroded by storm water. If necessary, shade cloth or other suitable measures must be used to stabilise and protect the stockpile from wind/water erosion. Topsoil stockpiles must not be covered with tarpaulin, as this may smother and decrease the virility of topsoil.
- Handling of topsoil must be minimised as much as possible, and the location of the topsoil berm must be chosen carefully to avoid needing to relocate the topsoil berm at a later date. The ECO must be consulted with regards to the placement of the stockpiles, to ensure that the selected location is in compliance with this EMPr and EA (once granted).
- Ideally, topsoil is to be handled twice only, once to strip and stockpile, and once to replace, level, shape and scarify.
- If soil stockpiles will be stored for an extended period of time, the stockpiles must be kept clear of weeds and alien vegetation growth by regular weeding, (or application of herbicides if agreed with the ECO).

- Spoil material that will not be re-utilised on site may be removed from site and taken to an appropriate site for re-use or disposal.
- Note that the topsoil must be the final layer applied to a rehabilitated/ re-landscaped site, after subsoil/ spoil material has been placed and shaped on the site.

7.6 Integrated waste management approach

It is recommended that an integrated waste management system is adopted on site. The system must be based on waste minimisation and must incorporate reduction, recycling, re-use and disposal where appropriate. Waste bins for the different categories of recyclable waste (i.e., paper, plastic, metal) must be provided on site. These bins must be emptied, and the waste must be taken to a registered recycling facility. The receipts from the facility must be kept on file and must be available on request. Images 1 and 2 show two such systems within a construction site.

Image 1: Recycling system implemented on a construction site. Skips provided for general waste, plastic, cardboard and metal.

Image 2: Recycling system implemented on a construction site. Lidded bins provided for general waste, plastic, cardboard, and metal.

The non-recyclable and non-reusable waste (e.g., builder's rubble, etc.) generated on site must be stored and disposed of at a landfill site licensed in terms of the applicable legislation.

7.7 Hazardous substances and fuels

If hazardous substances and fuels such as diesel, oil, lubricant, detergents etc. are to be stored on site for construction purposes, a designated area must be set aside for this within the site camp.

- All hazardous substances must be stored in the designated area within the site camp.
- The area selected for storage of hazardous fuels must be located on a level area, well outside of any water courses, water bodies or surface drainage channels.
- The designated area must be clearly demarcated and secured by use of fencing and/or cages, to prevent access by un-authorised persons and/or animals.

- Access to the hazardous material storage area must be restricted to authorised personnel only and must be treated as a no-go zone to unauthorised personnel.
- Appropriate hazard signage indicating the nature of the stored materials must be prominently displayed at the storage area.
- Those persons tasked with handling any hazardous substances must be equipped with the knowledge, equipment, and safety gear necessary to handle the substance/s safely.
- Material Safety Data Sheets (MSDSs) must be available on site for all hazardous chemicals and hazardous substances to be used on site. Where possible and available, MSDSs must additionally include information on ecological impacts and measures to minimise negative environmental impacts during accidental releases or escapes
- Storage vessels of hazardous substances must be situated in an impermeable bunded area large enough to accommodate at least 110% of the capacity of the tank in question. If plastic sheeting is used to line the bunded area, care must be taken to ensure it is not punctured in any way during the course of the construction period.
- Fuel tanks must ideally be elevated so that leaks can easily be detected.
- No smoking may be permitted at or surrounding the area where fuels and hazardous substances are stored.
- Firefighting equipment must be located in close proximity to the storage area.

7.8 Cement and concrete batching

Cement and concrete batching is permitted on site, but may only take place on designated impermeable, bunded surfaces, as agreed with the ECO.

- Cement/ concrete must not be mixed on bare ground.
- Cement/concrete must not be mixed within any drainage lines.
- The impermeable/ bunded area must be established in such a way that cement slurry, runoff and cement water will be contained and will not flow into the surrounding environment or contaminate the soil.
- Cement run-off and excess cement slurry must be collected in the designated impermeable area, allowed to dry and then disposed of at an appropriate facility. Alternately, the contaminated water can be collected in sealed tanks and transported to an appropriate disposal site for disposal.
- Empty cement bags are currently not recycled within the Garden Route and must be disposed of in the un-recyclables waste bins on site.

7.9 Erosion control and stormwater management

Appropriate measures must be implemented to control the flow of storm water across the construction site, to prevent possible flooding, soil loss and dispersion of pollutants. All exposed earth surfaces must also be protected from wind and water erosion. Stripped areas must not remain uncovered for extended periods of time and must be provided with a suitable cover (vegetation, mulch, brush-packing) as soon as possible.

The scale and nature of the erosion and storm water control measures implemented on site must be appropriate to the conditions on site, and sufficient to achieve the desired outcomes (soil preservation, prevention of flooding, storm water control) to the satisfaction of the ECO and consulting engineer.

It may be necessary to implement small-scale erosion protection measures at the construction site, to prevent soil erosion. Such measures may include the use of shade netting, geo-fabric, brush-packing, logs and stakes or similar barriers in areas susceptible to erosion and along exposed slopes. The netting/fabric is placed directly across the path of flow of storm water. Poles and logs, staked in along the contours of a slope susceptible to erosion may also be used.

7.10 Excavations and Earthworks

Any major earthworks with heavy machinery must be under constant supervision and operators are to be aware of all the environmental obligations, as there is always the potential to inflict damage to the sensitive areas. Any unnecessary or excessive heavy machinery movement must be kept to a minimum i.e., only what is absolutely necessary. Areas to be excavated must be clearly demarcated. It may be necessary to demarcate excavations or earthworks along busier haulage routes with orange barrier netting (or a similar product).

All excavated material must be stored on a flat surface away from any drainage line or area susceptible to erosion. The location must be decided upon in consultation with the ECO. Stored material must be protected from wind and water erosion, and this may entail covering the material with suitable shade cloth material or similar (if and when necessary). The shade cloth may need to be weighed down by logs (or similar material) in such a manner that any stream flow is directed away from the stockpile, reducing the risk of erosion.

7.11 Routine groundwater monitoring and sampling

Routine groundwater monitoring and sampling of the newly installed monitoring boreholes should include the following:

- On-site monitoring of water levels in the monitoring boreholes, including the date and time of the measurement taken. A manual water level device (dipmeter) is recommended.
- Groundwater sampling and analyses of groundwater quality, including the date and time of each sample taken. Sampling methods include the following:
    - RECOMMENDED: Sampling utilising disposable bailers to avoid cross contamination.

  Or
    - Water-bearing monitoring boreholes can be purged using a <0.1 litre per second (l/s) pump to remove groundwater, until either three times of the volume of groundwater contained within the monitoring boreholes have been removed, or until the monitoring boreholes are pumped dry. This will aid in the removal of any stagnant water introduced into the boreholes. The sample should be collected prior to the end of pumping. Care should be taken to ensure that all equipment be de-contaminated between boreholes.

7.12 Faunal encounter best practice guidelines

- If any animals are seen on site, a photo or a video should be taken if possible (to assist in identification) and all fauna encountered on site should be reported to the EO or ECO immediately.
- This is particularly important when:
    - An animal is harmed or compromised in any way during construction.
    - Ground-dwelling animals their nests or eggs are unearthed during construction (e.g. moles, tortoise eggs, terrapins/frogs estivating).
    - Any animal with limited mobility is found on site (e.g. tortoises, moles, chameleons). - Any potentially dangerous animal is encountered. This includes any potentially venomous animal (e.g. snakes, scorpions) or any medium-large animal that has become cornered in an enclosed area such that it cannot escape (e.g. porcupines, monkeys, baboons, antelope).It is critical in the case of snakes/ scorpions to get pictures/videos to aid in identification and appropriate treatment of anyone needing medical assistance.
    - Any animal that shows a reluctance to escape or move away from the construction site thereby increasing its exposure to harm or increasing the risk of injuring people on site.
- The EO or ECO should provide guidance or assistance to get all animals to safety, treating any injured animals, and issuing instructions on when to continue with construction (once they are satisfied that all animals have been removed from site) or put additional mitigation measures in place to protect animals on the site from harm.
- For any injured animals or animals to be removed from site (domestic or wild):
    - A local SPCA or animal welfare society can collect and treat most animals and should be the first point of call for assistance. If they cannot directly assist, they will revert and notify the relevant authorities/vets.

- For any assistance with snake removals/relocations, identifications, or bite treatment contact the African Snakebite Institute. The contact details of a suitably qualified snake handler can be found at the following link: https://snakeremoval.co.za/george

7.13 Terrestrial Biodiversity and Botanical Best practice guidelines

- Define access routes and restrict vehicle movement to designated areas using temporary track mats or gravel paths.
- Use light-footprint machinery for construction and maintenance if and where possible.
- Avoid operations during wet conditions to minimize soil deformation.
- Minimize clearance zones to what's absolutely necessary for construction and operation.
- Implement erosion control measures (e.g., jute netting) in cleared areas.
- Rapidly revegetate disturbed areas using fast-establishing pioneer species (do not use NEMBA or CARA listed invasive species like kikuyu).
- Consider establishing a low-maintenance green belt around the facility with hardy, pollution tolerant native species,
    - e.g., Shrubs like Searsia lucida, Diospyros dichrophylla, Leonotus leonurus, Osteospermum moniliferum, Passerina falcifolia, Salvia africana-lutea, Agathosma ovata, and Leucadendron salignum.
    - Groundcovers like Carpobrotus edulis, Pelargonium capitatum, Helichrysum cymosum, and H. petiolare,
    - Graminoids like Eragrostis curvula and Cyperus textilis in wetter areas.

7.14 Compensation work for the loss of an artificial wetland for the BBF

Key rehabilitation measures include:

- Including the recommended rehabilitation in the project scope
- Provision of financial resources for rehabilitation efforts
- Appointment of a qualified engineer to design and implement interventions to rehabilitate the eroded channel
- Stabilisation of the erosion at the discharge outlet in the reach of the HGM2 wetland indicated in the maps below
- Compile a method statement for the removal of alien invasive plant species in the indicated rehabilitation area.
- Provide for the financial resources required for the alien plant clearing as part of this project
- Appoint and monitor the alien plant clearing activities
- Consult with an ecologist throughout regarding rehabilitation

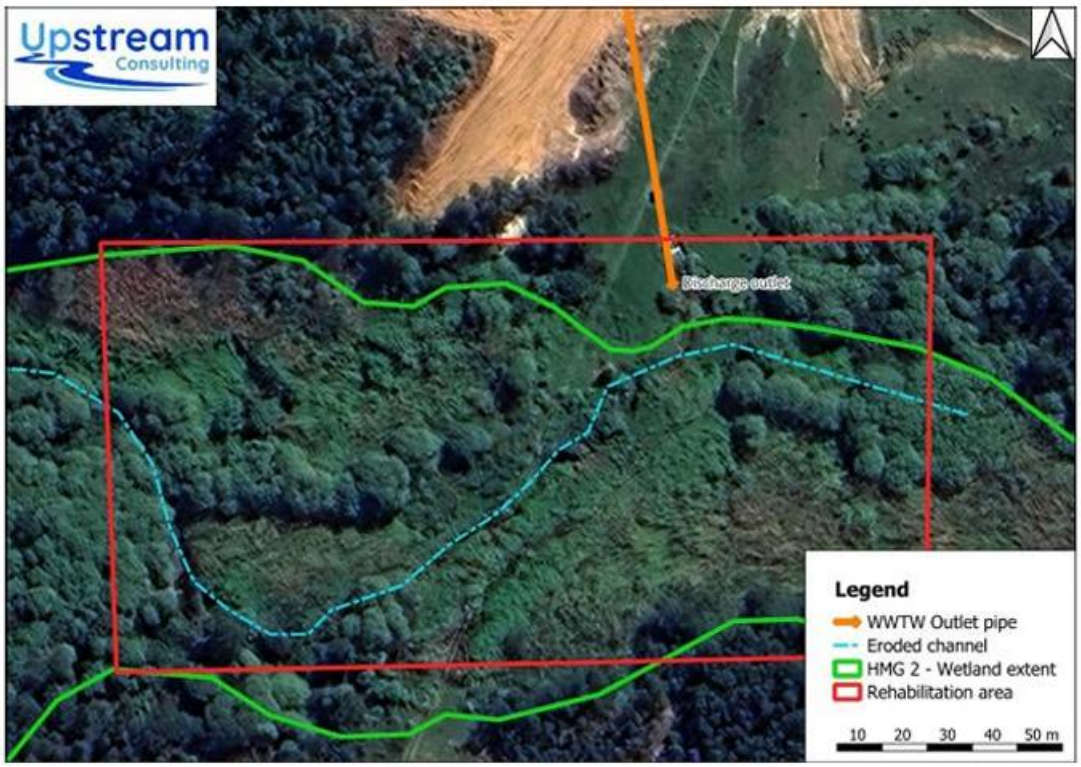


Figure 6: Location of the recommended rehabilitation area

7.14 Site closure and rehabilitation

Upon completion of the construction phase, all disturbed areas, including the working area (disturbance corridor), temporary access roads, and all areas utilised for the site camp and associated site camp facilities will require rehabilitation as follows:

- On completion of the construction operations, the site camp area must be cleared of all site camp facilities, ablution facilities, fencing, signage, waste and surplus material.
- All areas within the working area and site camp that have become devoid of vegetation or where soils have been compacted due to construction activities must be scarified or ripped to improve filtration and reduce run-off.
- All demarcation fencing, including all droppers, wires, netting and barrier tape must be removed from site and taken to an appropriate site for re-use or disposal.
- Surfaces are to be checked for waste products from activities such as concreting or asphalting and cleared in a manner approved by the ECO. Any soil contaminated with oil, fuel or other hazardous substance must be collected and disposed of as hazardous waste.
- All construction waste, litter and rubble is to be removed from the site and disposed of at an appropriate facility. Burying or burning of waste or rubble on site is prohibited.
- Topsoil that was removed and stockpiled before construction, must be replaced by spreading it evenly over the areas from which it was removed. This topsoil (and the seedbank it contains) will facilitate the re-vegetation of the site.
- Disturbed areas, especially areas where excavations have taken place, must be shaped as appropriate (original topography must be restored where possible), and covered with a layer of stockpiled topsoil as soon as possible.
- Any topsoil, subsoil or other excavated material that cannot be utilised during site rehabilitation must be removed from the site and disposed of at an appropriate disposal site.
- The disturbed, newly rehabilitated surfaces (particularly steeper slopes and areas recently covered with topsoil) must be protected from wind & water erosion using mulch, brush packing

or other appropriate erosion protection measures. Brush-packing/ mulching is done by covering the exposed surface with organic plant material such as branches, plant cuttings and leafy material. Ideally the vegetation removed from site at the start of the construction must be utilised. Brush-packing/ mulching plays a valuable role in erosion control, while also promoting re-vegetation of the site by retaining moisture in the soil, introducing seeds and/or trapping wind-blown seeds and providing organic material (compost) to promote new plant growth.

- Final rehabilitation of the site must be done to the satisfaction of the ECO, and must adhere to all conditions/ requirements of the Environmental Authorisation.
- If the site camp was located on the footprint of an erf or road, the location of the site camp must then be rehabilitated in accordance with the site development plan.

8. Environmental Impact Management Planning and design phase

No direct environmental impacts are associated with the planning and design phase. However, poor planning or inappropriate design decisions in this phase may result in environmental impacts arising during subsequent phases of the project.

Planning and design activities must therefore take into account the environmental constraints and opportunities identified during the Environmental Impact Assessment process, in order to avoid or minimise the potential future impacts of the development. Proper planning is also essential to ensure that adequate provision is made to implement the environmental requirements of this EMPr, and to ensure that the development remains compliant with the received Environmental Authorisation.

The environmental management objectives (goals) during this phase are to:

- Appoint an Environmental Control Officer.
- Environmental Control Officer to conduct an inspection prior to the commencement of construction activities on site

These environmental management outcomes, as well as the management actions that must be implemented in order to achieve the desired outcome and avoid/minimise potential impacts are discussed in more detail below.

OBJECTIVE 1: APPOINTMENT OF AN ENVIRONMENTAL CONTROL OFFICER

***Impact Management Objective:* To appoint a suitably qualified and experienced Environmental Control Officer.**			
Potential impact to avoid	Failure to appoint an ECO will result in non-compliance with the Environmental Authorisation and the requirements of the EMPr.		
Impact Management Outcome	The conditions of Environmental Authorisation and the requirements of the EMPr are implemented and monitored during all phases of the development, which will promote sound environmental management on site.		
IMPACT MANAGEMENT ACTIONS			
Mitigation measure		Responsible party	Time period
• A suitably qualified and experienced Environmental Control Officer must be appointed before any activities commence on site. • The appointed ECO must adhere to the requirements stated in Chapter 15 and 17 of the EMPr and any other requirements specified in the Environmental Authorisation. • The appointed ECO must be advised of the construction start date, before any activities commence on site so that the ECO can perform a pre-commencement inspection and plan for environmental awareness training of construction workers.		*The George Municipality*	During design phase
Performance Indicator	A qualified ECO is appointed prior to the commencement of any construction activities (including pre-construction set-up activities) on site.		

OBJECTIVE 2: UPDATE ENVIRONMENTAL MANAGEMENT PROGRAMME

The Environmental Authorisation issued for the development may require certain amendments to be applied to the EMPr. In addition, the final site layout and detailed design may also necessitate the amendment of the EMPr, in order to ensure that the development is accommodated in the EMPr.

Impact Management Objective: ***To ensure the EMPr adheres to the requirements of the Environmental Authorisation and makes provision for the final detailed site layout.***		
Potential impact to avoid	• Failure to update the EMPr in accordance with conditions specified in the EA may result in non-compliance with the EA. • Failure to update the EMPr to accommodate the final detailed site layout may result in non-compliance with the EA.	
Impact Management Outcome	Good environmental management is promoted on site.	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• An independent Environmental Consultant must be appointed to amend the EMPr. • All amendments to the EMPr specified in the EA must be applied to the EMPr unless agreed otherwise in writing with the Competent Authority. • Amendments to the EMPr must be approved in writing by the Competent Authority. • Public participation may be required on the proposed EMPr amendments. The Competent Authority must be consulted for clarity on these requirements.	*The George Municipality*	During design phase
Performance Indicator	An updated EMPr that adheres to the conditions of the EA and that reflects the requirements of the final detailed site layout is approved by the Competent Authority prior to commencing activities on site.	

9. Environmental Impact Management Pre-Construction Phase

Proper set-up during the pre-construction phase can set the foundation for good environmental management during the active construction phase to follow and can avoid potential impacts from arising at a later date.

The Impact Management Objectives for this phase of the project relate to:

- Demarcation of no-go areas and working areas.
- Establishment of site camp and associated site facilities.
- Pre-construction ECO visit.

OBJECTIVE 1: IDENTIFY & DEMARCATE NO-GO AND WORKING AREAS

Impact Management Objective: ***Identify and demarcate no-go areas, working areas and site facilities.***			
Potential impact to avoid	• Insensitive location of working areas and site facilities may result in environmental impacts during construction phase. • Failure to accurately demarcate working areas may result in increased disturbance footprint. • Failure to demarcate no-go (open spaces) areas may result in disturbance to these areas during construction.		
Impact Management Outcome	Future construction activities will be restricted to within the designated areas & environmentally sensitive areas (no-go areas) will be protected from disturbance.		
IMPACT MANAGEMENT ACTIONS			
Mitigation measure		Responsible party	Time period
• The no-go areas must be identified. • Demarcation of working area and no-go areas must be done in accordance with Section 8.2 of this EMPr. • Site camp facilities must be situated as far away from the No-Go areas as possible.		Engineer / Contractor	Pre-construction phase (prior to arrival of construction equipment, machinery, or workers on site)
Performance Indicator	No-go areas, working areas and areas for site camp facilities have been identified and appropriately demarcated to the satisfaction of the ECO, before construction activities commence on site.		

OBJECTIVE 2: ESTABLISH ENVIRONMENTALLY SENSITIVE SITE CAMP & SITE FACILITIES

Impact Management Objective: ***To set up and equip the site camp and associated site facilities in a manner that will promote good environmental management.***		
Potential impact to avoid	• Inappropriate siting of site camp facilities may result in impacts to sensitive resources (e.g. contaminated run-off from refuelling area may contaminate soil). • Failure to properly demarcate and set up site facilities may result in disorganised construction activities and unnecessary disturbance to the site. • Failure to provide the necessary site facilities and/or failure to equip these facilities with the necessary equipment/materials may impede good environmental management & compromise ability to respond to emergencies.	
Impact Management Outcome	Site camp facilities do not impact significantly on environment. The equipment required to implement the provisions of the EMPr are provided on site.	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• The site camp and site facilities described in Section 8 of this EMPr must be provided on site. • The site camp and associated site facilities must be set-up and managed in accordance with the general environmental management measures specified in Section 8 of this EMPr.	Contractor	Pre-construction phase (prior to start of construction activities)
Performance Indicator	Appropriate, well organised and properly equipped site facilities are available on site prior to commencement of construction activities. The location and set up of the facilities does not impact on the natural resources.	

OBJECTIVE 3: PRE-CONSTRUCTION ECO INSPECTION

It is essential that the appointed ECO be advised of the intended construction start date before construction activities commence on site, so that the ECO can conduct an initial site inspection to assess the pre-commencement condition of the site. The ECO can also advise on the appropriate siting and demarcation of the site facilities, and the identification and demarcation of the no-go areas. The ECO may also conduct the first round of environmental awareness training at this stage, if the construction workers are present on site.

Impact Management Objective: ***Environmental Control Officer to conduct an inspection prior to the commencement of construction activities on site.***		
Potential impact to avoid	• Failure to appoint ECO or to notify ECO of commencement prior to commencement will result in non-compliance with the EA. • If a pre-commencement ECO inspection is not performed, the Applicant may be held liable for environmental degradation that took place prior to the Contractor commencing work on site.	
Impact Management Outcome	• Good environmental management is promoted and enforced by the ECO during the full pre-construction and construction phases. • Site facilities are appropriately located on site. • Construction workers receive environmental awareness training before commencing work on site.	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• The appointed ECO must be advised of the construction start date, before any activities commence on site so that the ECO can perform a pre-commencement inspection and plan for environmental awareness training of construction workers.	Contractor	Start of construction phase
Performance Indicator	A pre-commencement site inspection is conducted by the appointed ECO before construction activities commence on site.	

10. Environmental Impact Management Construction Phase

A number of potential environmental impacts may arise during the construction phase of the development. These impacts have been identified and assessed during the Environmental Impact Assessment process. Environmental Management outcomes and actions that will prevent the identified potential impacts from arising – or where avoidance is not possible, that will minimise and mitigate the impact – are provided in this section.

The environmental management actions and mitigation measures prescribed in this section must be implemented throughout the construction phase, and must be implemented in conjunction with the general management measures specified in Chapter 8 of this EMPr as well as any other conditions stated in the Environmental Authorisation. The Environmental Control Officer must monitor and enforce the implementation of the relevant environmental management measures and may provide guidance on the implementation of these environmental management measures as and when required.

The environmental management objectives (goals) for the Construction phase are:

- Prevent erosion and input of sediment into the wetland
- Limit noise and other construction nuisances
- Create employment opportunities
- Support capital expenditure
- Prevent disturbances to aquatic habitat biota
- Prevent changes in water quality

The environmental management actions that must be implemented in order to achieve the desired outcomes and avoid/minimise potential impacts are discussed in more detail in the sections below.

OBJECTIVE 1: TO PREVENT EROSION AND INPUT OF SEDIMENT INTO THE WETLAND

Impact Management Objective: ***TO PREVENT EROSION AND INPUT OF SEDIMENT INTO THE WETLAND***		
Potential impact to avoid	• Erosion • Sedimentation	
Impact Management Outcome	No erosion on site or sedimentation of the wetland during the construction phase	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• Efficient site stormwater management • Stabilise any erosion features upslope of watercourses and do not concentrate flows into wetland • Prevent erosion at outlet and design upgraded structure accordingly • Do not encroach into wetland habitat with excavations or drains • The volume and velocity of water must be reduced through discharging the surface flow at multiple locations surrounding the WWTWs. Effective stormwater management must include effective stabilisation of exposed soil. • Sedimentation must be minimised with appropriate measures. Any construction causing bare slopes and surfaces to be exposed to the elements must include measures to protect against erosion using covers, silt fences, sandbags, earthen berms etc.	Contractor	Construction phase
Performance Indicator	No erosion on site or sedimentation of the wetland during the construction phase	

OBJECTIVE 2: TO LIMIT NOISE AND DUST

Impact Management Objective: ***To limit noise and dust generated by construction activities***		
Potential impact to avoid	• No unnecessary noise should be allowed • No excessive dust generated by the site	
Impact Management Outcome	No avoidable noise or dust impacts emanate from the site during the construction phase	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• Construction should only be allowed during normal construction working hours. • A register will be kept on site in order to report any complaints received. • No unnecessary noise disturbances should be allowed to emanate from the construction site (i.e., loud music).	Contractor	Construction phase

• If required, water spray vehicles will be used to control wind cause by strong winds during activities on the works. • No over-watering of the site or road surfaces. • Wind screens should be used to reduce wind and dust in open areas		
Performance Indicator	No avoidable noise or dust impacts emanate from the site during the construction phase	

OBJECTIVE 3: JOB CREATION

***Impact Management Objective:* To create employment opportunities with potential for skills transfer, for members of the local community.**		
Potential impact to be promoted	• Temporary jobs opportunities • There may be opportunities to transfer skills from more experienced workers to less experienced workers.	
Impact Management Outcome	The local community benefits from the employment opportunities created during the construction phase.	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• No mitigation required for this positive benefit. However, where practical preference must be given to previously disadvantaged individuals from the local community when appointing contractors/ workers. • Skills transfer between members of the workforce should be encouraged	Contractor	Construction phase
Performance Indicator	The majority of the construction team is from the local community, with preference given to historically disadvantaged individuals. Skills transfer from experienced to less experienced workers is actively encouraged on site.	

OBJECTIVE 4: SUPPORT CAPITAL EXPENDITURE

***Impact Management Objective:* To support capital expenditure**		
Potential impact to be promoted	• Capital influx for businesses involved and knock on effect as the businesses that will supply services and materials • General influx of capital into the construction sector support industries	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• No mitigation required for this positive benefit; however, local business should be supported as far as possible	Contractor	Construction phase
Performance Indicator	Local businesses and services are used for the project	

OBJECTIVE 5: PREVENT DISTURBANCES TO AQUATIC HABITAT BIOTA

***Impact Management Objective:* To prevent disturbances to aquatic habitat during the clearing of vegetation and earth works**		
Potential impact to avoid	Disturbances to aquatic habitat biota during the clearing of vegetation or earth works	
Impact Management Outcome	No disturbances to aquatic habitat biota during the clearing of vegetation or earth works	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• A construction method statement must be compiled and available on site. It must consider the no go area and include methods to avoid unnecessary disturbance and prevent material being washed downslope into the wetland. • Any contractor found working within No-Go areas must be fined as per fining schedule/system setup for the project. • It is the contractor's responsibility to continuously monitor the area for newly established alien species during the contract and establishment period, which if present must be removed. Removal of these species shall be undertaken in a way which prevents any damage to the remaining indigenous species and inhibits the reinfestation of the cleaned areas. Any use of herbicides in removing alien plant species is required to be investigated by the ECO before use. • Where vegetation has been cleared in the buffer and open ground in the riparian area has resulted it is recommended that cover components be reinstated appropriately. Only indigenous species are to be considered. • Monitoring by an independent ECO during construction in the outlet area.	Contractor	Construction phase
Performance Indicator	No disturbances to aquatic biota habitat during the clearing of vegetation or earth works	

OBJECTIVE 6: PREVENT CHANGES IN WATER QUALITY

***Impact Management Objective:* TO PREVENT CHANGES IN WATER QUALITY**		
Potential impact to avoid	Water contamination during outlet upgrades	
Impact Management Outcome	No changes in water quality and no contaminated water detected.	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• Habitat restoration of the HGM 2 wetland through alien plant eradication and halting erosion.	Contractor	Construction phase

• The reuse of the effluent, recommended above, will also contribute to mitigating against cumulative water quality change impacts. • The Department of Water Affairs regional office should be notified, as soon as possible, of any significant chemical spill or leakage to the environment where there is the potential to contaminate surface water or groundwater. • Implement continuous monitoring systems to regularly check the quality of the treated effluent • Establish strict maintenance protocols to ensure that all treatment equipment and infrastructure are functioning optimally, preventing any bypass or failure in the treatment process. • Develop and implement emergency response plans to address accidental discharges or treatment failures. This includes having backup systems in place and protocols for immediate action to contain and mitigate any potential impacts on the river. • Improve sludge management to reduce the amount of sludge stockpiles on unlined ground.		
Performance Indicator	No changes in water quality and no contaminated water detected.	

11. Environmental impact management post construction rehabilitation phase

After all construction activities have ceased, the sites must be cleared of all construction related equipment, materials, facilities and waste. In addition all disturbed surfaces – including disturbed areas around the structures and all areas utilised for site facilities – must be stabilised, rehabilitated and provided with a suitable cover. All temporary access roads constructed must rehabilitated and access must be restricted from the public.

The environmental management objective (goal) for this phase is to:

- Rehabilitate all areas disturbed by construction activities in an environmentally sensitive manner
- Prevent changes to the hydrological regime

OBJECTIVE 1: SITE CLOSURE & REHABILITATION

***Impact Management Objective:* To rehabilitate all areas disturbed by construction activities in an environmentally sensitive manner.**		
Potential impact to avoid	• Failure to remove all construction related waste and materials may result in environmental pollution. • Failure to remove all construction related equipment, machinery and site facilities may pose an impact to the natural environment. • Failure to stabilise disturbed surfaces may result in soil erosion and increased storm water run-off, which may limit successful revegetation of the site.	
Impact Management Outcome	• The site is neat and tidy, and all exposed surfaces are suitably covered/ stabilised. • There is no construction-related waste or pollution remaining on site.	
IMPACT MANAGEMENT ACTIONS		
Mitigation measure	Responsible party	Time period
• On completion of the construction operations, the site camp area must be cleared of all site camp facilities, ablution facilities, fencing, signage, waste and surplus material. • Surfaces are to be checked for waste products from activities such as concreting or asphalting and cleared in a manner approved by the ECO. • Any contaminated soil must be collected and disposed of as hazardous waste. • All construction waste, litter and rubble are to be removed from the site and re-used elsewhere or recycled/disposed of at an appropriate facility. • Burying or burning of waste or rubble on site is prohibited. • All areas within the working area and site camp that have become devoid of vegetation or where soils have been compacted due to construction activities must be scarified or ripped.	Contractor	Post-Construction phase

• Topsoil removed during the establishment of the site camp and the working area must be spread evenly over the entire site camp area and all other disturbed/ exposed areas after those areas have been ripped, scarified, shaped and contoured (as required). • Where necessary seeding and planting of vegetation can take place after the replacement of the topsoil. Hardy, drought tolerant, non-invasive plant species must be selected. If needed, a layer of mulch can be applied to the newly shaped/ landscaped and topsoiled areas. The mulch will serve to limit erosion and will promote the re-vegetation of the site by retaining moisture in the soil and providing organic material (compost) for new plant growth. Mulched material must be spread to a depth of ± 50mm – a thinner layer is likely to be ineffective in protecting the site, while thicker layers may suppress plant growth. • All exposed soils and recently topsoiled areas are to be re-vegetated or stabilised to the satisfaction of the ECO, to protect these areas from wind and water erosion. No areas are to be left exposed to erosive forces. Erosion protection measures that can be applied include mulching (described above), the placement of geotextile, onion bags filled with wood chips, brush-packing or other similar measures. • Any topsoil, subsoil or other excavated material that cannot be utilised during site rehabilitation must be removed from the site and reused elsewhere on the property or disposed of at an appropriate disposal site. • Where necessary disturbed soils must be revegetated with the local indigenous vegetation such as that which occurs at the site or provided with other suitable cover. • It is recommended that follow-up alien clearing be conducted 6 months after construction is complete.		
Performance Indicator	• All construction-related materials, equipment, facilities, waste and contaminated soils have been removed from the site. • Compacted soils have been scarified/ ripped and stabilised. • All disturbed/exposed surfaces have been provided with a suitable covering and/or stabilised. • No alien vegetation is evident on site.	

OBJECTIVE 2: PREVENT CHANGES TO THE HYDROLOGICAL REGIME

***Impact Management Objective:* TO PREVENT CHANGES TO THE HYDROLOGICAL REGIME**			
Potential impact to avoid	• Deterioration in freshwater ecosystem integrity and reduction in the supply of ecosystem services		
Impact Management Outcome	• Freshwater ecosystem is not altered. • Ecosystem service supplies are not altered.		
IMPACT MANAGEMENT ACTIONS			
Mitigation measure		Responsible party	Time period
• Effluent will be recycled and pressurized on-site in a wash water ring main for various uses including irrigation, reducing the potable water demand of the WWTW. • Habitat Restoration: Restoring and protecting natural habitats can enhance the river's resilience to changes in water flow and quality.		Contractor	Post-Construction phase
Performance Indicator	• Freshwater ecosystem is not altered. • Ecosystem service supplies are not altered		

12. Emergency Preparedness

12.1 Emergency response procedures

The potential environmental risks that may arise as a result of construction activities must be identified, and appropriate emergency response procedures must be compiled for each emergency scenario. Potential environmental emergencies that require an emergency response include – but are not limited to – unplanned fires, sewage spills, spills of hazardous chemicals, snake bites etc.

- The construction contractor is responsible for ensuring that the requirements of the Occupational Health & Safety Act (OHSA) are adhered to during the construction phase. The Applicant is responsible for ensuring compliance with the OHSA during the undertaking of construction activities.

12.2 Emergency preparedness

The following measures must be implemented, as appropriate, to ensure effective responses to emergencies:

- All workers on site during the construction and maintenance phase must be properly educated about possible emergency incidents that may arise, how to avoid such incidents and how to respond in the event of an incident. "Refresher" training sessions on emergency procedures must be held if needed.
- All workers must ideally be given basic fire-awareness training and advised on basic firefighting and safety techniques. Fire-fighting equipment must be available on site during construction activities (see section 8.3).
- All workers must be trained on how to respond in the event of a spill of a hazardous substance(fuel, chemicals etc.), if hazardous substances are to be used on site.
- A spill kit for containing and/or neutralising spills of hazardous substances (e.g., hydrocarbons) must be available on site at all times, when hazardous substances are present.
- Any incidents of pollution or spillage of hazardous materials during construction must be reported to the ECO as soon as possible. The ECO must then (depending on the nature of the spill) notify the relevant authorities, if needed. A first aid kit must be available on site at all times.
- Emergency contact numbers (including the fire department, police and ambulance) must be prominently displayed on site at all times and regularly updated.
- All emergency incidents must be recorded in a site incident log. The cause of the incident, the measures taken in response to the incident and the efficacy of those measures must also be recorded. This information must be used to inform future emergency preparedness planning, and to avoid prevent similar incidents from arising again.

12.3 Control of emergency incidents

In the event of an emergency incident, Section 30 of the National Environmental Management Act. 1998, must be complied with.

Any incidents must be reported to the relevant authorities and within the prescribed period.

Table 4: NEMA Section 30

30.(1) in this section
(a) "incident" means an unexpected sudden occurrence. including a major emission, fire or explosion leading to serious danger to the public or potentially serious pollution of or detriment to the environment. Whether immediate or delayed.

(b) "responsible person" includes any person who
(i) is responsible for the incident
(ii) owns any hazardous substance involved in the incident; or
(iii) was in control of any hazardous substance involved in the incident at the time of the incident

(c) "relevant authority" means
(i) a municipality with jurisdiction over the area in which an incident occurs
(ii) a provincial head of department or any other provincial official designated for that purpose by the MEC in a province in which an incident occurs:
(iii) the Director-General
(iv) any other Director-General of a national department

(2) Where this section authorises a relevant authority to take any steps. such steps may only be taken by
(a) the person referred to in subsection (1)(c)(iv) if no steps have been taken by any of the other persons listed in subsection (1)(c):
(b) the person referred to in subsection (1)(c)(iii) if no steps have been taken by 20 any of the persons listed in subsection (1)(c)(i) and (c)(ii):
(c) the person referred to in subsection (1)(c)(ii) if no steps have been taken by the person listed in subsection (1)(c)(i):
Provided that any relevant authority may nevertheless take such steps if it is necessary to do so in the circumstances and no other person referred to in subsection (1)(c) has yet taken such steps.
(3) The responsible person or. where the incident occurred in the course of that persons employment. his or her employer must forthwith after knowledge of the incident. report through the most effective means reasonably available.
(a) the nature of the incident
(b) any risks posed by the incident to public health. safety and property
(c) the toxicity of substances or by-products released by the incident; and
(d) anv steps that should be taken in order to avoid or minimise the effects of the incident on public health and the environment to
(i) the Director- General
(ii) the South African Police Services and the relevant fire prevention service:
(iii) the relevant provincial head of department or municipality: and
(iv) all persons whose health may be affected by the incident

(4) The responsible person or. where the incident occurred in the course of that person's employment. his or her employer. must. as soon as reasonably practicable after knowledge of the incident
(a) take all reasonable measures to contain and minimise the effects of the incident. including its effects on the environment and any risks posed by the incident to the health. safety and property of persons;
(b) undertake clean-up procedures:
(c) remedy the effects of the incident:

(d) assess the immediate and long-term effects of the incident on the environment and public health:

(5) The responsible person or, where the incident occurred in the course of thatpersons employment. his or her employer. must. within 14 days of the incident, report to the Director-General. provincial head of department and municipality such information as is available to enable an initial evaluation of the incident, including
(a) the nature of the incident
(b) the substances involved and an estimation of the quantity released and their possible acute effect on persons and the environment and data needed to assess these effects;
(c) initial measures taken to minimise impacts:
(d) causes of the incident, whether direct or indirect. including equipment, technology. system. or management failure; and
(e) measures taken and to be taken to avoid a recurrence of such incident.

(6) relevant authority may direct the responsible person to undertake specific measures within a specific time to fulfil his or her obligations under subsections (4) and (5): Provided that the relevant authority must. when considering any such measure or time period. have regard to the following:
(a) the principles set out in section 2
(b) the severity of any impact on the environment as a result of the incident and the costs of the measures being considered;
(c) any measures already taken or proposed by the person on whom measures are to be imposed, if applicable:
(d) the desirability of the state fulfilling its role as custodian holding the environment in public trust for the people
(e) any other relevant factors.

(7) A verbal directive must be confirmed in writing at the earliest opportunity. Which must be within seven days.

(8) Should
(a) the responsible person fail to comply, or inadequately comply with a directive under subsection (6):
(b) there be uncertainty as to who the responsible person is: or
(c) there be an immediate risk of serious danger to the public or potentially serious detriment to the environment
A relevant authority may take the measures it considers necessary to
(i) contain and minimise the effects of the incident:
(ii) undertake clean-up procedures: and
(iii) remedy the effects of the incident.

(9) A relevant authority may claim reimbursement of all reasonable costs incurred by it in terms of subsection (8) from every responsible person jointly and severally.

(10) A relevant authority which has taken steps under subsections (6) or (8) must. As soon as reasonably practicable. prepare comprehensive reports on the incident. Which reports must be made available through the most effective means reasonably available to
(a) the public:
(b) the Director-General
(c) the South African Police Services and the relevant fire prevention service;
(d) the relevant provincial head of department or municipality: and

(e) all persons who may be affected by the incident.
(11) A person who contravenes or fails to comply with subsection (3), (4), (5) or (6) is guilty of an offence and liable on conviction to a fine not exceeding R1 million or to imprisonment for a period not exceeding 1 year, or to both such a fine and such imprisonment.

13. Method statements

The Competent Authority and/or the ECO may require the Applicant or Construction Contractor to submit Method Statements for one or more construction-related activity, or any aspect of the management of the site, before the activity is undertaken or during the performance of the activity if the activity is causing or may cause significant environmental damage or pose a health and safety risk.

Method Statements need not be complex and lengthy, but must clearly state **how**, **when** and **where** the activity concerned will be undertaken, and must specify **who** will be responsible for undertaking each component of that activity. Method Statements must be prepared by the Construction Contractor and submitted to the ECO for approval before undertaking the activity concerned.

The ECO and / or Competent Authority have the authority to request method statements for other activities, including but not limited to:

- Establishment of site camp and stockpile area.
- Cement/ concrete batching, disposal and emergency contingencies.
- Topsoil and sub-soil storage/ stockpiling.
- Storage of fuels and hazardous chemicals and emergency contingencies.
- Waste management system.
- Storm water management and control.
- Emergency preparedness plan / emergency response procedure (see Chapter 13).

The ECO has the authority to prevent activities from being undertaken until such time as a satisfactory Method Statement has been submitted to the ECO and approved by the ECO.

14. Roles and Responsibilities

This EMPr, once approved by the competent authority (DEADP), should be seen as binding to the Applicant, and any person acting on the Applicant's behalf, including but not limited to agents, employees, associates, contractors and service providers.

The Applicant and all other persons who may be directly involved in the development are also bound by their general Duty of Care, as stated in Section 28 of the National Environmental Management Act, 1998:

Duty of Care:

"Every person who causes, has caused, or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm cannot reasonably be avoided or stopped, to minimize and rectify such pollution or degradation of the environment"

14.1 Duties and Responsibilities of the Applicant

The Applicant is ultimately responsible for ensuring that the environmental management measures specified in this EMPr, as well as any other conditions specified by the competent authority, are implemented and adhered to during the construction phase of the proposed development.

The Applicant or party delegated by the applicant is responsible for monitoring during the construction phase. The Applicant must ensure that all appointed service providers, contractors and workers are capable of complying with all statutory requirements of this EMPr and the conditions of the Environmental Authorisation. The Applicant is responsible for ensuring that this EMPr and the conditions of the Environmental Authorisation are implemented and adhered to during construction activities undertaken by the Applicant.

The Applicant or appointed consultant is responsible for identifying emergency situations that may arise during operational activities undertaken by the Applicant and must formulate appropriate emergency response procedures for these emergency scenarios.

14.2 Duties and Responsibilities of the Contractor

The "Construction Contractor" is the entity responsible for undertaking the physical construction of the residential development. The construction contractor is responsible for ensuring that all environmental management measures specified in this EMPr and in the EA are implemented during the pre-construction, construction and post-construction rehabilitation phases, unless agreed otherwise with the Applicant. The contractor will be responsible for all costs incurred in the rehabilitation of the site and for ensuring effective environmental management during construction. The contractor must therefore make adequate financial provision for the implementation of all prescribed measures.

It is strongly recommended that the Construction Contractor appoint an Environmental Site Officer (ESO), who will act as the Contractor's representative to monitor and enforce compliance with the conditions of this EMPr, throughout all phases of construction.

In addition to the above, the Construction Contractor is responsible for the following:

- Identify emergency situations that may arise as a result of construction activities and formulate appropriate emergency response procedures (see Chapter 13).
- Ensure that all construction workers, including sub-consultants and service providers, undergo environmental awareness training prior to commencing work on site, or as soon as possible thereafter (see Chapter 16).
- Compile the required method statements, which must be to the satisfaction of the ECO, before commencing with the activity to be governed by the method statement (Chapter 14).
- Respond to concerns or issues identified by the ECO, as relates to environmental management, and implement the appropriate management or remediation measures, at the Contractor's own expense (unless agreed otherwise)
- Should third parties be called to the site to perform clean up and rehabilitation procedures, the Construction Contractor will be responsible for all associated costs.

Note that failure to comply with the requirements and conditions of this EMPr and the Environmental Authorisation may result in fines or other penalties being levied against the Construction Contractor by the Competent Authority.

14.3 Duties and Responsibilities of the ECO

The appointed Environmental Control Officer (ECO) is responsible for undertaking regular site visits to monitor and report on the implementation of the EMPr and adherence to the conditions of the Environmental Authorisation during the pre-construction, construction and post-construction rehabilitation phases. The ECO is not required to monitor the site during the operational phase of the development.

Competency of the ECO

The ECO must be independent of the Applicant, Engineer, Construction Contractor and their service providers. The appointed ECO must be suitably qualified and experienced, and must be able to demonstrate that he / she is of sufficient competency to undertake the required task. The ECO should preferably be a resident in close proximity to the development area to ensure quick response if required. The ECO must work in close co-operation with the Construction Contractor, resident engineer or ESO (where applicable) and all contractors in order to identify potential problems before they occur, and provide suitable guidance as to how the identified problems (environmental impacts) can be avoided.

Duties of the ECO

The duties of the ECO include, but are not limited to:

- Conduct a pre-construction site inspection to ascertain the pre-commencement condition of the site (i.e. the status quo) and determine whether faunal search-and-rescue is required;
- Conduct environmental awareness training (see Chapter 16);
- Undertake regular site visits to monitor compliance with all mitigation, monitoring and management measures contained in the EMPr and the Environmental Authorisation, during the pre-construction, construction and rehabilitation phases of the development (see section below regarding frequency of ECO visits).
- Evaluate the achievement of the performance indicators associated with each impact management outcome specified in this EMPr (Chapters 9-12)
- Liaise with site contractors, engineers and other members of the development team with regard to the requirements of the EMPr;
- Provide guidance as and when required regarding the implementation of the environmental management measures contained in the EMPr and EA, so as to assist the Applicant and contractor in remaining compliant with these measures;
- Assist in finding environmentally acceptable solutions to construction problems;
- Ensure that the working area, site camp facilities, access roads and no-go areas are properly demarcated;
- Ensure that proper topsoil management practices are adhered to on site;
- Ensure that proper waste management & pollution prevention strategies are practised on site;
- Examine method statements;
- Email contractors with potential non compliance notices in case of contravention of the EMPr;
- Ensure satisfactory rehabilitation of disturbed areas on site, after construction is complete;
- Keep detailed records of all site activities that may pertain to the environment, and produce compliance-monitoring reports (ECO Reports) for submission to the Applicant, and the Competent Authority at regular intervals during the construction phase;
- Submit a final post-construction inspection report, within 6 months of completion of the construction phase. The audit report must detail the rehabilitation measures undertaken,

describe all major incidents or issues of non-compliance and any issues or aspects that require attention or follow-up.
- All ECO Reports and Inspection Reports must be submitted to the Applicant and Competent Authority.

Frequency of ECO visits

The ECO must conduct weekly site visits during the initial bulk earthworks (civils) and compensation work in the wetland, to check compliance with the conditions of the EA and mitigation measures and recommendations of this EMPr. Once the Civils construction has been completed and construction activities shift to within the footprint of the site, the ECO can then reduce the weekly visits to a frequency of twice a month (fortnightly). The ECO has the discretion to undertake additional visits if he / she feels this is justified due to the actions of the contractors, and to make *ad hoc* visits in order to ensure compliance.

The ECO must also undertake a final inspection (audit) 6 months of completion of construction activities. The purpose of this final inspection is to ensure that the rehabilitation measures applied at the conclusion of the construction phase have been sufficient to promote the successful rehabilitation of the site, and to identify any further issues that require attention or follow-up.

Authority of the ECO

The ECO has the authority to recommend that the Engineer suspend all works (or part thereof) occurring on site, should any action being undertaken on site not comply with the environmental requirements, and where such actions pose a serious threat to any element of the surrounding environment.

The ECO has the authority to recommend measures to the Engineer, regarding measures that must be implemented on site in order to ensure compliance with the EMPr and Environmental Authorisation, and/or to prevent environmental degradation or pollution from occurring.

The ECO has the authority to issue verbal and written warnings to contractors. Should verbal and written instructions and/or warnings be ignored, the ECO has the authority to request the Engineer to issue pre-determined fines or other penalties.

15. Environmental Awareness Plan

Environmental Awareness Training must be conducted prior to the commencement of construction activities. It is the applicant's responsibility to familiarise himself/herself with the content and requirements of this EMPr. The applicant is also responsible to ensure that the contractor and all labourers working on site during the construction phase are familiar with the content of this EMPr.

The following actions must be taken to ensure that all relevant parties are aware of their environmental role and duties:

1. This EMPr must be kept on site at all times.
2. The provisions of this EMPr and the conditions of the Environmental Authorisation must be explained in detail to all staff during Awareness Training.
3. Training booklets will be handed out to all labourers and must be explained to them.
4. Weekly checks to be done by the Applicant's environmental representative (where available) who must be on site at all times.
5. The ECO to do frequent site visits, as recommended in Section 15.3 of the EMPr.

6. Monthly monitoring reports to be compiled by the ECO. These reports will be circulated to all parties involved (including the applicant, contractor and the competent authority).

The Construction Contractor must make allowance for all construction site staff, including all subcontractors that will be working at the site, to attend environmental awareness training sessions (undertaken by the ECO) before commencing any work on site. During this training, the ECO will explain the EMPr and the conditions contained therein. Attention will be given to the construction process and how the EMPr fits into this process. Other items relating to sound environmental management which must be discussed and explained during the environmental awareness training sessions include:

- The demarcated "No-Go" areas;
- General do's and don'ts of the site;
- Making of fires;
- Waste management, use of waste receptacles and littering;
- Use of the toilets provided;
- Use and control of construction materials and equipment etc.;
- Control, maintenance and refuelling of vehicles;
- Methods for cleaning up any spillage;
- Access and road safety;
- Emergency procedures (e.g. in case of fire, spillage etc.)
- General "best practice" principles, with regards to the protection of environmental resources.

Environmental awareness training and education must be ongoing throughout the construction phase and must be undertaken regularly if deemed necessary (especially if it becomes apparent that there are repeat contraventions of the conditions of the EMPr), or as new workers come to site. Translators must be utilised where needed. An Environmental Awareness Guideline has been compiled and is included in Appendix F of the EMPr.

16. Monitoring, Record Keeping and Reporting

16.1 Environmental Auditing

In accordance with the requirements of the Amended Environmental Impact Assessment Regulations of 2014 (GN No. R.327 of 7 April 2017), the holder of the Environmental Authorisation (i.e. the Applicant) must, for the period that the Environmental Authorisation is valid, appoint a suitably qualified independent person to conduct an environmental audit to audit compliance with the conditions of the Environmental Authorisation and the EMPr.

The appointed auditor must undertake environmental audits within 6 months after the completion of the rehabilitation measures. Following each audit the environmental auditor must submit an audit report to the Competent Authority (in this instance the DEA&DP). The Auditor must be independent from the EAP and ECO.

- Environmental auditing and environmental audit reports must adhere to the requirements of the Environmental Impact Assessment Regulations, in particular Section 34 (*Auditing of Compliance with Environmental Authorisation, Environmental Management Programme*) and Appendix 7 (*Objective and Content of Environmental Audit Report*).
- The audit report must provide verifiable findings on the level of compliance with the provisions/ conditions of the Environmental Authorisation and the EMPr, and must also comment on the ability of the measures contained in this EMPr to sufficiently avoid, manage and mitigate environmental impacts.

- Where the findings of the audit report indicate that the impact management measures stated in the EMPr are insufficient to adequately address environmental impacts, recommendations as to how the EMPr must be amended so as to address the identified shortcomings must be made and submitted to the competent authority together with the audit report.

16.2 Construction phase monitoring, reporting and record keeping.

The appointed Environmental Control Officer (ECO) is responsible for monitoring the site at regular intervals during the construction phase, in order to ensure that the provisions of this EMPr and the Environmental Authorisation are adhered to and that sound environmental management is ensuing on site.

The ECO must compile a monthly ECO report detailing the ECO's observations on site, any instances of non-compliance and any issues or aspects that require attention, follow-up or remedial action. The ECO reports must be submitted to the Applicant, and to the Competent Authority as requested by the DEADP in the EA. The ECO inspection reports must include both photographic and written records.

ECO Inspections - Photographic Records

The condition of the surrounding natural environment must be monitored regularly in order to ensure that construction and management activities are not impacting negatively on the condition of the landscape and any sensitive ecosystems. The most effective way to achieve this is by means of a detailed photographic record. In this way, a record of any shift in ecosystem condition can be maintained and potential impacts be detected at an early stage. It is thus recommended that fixed-point photo-monitoring sites could be set up, and photographs should be taken at these sites during each ECO inspection. Where necessary, the entire working area should be well documented and photographed.

ECO Inspections - Written Records

The following record-keeping during the pre-construction, construction and rehabilitation phases of the development is recommended:

- The ECO should complete an ECO Checklist after each ECO site visit.
- The ECO must compile an ECO monitoring report and submit this to the Applicant, the Contractor and the Competent Authority (the latter only if required by the Competent Authority). The monthly reports must be a summary of the ECO inspections from the preceding month and must highlight the key concerns/ issues on site, instances of non- compliance with the EA and EMPr, all instructions issued to the contractor, actions taken and aspects that still require attention.
- All ECO reports and ECO instructions must be retained on file by the Applicant at least for the duration of the construction period (retaining reports for a period of at least 5 years is recommended, in the event that the Competent Authority should request information).
- A record (minutes) of construction site meetings, liaison site meetings between the ECO and resident engineer or contractor, monitoring reports, ECO instructions and ECO observations should be clearly documented and filed on a master file off-site for safe keeping.
- It is recommended that a site register (incident register) should be kept on site at the site office for the recording of any environmental incidents (e.g., fires, spills etc.), observations which are contrary to the stipulations within the EMPr and any other contravention deemed necessary for the attention of the resident engineer. Actions taken to remedy the incidents should also be recorded.

- A complaints register should be kept on site in which complaints by any member of the public should be logged.
- The ECO must compile a final post-construction audit report, within 6 months of completion of each construction phase. The audit report should detail the rehabilitation measures undertaken, describe all major incidents or issues of non-compliance and any issues or aspects that require attention or follow-up.

Construction Phase Record Keeping

A copy of the approved EMPr, the Environmental Authorisation and any relevant construction method statements must be kept on site at all times during pre-construction, construction and rehabilitation activities. The ECO Reports must be retained by the Applicant for a period of at least 5 years and must be provided to the Competent Authority upon request. Additionally any groundwater or water quality results must be made available to all relevant authorities upon request.

16.3 Corrective Action Procedure

Correction actions need to be followed in the event where there is non-compliance with a condition of the EA and any recommendation and mitigation measure as stipulated in this EMPr in order to rectify the non-compliance and to prevent reoccurrence.

The ECO will be responsible for reporting non-compliance with any condition of the EA and the recommendations and mitigation measures as included in this EMPr. The ECO will also be responsible for the compilation of non-compliance reports and identifying steps to correct the non-compliance.

The ECO must report all non-compliance issues to the contractor whose responsibility it is to correct. A timeframe for the completion of the corrective actions must be agreed to the ECO. Once the corrective actions have implemented the contractor must notify the ECO. The ECO must review the effectiveness of the corrective actions and if it is found to be inadequate, additional measures must be implemented. Only once the corrective actions have been completed to the satisfaction of the ECO will the matter be considered as closed.

In instances where there are repeated instances where the requirements and conditions of this EMPr and the Environmental Authorisation are contravened or not fully complied with, the Construction Contractor may be liable for financial penalties. Penalties shall be issued by the Engineer, in accordance with the Schedule of Fines contained in the table below. Penalties may be issued at the Engineer's discretion, and/or upon the request/ recommendation of the ECO or Competent Authority.

Depending on the nature of transgression, the Engineer and/or ECO may issue one or more warnings to the Contractor prior to the issuing of a fine. Warnings may be given in writing or orally, but oral warnings must be followed up with written confirmation of the warning within 48 hours of the oral warning. The Engineer has the discretion to issue a fine <u>without</u> first issuing a warning, if the severity of the transgression is judged by the Engineer and/or ECO and/or Competent Authority to warrant such action.

The Engineer must ensure that the levying of fines/penalties forms part of the contract between the Construction Contractor and the Engineer and is subject to the provisions of South African contract law.

The table below specifies the transgressions for which the Construction Contractor may incur financial penalties, and the amount of the fines that may be levied. Levying of fines/ penalties is subject to alignment with South African Contractual Law. For repeat offences of the same/ similar transgression by the same party, the value of the fine shall be doubled for each subsequent repeat offence to a maximum value of **R50 000.00** per offence.

Note: "Provisions", as stated in the table below, relates to the requirements specified in this EMPr and any requirements or conditions specified in the EA, as well as any other requirements governing the

environmental management aspects of the development, which the Contractor is responsible for implementing.

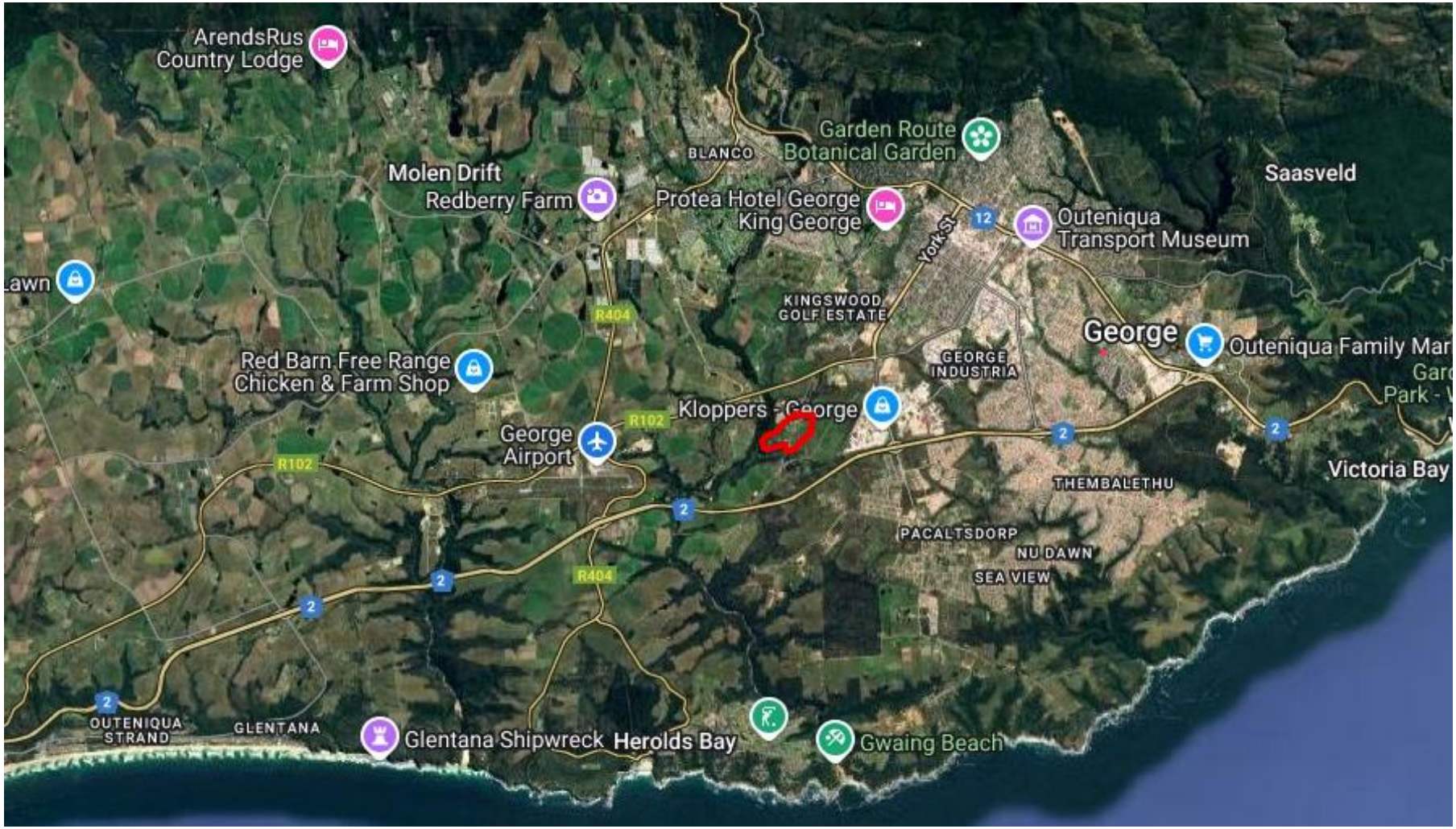
#	Finable Transgression	Min Fine	Max Fine
1	Failure to notify the ECO of the commencement of construction or pre-construction activities, prior to the commencement of such activities	R1 000	R2 000
2	Failure to comply with the provisions relating to the demarcation of the working area, site camp and associated facilities, and the maintenance of the demarcated boundaries.	R1 000	R5 000
3	Failure to comply with the provisions relating to the demarcation of all "no-go" areas, and the maintenance of the demarcated boundaries.	R2 000	R5 000
4	Failure to provide secured ablution facilities (1:30 ratio) on site.	R500	R15 000
5	Failure to comply with the provisions relating to the clearance of vegetation on site.	R2 000	R5 000
6	Clearance of indigenous vegetation (regardless of the density of alien vegetation present) outside of the demarcated boundaries of the working area and site camp.	R2 500	R15 000
7	Damage to indigenous vegetation in the surrounding areas within No-Go areas	R2 000	R10 000
8	Failure to apply herbicide to alien vegetation when required to do so.	R500	R2 000
9	Failure to adhere to designated access routes and/or the driving of vehicles through undeveloped vegetation outside of the demarcated working area or site camp.	R1 000	R5 000
10	Movement of vehicles and/or construction workers in no-go areas;	R1 000	R10 000
11	Empty cement bags found on site or surrounding vegetation. Open cement bags on site with cement blowing from the bag	R2 500	R15 000
12	Parking or storage of vehicles, machinery, tools and other materials or equipment related to the Contractors operations, within designated "no-go" areas.	R1 000	R10 000
13	Parking or storage of vehicles, machinery, tools and other materials or equipment related to the Contractors operations, outside of the areas demarcated for such parking/storage.	R500	R5 000
14	Failure to comply with the provisions relating to the management of topsoil and subsoil.	R1 000	R5 000
15	Excessive excavation of material in areas not depicted for such purpose / activity on the approved design plans.	R2 500	R10 000
16	Failure to comply with the provisions relating to waste management on site i.e. recycling of waste	R500	R5 000
17	Failure to comply with the provisions relating to the storage, use and management of hazardous substances and fuels on site and/or the spillage of hydrocarbons or hazardous substances on site.	R1 000	R10 000
18	Mixing cement or concrete on bare ground and/or failure to comply with any other provision regarding cement/ concrete batching	R1 000	R5 000
19	Failure to provide adequate fire-fighting equipment (in working order) on site at all times and/or failure to comply with the provisions relating to fire prevention and/or the occurrence of unattended or out of control fires.	R500	R5 000
20	Refuelling of vehicles, machinery or equipment outside of the designated refuelling area.	R500	R2 000
21	Maintenance of vehicles, machinery or equipment outside of the designated maintenance yard, except in emergencies	R500	R2 000

22	Failure to undertake refuelling or repairs over a drip tray or other impermeable bunded surface to collect spilled hydrocarbons (fuels, lubricants, oils etc.) and other hazardous substances; failure to provide drip trays under fuel burning equipment (including pumps and generators) where there is a risk of hydrocarbon leakage.	R500	R2 000
23	Storing / placing fuel containing equipment (i.e. bowsers and other fuel containers) within a drainage line.	R2 500	R10 000
24	Failure to produce a required method statement/s to the engineer's and ECO's satisfaction prior to undertaking the activity concerned and/or failure to adhere to an approved method statement	R1 000	R5 000
25	Waste found to be buried or burnt on site	R5 000	R15 000

17. CONCLUSION

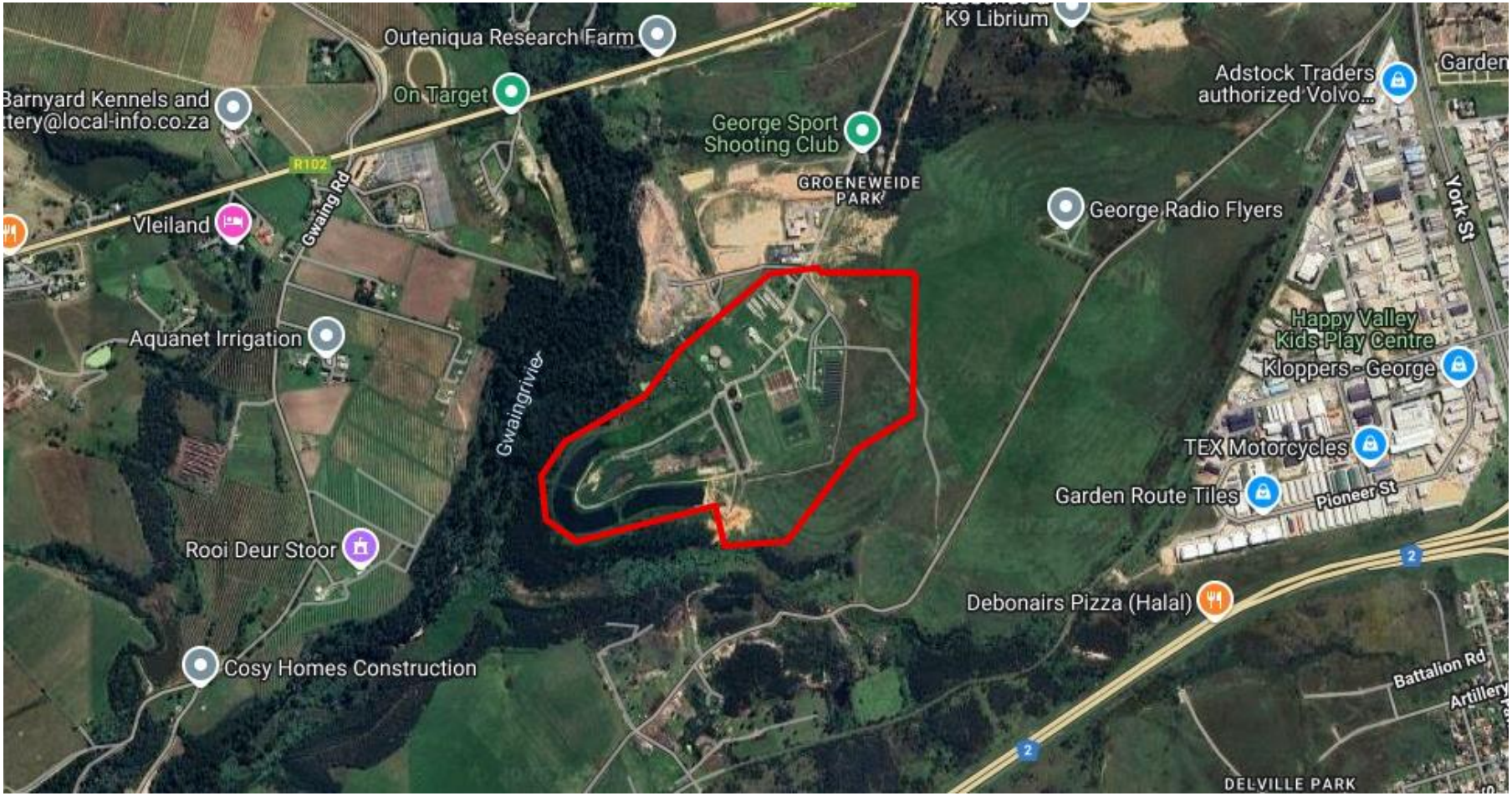
The recommendations and mitigation measures prescribed in this EMPr have been formulated with the intention of addressing potential pre-construction, construction and operational phase impacts on the environment. It is likely that if the conditions, requirements and recommendations of the above EMPr are implemented as described and the relevant stakeholders adhere to the various mitigation measures, then the project will be completed without unforeseen negative environmental impacts. Familiarity with the contents of this EMPr by the contractors and other individuals involved in the development project will assist in achieving "environmental best-practice", which ultimately ensures that the project arrives at a sustainable outcome.

APPENDIX A **LOCALITY MAP**



Prepared for:
The George Municipality

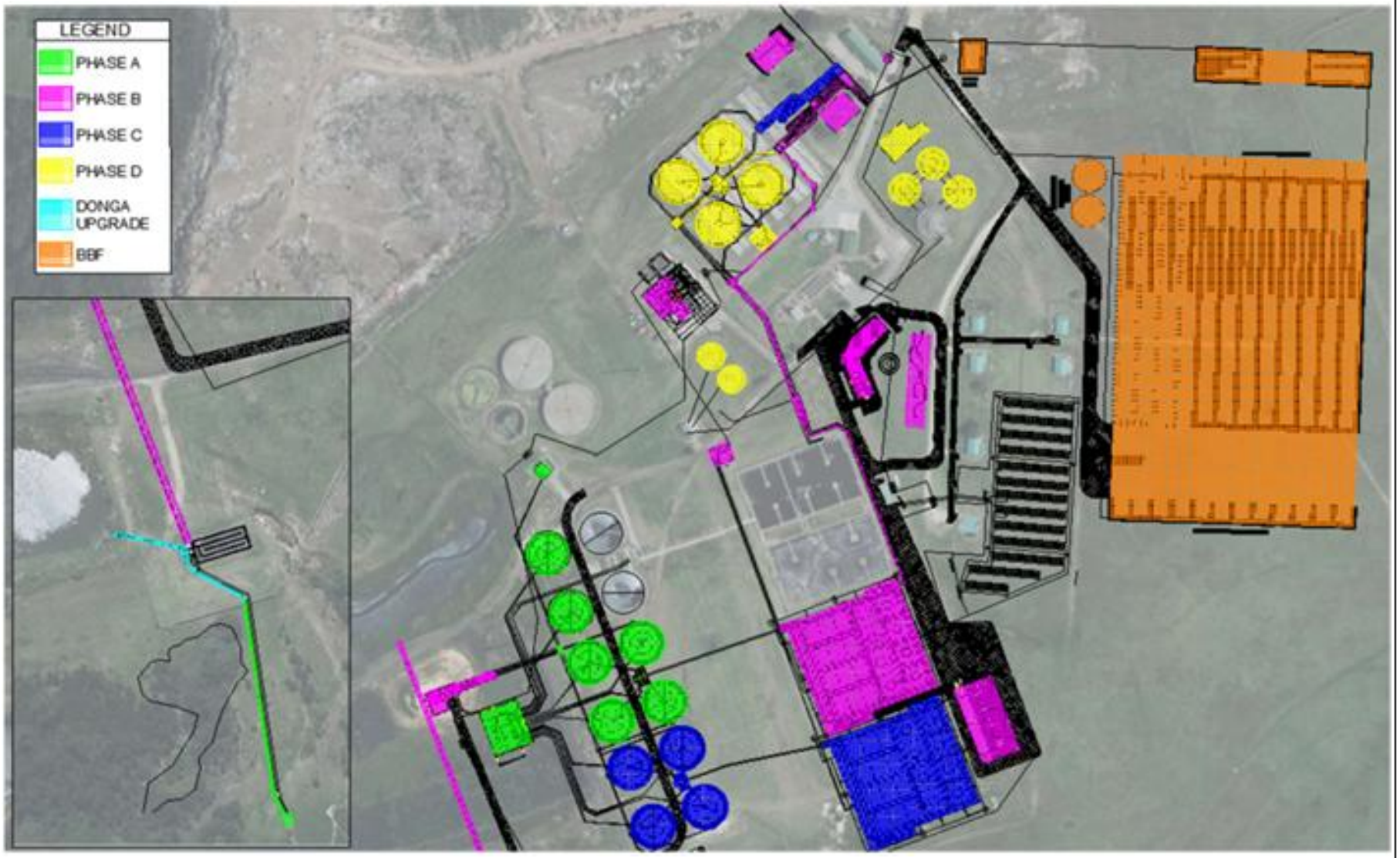
Date:
July 2025



Prepared for:
The George Municipality

Date:
July 2025

APPENDIX B	PROPOSED SITE DEVELOPMENT PLAN	ALL PHASES

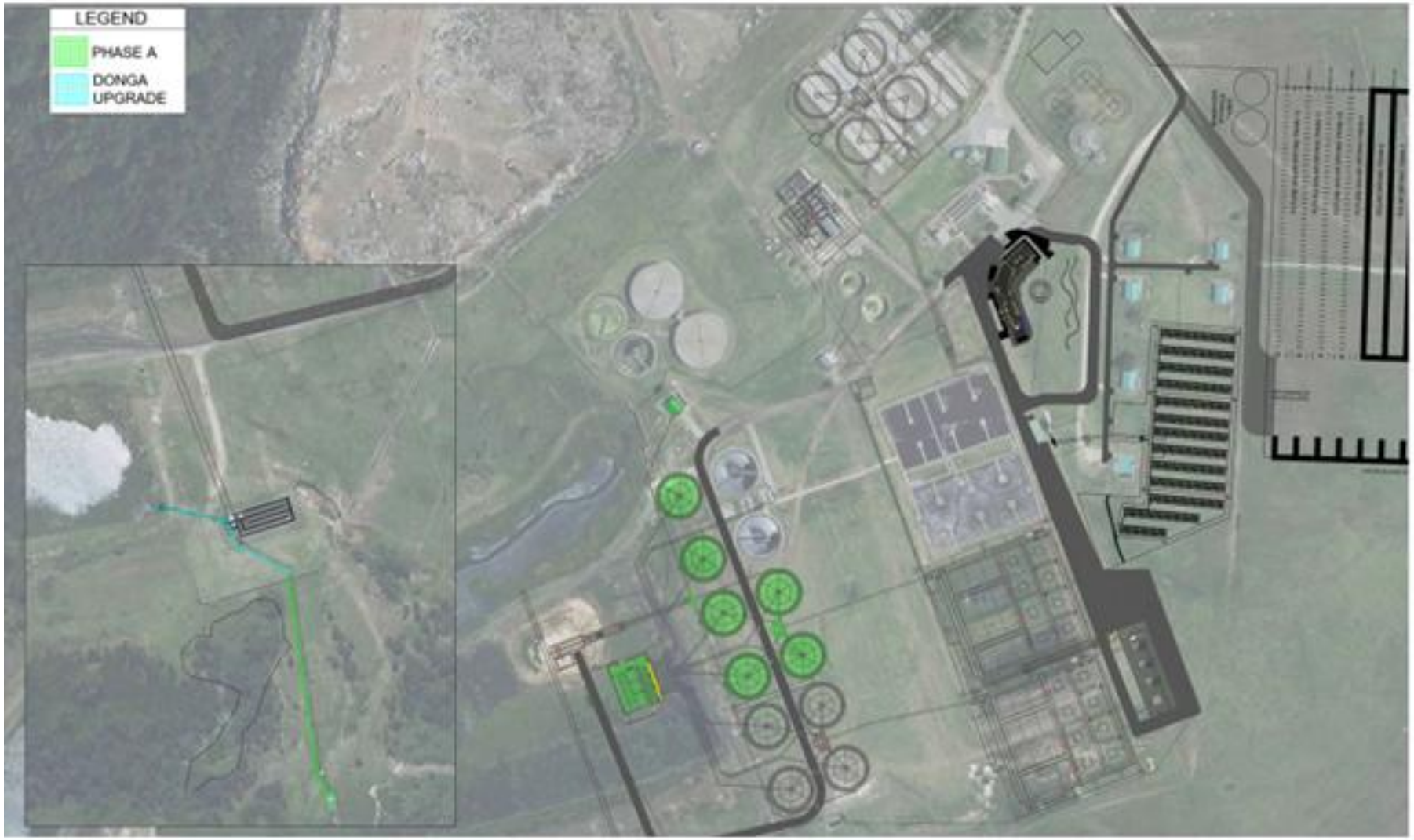


Prepared for:
The George Municipality

Date:
July 2025

Sharples Environmental Services

APPENDIX B	PROPOSED SITE DEVELOPMENT PLAN	PHASE A



Prepared for:
The George Municipality

Date:
July 2025

APPENDIX B	PROPOSED SITE DEVELOPMENT PLAN	PHASE B

Prepared for:
The George Municipality

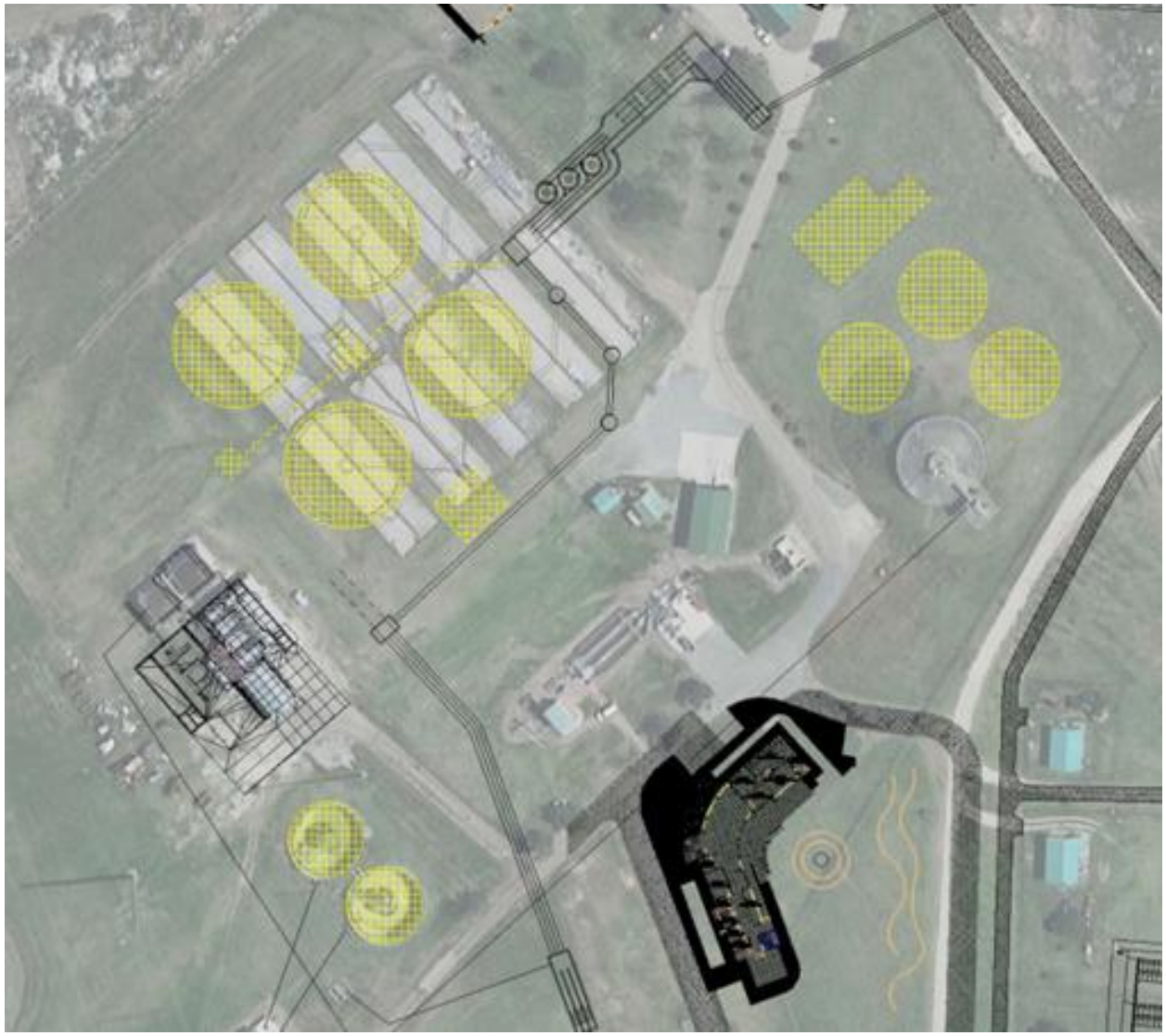
Date:
July 2025

APPENDIX B **PROPOSED SITE DEVELOPMENT PLAN** **PHASE C**

Prepared for:
The George Municipality

Date:
July 2025

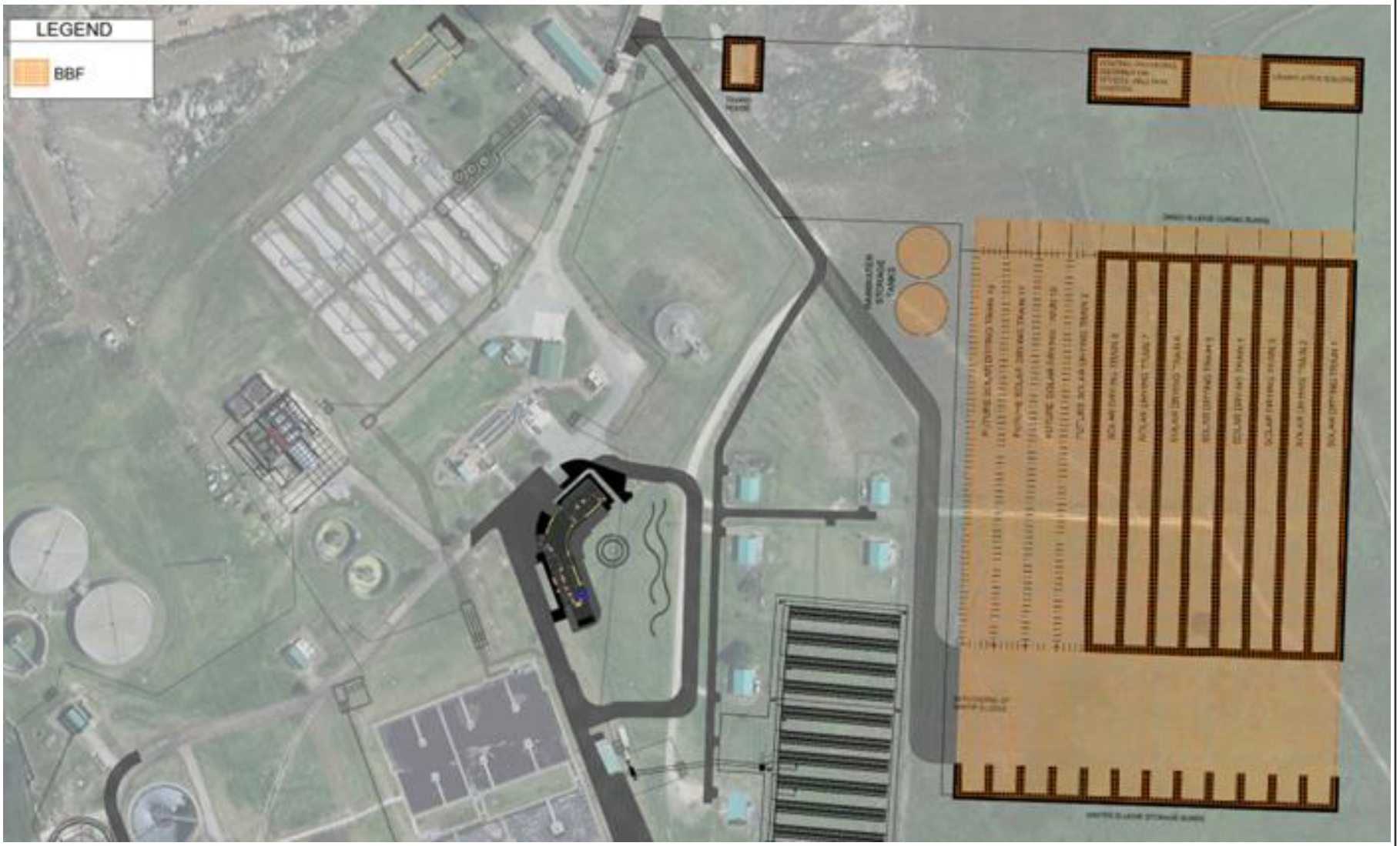
APPENDIX B **PROPOSED SITE DEVELOPMENT PLAN** **PHASE D**



Prepared for:
The George Municipality

Date:
July 2025

APPENDIX B **PROPOSED SITE DEVELOPMENT PLAN** **BBF PHASE**



Prepared for:
The George Municipality

Date:
July 2025

Sharples Environmental Services

GEORGE
TEL: +27 (0) 44 873 4923 **FAX:** +27 (0) 44 874 5953
EMAIL: info@sescc.net **WEBSITE:** www.sescc.net
ADDRESS: Unit 17 Cathedral Square,
Cathedral Street, George, 6530
PO BOX: 9087, George, 6530

CAPE TOWN
TEL: +27 (0) 21 554 5195 **FAX:** +27 (0) 86 575 2869
EMAIL: betsy@sescc.net **WEBSITE:** www.sescc.net
ADDRESS: Tableview, Cape Town, 7441
PO BOX: 443, Milnerton, 7435

ENVIRONMENTAL AWARENESS TRAINING BOOKLET

APPENDIX C

Environmental Monitor's Foreword

SES is here to ensure that everyone complies with the conditions of "Duty to Care". If these conditions are not complied with the project can be stopped and fines can be issued.

We hope that with your co-operation the project won't be stopped and fines won't be issued, and a successful project can be finished on time.

Notes:

- Workers working on this project must undergo environmental training.

- The information contained in this document should be used during day-to-day activities.

HOW IS THIS PROJECT IMPLEMENTING ENVIRONMENTAL MANAGEMENT?

This project is implementing Environmental Management on an ongoing basis throughout the duration of the project. The following aspects would be implemented to achieve the above stated:

- A dedicated Environmental Manager or Environmental Control Officer appointment to the project to implement and monitor Environmental Management.
- Regular environmental inspection on the site.
- Regular environmental training for workers
- Environmental audits on a regular basis.

WASTE TREATMENT

Refuse:

- Refuse waste includes: waste food, food containers, packaging materials, cans, bottles, newspapers and magazines.
- Day to day household waste should always be disposed of in the containers provided on site by the company.
- No dumping of waste anywhere other than in the bins provided.
- No burning of refuse.
- If there are not enough refuse containers on site, the ECO or supervisor needs to be informed.

Construction Waste:

- Construction waste includes: concrete, steel, cement, rock, pre-coated chips, wood, plastic, empty bags and rubble.
- Construction waste must be discarded in skips located in strategic areas for removal.
- Construction waste must not be discarded in holes or burned on site.

- Small amounts of construction waste should be collected and not discarded into vegetation or down fill slopes.
- Material should only be spoiled if a rehabilitation plan has been designed for the area.

Liquid waste:

- Liquid waste includes: concrete, paint, thinners, diesel, hydraulic fluids, cooking oil, chemicals, other fuel and sewage.
- Use facilities provided for waste.
- The liquid waste should be recycled as far as possible.
- Use chemical toilets and ablution facilities.

INFORM THE ENVIRONMENTAL CONTROL OFFICER (ECO) IMMEDIATELY OF ANY IMMEDIATE OR POTENTIAL ENVIRONMENTAL INCIDENT.

SPECIFIC ENVIRONMENTAL ISSUES

SPESIFIEKE OMGEWINGSKWESSIES
IMIBA ETHILE YEZOBUME BEMEKO YENDALO

The basic Do's and Don'ts towards environmental awareness are as follows:

Die basiese Moets en Moenies van omgewingsbesinning is as volg:

Oondoqo bo mawukwenze no mawungakwenzi kwilinge lezobume be meko yendalo bume ngoluhlobo:

Toilet Facilities:
Toilet Fasiliteite:
Izindlu Zangasese:

DO:
USE THE TOILET FACILITIES PROVIDED - REPORT FULL FACILITIES
MOET:
GEBRUIK MAAK VAN TOILET FASILITEITE WAT VOORSIEN WORD – RAPPORTEER AS FASILITEITE VOL IS
OMAWUKWENZE: SEBENZISA IZINDLU ZANGASESE EZIBONELELWEYO- NIKA INGXELO NGAMALUNGISELELO AGCWELEYO.

DO NOT:
USE THE BUSH
MOENIE:
DIE BOS GEBRUIK NIE
OMAWUNGAKWENZI: UKUSEBENZISA ITYHOLO.

Vehicles operation and maintenance:
Voertuig werking en onderhoud:
Ulawulo nophatho lezithuthi:

DO:
ENSURE THAT VEHICLES AND MACHINERY DO NOT LEAK FUEL OR OILS. REFUELLING, MAINTENANCE, SERVICING OR WASHING MUST BE DONE WITHIN THE DESIGNATED AREA IN THE CONSTRUCTION CAMP AREA ONLY.
MOET:
VERSEKER DAT VOERTUIE EN MASJINERIE NIE OLIES OF BRANDSTOF LEK NIE. VOLMAAK, ONDERHOUD, DIENS OF SKOONMAAK VAN VOERTUIE MOET SLEGS IN AANGEWYSTE AREAS IN DIE KONSTRUKSIE KAMP GESKIED.
OMAWUKWENZE: QINISEKISA IZITHUTHI NOMATSHINI ABAVUZI MAFUTHA OKANYE I OYILE, UKUGALELA, UKUPHATHA, UKULUNGISA OKANYE UKUHLAMBA KUFUNEKA KWENZIWE KUMMANDLA OTYUNJIWEYO KWINKAMPI YOLWAKHIWO KUPHELA NGOKUKHAWULEZILEYO.

DO:
REPORT ALL FUEL OR OIL SPILLS IMMEDIATELY & STOP THE SPILL CONTINUING.
MOET:
RAPPORTEER ENIGE BRANDSTOF OF OLIE STORTE & VERHOED DAT DIE STORT AANHOU.
OMAWUKWENZE: NIKA INGXELO NGE OLI NAMAFUTHA ACHITHEKILEYO, UZE UNQANDE UCHITHEKO LUNGAQHUBEKI.

DO:
PREVENT CONTAMINATION OR POLLUTION OF STREAMS AND WATER CHANNELS.
MOET:
VERHOED DIE KONTAMINASIE EN BESOEDELING VAN STROME & WATERKANALE.
OMAWUKWENZE : NQANDA USULELEKO OKANYE UNGCOLISEKO LWEMILAMBO NEMISELE YAMANZI.

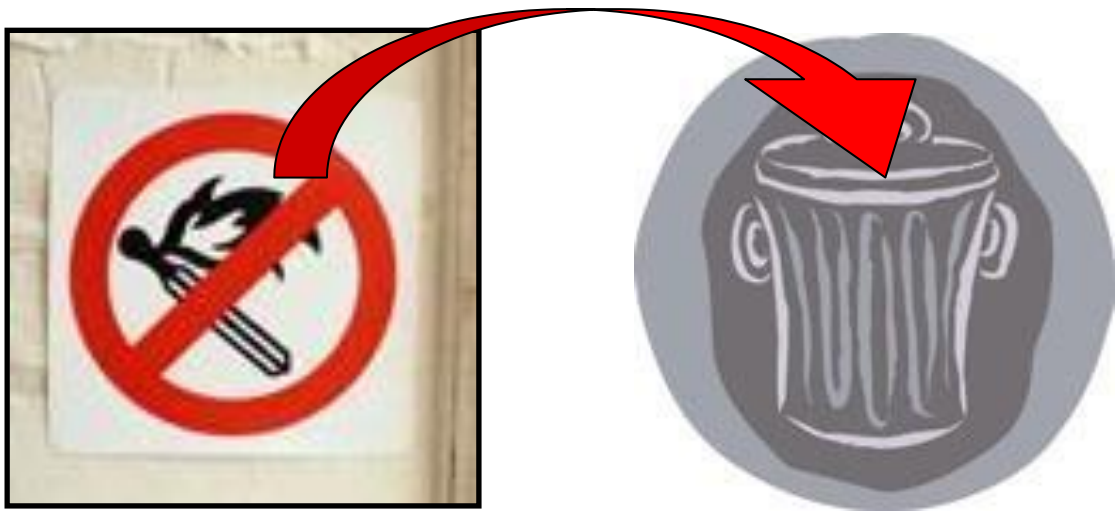
DO NOT:
ALLOW WASTE, LITTER, OILS OR FOREIGN MATERIALS INTO THE STREAM
MOENIE:
TOELAAT DAT AFVALPRODUKTE, GEMORS, OLIES OF VREEMDE MATERIALE IN STROME BELAND NIE.
OMAWUNGAKWENZI: MUSA UKUVUMELA INCITHO, ULAHLO, IOYILE OKANYE EZINYE IZINTO EMILANJENI.

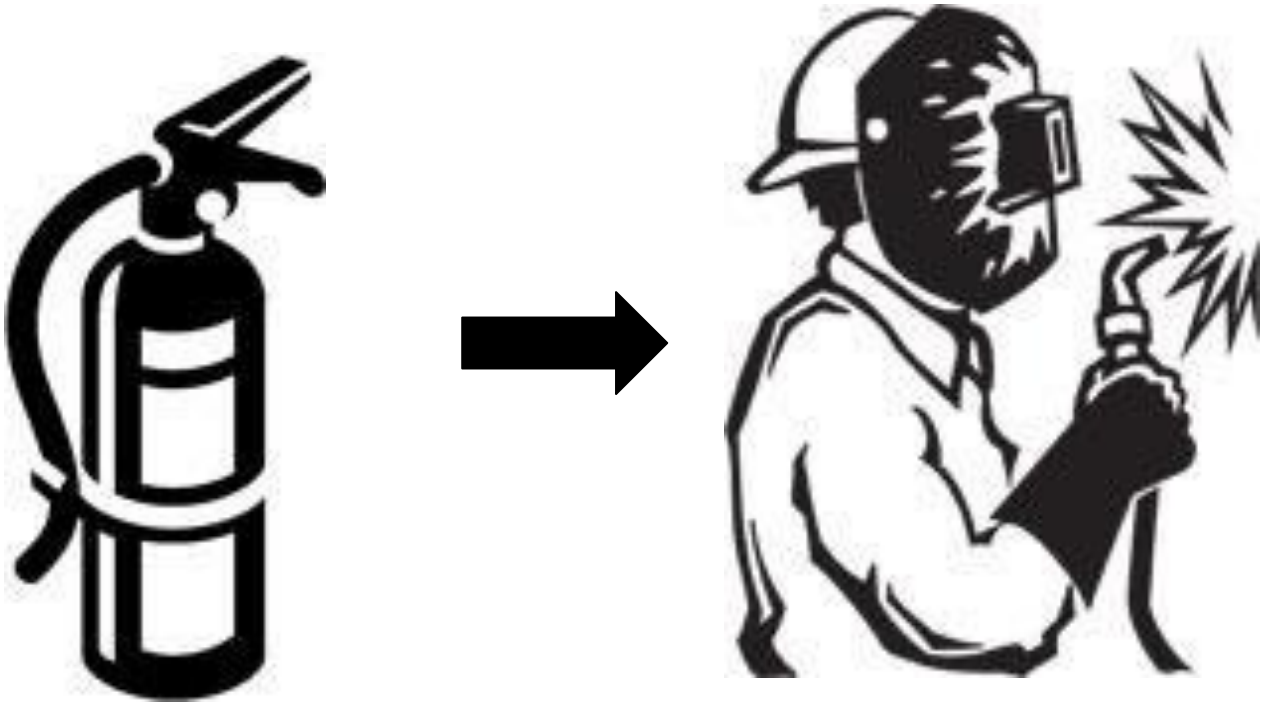
Fire Control:
Vuur Beheer:
Ulawulo Lemililo:

DO:
DISPOSE OF CIGARETTES AND MATCHES CAREFULLY. (Littering is an offence.)
MOET:
GOOI SIGARETTE & VUURHOUTJIES OP GEPASTE MANIER WEG WEG (rommelstrooi is 'n oortreding)
OMAWUKWENZE: LAHLA ISIGARETE NOOMATSHISI NGONONOPHELO (ukulahla lityala).

DO:
ENSURE A WORKING FIRE EXTINGUISHER IS IMMEDIATELY AT HAND IF ANY "HOT WORK" IS UNDERTAKEN e.g. welding, grinding, gas cutting etc.
MOET:
VERSEKER DAT 'N WERKENDE BRANDBLUSSER BYDERHAND IS INDIEN "WARM WERK" GEDOEN WORD bv. Sweiswerk.
OMAWUKWENZE: QINISEKISA ISICIMA-MLILO ESISEBENZAYO SISESANDLENI UKUBA KUKHO UMSEBENZI "OTSHISAYO" OWENZIWAYO, umz. ukuwelda, ugubo, ukuqhawula ugesi, njl.

DO NOT:
MAKE ANY FIRES
MOENIE:
ENIGE VURE MAAK OF ENIGEIETS VERBRAND NIE
OMAWUNGAKWENZI: UKWENZA IMILILO OKANYE UTSHISE NOKUBA YINTONI.





Fencing and Restricted Areas:
Omheining en Beperkte Areas:
Ubiyelo Nemimanndla Engavumelekanga:

DO:
CONFINE WORK AND STORAGE OF EQUIPMENT TO WITHIN THE IMMEDIATE WORK AREA.
MOET:
BEPERK ALLE WERK EN STOOR VAN GEREEDSKAP TOT IN DIE GEGEWE WERKAREA.
OMAWUKWENZE:GCINA UMSEBENZI NEZIXHOBO ZOKUSEBENZA NGAKUMMANDLA OKUSETYENZELWA KUWO.

DO NOT:
ENTER ANY FENCED OFF OR MARKED AREA. SUCH AREAS HAVE BEEN MARKED WITH "NO-GO AREA" SIGNS AND SHOULD BE ADHERED TO.
MOENIE:
ENIGE OMHEINDE OF GEMERKTE AREAS BINNEGAAN NIE. SULKE AREAS IS MET "NO-GO AREA" TEKENS GEMERK EN MOET GEHOORSAAM WORD.
OMAWUNGAKWENZI: MUSA UKUNGENA KWI NDAWO EBIYIWEYO OKANYE EPHAWULWEYO. IMIMANDLA ENJALO IPHAWULWE NGAMAGAMA ATHI **" NO-GO AREA**".

NO-GO AREA

Safety:
Veiligheid:
Ukhuseleko:

DO:
USE ALL SAFETY EQUIPMENT AND COMPLY WITH ALL SAFETY PROCEDURES.
MOET:
GEBRUIK ALLE VEILIGHEIDSGEREEDSKAP EN VOLDOEN AAN ALLE VEILIGHEIDS PROSEDURES.
OMAWUKWENZE: SEBENZISA ZONKE IZIXHOBO ZOKHUSELEKO, UZE UTHOBELE YONKE IMIGAQO YOKHUSELO.

Driving and Dust:
Bestuur en Stof:
Uqhubo Nothuli:

DO:
DRIVE ON DESIGNATED ROUTES ONLY.
MOET:
NET OP AANGEWYSTE ROETES BESTUUR.
OMAWUKWENZE: QHUBA KWIMIMANDLA EPHAWULWEYO KUPHELA.

DO NOT:
SPEED OR DRIVE RECKLESSLY
MOENIE:
JAAG OF ROEKELOOS BESTUUR NIE.
OMAWUNGAKWENZI: SUKUQHUBA NGESANTYA ESIPHEZULU OKANYE NGOKUNGAKHATHALI.

DO NOT:
ALLOW CEMENT TO BLOW AROUND.
MOENIE;
TOELAAT DAT SEMENT WEGWAAI NIE.
OMAWUNGAKWENZI: MUSUKUVUMELA ISAMENTE ISASAZWE.

DO NOT:
CAUSE EXCESSIVE DUST
MOENIE:
OORDREWE STOF VEROORSAAK NIE.


SLOW


PPC

Vegetation protection:
Plantegroei Beskerming:
Ukhuselo Lwezityalo:

DO NOT:
DAMAGE OR REMOVE ANY VEGETATION WITHOUT DIRECT INSTRUCTION.
MOENIE:
ENIGE PLANTEGROEI SONDER DIREKTE INSTRUKSIE BESKADIG OF VERWYDER NIE.
OMAWUNGAKWENZI: MUSA UKUTSHABALALISA OKANYE USUSE NASIPHINA ISITYALO NGAPHANDLE KOMYALELO.

Animals:
Diere:
Izilwanyana:

DO NOT:
INJURE, CAPTURE/SNARE, FEED OR CHASE ANIMALS – this includes birds, frogs, snakes, lizards, tortoises, etc.
MOENIE:
ENIGE DIERE BESEER, VANG, VOER OF JAAG NIE – dit sluit in: voëls, paddas, slange akkedisse, skilpaaie ens.
OMAWUNGAKWENZI: MUSA UKWENZAKALISA, UKUBAMBA, UKONDLA OKANYE UKULEQA IZILWANYANA- okuquka iintaka, amasele, iinyoka, amacilikishe, izikolopati.

DO:
REPORT ANY INJURY OF AN ANIMAL.
MOET:
DIE BESERING VAN 'N DIER RAPPORTEER.
OMAWUKWENZE: XELA NASIPHI ISENZAKALO SESILWANYANA.

Preventing Pollution:
Voorkoming van Besoedeling:
Ukhuselo Longcoliseko:

DO:
CLEAR YOUR WORK AREAS OF LITTER AND BUILDING RUBBLE AT THE END OF EACH DAY – use the waste bins provided and ensure that litter will not blow away.
MOET:
RUIM NA ELKE DAG DIE WERK AREA OP EN GOOI ENIGE ROMMEL WEG IN DIE GEGEWE HOUERS – maak seker dat rommel nie kan wegwaai nie.
OMAWUKWENZE: COCA INDAWO OSEBENZA KUYO, IZINTO EZILAHLIWEYO NENKUNKUMA YOKWAKHA QHO EKUPHELENI KWEMINI-sebenzisa imigqomo yenkunkuma uze uqiniseke ukuba inkunkuma ayivuthuzwa ngumoya.

DO NOT:
ALLOW WASTE BINS TO OVERFLOW OR WASTE TO BLOW AROUND.
MOENIE:
TOELAAT DAT ROMMELHOUERS OORVLOEI OF DAT ROMMEL ROND WAAI NIE.
OMAWUNGAKWENZI: MUSA UKUVUMELA IMIGQOMO YENKUNKUMA IGCWALE KAKHULU OKANYE INKUNKUMA ISASAZEKE.

DO NOT:
LITTER OR LEAVE FOOD LAYING AROUND
MOENIE:
ROMMEL OF KOS LAAT RONDLÊ NIE.
OMAWUNGAKWENZI: MUSA UKUNGCOLISA OKANYE USHIYE UKUTYA KULELE INDAWO YONKE.

DO NOT:
BURY ANY LITTER OR WASTE IN THE GROUND.
MOENIE:
ENIGE ROMMEL OF GEMORS IN DIE GROND BEGRAWE NIE.
OMAWUNGAKWENZI: MUSA UKUNGCWABA INKUNKUMA EMHLABENI.


GLASS
CARDBOARD
PAPER

APPENDIX D

CURRICULUM VITAE

MICHAEL JON BENNETT

PERSONAL

Profession: Principle Environmental Assessment Practitioner and Senior Environmental Control Officer, Sharples Environmental Services cc, George

Nationality: South African

Date of Birth: 22 October 1985

Languages: English (read, write and speak) & Afrikaans (read, write and speak)

Marital Status: Single

Drivers License: Code B

Health: Excellent

EAPASA Reg: 2021/3163

IAIASA Membership: 7334

WORK EXPERIENCE

2014 – Present: Sharples Environmental Services cc, George, WC

Environmental Assessment Practitioner

I have gained extensive experience in assessments and monitoring and have worked on a variety of multidisciplinary projects and am proficient in:

- Basic Assessments Reports
- Water Use Authorisation Applications
- Environmental Monitoring and Reporting
- Environmental Management Programmes
- Environmental Control Officer Training
- Conducting Outeniqua Sensitive Coastal Area licensing applications

2016 – 2017: Sharples Environmental Services cc, Cape Town, WC

Intrim Office Manager, Environmental Assessment Practitioner

2011 – 2014: Peninsula Permits & NCC Group, Cape Town, WC

Environmental Control Officer

- Environmental Monitoring

TERTIARY EDUCATION

2010 University of Cape Town

- I hold a Bachelor of Science Degree specialising in Environmental and Geographic Science & Ocean and Atmospheric Science

PROJECTS

2023 George Urban Country Estate (Pty) Ltd

- Basic Assessment Report for the proposed residential development on erf 19374 (remainder erf 6182, erven 6179 and 6156), George, Western Cape

2023 George George Municipality

- Basic Assessment Report for the Upgrading of the Eden Pumpstation, George, Western Cape

2023 Mossel Bay Paprenax Trading 6 cc

- Amendment of Environmental Authorisation (Part 2, Substantive amendment) for the proposed establishment of a filling station and associated business infrastructure on a portion of erf 13996, Kwanonqaba, Mossel Bay, Western Cape

2023 George George Municipality

- Basic Assessment Report for proposed upgrade of the Schaapkop Pumpstation rising main on remainder of erf 464 and erf 13486, George, Western Cape

2023 George Garden Route Gateway Plaza

- Basic Assessment Report for proposed mixed-use development on portions 278 and 282 of farm Kraaibosch no. 195, George, Western Cape

2023 George George Municipality

- Basic Assessment Report for proposed development of a Photovoltaic Solar Plant on erf 2819, George, Western Cape

2023 George EARP Construction

- Basic Assessment Report for the proposed commercial development on portion 49 of Farm Hansmoeskraal 202, George, Western Cape

2022 George Pieterkoen Trust

- Basic Assessment Report for the proposed residential development on Portion 21 of the Farm Kraaibosch No. 195 (Pieter Koen), George, Western Cape

2022 Mossel Bay Dalmar

- Amendment of Environmental Authorisation (Part 2, Substantive amendment) for the Proposed Residential Development On A Portion Of The Farm Vaale Valley 219, Mossel Bay (Hartenbos Landgoed II), Western Cape

2022 George Dalmar

- Amendment of Environmental Authorisation Proposed Development of Herold's Bay Country Estate on A Portion of Portion 7 of The Farm Buffelsfontein No. 204, Herold's Bay, Western Cape

2022 George Pieterkoen Trust

- Basic Assessment Report for the proposed residential development on Portion 21 of the Farm Kraaibosch No. 195 (Pieter Koen), George, Western Cape

2022 Still Bay W. Nel & Irma Oosthuizen Trust IT 1596/2008

- Basic Assessment Report for the development of 5 residential units on erven 4139, 4140, 4141, 4142, 4143, 4144, 4145 (Erf 3997), Still Bay West, Western Cape

2022 George Octo Trading 377 cc

- Section 24 G Retrospective Environmental Authorisation for the alleged unlawful construction of a road clearance of vegetation to establish a house on remainder of Farm Holle Kloof 91 and Portion 1 of the Farm Plattekloof 131, Waboomskraal, George, Western Cape

2022 Knysna CapeNature

- Basic Assessment Report for the Proposed development on Portions 38 and 39 of Farm 205 and Remainder of Farm 211, Goukamma Nature Reserve, Knysna, Western Cape

2021 Prince Albert Jurie Klue

- Section 24 G Retrospective Environmental Authorisation for the alleged unlawful clearance of vegetation on Farm Angliers Bosch (Fernkloof), Remainder of Farm 157, Klaarstroom, Prince Albert, Western Cape

2021 Mossel Bay Mossel Bay Municipality

- Basic Assessment Report for the proposed Dana Bay Emergency Access Road on Remainder of Portion 7 of the Farm 225, Dana Bay, Mossel Bay, Western Cape

2021 Willowmore LEZMIN 2087cc

- Basic Assessment Report for the proposed development of Portion 1 of the Farm Matjiesfontein No. 206, Baviaanskloof, Division Willowmore, Eastern Cape

2020 Sedgefield Knysna Municipality

- Basic Assessment Report for the proposed housing development on erven 3861, 3865, 3866, 3917, 3918 and 5010 in Sedgefield, Knysna, Western Cape

2020 Mossel Bay Paprenax Trading 6 cc

- Basic Assessment Report for the proposed establishment of a filling station and associated business infrastructure on a portion of erf 13996, Kwanonqaba, Mossel Bay, Western Cape

2020 Ladismith Department of Transport and Public Works

- Maintenance Management Plan for the periodic maintenance of Trunk Road 31, section 4, km 30.8 to km 76.06, Barrydale to Ladismith, Western Cape

2020 Knysna Knysna Municipality

- Maintenance Management Plan for the Maintenance of the potable water pipeline system on Erven 4197, RE/1352, RE/1351, RE/1146 and 1316 in Knysna, Western Cape

2020 Humansdorp Kouga Municipality

- Environmental Control Officer for the Phase 1A of New municipal 66kV double circuit overhead line between the Melkhout substation at Humansdorp and the main intake substation at Jefferys Bay, Eastern Cape

2020 Humansdorp Kouga Municipality

- Environmental Control Officer for the Construction of a new 22kv overhead powerline between Melkhout substation and Allison Street, Humansdorp, Eastern Cape

2020 Knysna Knysna Municipality

- Environmental Control Officer for the Charlesford raw water pumping scheme: Upgrade and refurbishment of pumpstation: Mechanical and electrical, Knysna, Western Cape

2020 Seweweekspoort, Department of Transport & Public Works

- Amendment of Environmental Authorisation (Part 2, Substantive amendment) for the flood damage repairs to road structures on MR309 in Seweweekspoort, Western Cape

2019 – 2021 Seweweekspoort, Department of Transport & Public Works

- Environmental Control Officer for the flood damage repairs to road structures on MR309 in Seweweekspoort, Western Cape

2019 George George Municpality

- Environmental Control Officer for the Raising of the Garden Route Dam Spillway on Portion 3/352, Remainder of 536 of Erf 221, Erf 3055 and Erf 3056, George, Western Cape

2019 Laingsburg Department of Agriculture

- Environmental Control Officer for the Construction Of Erosion Prevention Structures Within The One In Ten Year Flood Line Of The Buffels River, Laingsburg, Western Cape

2019 Williston Williston Municipality

- Environmental Control Officer for the Upgrading of bulk water network in Williston – Phase 3, Williston, Northern Cape

2019 George George Municipality

- Environmental Control Officer for the construction of new 66kV overhead line between Ballots Bay and Glanwood substations, George, Western Cape

2019 Oudtshoorn Department of Transport & Public Works

- Environmental Control Officer for the Periodic maintenance of Trunk Road 31, Section 6, km 23.3 to km 47.8 Calitzdorp to Oudtshoorn, Western Cape

2019 Kleinbrak Mossel Bay Municipality

- Environmental Control Officer for the Upgrading of Beyers Street, Klienbrak River, Western Cape

2019 George Outeniqua Eye Clinic Body Corporate

- Environmental Control Officer for the proposed expansion of parking area on erf 5950 and part of remainder erf 464, George, Western Cape

2019 Mossel Bay Hey Innovations

- Basic Assessment Report for the proposed establishment of a residential development on Erf 2839, Great Brak River, Western Cape

2019 Oudtshoorn Oudtshoorn Municipality

- Environmental Management Programme for the Blossoms Emergency Supply Scheme, Oudtshoorn, Western Cape

2019 Humansdorp Clinkscales Maughan-Brown

- Environmental Management Programme for the proposed construction of a new 22kV overhead powerline between Melkhout Substation and Allison Street, Humansdorp, Eastern Cape

2019 George PN&MR Lotter Family Trust

- Addendum to the Environmetnal Management Programme for the Establishment of a Township (Rivendale) on Portions 5, 15, 16 and 31 of the Farm Hansmoeskraal 202, Western Cape

2019 Oudtshoorn Department of Transport and Public Works

- Basic Assessment Report for the Proposed Maintenance Activities of Trunk Road 33/4 between km 4.6 and km 14.4, Meiringspoort, Western Cape

2019 George Dynarc Capital

- Substantive amendment of environmental authorisation for the proposed Development of Portion 130, 131 and 132 of the Farm Gwayang 208

2019 George Department of Transport & Public Works

- Basic Assessment Report for the proposed Upgrading of Bridge No. 2221 on Trunk Road 2/9 at km 15.1 over the Maalgate River.

2018 - 2019 Oudtshoorn Department of Transport and Public Works

- Maintenance Management Plan for the proposed periodic maintenance of Trunk Road 31, section 6, km 23.3 to km 47.8, Western Cape

2018 - 2019 Humansdorp Clinkscales Maughan-Brown

- Applicability of the EIA regulations Checklist for the proposed new 22kV overhead line between Melkhout Substation and Allison Street, Eastern Cape

2018 - 2019 Knysna Knysna local Municipality

- Applicability of the EIA regulations Checklist for the proposed Rheenendal infill housing, subdivision and rezoning of portions of erf 42, 36 and 387 as well as erven 535, 536, 553, 54, 393, 406, 672, 673 and 68, Rheenendal, Western Cape

2018 - 2019 Knysna Knysna local Municipality

- Applicability of the EIA regulations Checklist for the proposed infill housing and subdivision of erven in Welsyndorp and the rezoning and subdivision of erven in Bosdorp, Karatara, Western Cape.

2018 Port Elizabeth ACSA P.E.

- Applicability of the EIA regulations Checklist for the proposed ACSA Port Elizabeth Airport Photovoltaic Plant, Eastern Cape Province

2018 Mossel Bay TopUp Prop Inv.

- Applicability of the EIA regulations Checklist for the proposed Farm Stall Centre and filing Station on Portion 65 of the Farm Hartenbosch 217, Hartenbos

2018 George Outeniqua Eye Clinic Body Corporate

- Basic Assessment Report for the proposed expansion of parking area on erf 5950 and part of remainder erf 464

2018 Beaufort West Beaufort West Municipality

- Environmental Control Officer for the First and Second Environmental Audit for the provision of adequate water supply within the jurisdiction of the Beaufort West municipality

2018 Mossel Bay Element Consulting Engineers

- Environmental Management Programme update for the replacement of 22kV overhead powerline between Power Town and Hartenbos and between Hartenbos and the Hartenbos sewage substation and the construction of a new 22kV overhead power line between the Midbrak and Kleinbrak Substations.

2018 Mossel Bay Element Consulting Engineers

- Environmental Control Officer for the construction of a new 22kV overhead power line between the Midbrak and Kleinbrak Substations

2018 Mossel Bay Element Consulting Engineers

- Environmental Control Officer for the Upgrade of Amy Searle Canal – Phase 5, Great Brak River

2018 Gouritsmond Hessequa Consulting Engineers

- Environmental Control Officer for the Upgrade and expansion of the Gouritsmond Water Water Treatment Works on remainder of erf 140, Gouritsmond

2018 George Biprops 14

- Environmental Control Officer for the residential development on portion 5 of the farm Kraaibosch No. 195, Groenkloof Woods: Phase C & D

2018 Knynsa Knysna Municipality

- Environmental Control Officer for upgrading of Knysna bulk water supply scheme: phase 2B

2018 Plettenberg Bay Bitou Municipality

- Environmental Control Officer for the upgrade of the Kranshoek Bulk Water Supply Scheme: Construction of Pipelines, reservoirs and associated infrastructure near Plettenberg Bay.

2018 Mossel Bay SMEC

- Environmental Control Officer for the Upgrade of Kusweg and associated infrastructure in Rheebok

2017 George EARP Construction

- Invasive Alien Management Plan for the proposed residential development on portions 21, 23, 24 & 48 of Farm Hansmoeskraal 202 near George

2017 Mossel Bay Mossel Bay Municipality

- Environmental Control Officer for the development of the new Mossel Bay municipal cemetery on erf 2001/0

2017 Knynsa Knysna Municipality

- Environmental Control Officer for the remedial work to prevent further settlement of the low-lift pump sump and retaining wall at Gouna River Pump Station

2017 Knynsa Knysna Municipality

- Environmental Control Officer for upgrading of Knysna bulk water supply scheme: phase 1

2017 George Biprops 14 (Pty) Ltd

- Environmental Control Officer for the residential development on portion 5 of the farm Kraaibosch No. 195

2017 Still Bay Hessequa Municipality

- Environmental Control Officer for the construction of a reservoir, booster pump station and associated infrastructure in Melkhoutfontein near Still Bay

2016 - 2017 Heidelberg Department of Transport & Public Works

- Environmental Control Officer for the flood damage repairs to structures in the Central Eden District Municipality Region, Heidelberg North

2016 - 2017 Riversdale Department of Transport & Public Works

- Environmental Control Officer for the flood damage repairs to structures in the Central Eden District Municipality Region, Riversdale East area

2016 - 2017 Still Bay Department of Transport & Public Works

- Environmental Control Officer for the upgrade of main road 332 near Still Bay

2016 - 2017 Mossel Bay The South Cape College

- Environmental Control Officer for the extension of the South Cape College: Phase 3, Mossel Bay Campus

2016 - 2017 Klein Brak Mossel Bay Municipality

- Environmental Control Officer for the removal of obstructions in the lower floodplain of the Klein Brak River Estuary

2016 Prince Albert Milway Trade and Invest 1014cc

- Basic Assessment for the proposed guest lodge on remainder of Farm Rietpoort 13

2016 Plettenberg Bay Bitou Municipality

- Basic Assessment for the proposed Qolweni phase 5 development near Plettenberg Bay

2016 Mossel Bay Element Consulting Engineers

- Environmental Management Programme for the replacement of 22kV overhead powerline between Power Town and Hartenbos and between Hartenbos and the Hartenbos sewage substation

2016 George SMEC

- Environmental Policy for the resurfacing of York Street, George

2016 Mossel Bay Department of Transport & Public Works

- Maintenance Management Plan for proposed upgrade of Louis Fourie Road.

2016 George Oaklands Bridge Country Estate HOA

- Maintenance Management Plan for proposed repair and maintenance of the riverbank at Oaklands Bridge Country Estate in Heather Park

2016 Gouritz Department of Transport & Public Works

- Update of the Maintenance Management Plan for proposed repair and maintenance of the Gouritz River Bridge bank protection along the R325 near Gouritzmond

2016 George Ivorybell Investment (Pty) Ltd

- Outeniqua Sensitive Coastal Area Environmental Impact Report for the proposed new house on erf 379 in Heralds Bay

2016 George George Municipality

- Environmental Assessment Report for the substantive amendment of environmental authorisation of the proposed upgrade and extension of the overhead power lines and associated substations

2016 Oudtshoorn SA Army Infantry School

- Environmental Control Officer for the construction of a fighting in built up areas (FIBUA) range on portion 10 of the farm Blaauwtjes Drift 110 in Oudtshoorn

2015 - 2016 Gouritz Department of Transport & Public Works

- Environmental Control Officer for the repair and maintenance of the Gouritz River Bridge bank protection along the R325 near Gouritzmond

2015 - 2016 Albertinia Garden Route Game Lodge (Pty) Ltd

- Environmental Control Officer for the five new units at the Garden Route Game Lodge

2015 - 2016 Mossel Bay Element Consulting Engineers

- Environmental Control Officer for the replacement of 22kV overhead powerline between Power Town and Hartenbos and between Hartenbos and the Hartenbos sewage substation

2014 - 2016 Plettenberg Bay Chauke Quanity Surveyers

- Environmental Control Officer for the Qolweni and Kwanokuthula High Density Units and engineering services

2016 Plettenberg Bay Bitou Municipality

- Environmental Control Officer for the civil engineering works for Kwanokuthula Phase 4 and the extension of Sishuba Street

2014 - 2016 Mossel Bay The South Cape College

- Environmental Control Officer for the extension of the South Cape College, Mossel Bay Campus

2016 George SMEC

- Environmental Control Officer for the resurfacing of York Street

2014 - 2015 Mossel bay The Muller Murray Trust

- Environmental Control Officer for the construction of gravity pipeline from the Nautilus take-off to the Boggomsbaai Reservoir phase 2

2015 Swellendam Casidra SOC Ltd

- Environmental Control Officer for the Grootvaderbos Groynes in the Buffeljags River

2015 George Element Consulting Engineers

- Environmental Control Officer for the upgrading and extension of overhead power lines and substations: construction of a new 66kV overhead line between Protea and Ballots Bay substation

2014 - 2015 George Department of Transport & Public Works

- Environmental Control Officer for the flood damage repair projects in the George and Knysna local municipal areas

2015 George BDE Consulting Engineers (Pty) Ltd

- Environmental Control Officer for the photovoltaic solar plant for the ACSA George Airport

2015 Heidelberg Bergstan South Africa

- Environmental Control Officer for the Duiwenhoks River stabilization works: Sites B31, B38 and B39

2015 Krakeel Element Consulting Engineers

- Environmental Control Officer for the construction of filling station at SSK Tuinrote Agri on portion 5 of the farm no. 320

2014 - 2015 Herbertsdale SMEC

- Environmental Control Officer for the flood damage repairs to structures in the Eden region: Herbertsdale area

2014 - 2015 George Department of Transport & Public Works

- Environmental Control Officer for the flood damage repair projects in the George and Knysna local municipal areas

2015 George SMEC

- Environmental Control Officer for the improvements to the Pacaltsdorp interchange and new pedestrian bridge

2014 - 2015 Still Bay De Villiers & Moore Consulting Engineers

- Environmental Control Officer for the Still Bay 66kV substation and overhead powerline

2014 Beaufort West Worley Parsons Consulting Engineers

- Environmental Control Officer for the Nelspoort bulk water supply scheme northeast of Nelspoort

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CURRICULUM VITAE

LU-ANNE DE WAAL

PERSONAL

Profession: Candidate Environmental Assessment Practitioner, Sharples Environmental Services cc, George
Nationality: South African
Languages: English (read, write and speak) & Afrikaans (read, write and speak)
Drivers License: Code B
EAPASA Registration: 2024/7962

SUMMARY

Lu-anne studied at North-West University completing a Bachelor of Science degree majoring in Zoology and Botany. Lu-anne also studied at the University of South-Africa completing a Bachelor of Science Honours degree majoring in Environmental Management. Lu-anne joined SES in 2023. Lu-anne is registered with EAPASA as a Candidate Environmental Practitioner (**EAPASA # 2024/7962**).

WORK EXPERIENCE

September 2023 - Present: Sharples Environmental Services cc, George, WC
Candidate Environmental Assessment Practitioner

- Basic Assessments Report
- Environmental Monitoring
- Environmental Management Programmes
- Amendment of Environmental Authorisations and EMPr
- Public Participation Process

TERTIARY EDUCATION

2023 University of South-Africa
- Bachelor of Science Honours – Environmental Management

2022 North-West University
- Bachelor of Science – Zoology & Botany

ACCREDITATION / ASSOCIATION

- **EAPASA** Registration: 2024/7962
- **Member IAIA South Africa:** 7770

KEY PROJECTS

2024-current **George** **George Municipality**

- Basic Assessment Report and Environmental Management Plan for the Proposed upgrade of the Gwaing Wastewater Treatment Works on Erf RE/464, George.

2024-current **Herold's Bay** **George Municipality**

- Basic Assessment Report and Environmental Management Plan for the proposed upgrading of the Herold's Bay Pump station and associated rising main and development of new associated infrastructure.

2024-current **George** **Mr Prakash Jivan**

- Basic Assessment Report for the proposed construction of a mixed-use development on Farm Portion 50, Hansmoeskraal Farm 202

2025 **George** **Garden Route Gateway Plaza (Pty) Ltd**

- Notice of Intent and Site Sensitivity Verification Report for the proposed construction of a mixed-use develop Portion 278 of Farm Kraaibosch No 195, George.

2025 **Mossel Bay** **Hartland Lifestyle Estate PTY LTD**

- Amendment of the EA and EMPr and Environmental Impact Report for the proposed residential development on a portion of the Farm Vaale Valley 219, Mossel Bay – Hartland Lifestyle Estate

2025 **Mossel Bay** **Exact Trade 139 (Pty)**

- Amendment of the EA and Environmental Impact Report for the proposed Eagles Creek residential development on portions 187 and 188 and the remainder of portion 47 of the farm Vyf Brakkenfontein 220, Mossel Bay.

2025 **George** **Tremayne de Jager**

- Basic Assessment Report and Environmental Management Plan for the proposed flood damage repairs to the Langenhoven Substation, George Western Cape.

2024-2025 **Prince Albert** **Prince Albert Municipality**

- Notice of Intent and Site Sensititivity Verification Report for the proposed construction a PV Solar Plant and Battery Energy Storage System, Prince Albert, Western Cape

2024-2025 **Plettenberg Bay** **MORE Family Collection**

- Basic Assessment Report and Environmental Management Plan for the proposed expansion of Milkwood Manor House and parking

2023-2024 **Mossel Bay** **Potgieter Familie Trust (TMP3113)**

- Amendment of Environmental Management Programme for the proposed development of Pansy Villas

2023-2024 **George** **SNA Consulting Engineers**

- Environmental Control Officer for the upgrade of Bridge No. 2221 on Trunk Road 2/9 at KM 15.1over Maalgate River

2023-2024 **Mossel Bay** **Department of Transport and Public Works**

- Environmental Control Officer for the upgrade of Louis Fourie Road

2023-2024 **Herold's Bay** **Long Island Trading 44 (Pty) Ltd**

- Environmental Control Officer for the proposed development of Herold's Bay Country Estate

2023 George George Municipality

- Applicability Checklist for the proposed new steel monopole structures for the 66kV overhead line between Proefplaas and Herold's Bay

2023 George The Board of Trustees Biprops 14

- Application for amendment of environmental authorisation for the residential development on the Farm Kraaibosch

2023 Mossel Bay Confuel (PTY) Ltd

- Environmental Control Officer for the proposed truck stop and associated infrastructure

2023 George Lukhozi Consulting Engineers

- Environmental Control Officer for repair and rehabilitation of flood damages along Camphersdrift River, Van Riebeeck Gardens

GEORGE MUNICIPALITY

GWAING WASTEWATER TREATMENT WORKS

OPERATIONS & MAINTENANCE MANUAL

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GEORGE MUNICIPALITY

GWAING WASTEWATER TREATMENT WORKS

OPERATIONS & MAINTENANCE MANUAL

CONTENTS

1 INTRODUCTION

1.1 IMPORTANCE OF EFFLUENT QUALITY

Increased consumption of water resources due to population increase and industrial factors has driven the implementation of stringent measures by regulatory agencies for treatment of wastewater to remove organic matter and other toxic material such as heavy metals and nutrients. The increase in fresh water contaminants originating from agricultural runoff of fertilizers, industrial effluents and poor treatment of domestic wastewater has exacerbated the continuing depletion of fresh water resources, thus putting a strain in natural means for the environment to deplete the pollutants.

In order to remove the burden from the natural environment, wastewater treatment works can be used to mimic natural conditions to remove pollutants, pathogens and the high energy contained in the wastewater. A growing concern for the concentration of nitrogen as nitrate or ammonium and phosphorus has seen more wastewater treatment works have to include nutrient removal as part of the treatment process.

As such the purpose of wastewater treatment is to:

(i) Satisfy the oxygen demand of the sewage. This can be split into two different categories – that of the organic compounds (DOD) and that of the ammonia. This requires the supply of oxygen to the sewage. In the activated sludge plant this is supplied by mechanical aerators, and in the biofilter works the oxygen is absorbed as the water trickles over the stones exposed to the atmosphere.

(ii) Nutrient Removal - Nitrogen and Phosphorus (N as NH_4^+ / $NO_3^-$and P as PO_4^{2-}) – this reduces the chance of eutrophication (nutrient enrichment of water) of the receiving waters. Eutrophication in warm climates generally results in algal blooms which pollute the water and can be toxic.

(iii) Removal of solids – solids in the final effluent will tend to settle in the receiving river or dam and affect the normal biological processes by covering the bottom of the water body. In addition to this the solids absorb oxygen

which lowers the dissolved oxygen in the river and kills the natural biota and causes fish kills.

(iv) Removal of Pathogens - Pathogens infect human beings and animals upon ingestion, and can result in disease which can at times be fatal. This is particularly serious where HIV positive individuals with reduced immunity are involved. The cost of disinfection is generally far lower than treating the diseases which would arise in the absence of disinfection.

In summary, wastewater is treated in order to render it safe to return to the river for further use. As such it should have a low oxygen demand, low nutrients and solids, and the pathogens should be disinfected.

1.2 LEGAL REQUIREMENTS FOR EFFLUENT COMPLIANCE

Table XXX: Final Effluent Quality required

Parameter	Original Standard	After 2006
COD mg/l	<75	<65
Ammonia mgN/l	<10	<3
Nitrate + nitrite mgN/l	Not specified	<15
Orthophosphate mgP/l	Not Specified	<1
Total SS mg/l	<25	<18

The "2006" standards were provided by DWAF with the proviso that should the standards not be achievable an application could be made for them to be relaxed. The chief standard of concern is that for ammonia which appears to stem from the General Authorisation for works <2Ml/d and has subsequently been increased to 6mg/l as it is too stringent.

1.3 ENERGY CONSIDERATIONS

Electricity is becoming expensive in South Africa and has an associated carbon footprint which results in global warming. As such the energy used should be kept to a minimum and thus wherever possible the most energy efficient route should be taken. In the case of the Gwaing WWTW this means:

- The biofilter works should be run whenever possible as the first choice of treatment. This may however be a problem in that the phosphate standard would be difficult to achieve.

- The aeration and pumping rates on the activated sludge plant should be kept to a minimum. As such the aeration setpoint for DO should be set as low as possible and the pumping rates should be reduced whenever possible, particularly at night and over weekends when flows are decreased.

1.4 PROCESS SELECTION

The Gwaing Wastewater Treatment Works was developed in 3 phases:

(i) Phase I (Mid 1970's) – A 6Ml/d conventional biological filter works was constructed including primary settling tanks and anaerobic digesters.

(ii) Phase 2 (1998) - the plant was extended to treat 11Ml/d. The use of primary sedimentation tanks and the anaerobic digesters was discontinued, being substituted with a set of two anaerobic and two facultative ponds. After passing through the ponds the effluent was passed over the biological filters (Petro process).

(iii) Phase 3 (2008) - the existing mothballed primary sedimentation tanks and digesters for the biofilter plant were re-commissioned to restore this process back to its original form but with a decreased capacity (3.6Ml/d instead of 6Ml/d) to increase nitrification and hence the quality of the effluent. In addition to this the Petro process ponds were replaced with a Biological Nutrient Removal (BNR) plant (UCT process) which is the state of the art technology for nutrient removal. The capacity of the BNR plant is 7.3Ml/d, which together with the biofilter plant gives a total treatment capacity of 11Ml/d (ADWF). The waste activated sludge generated by the UCT process is mechanically thickened and dewatered.

2 ABBREVIATIONS

The following abbreviations are used in this manual

ADWF – Average Dry Weather Flow
BNR – Biological Nutrient Removal
COD – Chemical Oxygen Demand
DO – Dissolved Oxygen
HMI – Human Machine Interface
MLSS – Mixed Liquor Suspended Solids
PST – Primary Settling Tanks
PWWF - Peak Wet Weather Flow
RAS – Return Activated Sludge
SST – Secondary Settling Tanks

UCT – University of Cape Town
VFA's – Volatile Fatty Acids
WAS – Waste Activated Sludge
WWTW – Wastewater Treatment Works

3 PROCESS FLOW DIAGRAM

Please see Appendix A

4 PROCESS MONITORING

4.1 STATUTORY MONITORING

Weekly samples of the raw sewage and final effluent are taken and analysed at the George Municipal Laboratory.

4.2 PROCESS MONITORING

The activated sludge plant operation is monitored as follows:

Sample	Analysis	Frequency
Mixed liquor	MLSS	2 x weekly
Final effluent	SRP Nitrate Ammonia	Daily
Final effluent	pH Alkalinity Temperature	4 hourly

5 PROCESS TROUBLESHOOTING

A Process Troubleshooting matrix is given in Appendix C.

6 PROCESS DESCRIPTION

The plant consists of the following:

6.1 PRE-TREATMENT

Description	Function	Capacity
Head of Works 1. Vacuum tanker offload bay 2. Nightsoil offload bay 3. Coarse screen (100mm) 4. Mechanical drum screens (2N^{o}) 5. Vortex degritter 6. Grit channels	1. Vacuum tanker emptying 2. Nightsoil offloading – includes dilution sumps 3. To remove large foreign objects such as branches or sacks 4. To remove foreign objects such as plastic bags and rags 5. To remove inorganic substances such as small stones and sand 6. To remove inorganic substances such as stones and sand	11Ml/d (ADWF)
Splitter or division box	To divide the flow between the biofilter plant (3.7Ml/d) and the activated sludge process (7.3Ml/d)	11Ml/d (ADWF)

6.2 BIOFILTER PLANT (3.7ML/D)

Description	Function
Primary sedimentation tanks (2N$^{o.}$)	To remove settleable COD for treatment in digester
Biofilters (2N$^{o.}$)	To remove COD, nitrify and denitrify
Humus tanks (2N$^{o.}$)	To remove the settleable material (humus) from the biofilter effluent
Biofilter recycle pumps (2N$^{o.}$)	To recycle the biofilter effluent back to the biofilter to improve nitrification
Humus recycling pumps (2N$^{o.}$)	To recycle the humus tank underflow to the primary settling tanks
Primary sludge pumps (2N$^{o.}$)	To transfer the raw sludge from the primary settling tanks to the anaerobic equipment
Anaerobic digester for primary sludge	To process the raw sludge by a process of lysis, acidogenesis and methanogenisis to reduce the COD and solids in the sludge and render it stable for disposal.
Drying beds	For drying the anaerobically digested sludge

6.3 BNR ACTIVATED SLUDGE PLANT (7.3ML/D)

Description	Function
Anaerobic basin receiving recycle from the anoxic basin (R-recycle) and equipped with two vertical shaft mixers to suspend biomass	Phosphate release from the activated sludge floc takes place under anaerobic conditions
Anoxic basin equipped with four vertical shaft mixers to suspend biomass	Denitrifies nitrates to nitrogen gas under anoxic conditions
Aeration basin with six surface mounted aerators	To oxidise organics and nitrify ammonia – the first two aerators run permanently, the next four aerators run in cycle depending on the DO level at the end of the aeration basin
Secondary settling tanks (SSTs) – flat bottom, sludge suction design	Separates the activated sludge biomass from the final effluent. The underflow is pumped back to the anoxic tank
A – Recycle pumps ($3N^{o}$) – axial flow	Recycle of nitrified activated sludge from aeration basin to anoxic basin
R – recycle ($3N^{o}$) – axial flow	Recycle of denitrified activated sludge from anoxic basin to anaerobic basin
S - Recycle pumpstation ($2N^{o}$) in RAS/WAS pumpstation	Transfers Return Activated Sludge (RAS) from SST's to anoxic basin
WAS pumps (2No) in RAS/WAS pumpstation	Transfers RAS to WAS sump at dewatering plant

6.4 TERTIARY TREATMENT

Description	Function
Chlorination	To dose chlorine to the final effluent
Maturation ponds ($4N^{o}$)	To allow aeration and dissipate chlorine

6.5 SLUDGE HANDLING

Description	Function
Sludge storage sump (Outeniqua)	To hold DAF thickened sludge pumped from Outeniqua WWTW
Sludge storage sump (Gwaing)	To hold XXX sludge from Gwaing WWTW
Beltpress for Outeniqua DAF thickened WAS	No linear screen upfront due to DAF thickening
Beltpress for Gwaing WAS	Linear screen upstream due to no DAF thickening of WAS

7 PROCESS THEORY

7.1 BIOFILTER THEORY

7.1.1 INTRODUCTION

One of the earlier methods of treating sewage was to run it into a tank filled with loose stone. After some 12 hours contact, the sewage was drained away and the stone left in contact with air. After a period of time a biological slime grew on the stone, which affected the oxidation of the sewage. These units were known as contact filters.

A modification to convert them to continuous operation, rather than batch, was made in 1893. The sewage was distributed across the surface of the contact bed by means of a moving mechanism. This was to prevent all the sewage falling on one spot and short-circuiting the greater mass of stone. The modern biological filter also known as tricking or percolating filter, was developed from this concept.

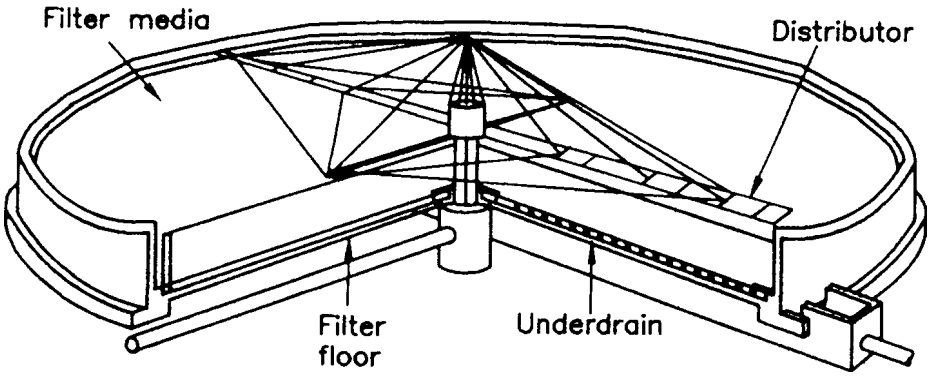


Figure :7.1 Cutaway view of a trickling filter

7.1.2 DESCRIPTION OF A BIOLOGICAL FILTER

A cutaway view of such a filter is given above. Not all biological filters are circular; the older designs were often rectangular in shape to save space. The principle of the operation remains the same irrespective of the shape.

The filter consists of an outer shell often made of concrete or interlocking cement retaining blocks. There are under-drains on the floor of the filter, which fulfil two requirements:

- To collect the effluent from the bottom of the filter and discharge it into a main drain.
- To allow the free passage of air through the filter.

This is important, as the micro-organisms, which grow in a filter, require oxygen from the air to live.

The shell is filled with filter media, the most common being crushed stone which has been carefully graded to ensure that flat pieces are eliminated. The size of stone commonly varies from 25 - 100 mm in diameter. The depth of the media also varies from 900 - 4 000 mm, the average being approximately 1 800 mm.

The filter media can also consist of coke, gravel, blast furnace slag, broken bricks, etc, but if used these commodities must be strong enough to support their own mass without failure. The media should also be weather resistant and not dissolve in the sewage. In the last 20 years, specifically designed plastic media has been available which has a much higher specific surface area and provides a support on which the bacteria can grow and its surface should, therefore be reasonably rough. All media should provide adequate air spaces between the individual pieces of media for ventilation. This is particularly important at higher loadings such as apply to plastic media.

Effluent from the primary clarifiers should desirably be applied to the biological filters in such a way that the distribution mechanism does not stick in one place thus continuously overloading that portion of the media. Placing a small balancing or dosing siphon between the primary clarifiers and the filter often overcomes this difficulty.

It is important in any distribution system that every portion of the media receives the same quantity of flow. In the case of circular filters, this means that distributor arms must be constructed to permit proportionately increasing amounts of effluent to be discharged from the inner pivot point to the outer circumference of the filter. This is done by spacing the holes closer together towards the ends.

Rotation is achieved by forcing water through the distribution holes and pushing the freely moving pipe away from the falling water. The available head of water and the size of the holes in the distribution pipe control the speed of rotation

7.1.3 PRINCIPLES OF BIOLOGICAL FILTRATION

Sewage is a suitable source of food for the micro-organisms in a biological filter as it contains nitrogen, organic carbon compounds, phosphorus and trace elements. Air circulates in the voids between the media, taking oxygen to the slime layer on the surface of the media. As sewage trickles over the media, the various organic substances are absorbed onto the biological film thus supplying the organisms with food.

Oxygen, which is present in the voids of the filter, dissolves in the water and is then transported to the slime layer. Metabolism of the substrate then takes place. If either food or oxygen is absent, this metabolism will stop. End products, which result from metabolism, are mainly water and carbon dioxide, which are liberated from the slime layer back into the main water flow. This process is most efficient when the slime layer is thin and totally aerobic.

The settled sewage sludge takes less than half an hour to trickle down over the media of a 3 600 mm high filter. This does not mean that all the settled sludge has been purified in such a short time. Dissolved impurities and the fine suspended matter, which is taken up into the biological film, take several hours or even days before they are broken down and leave the filter as end products.

The micro-organisms in the biological film multiply and grow as they utilise the available food and air. Thus the film becomes thicker. The organisms closest to the media will obtain food and oxygen last. These organisms then go into the endogenous phase of growth, i.e. they consume themselves because no other food is available. These organisms then lose their ability to cling to the surface of the media with the result that the biological film is washed off the media. Almost immediately a new biological film is formed, which again grows and then falls off so the process is repeated. The phenomenon of the biological film coming off the media is sometimes called sloughing. It is fortunate that sloughing occurs otherwise the film would grow to such an extent that all the voids between the media would close and then the aerobic organisms would be deprived of air and die. The biological film, which comes off the media, is allowed to pass out of the filter with the effluent. It is collected in a humus tank and then digested together with the primary sludge in a digester.

The biological life in the film consists of a host of aerobic and facultative bacteria fungi and protozoa. Higher forms of animals such as worms, insects, larvae, snails, etc., are present, usually on the surface of the biological film. It is interesting to note that all the organisms in a biological filter are in an ecological balance, i.e. no single organism is allowed to proliferate.

7.1.4 LOADING OF A BIOLOGICAL FILTER - HYDRAULIC LOADING

This refers to the daily flow, which is applied to the surface of the filter. It is important because, if the hydraulic load is too high, the biofilm can be washed off the media by the sheer force of the water. On the other hand, if the loading is too low, insufficient food and air will be carried to the organism and septic conditions will develop, resulting in unnecessary death of the micro-organisms

For a normal biological filter the hydraulic load would be in the range 1.2 to 5.0 $m^3/m^2.d$.

The calculation of the hydraulic load is obtained by dividing the flow to the filter in m^3/d by the surface area of the filter in m^2.

The above figures refer to the average daily flow. The actual flow rate of course varies throughout the day. During the day the flow is generally greater than the average but at night this becomes much less. In order to provide sufficient flow to turn the sprinkler mechanism, a device known as a dosing siphon is used. This stores the settled sewage in a small tank into which a siphon is installed As soon as the depth in the tank reaches a certain mark, the siphon primes and discharges at a fixed rate that will be sufficient to turn the mechanism

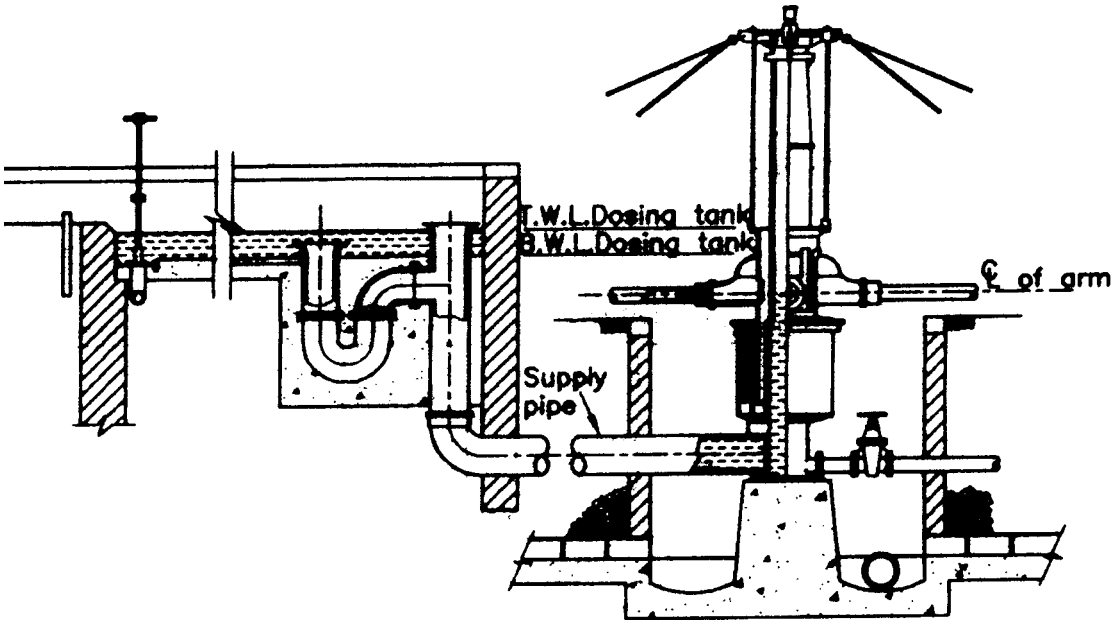


Figure :7.2 Dosing siphon

An alternative to a dosing siphon is to recirculate effluent continuously so that the filter arms keep turning at night

7.1.5 LOADING OF A BIOLOGICAL FILTER - ORGANIC LOADING

This is sometimes referred to as the BOD or COD loading. As the name implies it is related to the mass of COD or BOD applied per day per unit volume of filter. The normal organic loading rate is 80 - 400 g BOD/m^3.d.

In the high rate filter this is increased to 400 - 800 g BOD/m^3.d. The organic loadings on a filter will dictate the effluent quality. Generally, biological filters can remove 70% of applied BOD. If only carbon oxidation is required, a high organic load is generally used. If nitrification is required, i.e. where ammonia is oxidised to nitrates, a low organic load is applied.

7.1.6 RECIRCULATION

In certain cases it is advantageous to recirculate portion of the treated filter effluent through the filter. In cases where the incoming sewage is very strong, this will result in excessive growth of the biofilm, which could lead to the closing of the void volumes and failure of the filter. This phenomenon is sometimes referred to as ponding and should be avoided at all times. To overcome the problem of a strong waste, recirculation is introduced which results in the dilution of the wastewater. Recirculation is also serves to reduce odour and fly nuisance problems and keeps the distributor arms turning at low flow. The recirculation ratio is defined as the volume recycled divided by the feed volume and is often set at about 1:1.

7.1.7 PROBLEMS

Most problems in biological filtration are overcome by keeping the sewage as fresh as possible, and by not overloading the filters above their design capacity. Where this is not possible, the difficulties that can develop are ponding due to clogging of the surface layers of the filter media, the development of bad odours and excessive breeding of the psychoda filter fly. Chlorination of the settled sewage applied to the beds can relieve these troubles.

Chlorination can be carried out with chlorine gas from cylinders, or by adding bleaching powder. Another temporary remedy for ponding is to fork over the top layers of the bed concerned, or to apply powerful jets of water from a 75 mm fire hose. Excessive psychoda fly breeding can also be relieved by the cautious application of certain insecticides but these can damage the whole biological life of the bed. If certain limits are exceeded (e.g. excessive discharge of industrial wastes containing poisonous metallic salts, strong acids or alkalis into the sewers) or if overloading of the wastewater

works is too great, then the above problems will occur as the result of the decreased efficiency of the filters Complete breakdown of the normal biological purification processes in the filters may also occur.

7.1.8 MAINTENANCE

Although simple to operate, biofilters still need maintenance. One of the most common causes of poor filter performance results from the unequal distribution of the settled sewage over the surface of the filter. The design of the arms allows for this in the spacing of the nozzles; the spacing being greater nearer the centre where the distance travelled each revolution is least. The nozzles, however, are liable to block as a result of the carryover of plastic materials, frogs, and small animals falling into the settled sewage or the growth of slime. These can generally be flushed out by opening the valves at the outer end of the arms and by brushing within the nozzles. The distribution from the nozzles should be checked at least daily and preferably at each shift change so that appropriate action may be taken at the time.

The seals should be checked periodically to ensure that the settled sewage is not bypassing the filters at the central column. For good reasons, the mercury type seal is less frequently encountered and the tendency has been to use water seals and air seals. Maintenance and repair should be in accordance with the manufacturer's instructions.

Bearings should be lubricated in accordance with the manufacturer's instructions and checked to ensure that the mechanism rotates freely. Tension in the stay-wires should be periodically checked to ensure that the arms are straight and level and that they do not foul any obstruction.

7.2 ACTIVATED SLUDGE THEORY

Domestic sewage needs to be treated before release to the environment in order to remove organic pollutants, suspended solids, nutrients and pathogens. There are many means of domestic sewage including anaerobic digestion, trickling biofilters, rotating bio-contactors and activated sludge. This paper focuses on the latter technique.

Activated sludge is an extremely effective and efficient tool in treating a wide variety of domestic sewages and industrial effluents. Originally discovered at the turn of the last century the process has undergone a great deal of development in the last few decades, enabling not only the reduction of organic pollutants, but that of the nutrients nitrogen and phosphorous which lead to algal growth once released to surface waters.

It is a proud fact that much of this development has been conducted in South Africa by James Barnard, founder of the Bardenpho process, and the University of Cape Town. One of the main reasons for the interest in this field in South Africa is the scarcity of water which often requires the released effluent to be processed again downstream for further use. Unlike some countries the dilution factors in South Africa are small; eliminating the maxim “The solution to pollution is dilution!”

7.2.1 THE NEED FOR EFFLUENT TREATMENT

Why should a municipality treat sewage? There are both soft and hard issues which necessitate effluent treatment. These can be summarised as follows:

- Simple social responsibility
- Retain water quality and safety for downstream users
- Maintain a healthy environment
- Legal requirements for release into surface waters
- Reduction in WDCS charges
- Water reuse

7.2.2 WHAT IS ACTIVATED SLUDGE TREATMENT?

Activated sludge treatment was first observed in the UK where sewage was stored in pits before being irrigated onto land on so-called sewage farms. In order to reduce odours the engineers aerated these pits and soon observed that upon switching of the aeration the quality of the stored sewage was markedly better. This was due to the action of bacteria naturally occurring within the sewage which "fed" upon the constituents of the sewage using the oxygen for aeration. This batch system was then modified to produce a continuous process which consisted of an aerated tank followed by a settling tank with a recycle back to the head of the aerated tank as shown in Figure 1.

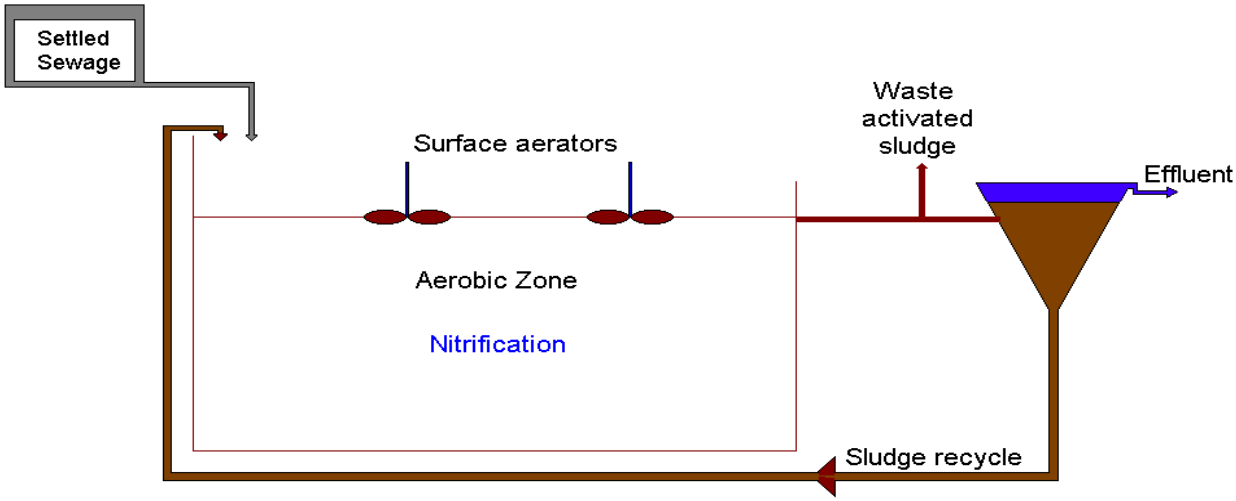


Figure :7.3 Simple activated sludge flow diagram

The bacteria in the sewage forms flocs as it grows and these then settle in the settling tank and are re-introduced into the aeration basin to continue the process. The greater the bacterial population the more the capacity to treat sewage within the limits of the reactor tank. If the floc concentration becomes too high then the settling tank becomes overloaded and the floc is discharged with the final effluent. Thus a certain fraction of the floc mass must be discarded or wasted daily. If a tenth of the floc or sludge mass is discarded daily then the mean cell residence time or sludge age is ten days, if one

twentieth is discarded the sludge age is said to be twenty days. This is expressed mathematically as:

$$\text{Sludge age} = \frac{\text{Total mass of sludge in system}}{\text{Daily mass of sludge wasted}}$$

The sludge age is a very important parameter and will be further discussed later.

7.2.2.1 Nitrification

It was later discovered that not only were the organic pollutants in the sewage removed by the activated sludge process, but that ammonia could also be removed according to the equations:

$$NH_4^+ + 3/2\ O_2\ (\text{Nitrosomonas}) \rightarrow NO_2^- + H_2O + 2H^+$$

$$NO_2^- + \tfrac{1}{2}O_2\ (\text{Nitrobacter}) \rightarrow NO_3^-$$

This was highly desirable as it reduced the ammonia odour, oxygen demand, and toxicity.

7.2.2.2 Denitrification

Further investigations showed that when the aeration was switched off for a period, the nitrates produced above were removed by bacteria which used the oxygen in the nitrate as an oxygen source for respiration. The equation for this reaction is:

$$NO_3^- + COD \rightarrow N_2 + CO_2 + H_2O + OH^- + \text{biomass}$$

This of course is highly desirable as it almost totally removes the nitrogen from the sewage thereby eliminating it as a nutrient. This could be included in a continuous process by introducing an unaerated anoxic zone in which the oxygen in the nitrate was the only oxygen source. This zone is usually placed in front of the aerobic zone to ensure sufficient food for the bacteria to denitrify. This arrangement is shown in Figure 7.4.

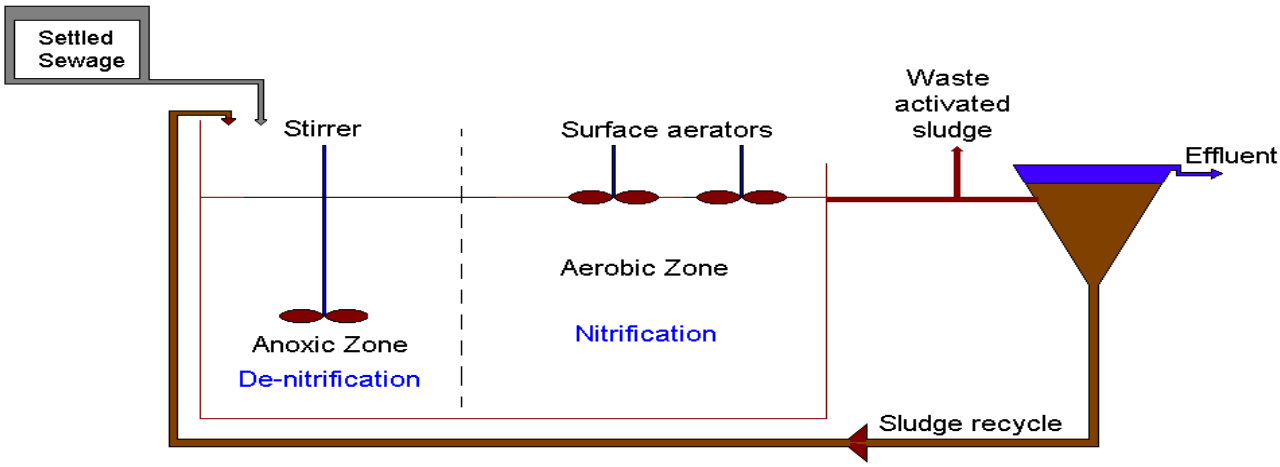


Figure :7.4 : Activated sludge with denitrification

7.2.2.3 Phosphate Removal

During the optimisation of denitrification it was further discovered that the insertion of an anaerobic zone ahead of the anoxic could produce phosphate removal. This is a result of the recycled bacteria desperately wanting to eat the sewage, but not having any oxygen to use for respiration. As an alternative to oxygen the bacteria actually release phosphate to gain energy by converting adenosine triphosphate (ATP) to adenosine diphosphate (ADP) which can be summarised by the equation:

$$ATP \longrightarrow ADP + P + energy$$

Once these bacteria reach the aerobic zone they take up phosphate once again, but do so in excess resulting in a net removal of phosphate. The process flow diagram is shown in Figure 7.5

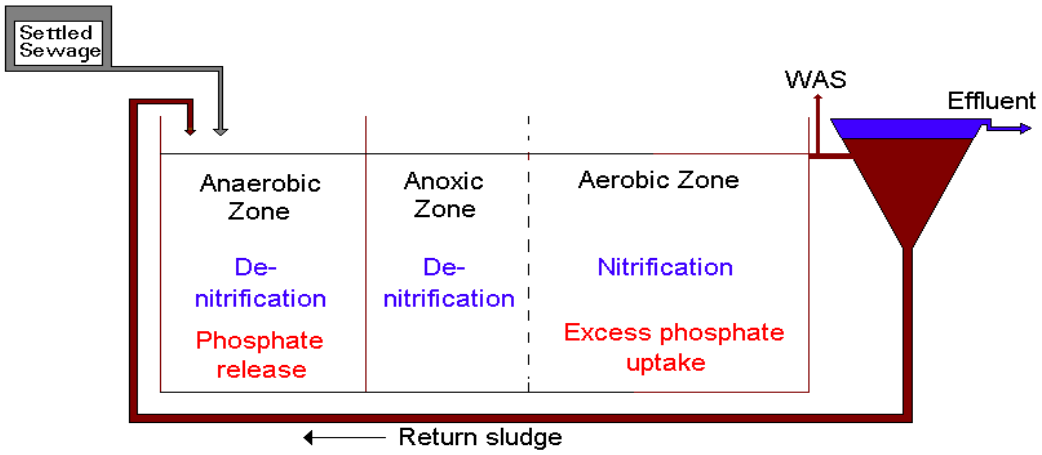


Figure :7.5 Phosphorous removal activated sludge

The Gwaing WWTW uses the UCT BNR Process which is best represented as follows:

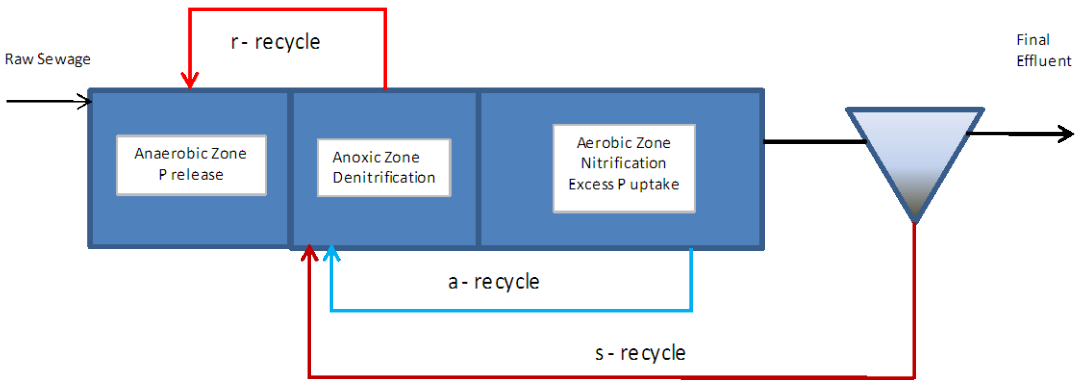


Figure :7.6 : Activated sludge with denitrification

7.3 DISINFECTION THEORY

7.3.1 INTRODUCTION

Raw sewage is considered a hazardous waste because it contains human waste, and human wastes contain, to a greater or lesser extent all known human pathogens. Typically, raw sewage contains high numbers of micro-organisms and each unit process used in treating wastewater reduces the number of micro-organisms as shown in the table below.

Table :7.1 - Removal of bacteria by different processes

Process	Percentage Removal
Coarse screens	0-5
Fine screens	10-20
Grit chambers	10-25
Primary sedimentation	25-75
Trickling filters	90-95
Activated sludge	98-99

There still remain high numbers of pathogenic micro-organisms in the treated wastewater even after the best possible biological treatment. To ensure that the effluent is safe for discharge to a public stream, some additional treatment is required. The most common additional process is disinfection.

The goal of water disinfection is to remove or inactivate pathogenic micro-organisms. Disinfection is not synonymous with the sterilization of water, in which all organisms are killed. In disinfection the primary pathogenic micro-organisms targeted for inactivation include bacteria, viruses and protozoan cysts.

The disinfection of water has been practiced for several hundred years, even though initially there was no understanding of the principals involved. Historical records show that the boiling of water had been recommended at least as early as 500 B.C.

Chlorine was identified as a chemical element in the early 1800s. Because of its characteristic colour, the name chlorine was derived from the Greek word chlorous, meaning pale green. It was not until sometime later, however, that its value as a disinfectant was recognised.

7.3.2 DISINFECTION WITH CHLORINE

Chlorine has been the dominant disinfectant of wastewater. It is available in different forms.

7.3.2.1 Liquid/gas chlorine

This is the basic chlorine compound and is used in large quantities for sanitary purposes; household bleaches, restaurant sanitizers, potable water treatment, wastewater treatment, swimming pools, cooling waters and other industrial process water treatment. Liquid-gas chlorine is the principal form of chlorine used m wastewater disinfection. It is also used for odour control, destruction of hydrogen sulphide, prevention and control of septicity and for elimination of activated sludge bulking.

7.3.2.2 Hypochlorite

Can be provided either in the form of sodium or calcium hypochlorite. Sodium hypochlorite is a clear liquid available in concentrations of up to 15% available chlorine by weight. Calcium hypochlorite is available either as a dry granular white powder or in tablet form in strengths of 70% available chlorine by weight.

7.3.2.3 On-site hypochlorite generation

Complete systems are available in South Africa for the on-site manufacturing of chlorine and hypochlorite solutions by electrolysis from salt (sodium chloride) which also avoids the potential hazard of handling the liquid-gas chlorine in pressurised containers. The solution strength of this hypochlorite solution is normally about 0.7%

7.3.2.4 Chloramines

A combination of chlorine and ammonia, chloramines are less efficient as a biocide as compared with free chlorine, but react to form fewer organic by-products.

7.3.3 CHLORINATION PRACTICE

Chlorination may be carried out by direct use of gaseous chlorine obtained from cylinders via purpose-designed chlorinators, or by dosage of hypochlorite solution which contains chlorine. Only the former will be discussed here.

7.3.3.1 Gas Chlorinators

Chlorine is obtained in 68 kg or 900 kg cylinders. The chlorine is compressed to a high pressure in the cylinders so that it is stored in liquid form. Chlorine is normally drawn off as a vapour or gas from the cylinders. When the gas is drawn off some of the liquid chlorine evaporates to replace it. The evaporation process requires heat and cools the surroundings. There is, therefore, a limit on the rate of draw-off of chlorine from a cylinder if freezing is to be avoided. The maximum draw-off is approximately 2 kg/h for a small cylinder and 10 kg/h for a large cylinder. This depends on the area, however, and should be checked with the suppliers.

A chlorinator basically consists of a vacuum regulator with adjustable gas flow measurement by needle valve via a float tube and an ejector on a pressure water line. The water passing through the ejector creates a vacuum, which sucks the chlorine gas into the water at the ejector and into solution. The solution of chlorine in water is then added to the effluent at a suitable point. The amount of gas drawn into the water at the ejector is regulated by a valve and measured on the float tube. Safety devices are normally built into the chlorinator to close off the gas in the event of water supply failure and to prevent water entering the gas lines.

Wet chlorine gas or chlorine solution is extremely corrosive and normal materials cannot be used. Most metals, lubricants and packing compounds are attacked. Special plastics and synthetic compounds are therefore used.

7.3.4 CHLORINE SAFETY PRECAUTIONS

Apart from being corrosive, chlorine is also very poisonous and can be explosive under certain conditions. The storage and use of chlorine therefore requires rigid adherence to safe practice procedures. Full details regarding these can be obtained from the suppliers who, from time to time, also conduct courses in the use and handling of chlorine.

In general, one must ensure that no chlorine leaks occur. These are readily detected by means of a cloth or cottonwool dampened with ammonia solution, which will produce white fumes when chlorine gas is encountered.

Where a leakage is possible or has been detected, suitable gas masks or respirators should be worn when entering the affected area. Cartridge type masks should only be used for limited periods and respirators with their own air supply should be used when entering a chlorine house whenever there is a leak requiring corrective procedures. Never enter an area if you are alone and the local emergency services should always be notified.

Ventilation of the storage and dosage area must be designed to prevent accumulation of chlorine gas, which is heavier than air. Floor level discharge ducts and fresh air fans entering near the ceiling as is a semi-open type of structure are common practice.

7.4 ANAEROBIC DIGESTION THEORY

When raw sludge enters the anaerobic digesters the COD rich solids are mixed with the digesting sludge already in the digester and three processes take place simultaneously:

- The settled particles are broken down into much smaller particles by enzymes in a process called hydrolysis.
- These microscopic particles are than converted to volatile fatty acids (VFA's) through a process of acetogenesis or acidogenesis.
- The volatile fatty acids are turn converted to carbon dioxide and methane by means of methanogenesis. Carbon dioxide and methane are both gases and are generally released to the atmosphere. If the gas is captured it can be converted to electricity by means of a generator.

The processes are shown in the flowing diagram:

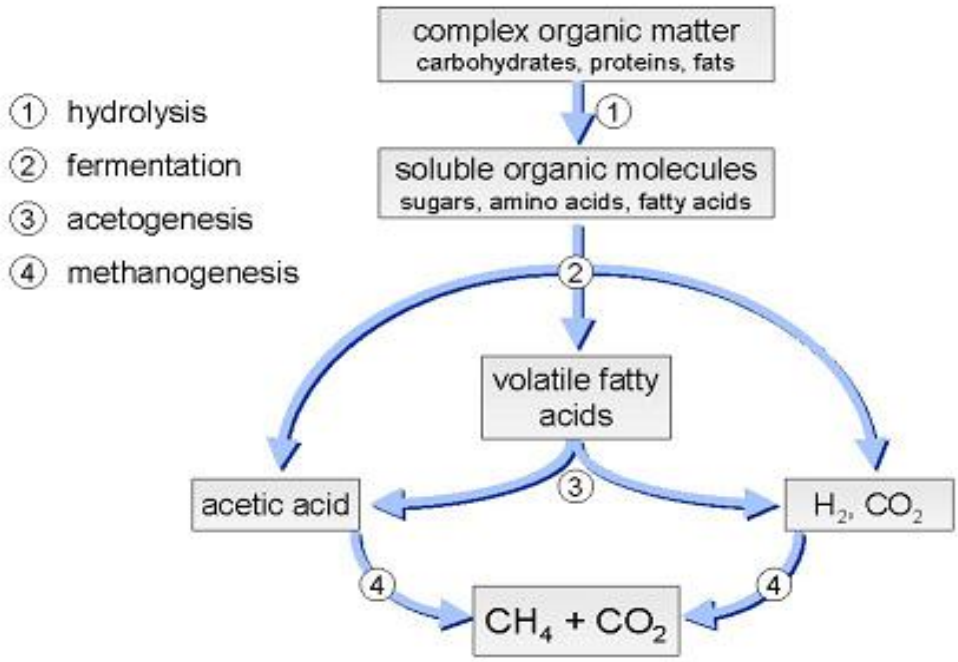


Figure :7.7 Anaerobic digestion processes

In summary, the COD in the particles is converted into gas which is released. This process consumes volatile solids, and results in their reduction. VSS removal by anaerobic processes in digesters is generally about 45%.

Digester can be mixed or unmixed, heated or unheated. Mixed digesters have required lower residence times than unmixed digesters, while heating digesters to 34-37C van halve their retention times.

7.5 DRYING BED THEORY

Drying beds are used both for dewatering digested sludge and for dewatering and drying waste activated sludge. The application rates are different for the two processes but the basic principles are similar.

7.6 PRINCIPLES OF DRYING BED OPERATION

Sludge on sand beds is mainly dewatered by a three-step process, namely drainage, decantation and evaporation:

1. **Drainage:** The sludge solids settle onto the surface of the sand forming a layer through which much of the water drains. Drainage occurs from the time the sludge is applied to the bed, with the water moving downwards under the influence of gravity into the sand layer, where underdrains remove it. It is the sludge characteristics that determine the drainage rate, as the water has to flow through the consolidating layer of sludge. This step, normally requiring a few days, lasts until the sand clogs with fine particles or until all the free water drains.

2. **Decantation:** A layer of supernatant water forms on the surface, which is drawn off (decanted) in certain bed designs thus reducing the volume of water that must be drained or evaporated from the sludge. This step also removes rainwater that, if allowed to accumulate on the surface, would slow down the drying process. Decanting may also be necessary to remove free water released by chemical conditioning of the sludge.

3. **Evaporation:** Finally, drying of the sludge occurs through the loss of moisture to the atmosphere by evaporation until the desired solids concentration is reached (about 30 to 40% total solids for digested sludge or even somewhat higher for activated sludge).

7.7 VARIABLES WHICH AFFECT THE DRYING PROCESS

The performance of sand drying beds is affected by the following factors:

7.7.1 WEATHER CONDITIONS

Open air-drying is especially suited to warm and dry weather areas. High wind velocities improve drying while high relative humidity and rainfall retard drying. In cold or wet climates, air-drying systems should be covered.

7.7.2 SLUDGE CHARACTERISTICS

Anaerobically digested primary sludge will dewater more easily and to a higher solids concentration than either a mixture of anaerobically digested primary and waste activated sludge, waste activated sludge alone, or aerobically digested sludge. Furthermore, sludge that is only partially digested will not drain as rapidly and dries more slowly than a well-digested sludge. The stabilised concentration of solids in the feed sludge also affects the drying time; the higher the solids concentration, the shorter the drainage and evaporation time. Some sludges, particularly aerobically digested sludges are not amenable to mechanical dewatering. These sludges can generally be dewatered on sand drying beds with good results.

7.7.3 SYSTEM DESIGN

The type of sand media, distribution of piping and drains, sludge distribution system and pumping equipment can all affect the operation and maintenance of an air drying system.

7.8 DESCRIPTION OF A TYPICAL SLUDGE DRYING BED

Sludge dewaters by drainage through the sludge mass and supporting sand and gravel, by decantation of the supernatant liquor and by evaporation from the surface exposed to the air. The main features of a sand drying bed are discussed below:

7.8.1 PIPING TO THE BEDS

Piping to the sludge beds should drain to the beds and should be designed for a velocity of at least 0.75 m/s. Cast-iron or plastic pipes are frequently used. In cold climates arrangements should be made to flush the lines if blockages occur and to prevent their freezing in cold climates.

7.8.2 SLUDGE INLET ARRANGEMENT

Distribution boxes are required to divert the sludge flow into the selected bed. One or two inlet points per bed are generally adequate and provision for preventing erosion of the sand base must be made using splash plates. The inlet flow should be controlled with a valve so as to apply an even layer of sludge over the bed.

7.8.3 SUPERNATANT OUTLET ARRANGEMENT

A supernatant withdrawal arrangement should be provided which should be positioned at the end opposite the inlet. Typical adjustable overflow weirs enable the clarified liquor to be decanted from the surface as this greatly increases the rate of drying.

7.8.4 SAND SELECTION

The sand layer should be from 230 - 300 mm deep Deeper sand layers generally retard the draining process. The sand should have a uniformity coefficient of not more than 4.0 and an effective size of 0.3 to 0.75 mm.

7.8.5 UNDERDRAINAGE

Most of the water leaves the sludge by drainage to a central sump. Drying beds are equipped with lateral drainage lines (vitrified clay pipes laid with open joints or perforated plastic pipe lines, with a diameter of at least 110 mm), sloped at a minimum of 1 % and spaced 2 5 - 6 m apart. The drainage lines should be adequately supported and covered with coarse gravel or crushed stone. The drying beds generally have a concrete floor slab laid at a slope of 1:12.

7.8.6 SIZE OF INDIVIDUAL BEDS

The drying area should be partitioned into rectangular, individual beds, maximum approximately 6 m wide by 20 - 30 m long. For smaller works a convenient size should be chosen so that one or two beds will be filled by a normal loading cycle, such as withdrawal of sludge from the digesters or wasting activated sludge at the desired sludge age.

7.8.7 SLUDGE DEPTH APPLIED

Most of the resistance to drainage comes from the sludge layer itself. The thickness of the sludge layer is all-important to the economics of the process. A thin layer of 100 mm will drain, cake and crack within a few days. For digested sludge a layer of some 200 - 300 is considered suitable. For waste activated sludge the amount wasted should give a dry cake about 15 mm thick. In comparison, thicker layers will take so much longer to dry that the overall drying rate is significantly reduced.

8 OPERATIONAL PROCEDURES – HEAD OF WORKS

8.1 VACUUM TANKER OFFLOAD BAY

The vacuum tankers must ensure that they offload their contents as hygienically as possible and their staff must rinse the area until it is properly clean to ensure that it is odour free and hygienic for the next customer.

8.2 NIGHTSOIL OFFLOAD BAY

Proper protective equipment should be used while offloading nightsoil, and the area should be rinsed once the operation has been completed. The contents of the sumps should be replenished as necessary.

8.3 COARSE SCREEN

The coarse screen should be cleaned as required with the custom made rake. Every attempt should be made to remove as much of the screenings as possible and to prevent screenings breaking loose and passing through.

8.4 MECHANICAL SCREENING

There are two mechanical drum screens. The units are fully automated in terms of their cycles, being triggered by headloss. The screenings are automatically rinsed into a centreless screw and transported to a conveyor belt for removal and compaction. The screenings should be disposed of in a manner acceptable to the Department of Water Affairs.

The screens should be inspected at least twice a day for any foreign objects such as branches or planks which may have passed through the coarse screen into the fine screen and have potential to cause damage.

The screens can be started on the SCADA or locally.

8.5 VORTEX DEGRITTER

The vortex degritter is designed to remove organic solids by means of centrifugal forces with the solids hitting the side wall and settling to the sump at the base of the unit. From there the grit is pumped by an airlift pump to a selector to allow the excess water to be removed and to return any organic solids back to the mainstream.
The pumping cycle of the degritter is automated and can be optimised by changing the interval between the pump operating and the pump operating duration itself.

If the grit removal from the sump experiences problems it is highly likely that the airlift pump has become blocked with debris and needs to be cleaned.

The quantity of the grit removed should be recorded on a regular basis. A sudden increase in grit coming into the works can mean a structural problem in the outfall sewer, allowing sand into the system.
The degritter can be started using the SCADA or locally.

8.6 GRIT CHANNELS

The grit channels remove the remaining grit after the vortex degritter. They must be isolated and cleaned out on a regular basis as determined by the plant superintendent to prevent grit entering the rest of the works as this will cause deposits in the basins, damage to the pumps and accumulation in the digesters. The channels may need to be cleaned more often during the wet season due to higher flows carrying more grit.

8.7 PARSHALL FLUME

A Parshall flume is a venturi like structure through which the sewage passes. The upstream level of the sewage flow can be converted to a flow by means of an equation. The design of the flume is such that little rubbish adheres to it. The level is generally read using an ultrasonic probe. Should the probe ever fail the depth can be read using a measuring stick and then converted to a flow.

8.8 DIVISION STRUCTURE 1

The influent from the inlet works flows to division box no.1 where the flow is split to 7.3Ml/d for the BNR system and 3.7Ml/d for the Biofilter Plant.

9 OPERATIONAL PROCEDURES – BIOFILTER PLANT

The theory, operation and maintenance of biofilters have been dealt with in detail above.

9.1 OPERATING THE BIOFILTER PLANT

In order to operate the biofilter plant the following steps should be taken:

- Ensure that the PST drives are functional
- Ensure that the primary sludge pumps are operational
- Ensure that the biofilter arms are free to move
- Ensure that the humus tank outlets are not blocked
- Ensure that the recycle pumps are operational
- Ensure that the humus pumps are operational
- Ensure that the anaerobic digester is functional

Once all these checks have been done flow can be introduced to the PST's and hence the biofilters.

The recycle pump will recycle the outflow from the biofilter back to the upstream side of the biofilter. The object of this exercise is twofold:

- To ensure that the biofilter keeps operating regularly even when flows are low to prevent it drying out and the biomass dying.
- To enhance nitrification – without the recycle nitrification will be poor.

Never operate the biofilter without the recycle operating – the effluent quality will deteriorate

The following maintenance is extremely important:

- The openings in the rotating arms must be cleaned out on at least a daily basis and the end caps removed and the arms flushed as required.
- The biofilters must be flushed periodically to prevent clogging with solids. This is done by taking one biofilter out of duty and then directing the entire flow through the other biofilter. At the same time the rotation of the biofilter arm must be slowed down manually to thoroughly flood the biofilter being flushed.
- If visible ponds of liquid appear on the surface of the biofilter then the biofilter must be flushed as described above until the blockage is cleared. If the ponding continues the biofilter must be taken out of duty and the media removed in the area of the ponding up to a depth of 1m and the material blocking the biofilter removed manually.

9.2 OPERATION OF THE PST'S AND ANAEROBIC DIGESTERS

The primary settling tanks should be desludged manually every 2-4 hours depending upon the weather and hence the inflow to the works. Generally high flows during wet weather will result in the desludging having to take place more frequently.

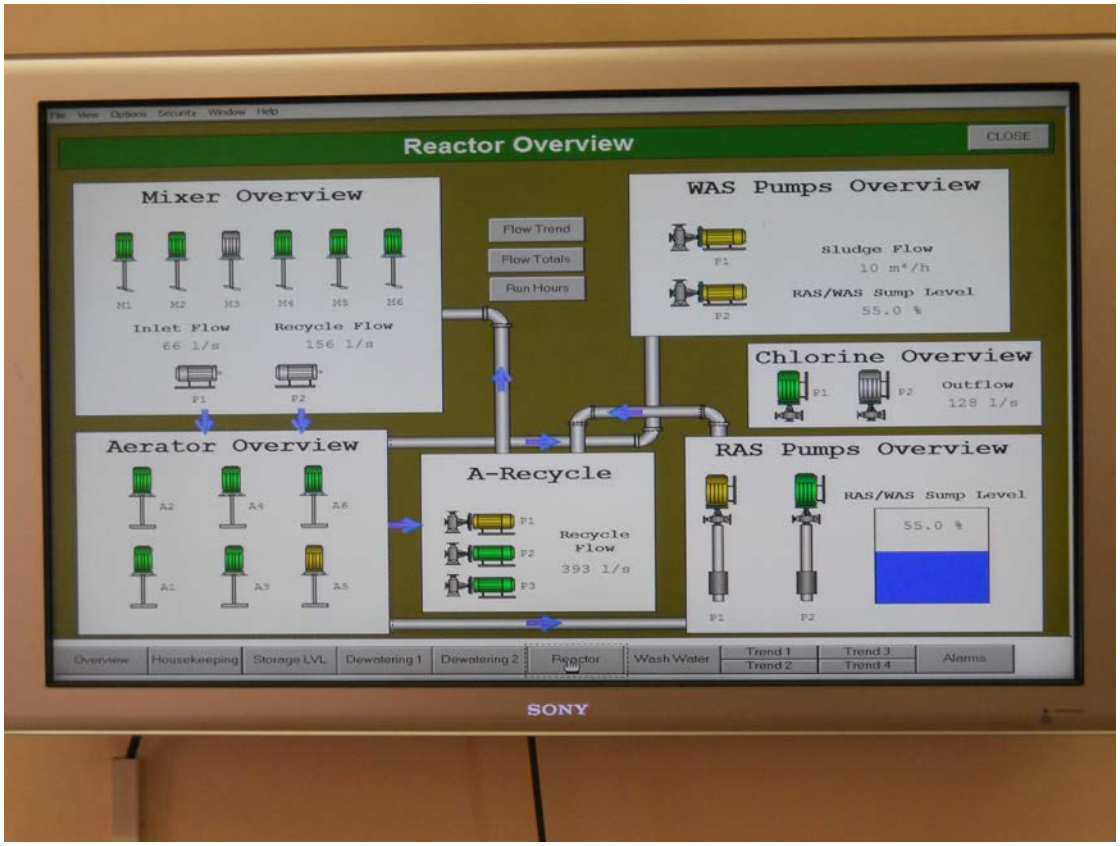
The raw sludge from the PST's is pumped up to the digester using the raw sludge pumps operated manually. This is performed every 4-8 hours

There are three supernatant valves on the digester. Samples should be taken from these and allowed to settle for 60 minutes to determine which contains the least solids. The supernatant is then withdrawn from the digester and flows to the inlet works.

Digested sludge is withdrawn from the anaerobic digester and flows to the drying beds. 1-6 drying beds of anaerobic sludge are withdrawn per month. The sludge drying period will very much depend on the weather, and once the sludge has dried (cracked and curled up a little) it should be removed from the bed and disposed of.

10 OPERATIONAL PROCEDURES – ACTIVATED SLUDGE PLANT

The activated sludge plant is largely automated, being controlled by the SCADA or HMI. For the purposes of testing during maintenance individual components can be run on "Manual" but it should be remembered that no interlocks apply in this mode.



The unit processes and installations related to the 7.3Ml/d modifications and the sludge thickening and dewatering facilities are described in this chapter.

10.1 FEED CHANNEL AND MEASURING FLUME

The 7.3Ml/d of division box no.1 outflow is passed on to the anaerobic basin of the bioreactor. A measuring flume with ultrasonic level detector is installed in the channel feeding the anaerobic basin.

10.2 ACTIVATED SLUDGE BIOREACTORS

The activated sludge plant should be started up using the start up sequence programmed into the SCADA.

Alternatively the plant can be started up according to the programme on the Human Machine Interface (HMI).

Should the plant be required to be started manually then the following sequence should be used:

- Start one RAS pump
- Start the clarifier bridges on the SST's
- Start the aerators
- Start the A and R recycles
- Start the mixers on the anaerobic and anoxic basins

The dimensions of the activated sludge basins are as follows (further data is supplied in Appendix B: Design Data):

Description	Volume (m^3)	Depth (m)
Anaerobic Basin	2940	4.7
Anoxic Basin	5090	4.7
Aerobic Basin	7514	4.45

Three recycles operate:

A- recycle – from the aerobic zone to the anoxic zone to provide denitrification (3 No axial flow pumps with a flowrate of 210 l/s with 2 pumps in operation and 1 on standby)
R- recycle – from the anoxic zone to the anaerobic zone to provide denitrified biomass for optimal P-release (3 No axial flow pumps with a flowrate of 170 l/s with 2 pumps in operation and 1 on standby)
S- recycle - from the SST underflow to the anoxic zone to provide denitrification (2 No. centrifugal pumps with a flowrate of 120 l/s with 1 pump in operation and 1 on standby)

10.2.1 ACTIVATED SLUDGE PROCESS SUMMARY

When the sludge in the anaerobic basin mixes with the raw sewage the sludge releases phosphate in order to provide energy for the uptake of VFA's.

The sludge in the anaerobic basin is passed on to the anoxic basin where the biodegradable COD is removed together with nitrate. This process is known as denitrification where nitrate is used as an electron acceptor instead of oxygen. The nitrate enters the anoxic basin via the A-recycle from the aerobic basin.

The A-recycle needs to be controlled to keep the anoxic basin underloaded with nitrate so that no nitrate is recycled to the anaerobic reactor.

Denitrified sludge is passed onto the aerobic reactor where nitrification of the ammonia takes place with oxygen.

The uptake of P in the aerobic reactor is greater than the release of phosphate in the anaerobic basin therefore excess uptake thus phosphate removal from the liquid phase to the solid phase [uptake of polyp by new cell mass]

Outflow from the aerobic basin is passed onto the secondary clarifier where the solids are separated from the liquid by settling. The settled sludge is discharged via the underflow where some of the sludge is removed as waste activated sludge and the remainder is recycled back to the anoxic reactor via the RAS recycle. Recycling to the anaerobic basin introduces nitrate, which would prevent formation of VFAs.

10.2.2 VERTICAL SHAFT MIXERS

The unaerated zones are equipped with 11KW vertical shaft mixers that keep solids in suspension. Two mixers are in the anaerobic zone and four in the anoxic zone. The contents of the basins are gently mixed without introducing oxygen through surface agitation or vortexing.

10.2.2.1 Operation

The mixers require minimal maintenance and are not prone to accumulation of rags or debris. They are also equipped with stop/start control.

10.2.2.2 Failure of shaft mixers

Failure of mixers to power failure may result in settling of sludge. Once restarted the scour velocities near the bottom of the basin will lift the sludge and bring it back into suspension.

10.2.3 VERTICAL SHAFT LOW SPEED AERATORS

The aerated zone is fitted with six low speed, bridge mounted mechanical aerators of the following size: 4 aerators 55kW motors and 2 aerators 45kW motors.

Due to the variable oxygen demand in the plant, the oxygen transfer rate of the aerators is controlled by means of switching the aerators on and off. The number of operating aerators at any one time is determined by the DO measured by a probe in the reactor basin.

A further means of control is by varying the immersion depth of the aerator turbines. A 3 m long overflow tilting weir is provided. The weir shall be set to give the optimum oxygen transfer efficiency of each aerator at peak loads.

Note: Due to abundance of reactor volume future increase of loads to the plant can be managed by upgrading the aerator oxygenation capacity by fitting pairs of 90kW, 75kW and 55kW aerators. This would increase the capacity of the bioreactor by up to 45% of its present capacity.

10.2.3.1 Switching aerators on and off as required

- Sludge entering the aerobic zone from the anoxic zone should be aerated immediately in order to maintain aerobic conditions where the flow enters the aerobic zone. In order to achieve this, the first two aerators will normally be operated continuously.
- The second and third row of aerators will be switched on and off under the control of the DO meter.
- Following a power failure, the aerators must be started in a staggered manner with at least 30 seconds between each motor.
- The controlling PLC is programmed to ensure the following:

    - One aerator per row will be switched off at a time.

- In order to prevent “hunting” the DO meter(s) will only be interrogated every quarter of an hour and the DO level will have to be out of the specified range (1.8mg/L to 2.2mg/L with a setpoint of 2 mg/L) for two consecutive interrogations before the status of the aerators is changed. The setpoint can be changed by the process controller.

- Aerators will not be allowed to switch on and off for more than four times an hour.

- After an aerator has been switched off for a continuous period of 45 minutes it will automatically be switched on and the other aerator in the row will be switched off in order to prevent deposition and stagnation of the sludge on the floor of the bioreactor.

The “Golden Rule” for aeration is:

- If the final effluent ammonia concentration approaches 3mg/l then the DO setpoint must be increased – i.e. provide more air.
- If the nitrate concentrations in the final effluent approach 5 mg/l then the DO setpoint should be lowered.

10.2.4 AXIAL FLOW PROPELLER PUMPS (A-MLR PUMPS)

Three a-MLR pumps capable of lifting 210 l/s (2 duty, 1 standby) against a low head (ranging between 400 and 600 mm) recycle mixed liquor from the end of the aerobic zone back to the anoxic zone. One or two will be duty pumps that will lift the flow into the recycle channel.

- Rags may accumulate on the impellors or these pumps which will result in vibration being observed. The pump should be taken out of duty immediately and serviced.

10.2.5 AXIAL FLOW PROPELLER PUMPS (R-MLR PUMPS)

Two r-MLR pumps with variable speed driven motors, one duty and one standby, recycle mixed liquor from the end of the anoxic zone back to the anaerobic zone. The pumps are capable of lifting 170 l/s (2 duty, 1 standby) against a low head (between 400 and 800mm).

- Rags may accumulate on the impellors or these pumps which will result in vibration being observed. The pump should be taken out of duty immediately and serviced.

10.2.6 SECONDARY SETTLING TANKS (SST)

From the aeration basin the mixed liquor passes on to the two secondary settling tanks that are equipped with scraper mechanisms. Each clarifier has a 25m internal diameter, side water depth of 3.5m and horizontal floors. Sludge is withdrawn through the sludge draw-off siphon pipes attached to the rotating bridge. The siphons should be adjusted such that more sludge is removed at the periphery of the bridge than the center.

10.2.6.1 Access Bridge drive arrangements

The access bridge is driven by an electric motor through a general speed reducer and drive wheel to give the required peripheral speed. The bridge assembly shall rotate at a constant speed of between 1.5 and 2m/min.

10.2.6.2 Sludge withdrawal

Settled sludge is removed from the entire tank floor surface area by a system incorporating collection scrapers with hydraulic suction devices that are suitably spaced along the full length of the bridge.

10.2.7 RETURN ACTIVATED SLUDGE (RAS) PUMPS

Two RAS pumps are housed in the RAS/WAS pump station. The discharge of underflow from the clarifiers into the sump is controlled by telescopic valves. The operator shall manually set the telescopic valves in such a way as to prevent frequent low levels in the sump. The RAS pump speed is coupled to the inflow into the reactor basin. This control will be based on the ratio of the instantaneous inflow to a corresponding speed of the RAS pump depending on the pump specific curve. The required ratio is 1:1. The feedback loop will be slow, which will allow for some integration over a time period of the instantaneous flow. The percentage ratio on the HMI can be changed by the process controller.

10.3 WASTE ACTIVATED SLUDGE (WAS) PUMPS

Waste activated sludge is pumped from the WAS sumps which fills with RAS sludge

The sludge concentration in the reactor will be measured manually by the operator and the measured concentration will be logged. The percentage of solids that will be wasted (expressed as sludge age in d^{-1}) will also be determined and logged. Based on these figures the PLC calculates the total quantity of sludge to be wasted according to the volume (15 544m^3) of the reactor.

The WAS pumps then run until this quantity of sludge has been wasted, as measured by the turbidity meter in the WAS sump, as well as the flow meter on the WAS discharge line. If the pump is interrupted prior to the total quantity being pumped, the cycle will cease into a "pause" situation until the limit has been reset. Pumping will stop due to:

(i) low level in WAS pump
(ii) high level in sludge tank at the dewatering plant and
(iii) low limit measured on turbidity meter in WAS sump (sludge not thick enough)

Once the WAS wasting has reached the total quantity and has stopped (not merely paused), the cycle will only commence again once the operator has "reset" the system by requesting sludge wasting again (via an HMI input).

10.3.1 SELECTION OF SLUDGE AGE

The initial design MLSS concentration is 2 500mg/l which is lower than the usually accepted 3 500mg/l. This is due to the large volumes of the reactors which were converted from a Petro pond system. With increased loads over time a more optimum sludge concentration will be reached.

By increasing or decreasing the sludge age the sludge concentration in the reactor can be increased or decreased respectively. Selection of the sludge age is the most fundamental and important decision. The sludge age of a plant will determine the stability of the process and influence the sludge settleability.

Generally phosphate removal is best at a lower sludge age, while nitrification is best at a longer sludge age which results in a trade-off in deciding the sludge age.

Short sludge ages (1-5 days) are for the purpose for COD removal only. Intermediate sludge ages (10-15 days) are obligatory when nitrification is required. Long sludge age (15-25 days) plants are more stable in operation. Although the oxygen demand per unit input is larger, it needs less supervision and the effluent COD remains low.

This plant has been designed for 20 days sludge age, but can be operated at a sludge age of as low as 13 days should the need arise as the COD load increases.

10.3.2 IMPORTANCE OF ALKALINITY

With low alkalinity wastewaters (like those encountered in the Western and Southern Cape), nitrification can cause a significant reduction in effluent pH. This not only causes problems with the nitrification process itself in that only partial nitrification is achieved (with the likelihood of non-compliance of the ammonia standard) but also tends to favour the development of poor settling sludges and to produce effluents which are aggressive towards concrete, removing the fines.

To reduce these problems deliberate biological denitrification has been incorporated in the process and this recovers approximately half the alkalinity used in nitrification. This results in a higher alkalinity and stable pH.

The alkalinity in the final effluent should always be maintained above 80mg/l to ensure good nitrification and prevent aggression towards concrete which results in fines removal.

11 OPERATIONAL PROCEDURES – TERTIARY TREATMENT

The chlorination plant is largely automated, being controlled by the SCADA. For the purposes of testing during maintenance individual components can be run on "Manual" but it should be remembered that no interlocks apply in this mode.

Tertiary treatment at the Gwaing WWTW consists of:

- Maturation ponds for the biofilter effluent
- Disinfection by chlorination for the activated sludge effluent and the pond effluent

11.1 MATURATION PONDS

The maturation ponds require little in the way of operational management. The chief problem that they are likely to experience is the build up of solids from carryover on the humus tanks and diversions of stormflows. The accumulation of solids can give rise to the release of ammonia in the ponds, which will affect the final effluent quality.

For this reason a monthly sample should be taken at the beginning and end of the maturation pond to check for ammonia release.

11.2 DISINFECTION BY CHLORINATION

WARNING: Chlorine gas is extremely poisonous. One full breath of chlorine is usually fatal. Utmost care must be exercised in handling chlorine gas and must be limited to personnel trained in the handling of chlorine gas

The gas chlorination unit installed at the works uses 990kg cylinders and is proportional to the flow, being controlled by the SCADA. The system has a start up sequence on the SCADA.

Any problems encountered with the chlorination system should be addressed according to the supplier's detailed manual in conjunction with the supplier.

The following instructions are general instructions for chlorination installations and are provided merely as a guideline.

11.2.1 CHLORINE HANDLING PROCEDURE

Chlorine is a highly toxic gas; it can kill or injure when inhaled. It is therefore important that the necessary precautions are observed when handling chlorine:

1. Employees must be trained correctly on how to handle chlorine
2. Only trained and certified operators should be allowed to work with chlorine
3. Self-contained breathing apparatus (SCBA) should be worn when working with chlorine; this is before opening valves or changing chlorine containers
4. SCBA should always be checked before wearing them
5. Always adhere to plant safety policy.
6. Never enter an area where there is gas alone
7. Notify the local emergency services

11.2.2 START-UP AND SHUTDOWN PROCEDURE

A specific sequence should be followed when starting or shutting the chlorination system:

1. The following steps should be followed when starting a chlorination system:
2. Position full chlorine container on the scale
3. Follow safety procedures
4. Always use new lead washers to prevent leaks
5. Open appropriate valves at the point of solution application
6. Activate water flow at the injector to create the required vacuum. A vacuum of at least 17 to 24 kPa is normally required at the chlorinator for proper operation
7. Activate the evaporator heat exchanger to attain the typical operating temperature of between 71 and 82°C (if applicable)
8. Open the evaporator inlet and outlet valves (if applicable)
9. Activate the chlorinator, alarm system and electric positioner where applicable
10. Activate chlorine gas leak detector
11. Open the chlorinator inlet and outlet valves
12. Activate the main changeover system (if applicable)

13. Check for leaks using fumes from the aqueous ammonia squeeze bottle. While doing this slowly open the main chlorine manifold and tank valve to no more than one turn. Repair any leaks immediately
14. Activate the chlorine residual analyser system (if applicable)
15. Monitor chlorination system devices for proper operation.

To close down the procedure should be reversed and carried out where applicable in the inverse order.

12 OPERATIONAL PROCEDURES – SLUDGE HANDLING

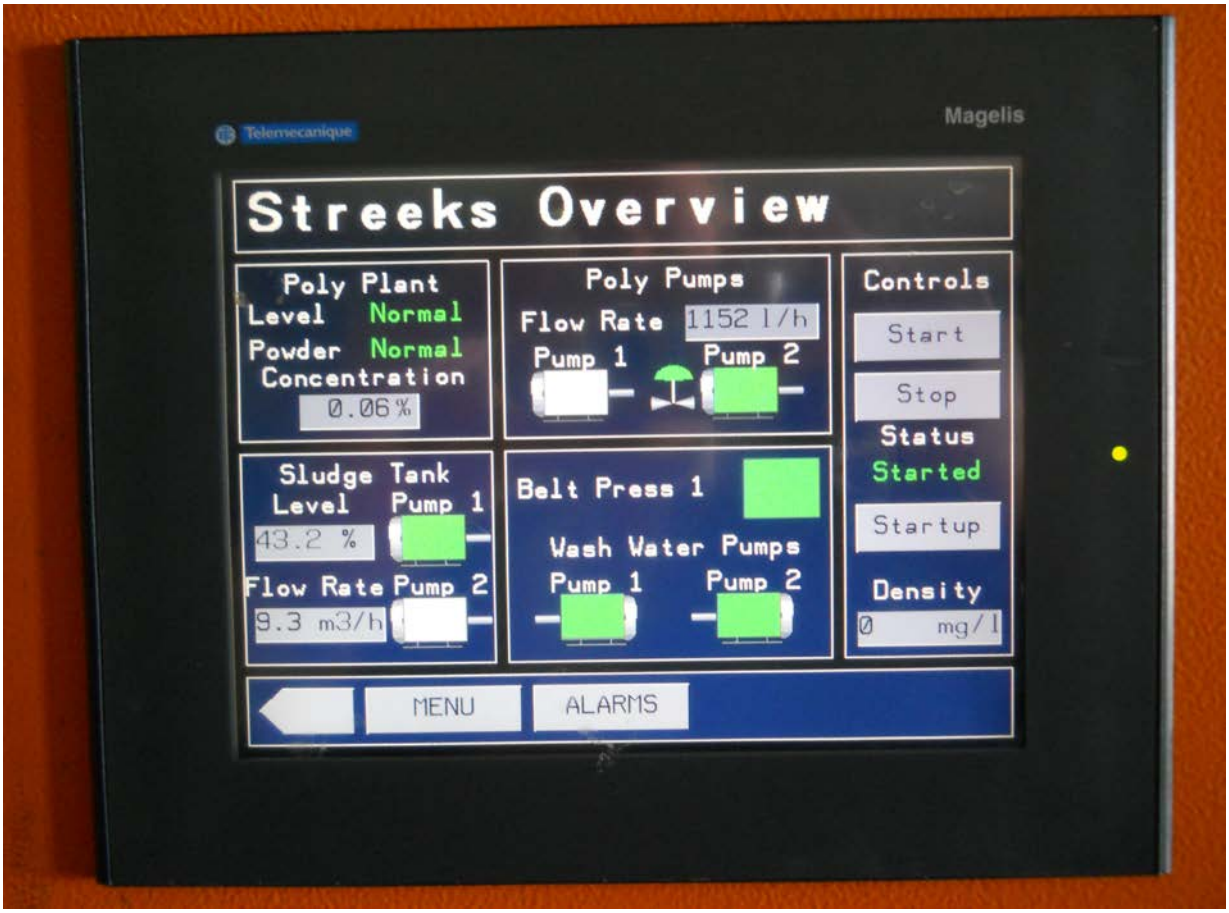
The beltpress plant is largely automated, being controlled by the SCADA or HMI. For the purposes of testing during maintenance individual components can be run on "Manual" but it should be remembered that no interlocks apply in this mode.

12.1 THICKENING AND DEWATERING OF GWAING WAS

The WAS is pumped by the WAS pumps to the sludge holding tank at the Beltpress Building, where it is mixed by aeration. From there the sludge is pumped by two variable speed progressive cavity pumps to a linear screen / belt press train for thickening and dewatering. The sludge feed pipeline is fitted with a flow meter, sludge solids density meter and sludge/poly mixing device.

There is an existing poly make-up system installed in the dewatering building, supplying polyelectrolyte both for the thickening/dewatering train and for the existing dewatering beltpress treating the Outeniqua WWTW sludge.

The beltpresses are generally operated using the HMI nearby.



The control philosophy of the system is described below.

12.1.1 POLY MAKE-UP

- ***Continuous batch make-up system with three tanks, overflowing into each other.***
- ***Low level in third (dosing) tank triggers make-up sequence.***
- ***Open solenoid valve for water feed into first (make-up) tank. After time delay, start screw feeder to measure preset quantity of dry poly into tank. This will be based on the rate of the feed of the screw feeder, and will be set by the operator on the HMI (in percentage poly solution required).***

12.1.2

12.1.3 DEWATERING CONTROL

- ***The belt speed will be adjusted by the operator depending on the quantity of sludge required to be dewatered.***
- ***The sludge feed pumps will vary their speed and hence pumping rate based on the sludge density to produce a defined solids sludge cake, up to the maximum capacity of the belt press at the speed set point. This will be a product of the density and flow as measured by turbidity meter in the sludge holding tank, and the flow meter in the sludge feed line***
- ***The poly dosing pumps will vary their speed according to the mass of sludge going to the belt press, based on the required poly dosing rate as set by the operator on the HMI***

12.1.4 DRAIN BELT/BELT PRESS START-UP SEQUENCE

- *Perform safety check (E-stops, Limit Switches)*
- *Check sufficient air pressure*
- *If drain belt level low, open potable water solenoid for predetermined time*
- *Wait 30 sec*
- *Start belt*
- *Wait 5 sec, if OK*
- *Start conveyer*
- *Wait 5 sec if OK*
- *Start poly dosing pumps*
- *Wait 10 sec, if OK*
- *Start sludge feed pumps*
- *Wait 10 sec, if OK*
- *Start wash water meter*
- *If any of the above fail, stop start –up sequence, identify problem step on HMI*

12.1.5 BELT PRESS SHUTDOWN SEQUENCE (NORMAL):

- *Stop sludge feed pumps*
- *Stop poly dosing pumps*
- *Wait 5 min (adjustable 0-30min)*
- *Stop wash water pumps*
- *Wait 10 sec*
- *Stop belt press*
- *Stop conveyer*

12.1.6 EMERGENCY SHUTDOWN. THE FOLLOWING WILL STOP THE BELT PRESS AND ALL ASSOCIATED EQUIPMENT IMMEDIATELY:

- ***Any E-stop***
- ***Any Belt tracking limit switch***
- ***Low air pressure***

12.2 THICKENING AND DEWATERING OF REGIONAL/OUTENIQUA DAF THICKENED WAS

The waste activated sludge from the Outeniqua WWTW is DAF thickened at the Outeniqua WWTW and then pumped to the Gwaing WWTW where it is stored in a dedicated sump before dewatering on a dedicated beltpress.

The PLC control and poly makeup station is shared with the Gwaing WWTW beltpress.

The operation of the Regional/Outeniqua beltpress is similar to that described above and is selected on the same HMI.

As such it is unnecessary to repeat the detailed procedure.

13 MAINTENANCE

13.1 INTRODUCTION

Good maintenance practice saves money overall. Most of the failures experienced have been due to inadequate maintenance. There is always a difference in opinion between those advocating preventative maintenance and those who belief that equipment should be operated until something goes wrong. Preventative maintenance obviously costs money and too early replacement of wearing parts can be expensive. However good preventative maintenance can avoid costly and embarrassing breakdowns and prolong the service life of equipment considerably

In order to minimise mechanical equipment breakdowns, it is necessary to carry out preventative maintenance rather than corrective maintenance, which involves repairing and replacing damaged parts. This type of maintenance combines both the manufacturer's recommendations and the process controllers' experience acquired over a period of time. Preventative maintenance includes detailed inspection, reasonability checking cleaning, lubrication, replacement of defective parts and calibration where required Task schedules must be planned for maintenance that needs to be done by the process controllers or his assistants. Certain equipment must be checked daily, others at a set time intervals or during the actual running hours of the equipment. The efficiency of the process controllers can be maximised by keeping charts that show equipment maintenance requirements (i.e. what and when maintenance is to be done) thereby prioritising work to be done. A copy chart can be kept at a convenient spot for the process controller and his assistants.

Process controllers should be careful not to replace parts that are in good condition, just to carry out preventative maintenance. This implies that they must avoid replacing equipment parts without proper inspection.

13.2 MECHANICAL MAINTENANCE

Proper mechanical maintenance of equipment contributes to the efficiency and life span of the equipment. The process controller should do a routine check of mechanical plant for problems such as leaks, overheating, vibrations, noise or any other abnormalities. The process controller should check that equipment is free of obstruction, properly aligned and moving at normal speed. Mechanical maintenance of equipment must be according to the manufacturer's instructions. This could cover areas such as type and grade of oils and grease to be used, the frequency of greasing and oil changes, how much oil or grease must be used, and troubleshooting in case of problems, e.g. overheating, excessive vibrations.

13.3 PUMP MAINTENANCE

Pumps on a wastewater treatment plant are used for various duties depending on the material being pumped, for example, influent, sludge, effluent and grit. The maintenance programme of pumps depends on the type of duty the pump performs. All pumps should be checked for excessive noise, vibrations, overheating and leaks. Grit pumps are prone to rapid wear and should be opened up periodically for inspection and replacement of wearing parts. If more than one pump of the same size is used, they should be alternated in their duties to equalise their wear. This will also keep the motor windings dry, distribute lubricants in the bearings and avoid bearing failures which are common with standing machinery.

Pump packing glands must be checked for excessive leakage during operation. A slight seal leak should be allowed when pumps are running to keep the packing cool. However excessive leakage of the packing glands causes the water to enter the bearing housing thus leading to failure of the bearings.

Lubrication of the pumps should be in accordance with the manufacturer's instructions. The process controllers must be aware of the service frequency requirements of pumps in operation.

13.4 ELECTRICAL MAINTENANCE

1. The power should always be off when doing electrical maintenance
2. Electrical equipment should be kept free of dirt or moisture
3. Always check electrical equipment for loose leads
4. When the power is off, perform a sequenced start-up procedure
5. The motor control centre (MCC) should be checked periodically. Maintenance of MCCs should include cleaning the equipment, checking for damages and loose leads

Process controllers should check **electrical motors** for:

1. Unusual vibration and noise
2. Speed of the motor
3. Continuous sparking of brushes

13.4.1 STAND-BY GENERATORS:

1. Check the battery charge status monthly
2. Exercise the generator weekly
3. Check the warning light weekly to see if the generator energised
4. Carry out a diagnostic tune-up of the generator twice a year.

13.5 LUBRICATION

Lubrication forms part of preventative maintenance. Lubrication prevents metal-to-metal contact. Whether it is oiling or greasing the equipment, lubrication should always be in accordance with the manufacturer's instructions. A record of lubrication consisting of the frequency, type and amount of lubricant used should be kept for reference. A lubricant should be chosen according to the manufacturer's recommendations bearing in mind the operating conditions and material used.

13.6 PROTECTIVE COATING AND PAINTING

Plant facilities and equipment need to be protected from corrosion by maintenance painting. Process controllers are required to inspect facilities and equipment for possible repainting. A schedule should be provided outlining the structures to be inspected, frequency and type of inspection. When protective coating repair is necessary, the process controller should decide whether it is to be an immediate repair job or if complete repainting is required. Protective coating should be chosen according to the environment and application.

13.7 RECOMMENDED MAINTENANCE TASKS FOR MECHANICAL/ ELECTRICAL EQUIPMENT

Note that these tasks should be carried out in addition to any maintenance requirements specified in the manufacturer's operating manuals.

13.7.1 WEEKLY ITEMS

1. Visual inspection of all equipment for leaks, misalignment, excessive wear and breakages
2. Oil level check
3. Noise and vibration checks on all pumps and aerators

4. Grease all rotating elements
5. Clean floating debris and rags etc. from float switches
6. Check pump selection switches and record readings from hours run meters (where fitted)
7. Check aerator selection switches and record readings from hours run meters (where fitted)
8. Check operation of automatic flow meters and record readings (where fitted)
9. Check panel globes in MCC and replace as necessary
10. Check amperage draw for mechanical equipment against manufacturer's specifications
11. Check control circuits for pumps and dry run protection (where fitted)
12. Manual check of all auto systems and any interlocks
13. Check that all screenings/washings are collected in correct storage bins
14. Clean out all overflow weirs and launder channels around sedimentation tanks
15. Check status of sludge drying beds – rotate operation as required

13.7.2 MONTHLY ITEMS

1. Grease all motor bearings
2. Swap over duty/standby pumps and check impellors for any blockages
3. Manually operate all valves, and check for signs of leakage
4. Check gland packing to all valves and pumps, and replace as required
5. Top up oil levels, according to manufacturer's recommendations
6. Wash down sumps and clear all debris
7. Touch up and wire brush any corroded steelwork
8. Empty and clean out degritter sump

13.7.3 ANNUAL ITEMS

1. Change gearbox oil
2. Remove each pump, check for wear to impellor, renew gland packing, check for wear to cables
3. Strip all non-return valves, clean internally and repair as required
4. Recalibrate all flow meters
5. Re-align and undertake vibration tests for aerators, mixers and pumps

14 PUMPS

14.1 INTRODUCTION

The Egyptian "Wheel of pots" utilised manual or animal power to raise water from the river for the irrigation of crops and this was developed further into the water wheel or scoop wheel. Many hundreds of these were used in Holland and parts of England for land drainage until about 50 years ago. These were originally driven by windmills but were later converted to steam engine drives.

The best known of the early pumps, the Archimedean screw pump, was invented 2300 years ago and the same principle is still used today for large quantity, low head applications in wastewater plants and for land drainage and irrigation.

14.2 CLASSIFICATION OF PUMPS

In this manual, pumps have been broadly classified into the following groups:

- Rotodynamic, including centrifugal, axial flow and mixed flow
- Positive displacement, including reciprocating, progressive cavity and peristaltic Diaphragm pumps
- Air lift and ejector pumps Screw pumps.

14.2.1 ROTODYNAMIC PUMPS

These pumps incorporate a wheel or rotor of some kind whose rotating blades or vanes impart acceleration to the liquid passing through the pump. The speed of rotation will vary with the application and could be 500 rpm for a large raw sewage pump and up to 2950 rpm for a small high head clean water pump.

Of the pumps forming the group of rotodynamic pumps, the Centrifugal type is the most common. Each pump of this type comprises two principal components-

- The impeller, which forces the water into rotary motion

- The pump casing, which guides the water into the eye of the impeller and leads it away at a higher pressure.

The impeller is mounted on a shaft, supported in bearings and driven through a rigid or flexible coupling by a driver. This is usually an electric motor but could be an internal combustion engine, steam turbine or water turbine.

The pump casing includes the suction and discharge pipe connections, supports the bearings, and houses the rotor assembly. Sealing devices are included to prevent liquid escaping around the shaft and between the impeller and the casing. The detailed design of a centrifugal pump is influenced by the nature of the liquid to be pumped. When pumping clean water a closed impeller will be used and efficiencies of 80 to 95% can be achieved. For high pumping heads, multi-stage pumps can be constructed and for boiler feed duties, heads can be in excess of 300 Bar (30 000 kPa). For the pumping of raw sewage containing large solids, grit and stringy matter a different type of impeller is required. This requires large passages to allow solids to pass and may be of the closed design (with a plate each side of the vane) or the open design (with vanes mounted on a single rotating plate). Sewage pumps must always be specified to suit the maximum size of solids to be pumped and this may be called "freeway" with a capability of passing, say 80 mm diameter solids or "fullway" with a capacity of passing any solid coming down the suction pipe.

Fullway pumps are usually less efficient than freeway pumps but this disadvantage is offset by the lesser attention they require. There are many designs of impellers for handling raw sewage and these can be a simple S-shaped vane on a back plate, a single channel closed impeller, an open multi-vane impeller or even a vortex impeller. This last impeller type is recessed into the back cover of the casing and the impeller vanes do not protrude into the pump casing. They work by inducing a strong vortex in the liquid passing through the casing and are virtually un-chokeable. They have a low efficiency rate, around 35%, and can only generate low heads.

Other special types of pump incorporate cutting blades that cut or grind solid matter into pieces small enough to be handled by the pump. These are also less efficient and the cutting blades require regular replacement, especially where grit is present. Some pumps are provided with rubber linings to resist the abrasive effects of grit in the sewage.

It can be expected that any sewage pump will eventually become blocked from time to time and pipework should be arranged so that it is possible to quickly access the interior of the pump to clear a blockage Where possible, a solution is to purchase a pump having "Back-pull-out" construction, in conjunction with a spacer coupling In this design the spacer in the coupling is removed and the bearing bracket, back cover of the casing and rotating element is removed to give clear access to the interior of the pump casing without disturbing the pipework or the motor. Where the particular design of the pump does not provide this feature, adequate handholes with quickly removable covers should be provided on the pipework

The centrifugal pump is sometimes known as a "radial flow" pump and has some disadvantages. The freeway or fullway impeller tends to have a flat head/quantity curve so that a small change in operating head produces a large change in quantity pumped. Conversely if the head reduces, the quantity increases and the power requirement also increase so that larger sized motors become necessary to cater for this condition. Where several pumps run in parallel, this phenomenon is exaggerated and the selection of suitable motors must allow for this requirement.

In an axial flow pump, liquid approaches the impeller axially and the forward flow of liquid is parallel to the shaft axis. The impeller resembles a ship's propeller and these pumps are also known as propeller pumps. These pumps are suitable for handling large quantities at low heads but do not have good solids handling capabilities. They are suitable for recirculating effluents or similar duties. The axial flow pump has a steep head-quantity curve so that the quantity varies only slightly over a wide change in head and the power falls off as the flow increases. It does, however, absorb much more power as the flow is reduced towards zero and arrangements should be made to ensure that such pumps can never be run against a closed delivery valve.

All the rotodynamic pumps may be installed with the shafts horizontal, vertical or at an intermediate angle, although it is most usual for the horizontal arrangement to be adopted, with the driving motor on a single base plate. This has the advantage of easy access for cleaning and maintenance. The vertical arrangement is preferred when it is necessary to reduce the area of the pump station and the motors can be mounted directly on top of the pumps or located at a higher level, well above any possible flood level. Some designs can be suspended from a base plate at floor level to hang directly into the wet well or suction sump. This makes maintenance difficult and is not encountered often as the whole pump has to be pulled out of the sump.

All types of pump must be filled with water before starting and the easiest way is to arrange for the pump to be located in a dry well, below the level of the liquid to be pumped. This may not always be possible and several options are available. These include the provision of a small vacuum pump to evacuate the air from the pump casing before starting the pump. It is possible to provide a priming tank to allow the pump to fill itself with liquid during start-up but these tend to become clogged with solids on sewage duty. It is also possible to provide a foot valve on the suction pipe and to fill the pump with water before starting This arrangement has two serious disadvantages, in that these foot valves often leak and they present a high head loss to the suction Whatever the method of priming, there must always be an air release valve at the highest point on the pump casing to vent off any accumulated air or gas.

A further variation is the submersible pump, in which the pump is directly connected to a submersible electric motor and is positioned below the surface of the liquid. These are often used for small lift stations in remote areas and have the advantages of being installed in a manhole safe from vandalism and other damage. They are simple but can be expensive to repair.

14.2.2 POSITIVE DISPLACEMENT PUMPS

Theoretically, positive displacement pumps deliver a fixed quantity irrespective of the delivery head but in practice, the quantity does drop off as the head increases. The simplest type of positive displacement pump is the reciprocating or piston pump, with a piston moving forwards and backwards in a cylinder, to suck water into the cylinder and discharge it to a higher pressure. This type of pump has been in service for several hundreds of years for water supply and for pumping of water, sewage and other fluids. Many hundreds of farmers' borehole pumps are still of this type, often powered by windmills. They are also commonly used as hand pumps for water supply in small communities.

In the wastewater industry today, reciprocating pumps are usually used as specially designed high head pumps to handle sewage or sludge or in small sizes as chemical dosing or metering pumps, since every stroke delivers the measurable amount of fluid. The reciprocating type of pump cannot produce a steady rate of flow and it is advisable to provide an air vessel, on the discharge side, to control the pressure fluctuations. Although these pumps are self-priming, they should not be run dry as they will rapidly overheat and seize.

A number of rotary positive pumps are also found in wastewater plants and these include rotary lobe pumps and progressive cavity pumps. The rotary lobe pump is developed from the much older gear pump and comprises two elastomer-coated rotors connected together by an integral gear system with synchronised timing gears. The two rotors, which typically have two or more lobes, run without touching each other or the outer casing. The liquid is drawn into the inlet port and into the pockets between the lobes and chamber walls and is discharged in the direction of rotation of the outer lobes into the discharge nozzle. The discharge flow is continuous and smooth and is relatively non-agitating and non-shearing. The pump is self-priming and can be run dry for short periods. It is ideally suited to the pumping of a wide range of sludges.

A pump of similar capability, but different construction, in the progressive cavity pump, which comprises a hard steel rotor of helical spiral form which rotates in a stator of natural or artificial rubber with a similar internal helical spiral form. As the rotor turns, it contacts the stator, along a continuous sealing line, to create a series of sealed cavities that progress to the discharge end. The cavity fills with liquid as it opens at the suction end and this trapped liquid is transported along the rotor to the discharge and is gradually discharged in an axial direction. This type of pump is self-priming but must never be run dry. The initial starting load is high because of the dry contact between the rotor and the stator, but this drops off immediately once the pump starts to turn. Progressive cavity pumps are widely used for handling all types of slurries and sludges and can handle small solids. Where significant quantities of grit are present in the sludge, operating speeds must be kept below 350 rpm to minimise wear on the components.

A recent development in the pumping of sludges and slurries is the peristaltic pump. This is a simple design and comprises a semicircular chamber housing a rubber hose. A system of rotating rollers progressively squeezes the hose, pushing out any fluid in front of the rollers and sucking more fluid in behind it. A sufficient number of rollers are provided to maintain a constant flow through the hose. This type of pump is used in wastewater plants overseas but has not yet found general application in South Africa. It is self-priming, can be run dry and can handle a certain amount of solid matter. It is vulnerable to damage to the hose by sharp objects, although the hose can be easily and quickly replaced when necessary.

A variation of the reciprocating pump uses a flexible diaphragm in place of the piston. This form of construction eliminates the wear between the piston and cylinder but still has the problem of suction and delivery valves becoming fouled or jammed. Various patterns of diaphragm pump are in use and these include mechanically driven versions

for dewatering excavations, compressed air operated versions for sludge handling and a diaphragm dosing pump for metering duties.

14.2.3 THE COMPRESSED AIR OPERATED TYPE PUMP

The compressed air operated type pump is of particular use in the pumping of sludges and has the advantage of being adjusted to suit the rate of sludge flow, by varying the length of stroke and the number of strokes per minute. The need to provide a supply of compressed air makes this pump expensive to purchase and to operate

Compressed air is also used to operate several other types of pump used in the wastewater industry. These include the airlift pump, which is comprised of a tube with a supply of compressed air, immersed in the liquid. The mixture of air and water is less dense and the pressure outside the tube forces this lighter mixture to the top of the tube where it is discharged. Airlift pumps can be used for activated sludge return where heads are lower than about 2.0 m and they have no moving parts requiring maintenance. They have limited flexibility in operation and are low in efficiency.

Another compressed air device is the air ejector lift station to lift fairly small quantities of raw sewage to the main outfall sewer. This device comprises a steel vessel arranged to collect the raw sewage. When the vessel is full, a supply of compressed air is blown into it to force the collected sewage up a rising main to the main sewer. These units were in regular use some years ago but have tended to be replaced by small submersible pumps in lift stations.

Compressed air can also be used to power ejectors for pump priming or for emptying sumps.

The Archimedes screw pump comprises a rotating torque tube, carrying one or more sets of spiral flights, located in a concrete or steel trough and supported by a combined thrust and radial bearing at the top and a sealed radial bearing at the bottom Pockets formed between the spiral flights and the trough, trap the liquid and move it up the incline in a continuous manner.

Screw pumps can handle large solids and high grit content and also have the facility of being able to pump the exact quantity entering the pump, from zero flow to full design flow, without any problems. The pump can be left running dry for an indefinite period.

The screw pump is rather restricted in terms of head, being limited to about 8.5 m in the larger sizes and reduced as the diameter decreases. This limitation can be overcome to an extent by arranging two pumps in series. It requires a large amount of space and the civil construction costs are high. The design of the bottom, submerged bearing is critical and must be given special attention.

14.3 PUMP DRIVERS

Most pumps found in a wastewater plant will be driven by electric motors but other types of drive can also be encountered. These include internal combustion engines, for temporary installations or for emergency service to back-up electric sets, and steam or water turbines. Wherever possible, the driver is connected directly to the pump through a flexible coupling but it may be preferable to incorporate a vee-belt drive or gearbox to change the speed.

In the case of self-priming sewage pumps, it is not possible to adjust the flow by reducing the impeller diameter and these pumps are regularly driven through a belt drive. Progressive cavity pumps are limited to low speeds when required to handle high grit loads and these can also be driven through belts or gearboxes.

The most common electric motor is the squirrel-cage induction type. This has a fixed stator, accommodating the stator winding, and an aluminium rotor, housing a number of rotor bars. The motor design provides a number of pairs of electrical poles and the rotational speed of a motor is given by the formula:

rpm = frequency of supply x 60 Number of pairs of poles

Thus a 2 pole motor would run at a speed of 3000 rpm.

This is the theoretical speed and in practise, the actual operating speed is slightly lower because of electrical "slip". The amount of slip is influenced by the size of the motor, larger motors having lower slip than smaller sized motors. A 10 kW 2 pole motor will run at 2800 rpm, whereas a 300 kW motor will run at 2981 rpm under full load conditions. At less than full load, the motor will run slightly faster.

A serious disadvantage of the induction motor was that the speed is fixed by the number of poles. This has now been overcome by the use of variable frequency drives, which enable a standard induction motor to run at any required speed between zero rpm and

full rated speed, or even faster than full speed. This variable speed drive has another advantage in that starting is soft and gentle and acceleration can be controlled to reduce starting load on the electrical supply system It can easily be arranged for the motor speed to be controlled by a rate of flow device, so that a pump can match the change of flow of sewage influent to a pump station.

A much simpler version of this same device is the electronic "soft starter" which has the same features but without the variable speed facility. This gives the soft start capability that protects the motor and the supply system. It is possible to arrange for one soft starter to be shared between several motors of the same size and this can reduce initial costs considerably.

14.4 PROTECTIVE DEVICES

The current trend is increasingly towards full automatic control of pump stations and it is important to ensure that the plant is protected against abnormal operating conditions. The motors will always be provided with over-current protection and larger motors may also be fitted with devices to monitor winding temperature, bearing temperature and vibration levels.

Installations that run infrequently must be provided with electric heaters in motors and switch-gear panels to prevent any condensation of moisture. Where motors are not fitted with integral heaters, it is possible to arrange for a low voltage supply through the windings to keep them warm and dry when not in operation.

The pumps must be protected against dry running and this can be done by level switches in the suction sump, a limit switch on the non-return valve to sense that the valve is at least partly open or by actual flow measurement, or a combination of these. The control system must also monitor the discharge pressure and shut down the plant if the pumping head suddenly falls well below design levels. Other devices can be arranged to detect blocked screens, flooding of the pump house, abnormal gland leakage or even detect attempts to vandalise the installation.

Other control devices may be provided to protect the system against water hammer or pipeline surge. These may include special control valves or air-filled surge control vessels and will be specially designed to suit the individual system. The control system can be interfaced to a central control station by telephone or radio links. Every pump

should be equipped with at least a pressure gauge on suction and delivery branches to provide an indication of its performance.

14.5 OPERATION OF THE PUMPING PLANT

14.5.1 PREPARATION FOR FIRST START

This section applies to the first start after the plant is initially installed or after a major overhaul. A competent person, whose name is clearly recorded on the form along with the date of inspection, should inspect the installation against a formal checklist. The inspection shall include the electrical and instrumentation systems, the entire mechanical plant, including sump pumps and ventilation equipment.

1. The suction intake system, including influent flumes, screens and wet well, must be checked for cleanliness and all debris removed. It is a wise precaution to install temporary strainers to the pump suctions during initial commissioning All level measuring equipment must be checked and calibrated, if necessary.

2. The piping system should be pressure tested during installation and thoroughly checked for the tightness of all bolts, including restraints on flexible couplings and anchor points. Check all air release valves and small-bore piping to pressure gauges and safety devices.

3. Check that all valves have been installed correctly, especially non-return valves, and are fully operational. Check operation of all valve limit switches.

4. Ensure all valves are closed.

5. Ensure pump and motor are disconnected. Check and record coupling alignment Check pump and motor are both free to turn.

6. Check lubrication of pump bearings and seals. Check motor lubrication. Check rotation arrow on pump and check actual rotation required against volute casing.

7. "Bump" start motor by energising and immediately tripping to check motor rotation. Whilst motor is running down listen to bearing noises with a stethoscope or long screwdriver to check for abnormal noise.

8. Reconnect pump-motor coupling and replace guard.

9. With belt driven units, remove belts, check pulley alignment, check motor rotation and replace belts to correct tension and replace guard.

10. Check operation of any auxiliary services, such as flushing water to glands or cooling water to bearings.

11. Fill suction sump or wet well, preferably with clean water for the first start. Check operation of level sensors. Check for leaks through civil structure.

12. Slowly open suction valve and charge pump with water, ensuring all air is discharged Check pump gland or mechanical seal. Open suction valve fully.

13. Crack-open discharge valve and start pump. Check for leaks and check suction and discharge pressure gauges and the motor ammeter. As the rising main has not been charged with water, the line pressure will be low and the pumping rate must be restricted so as not to overload the motor. Check all bearings and glands/seals and continue pumping at a slow rate, whilst monitoring pump and pipeline pressure gauges

As the line fills with water, the line pressure will increase and the pump discharge valve can be gradually opened until the line pressure is roughly equal to the pump pressure, when the discharge valve can then be fully opened.

In the case of a self-priming pump, it will be necessary to first fill the pump casing with water after which the procedure is similar. A non-self priming pump must also be charged with water, either by a vacuum exhauster, which may be hand operated or powered, or by filling the suction system with water against a foot valve. The use of foot

valves is not favoured as they present a restriction to flow and cannot be relied on to be leak tight, especially when handling sewage.

After the pump has run for a sufficient time for bearing temperatures to stabilise and glands to settle down, the pump may be stopped. For the very first stop, it is recommended that the flow be reduced by closing the discharge valve partially and then tripping the motor. This will reduce the possibility of water hammer or surge If no surge is present, this procedure should be repeated a few times until the pump is tripped with a fully opened valve, without mishap.

This procedure will only apply in the case of a new installation.

In the case of a multiple pump installation, each pump will be started in turn until all have been set to work. After that, several pumps can be run together to establish the performance of the overall system.

Records should be maintained during all of these commissioning tests, as these will form the baseline for future reference. After all pumps have been run on manual control, the automatic control system may be selected and the tests repeated. The operation of all safety devices must be checked during these tests, including any interface links to central control.

14.5.2 NORMAL STARTING AND STOPPING

In most installations, normal operation will be under automatic control. Where manual control is required, this will generally be simply pressing the "Start" or "Stop" button. All valves will normally remain fully open.

14.5.3 OPERATING CHECKS

Even if full automatic control is provided, it is essential that the installation be regularly checked for correct operation. This should ideally be on a daily basis but may be extended to once per week. A log sheet should be maintained of record operating pressures, motor currents and flow rates. A record should also be kept of noise and vibration, gland leakage, bearing temperatures, etc. In the case of a manually controlled pump station, the log sheet should be more detailed with a record of when pumps were started and stopped, and flow meter and level readings.

The operating and maintenance instruction manual provided by the pump manufacturer will give the process controller or service technician detailed instruction for the maintenance of the pumps. Where this information is not available, maintenance must be based on observation by operating staff supplemented by regular inspections at three monthly intervals.

Problem	Possible Reason
No liquid delivered	Delivery valve closed. Suction valve closed
Pump not primed	System head too high
No water in sump	Impeller blocked
Insufficient liquid delivered	Valves partially closed
System head too high	Impeller partially blocked
Water in sump low	Wear in pump
Insufficient pressure, system head low	Air or gas in system. Wear in pump. Fractured Rising Main
Vibration and noise	Partially blocked impeller. Misalignment or damaged bearing

The most significant element of successful maintenance is quite simply "Good Housekeeping" This starts with keeping the plant clean, so that minor leaks can be

detected and attended to before they become serious. A minor oil leak can be readily seen on a clean machine and can be fixed before the bearing fails. A leaking gland can be adjusted before it fails and releases a torrent of dirty water into the pump bearing, washing away all the lubricant and resulting in a major failure.

One aspect, not often realised, is that flying insects are attracted into the pump house by the lights and they often finish up in the gland drainage basins and block the free outlet of gland water. This then builds up to the extent where it overflows into the pump bearing Regular attention to all drainage piping is essential.

The two most vulnerable items on any pump are the bearings and the glands/shaft seals.

14.6 BEARINGS

Many modern pumps and motors are now being fitted with "Sealed for life" bearings, which require no routine maintenance and are replaced after a predetermined period. Other types require replacement of the grease after a stated period, whereas other makers specify small regular injections of grease.

It is important to clearly identify the specific requirements of each pump. It is most important that grease be kept clean and that bearings not be overcharged with grease, as this will result in overheating and possible breakdown. Some manufacturers use oil-lubricated bearings and these should be checked at regular intervals and drained and refilled at annual intervals. Ball bearings will always run slightly warm and may be operated at up to 70°C. Any sudden increase in temperature should always be investigated immediately. A grease-lubricated bearing may be given one shot of grease but if this does not immediately improve the condition, no further grease is to be added. Instead, the pump must be stopped and the cause investigated.

Some large pumps are fitted with oil-lubricated bearings in which the oil is distributed by an oil ring running on the shaft. These rings should be regularly inspected to ensure that they are rotating correctly. These larger bearings are often water-cooled and it should be ensured that the cooling water is circulating.

The Archimedean screw pump has a bottom bearing submerged below the liquid and a mechanical lubricator, often with its own electric motor, usually keeps this charged with grease. It is essential that this bearing be kept charged with grease at all times, not only to provide lubrication but also to exclude dirty water and grit

It is imperative that the grease filled into the lubricator is absolutely clean, as many failures have been traced to grease pipes blocked by cotton waste used to clean the

grease container. The preferred method is to use a large grease container fitted with a charging pump, which is taken to the grease lubricator and connected by a flexible charging connector. Some screw pumps use a grease circulating system that returns excess grease to a container. The condition of this returned grease will give an indication of the bearing condition The returned grease must not be reused in the lubricator.

14.7 SHAFT SEALS

The item requiring the most attention and service on any pump is the shaft-sealing device. This can be a simple soft-packed gland or a sophisticated mechanical seal. The soft-packed gland or stuffing box seal comprises a number of rings of a square section packing material compressed between the end of the stuffing box and an adjustable gland follower. The packing is manufactured in many different materials, including animal fibres, vegetable fibres, asbestos, metal and graphite fibres, many synthetic fibres and other metals. These are provided with suitable lubricants that can include animal, vegetable and mineral oils and greases, synthetic lubricants and also dry lubricants such as graphite and teflon. Just to add further complication, packings are made in many grades of hardness and some glands use a mixture of hard and soft packings. The pump manufacturer will normally select the packing material and this should not be changed without referring to him. Many problems in service occur because of incorrect adjustment of glands and incorrect re-packing procedures.

Many modern packing materials require "bedding-in" and must be allowed to leak initially, and be gradually loaded. This is unacceptable for raw sewage pumps as grit particles will penetrate the gland, become embedded in the packing and rapidly score the shaft Good practise for this type of pump is for the gland to be provided with a grease seal to exclude the actual liquid from the packing and this grease seal must be maintained at all times.

When the gland is re-packed, all old packing must be removed and the stuffing box thoroughly cleaned. The shaft sleeve must be inspected to ensure that it is smooth and not scored. The packing must be cut to fit the shaft and each ring must be individually tamped to place in the stuffing box. Each ring must be compressed, by tamping or preferably by packing bushes, to expand in working condition. Each ring has to function as a pressure break device. Successive rings of packing must be tamped home, care being taken to ensure that joints in the rings are staggered to prevent leakage. Where glands incorporate lantern rings for supply of lubricant or flushing water, the position of these must be noted so that they can be reinstalled in the correct position

Mechanical seals are becoming more common and are imperative for certain types of pump, such as submersible sewage pumps. A mechanical seal comprises a rotating ring

on the pump shaft in contact with a fixed ring in the casing. The materials of the rings are selected to suit the individual application and can include various combinations of carbon, metal-filled carbon, tungsten carbide, silicon carbide, siliconised carbon and bronze for the primary rotating ring and ceramic cast iron, tungsten carbide and silicon carbide for the fixed mating ring. These rings have to be manufactured to stringent standards of flatness and highly polished to eliminate leakage. Seals are classified as single seals or double /multiple seals. A double seal could be used on a sewage pump, with a neutral clean water or light oil circulating between the two seals, to provide cooling and lubrication and to exclude any penetration of grit.

The seals on submersible pumps run in an oil bath and on the larger sizes of pumps. an electrical device monitors for any leakage of water past the seal. Oil-filled seals are also used on self-priming sewage pumps and the oil in these seal chambers should be changed at regular intervals.

14.8 OVERHAUL OF PUMPS

It is difficult to make general rules regarding the frequency of complete pump overhauls as so many different factors are involved. It is considered that a pump should not be opened for inspection unless there is real evidence that this is necessary. This may be that performance has fallen off significantly or vibration, noise, overheating or overloading indicates that trouble is present. It is for this reason that the establishment of baseline data at initial start-up and keeping of log sheets is important.

Pumps have many different types of construction, even from the same manufacturer. For example, a raw sewage pump may have an open or a closed impeller, which may be secured on the shaft by a screwed thread or may have a key and a securing nut. With the open type of impeller, internal clearances may be adjusted by the adjustment of the thrust bearing position or the suction wear plate and these adjustments may be by screws or studs, by inserting or removing shims, or by adjusting the number of gaskets between components. It is always preferable to make use of manufacturers maintenance manuals and drawings when carrying out any overhaul to a pump.

Particular care must be taken when handling ball/roller bearings, which must be carefully cleaned, inspected and relubricated. In many cases special tools may be required for dismantling and reassembly to avoid damage. In any case of doubt as to the integrity of the bearing, it should be replaced, as the replacement cost is a fraction of the cost of a failure at a later stage.

Similar remarks apply in the case of a mechanical seal, where the manufacturer's instructions must be followed implicitly. In the case of a major overhaul, consideration

should be given to returning the pump to the manufacturer who has the specialist knowledge, equipment and facilities to test the pump after the overhaul.

A special note of caution would be sounded against the use of spares from manufacturers other than the original supplier, as these parts may not restore original performance and, in extreme cases, may even result in further damage to the pump.

15 RECORDS

15.1 INTRODUCTION

Record keeping and reporting is a tiresome activity, but failure to do so may result in circumstances that might have been easily avoided had proper records been kept. Accurate and full records of all aspects of the construction, operation and maintenance of a wastewater works are vitally important for several reasons:

15.1.1 OPERATION

Only when the layout, process flow, size, characteristics and history of all parts of the works are known, can the process controller hope to be able to run his plant correctly. These records also reflect overall efficiency of the treatment process. Records of effluent quality will show if the treatment works is complying with regulations.

15.1.2 PLANNING

It is important to keep track of sewage flows and strengths and of the behaviour of the works in relation to changing loads. These records will assist the authority to plan properly for future sewers or works. Problems can also be detected well before they reach serious proportions.

15.1.3 MAINTENANCE

Proper maintenance records assist greatly in the timely servicing and repair of plant equipment. This minimises mechanical breakdowns and down time.

15.1.4 COSTING

For controlling and budgeting of expenses, it is important to have records of what work was done, by whom and how much was spent or materials Financial records can be useful when setting rates for customers.

15.1.5 RESEARCH

Full, accurate records are invaluable to a researcher studying aspects of the operation of a wastewater works. In many instances, long-term operating records are far more valuable than laboratory studies.

15.2 WHAT RECORDS SHOULD BE KEPT

The following is a brief guide to the type of records that should be kept on wastewater treatment works. Some process controllers may keep more and others less. Unless it takes up too much working time, though, more record keeping is better than less.

15.2.1 PLANS

There should be a full set of the final 'as built' drawings of the works showing the-layout, size, shape and details of all components, particularly for buried items such as pipelines and cables. These plans provide the plant personnel with records of the plant equipment regarding their location and their relationship with other plant equipment. The drawings are classified under the following categories: Plant layout, process flow and instrumentation, mechanical and electrical The drawings can be obtained from the designers of the works and must be carefully filed. The drawings should be updated when there are modifications to the plant because, when repairs or modifications are planned, they will be a most valuable source of information. Plant plans should be available to the operating personnel at all times and should be in good usable condition.

15.2.2 DESIGN PARAMETERS

The works process controller must know how his plant is expected to operate and the operating conditions. This will enable him to understand the plant and to know when certain components are under or overloaded. The design engineer should provide a report detailing the basis of design, design capacities and parameters The manufactures' handbook, outlining recommended operating guidelines, installation procedure and maintenance instructions, must be obtained.

15.2.3 DAILY LOG

A large, page-a-day diary or logbook will serve for this purpose and any information that does not logically fit in other records must be entered in the diary. Typical examples are staff movements, visitors, appointments, weather conditions and any deliveries made. Every process controller should keep a pocket book in which he should note any significant event on the works, such as a peculiar colour of the water, failure of equipment, or a strange smell, recording the date and time at which this occurs. These notes should be transferred to the Daily Log at the end of each shift.

15.2.4 WEEKLY AND MONTHLY RECORDS

These records will contain operating data of the wastewater treatment for example, aeration, disinfection, sludge digestion as well as the information mentioned in the daily logs. The monthly report should contain a summary of all the data collected during the month. From this data, operating parameters reflecting performance of the works can be calculated which will assist in process control. Analysis of data on a monthly basis will also show any deviations from previously established operation. Sampling or data collection points should be placed such that they are easily accessible to process controllers.

15.2.5 LABORATORY RECORDS

For purposes of presentation experimental readings are often collected together and presented in tabular form. The data can either be presented on sheets or notebooks. Laboratory data sheets may be developed for recording test results and calculations. The records of laboratory data should be prepared in such a way that recording, reviewing, or recovering of data is possible when necessary. These days it is often easier to store records via computers. However care should be taken to backup files onto other machines or CD's so that permanent records are preserved.

A copy of testing procedures should be provided in case there are staff changes so that procedures are consistent. Also original readings when performing a test should always be recorded not just the calculated values.

15.2.6 FLOW RECORDS

Depending upon the size and complexity of the works, this could vary from a few entries on a chart each day to a page full of figures. All flow meters on the works should be fitted with integrators. These can then be read at a fixed time each day and the figures recorded. If possible the main incoming flow rate should also be recorded continuously on a chart or SCADA system so the exact variations in flow rate can be studied. The strips or discs from such a recorder must be carefully labelled and filed. These records are essential for planning purposes and often for trouble-shooting on the works. It can also be useful to plot daily flows on a wall chart as this can give a clue to trends in flow. A record of the maximum and minimum instantaneous flows that occurred during each month may be kept. This can assist the planners to assess how much of the sewage flow is groundwater or rainwater infiltration.

15.2.7 PERFORMANCE RECORDS

All analyses made on the sewage must be properly recorded. A log sheet for this purpose can, in some cases, be combined with the flow record sheet. The following is a guideline, where applicable, of the sort of information that might be kept to evaluate the performance of the wastewater treatment work:

1. Influent flow Hydraulic loading
2. Organic loading Sludge age
3. Sludge blanket level
4. Sludge settleability
5. Suspended solids
6. Return sludge flow

7. Waste sludge quantity
8. Chemical dosages
9. Digester gas production.

In addition, information such as sewage temperature (inlet and outlet) and details of plant running times should be kept on the same log.

It is a good idea to make the log sheet flexible in layout for the first year of operation. This allows for more data to be added or for a better layout to be selected as the staff becomes used to working with the records. It may also be useful to get the process controllers to fill in a log sheet for each shift and then to transfer the important information for each day to the main log sheet.

15.2.8 EMERGENCY RECORDS

Documentation of emergency events and actions taken in response to these events will help plan future emergency responses. A record of all significant emergency events should be kept.

This report should include the following points:

1. Description and time of event
2. How the event affected the process
3. Length of time it took to get the process back to normal
4. Location where event first occurred
5. Action taken by process controllers/personnel in response to the emergency
6. Process equipment and structure affected
7. Description of repairs and replacements required
8. Costs of repairs and replacements
9. Emergency response plan in case of re-occurrence of similar event.

15.2.9 MAINTENANCE

Maintenance records are of vital importance and are discussed in a separate section.

15.2.10 ACCOUNTING

Although it is unlikely that a wastewater works process controller would be expected to keep his own books, he must nevertheless have some record of and control over costs. The costs of labour, materials, spare parts, new equipment, electricity and hired plant should all be recorded if possible. Delivery notes and invoices paid should be recorded so that any problems can be simply and quickly cleared up. If good information on quotes is available it can help the process controller to make the cheapest decision for future jobs. For example, it may be cheaper to buy a new pump than to have the various components overhauled and reassembled.

15.3 FILING

Records are only of use if they can be found easily and reliably. A piece of paper with a row of numbers on it may mean something on the day it is written but, when examined a year later, it will convey nothing. It is therefore essential that a systematic filing system be developed for each wastewater works.

Some records can be kept in books, which are stored away when full. Other information is best kept on loose leaves in lever-arch or suspended files. A box of small file cards can also be a most useful place for keeping multiple bits of brief information, such as equipment records. On the larger works, a computer system may be used to keep electronic records. Books and manuals should be stored in shelves. Drawings should be kept in drawers or filing cabinets.

16 SAFETY

16.1 INTRODUCTION

The formulation of, and adherence to, safe-working procedures is in the best interests of everyone concerned with the operation and maintenance of wastewater works plants. It should be remembered that a wastewater works has operating machinery, which requires the same care and precautions as would be required in any factory. In fact the provisions of the Factories, Machinery & Building Work Act, 1941 and the Machinery and Occupational Safety Act, 1983 and the current Occupational Health and Safety Act are applicable to wastewater works In addition; a sewage treatment installation has the additional hazard of disease infection.

On large plants, it is the responsibility of management to formulate and implement safety procedures. The operating and maintenance staff must actively support these. On small plants the process controller himself may have to take the initiative.

16.2 SAFETY COMMITTEES

In terms of regulations framed under the Occupational Health and Safety Act, Act No 85, one safety representative must be appointed in writing at any workplace for every 50 persons employed, except where there are less than 20 employees (farm labourers are excluded). It is mandatory for this safety officer to carry out at least one inspection per month of the workplace to which he has been designated. He must report any threat or potential threat to the health and safety of any employee to his employer or any safety committee established in terms of the Act.

In large undertakings, the various safety representatives would form a safety committee. At smaller installations it is suggested that such a committee should include the engineer or responsible person duly delegated by the Chief Executive Officer, the works manager, the maintenance foreman, a senior process controller, a labour representative and the safety officer.

Small works should at least be served by the engineer or responsible person, the superintendent or process controller, and representatives from maintenance and the labour force.

Meetings should be held on a routine basis or the entire purpose of the committee is lost. The committee's functions are to promote awareness of safety, investigate accidents, recommend safe practices and procedures, and to ensure compliance with statutory requirements.

16.3 INSPECTIONS

On the basis that prevention is better than cure, it is suggested that arrangements be made with the factories, or safety inspector to visit the Works occasionally and report any shortcomings. These can then be rectified before any problems occur.

16.3.1 BASIC RULES

All persons visiting or employed on a wastewater works should observe the following basic rules at all times:

1. Do not smoke or use an open flame on the works except in those areas that have been designated as safe
2. Wash hands well with soap and warm water after working with sewage or sludge and especially before eating
3. Do not touch electrical equipment or switches and treat all equipment that has not been isolated and locked as live
4. Do not touch moving machinery
5. Do not enter a sewage manhole or deep sump without testing for hydrogen sulphide (H_2S) and wearing a harness attached to a rope held by a man at the surface
6. Do not enter a digester unless it has been emptied, purged with air, tested and certified safe
7. Take care when standing near or working over tanks and channels where there may be deep or swiftly moving water
8. Ensure all moving machinery parts are adequately guarded

16.4 SAFETY EQUIPMENT

Each works should be equipped with the following items - quantities of each item depend on the number of people employed on the works:

1. Full parachute-type harness complete with a sufficient length of 12 diameter nylon rope.

2. Explosion-proof portable blower, lighting and extension cord.
3. Self-contained compressed air breathing apparatus consisting of a parachute harness and lifeline, full facemask, air supply hoses, a cylinder with a minimum of 30 minutes air supply and a pressure gauge. Note that certain types of respirator (gas mask) are unsuitable for wastewater works applications as they protect only against poisonous gases when these are in limited quantities and can only be used where there is no deficiency in oxygen.
4. In many manholes and sumps there will be a deficiency in oxygen, or the gas present will be methane (earth gas) that penetrates the ordinary respirator and will cause suffocation. The only suitable respirators are those connected to a supply of fresh air, or those generating there own oxygen from containers of appropriate chemicals.
5. An interchangeable compressed air cylinder to last for 10 minutes.
6. Portable oxygen deficiency explosive gas mixture meter, complete with alarm system.
7. Lead acetate paper.
8. Spark-proof tools.
9. Symbolic safety signs.
10. First aid kit.
11. Barricades, traffic cones, flashers and warning signs.
12. Fire-fighting equipment to suit each area.

16.5 PROTECTIVE CLOTHING

The items listed below make up the necessary basic clothing for all those employed on a wastewater works: (Records of the issues must be kept and signed for by the worker):

1. Hardhat - made of high-density polyethylene
2. Overall - elastic in cuffs and in the waist and having a zip front
3. Gumboots - lightweight with built-in toe protection and non-slip soles
4. Boots, leather, ankle protection type with toe protection and non-slip soles
5. Gloves made of strong flexible PVC with roughened palm

6. Oilskins
7. Earmuffs - if working in a blower room or similar noisy area.

In addition to the above, those who are involved in workshop activities should have:

1. Earmuffs
2. Appropriate goggles, gauntlets, etc, for use during welding, grinding and cutting operations
3. Workshop gloves - made of soft, flexible leather or pigskin with fingertip and knuckle protection.

Those involved in laboratory work require:

1. Acid-resistant dustcoats
2. Unlined neoprene gloves.

16.6 SUPERVISION

There is no point in equipping a works with all the recommended safety equipment and the personnel with protective clothing, if the equipment is not maintained and is allowed to deteriorate. A fire extinguisher, which does not work, is worse than no extinguisher at all. The safety equipment should be stored in an accessible position, outside the hazardous area. Similarly, there is no point in drawing up a safety manual and recommended procedures if they are not followed. The works manager, superintendent or responsible person must therefore ensure that procedures are adhered to, that ladders, fire extinguishers and respirators are inspected and tested on a routine basis; and that certain protective equipment such as earmuffs and eye protection, which may be unpopular, is in fact worn when necessary.

16.7 SAFETY PROCEDURES

The following are presented as a guide only. They may require to be amended to some extent for the circumstances applying to a specific works.

16.7.1 WORK IN MANHOLES, SEWERS AND DEEP SUMPS

1. Protect the job site against traffic hazards
2. Never work in confined spaces/areas alone - two or more persons should always be present in case of an emergency
3. Test the atmosphere for oxygen deficiency, explosive or flammable gas and for hydrogen sulphide by inserting a probe through a hole in the cover. If there are no holes in the cover, then the cover must be removed very carefully without causing sparks. This is important because sparks created by removing the cover can cause an explosion. Once the cover is removed, the atmospheric tests are carried out near the bottom and also about one third down from the top of the sump
4. If the tests indicate a safe atmosphere, the two adjacent manhole covers are removed and the sewer is allowed to ventilate for 10 minutes before any person enters
5. If the tests indicate an unsafe condition, forced ventilation must be used. All blower equipment must be placed upwind from the manhole to prevent any possibility of gas ignition by the blower equipment. Any other potential ignition sources should be eliminated, such as smoking in or near a manhole
6. Under emergency conditions, self-contained air breathing apparatus and a safety harness with lifeline must be used with two persons in attendance at the manhole opening
7. Persons entering a manhole should not be permitted to carry objects in their hands. Tools, etc, may be passed down to them by rope after they have reached the bottom
8. Carbon dioxide, which causes suffocation, is heavier than air. It is therefore necessary to use forced ventilation under all conditions where upward displacement of gas by air is required. This applies to deep sumps even when the pump station may be equipped with its own ventilation fan
9. The use of a safety hat, overalls to prevent contamination of regular clothes gumboots with toe protection and waterproof gloves are considered to be minimum acceptable dress for this type of work
10. In addition to the above dress the following equipment must be used:

- Safety harness with lifeline
- Anti-spark tools
- Explosion-proof lighting and equipment
- A ladder is preferred for entering or leaving a manhole or sump even if stepirons are present.

11. A blowtorch should never be used to melt ice, paint or bitumen, etc, around a manhole or any other surface cover.

16.7.2 WORK IN DIGESTERS OR SLUDGE STORAGE TANKS

The digester should be filled to its highest level in order that the gas space is reduced to a minimum. The gas line from the digester should then be closed. The gas pressure should then be slowly reduced by venting to the atmosphere. After the pressure has been reduced to atmospheric pressure the cover plates on the gas dome can be removed, using non-spark tools and fresh air forced into the digester by blowers to purge the gas. The purged air must be sampled and tested until the explosive level is below the lower limits. Once this level is reached, the tank contents can be lowered. Continuous purging must then be maintained until the tank is emptied and completely cleaned. Note that even this procedure contains a hazard in that the gas mixture passes through the explosive range during the initial stage of purging with air.

1. Absolutely every care should be taken to ensure that no spark is generated during the initial stage of purging. Ideally the first purge should be carried out with an inert gas such as nitrogen or carbon dioxide. However, this is not practical in most cases
2. After the tank is empty and before any person enters the tank, the levels of the explosive atmosphere and oxygen deficiency must be obtained
3. During cleaning operations the atmosphere must be monitored continually with an oxygen deficiency indicator and explosive gas detector both of which incorporate alarm devices that are activated when unsafe levels are reached
4. A properly qualified person should make the necessary tests of the interior of the tank to monitor the level of explosive or flammable gas and oxygen deficiency
5. The air purge must operate continuously until work is completed and commissioning starts

6. The power supply to mechanical or gas mixing equipment must be disconnected and all piping leading into the tank for gas or sludge transfer should be valved-off for the duration of the work
7. At least two men should be stationed at the entrance. They should be trained in the use of self-contained breathing apparatus, safety and some first aid. They should also be wearing self-contained breathing apparatus
8. self-contained air breathing equipment, safety harness and respirators should be stationed at the entrance to the tank during the entire time that persons are working in there
9. All smoking equipment, i.e. cigars, cigarettes, pipes, tobacco, matches and lighters must be stored in lockers by all those working in the digester area
10. Floating cover digesters: The only difference in procedure between fixed and floating roofs is that the first step is to draw off the supernatant liquor until the roof rests firmly on the supports. The draw-off is then stopped until the gas space been purged to below the lower explosive level in the same manner as that for fixed roofed digesters
11. Low voltage explosion-proof lights are permitted inside a confined space

16.7.3 MACHINERY

1. When working on a piece of equipment, ensure that it cannot be started or operated either by isolating at the panel and/or the local stop and disconnecting the means of starting
2. Always use the correct tools for the job
3. Keep chisels in good condition
4. Wear visors or goggles when grinding
5. Use correct grade of protective visor or goggles when welding or brazing
6. Do not manhandle heavy objects. Use lifting gear
7. Always replace belt guards and other safety shields
8. Always read the instructions carefully before carrying out any maintenance operation on a specialised piece of equipment.

16.7.4 ELECTRICAL

1. No unauthorised person shall work on electrical equipment, open a panel or enter a substation.
2. All equipment that is to be worked on shall be properly isolated and locked so that it cannot be switched on. Suitable notices shall be placed at the switch panel and adjacent to the equipment.
3. All installations shall be properly tested by a competent person before being put back into service.

16.7.5 MATERIALS HANDLING

Care should be taken in handling heavy or bulky objects. In order to reduce the number of injuries caused by the use of incorrect material handling methods, the following points should be considered:

1. Use suitable lifting gear wherever possible
2. No person should attempt to lift more than can be handled comfortably
3. Wear protective gloves as a general rule. Otherwise ensure that the hands and the object are clean and not slippery, and that it is free of jagged edges, metal slivers, nails, burrs and splinters
4. Ensure firm footing and good visibility whilst manoeuvring.

16.7.6 LABORATORY SAFETY

1. ***Glassware***. Gloves should be worn when setting up glass apparatus; cutting tubing or attempting to open tightly stoppered bottles. Chipped and cracked glassware should be discarded. Bottles should never be carried by their necks. Use copper gauze when heating glass vessels using gas flames
2. ***Gas***. Gas cylinders should be stored in well-ventilated areas outside the laboratory, or well away from heat if in the laboratory. Always double check that the gas is properly closed off after use. If there is a smell of gas in the laboratory open all doors and windows and operate all ventilation equipment. Identify the cause of the leaks if

possible, and isolate. Otherwise evacuate the laboratory and obtain specialist assistance

3. ***Chemicals***. All chemicals should be clearly marked as to their contents and possible hazard. Solvents should be stored in explosion-proof containers in a suitably ventilated place. Acids should be separately stored in an area where spillage can be dealt with. Rubber aprons, face shields, gloves and acid-resistant dustcoats should be used when working with dangerous chemicals. There should be a shower with a valve that can be quickly operated by means of a pull on a chain or a short movement of a lever.
4. ***Electrical***. All electrical equipment should be explosion proof and earthed. Earth leakage equipment should be installed on the laboratory circuits.
5. ***Safety and Fire Hazards***. Certain chemicals such as ammonia, nitric and perchloric acids can react violently with some organic chemicals giving rise to the possibility of fire or explosion. Many volatile solvents are inflammable. When working with solvents the work should be carried out under a ventilated hood. Suitable fire extinguishers should be available at accessible points and a first-aid kit should be kept in the laboratory
6. ***Procedures***. Suction bulbs should be used on pipettes for dangerous chemicals. Tongs and asbestos gloves must be used when handling heavy samples. Spillage should be cleaned up immediately. Hands should be washed with soap and hot water before eating or smoking. No smoking or eating should be permitted in the laboratory.

16.8 SAFETY LEGISLATION

All wastewater works plants must comply with the provisions of the Occupational Health and Safety Act (Act No 85 of 1993) and any amendments and regulations relating thereto. The regulations amongst other things provide for the following:

1. Depending on the total size of machinery power installed, the works may be required to be under the responsibility of a certified engineer or a designated responsible competent person. Delegations will be made in terms of the Occupational Health and Safety Act

2. The engineer (or responsible person) is responsible to the Divisional Factories Inspector for all safety procedures at the works and can be held responsible for any accidents, which may occur through neglect of safe working procedures.

The engineer (or responsible person) must also keep all records required by the Act such as registers for lifting gear, elevators, pressure vessels and boilers. He shall also submit accident reports and ensure that any inspections required in terms of the Act on pressure vessels and boilers are carried out timeously.

17 APPENDIX A: PROCESS FLOW DIAGRAM

18 APPENDIX B: LIST OF MECHANICAL EQUIPMENT

GWAING WWTW

1 Inlet Works

1.1 General Data

Number of units	2
Model number	
Country of origin	
Model Name	Huber Rotamat screens
Kilowatt rating	0.75 KW
General data gearbox	Bauer motor/gearbox
Drive end bearings and make	
Non-drive end bearings and make	
Bar spacing	
Drive sprocket shaft bearings size/make	
Bottom sprocket shaft bearings size/make	
Width of screen	

1.2 Conveyor :

Drive unit	Euro drive motor/gearbox…….
Kilowatt rating	1.1 KW……
Country of origin	
Drive Bearings and make	
Non drive Bearings and make	
Method of greasing	……
Length of belt /screw	……

1.3 Pista paddle drive gearbox

Make	Bearingman

Country of origin	
Power rating	1.1 KW
Power absorbed at Duty Point	
Maximum shaft power output	
Speed	
Frame size	
Greasing/oil	

1.4 Blowers

Make	Sutorbilt
Model	2LP
Kilowatt rating	4 KW
Number of units	1

1.5 Wash water pumps

Make	Franklin Electric booster pump
Model	
Country of origin	
Type	
Type of glands	
Drive end bearings and make	
Non-drive end bearings and make	
Greasing method	
Kilowatt rating	1.5 KW
Number of pumps	2
Valves inlet/outlet type	
Non return valves	

Lifting unit ....

Capacity of unit ....

Date tested ....

1.6 Classifier

Type of gearbox ..... Bauer motor/gearbox .....

Model\type ..... RoSF3 .....

Country of origin ....

Power rating ..... 1.1 KW .....

Type of material bridge ..... steel .....

Drive end bearings and make ....

Non-drive bearings and make ....

Centre Bearing size ....

Scum removal mechanism ....

De-sludge valves ....

Condition of Bridge ....

Bridge Drive wheels type ....

Method of greasing ....

2 BNR system

2.1 Aerators

Number of units ..... 4 .....

Kilowatt rating ..... 55 KW .....

Number of units ..... 2 .....

Kilowatt rating ..... 45 KW .....

Gearbox make ..... Flender .....

Gearbox Power rating ....

Gearbox drive end bearing and make ....

Gearbox Non-drive end bearing and make	
Coupling type	
Coupling size	
Rotor size	
Type of oil and capacity	

2.2 Mixers

Number of units	6
Make	Motorelli industrial motor and Mixtec gearbox
Model	
Drive end bearing and make (Gearbox)	
Non-drive end bearing and Make	
Coupling Type	
Kilowatt rating	11 KW
Type of oil and capacity	

2.3 “r” Recycling pumps

Number of units	6
Type of pumps	Vertical axial lift
Model	
Country of origin	
Sealing arrangement mechanical/gland	
Size of mechanical seal	
Make	Engineered pump & systems
Suction size	
Delivery size	
Delivery head	

Capacity of pump	.....
Kilowatt rating	11 KW .....
Valves inlet/outlet type	.....
Non-return valves.....	.....

2.4 “a” Recycling pumps

Number of units	3.....
Type of pumps	Vertical axial lift .....
Model	.....
Country of origin.....	.....
Sealing arrangement mechanical/gland	.....
Size of mechanical seal.....	.....
Make	Engineered pump & systems.....
Suction size.....	.....
Delivery size.....	.....
Delivery head	.....
Capacity of pump	.....
Kilowatt rating	11 KW .....
Valves inlet/outlet type	.....
Non-return valves.....	.....

3 SST`s Clarifiers

Number of units	2.....
Type of drive.....	SEW eurodrive motor/gearbox .....
Make gearbox.....	SEW.....
Kilowatt rating.....	0.12 KW .....
Type of oil.....	.....
Capacity of oil.....	.....

Centre bearing Type	.....
Centre bearing size	.....
Type/method of lubrication	.....
Material type centre bearing	.....
Make/type Bridge carrier wheels	.....
Condition of Bridge walkway structure	.....
Type of sludge discharge valves/sluice gates	.....
Chlorination pipe work/type and schedule	.....
Condition of weirs	.....
Type of weirs	.....
Condition of centre scum/baffle plates	.....
Type of scum discharge	.....
Condition of scum removal mechanism	.....
Condition of outlet V-Notch plates	.....

4 RAS/WAS Pump Station

Number of units	2
Type of pumps **RAS**	Gorman Rupp
Type of drive	.....
Pulley sizes Drive end	.....
Pulley sizes Non drive end	.....
Coupling guards material	.....
Taper lock bush sizes for coupling D/E	.....
Taper lock bush size for coupling Non D/E	.....
V-Belt sizes	.....
Number of belts	.....
Make of belts	.....

Direct coupling Yes/No	
Fennerflex coupling size	
Type of pumps **WAS**	Submersible
Number of units	2
Size of pumps	
Make/Model	
Make/material of guide poles	
Capacity of pump	
Delivery size of pump	
Valves inlet/outlet type	
Non-return valves	
Type of lifting equipment	
Capacity of unit	
Date of last testing	

5 CHLORINE BUILDING

Number of units (pumps)	2
Type of pumps	Grundfos booster pumps
Model	
Country of origin	
Type of Coupling	
Coupling size	
Capacity of pumps	
Kilowatt rating	1.1 KW
No of fans	2
Type of fans	Woods electric
Kilowatt rating	0.55 KW

Lifting unit ....

Capacity of unit..... .....

6 DEWATERING PLANT

6.1 Sludge pumps

Number of units	2
Type	Seepex cavity pumps
Make	Seepex
Model	
Capacity	
Kilowatt rating	4 KW
Type of coupling	
Size of coupling	
Type of drive	
V-belt drive Yes/No	
Pulley size drive end	
Pulley size Non-drive end	
Number of belts	
Type of belt	
V-Belt size	
Lifting unit	
Capacity of lifting unit	
Date tested	
Valves inlet\outlet type	
Non-return valves	

6.2 Air Ejectors

Number of units	2
Type	Flygt Flo-Get
Material type	

6.3 Mixers

Number of units	2
Type	Flygt
Country of origin	
Model	
Kilowatt rating	
Type of Gearbox	
Gearbox ratio/rpm	

6.4 Wash Water pump

Number of units	2
Type	Booster pump
Make	Franklin Electro
Model	
Capacity	
Kilowatt rating	1.5 KW
Type of coupling	
Size of coupling	
Type of drive	
Valves inlet/outlet type	
Non-return valves	

6.5 Pumps

Number of units	2
Type	High pressure in line
Make	Movitec KSB
Model	
Capacity	

Kilowatt rating	7.5 KW
Type of coupling	
Size of coupling	
Type of drive	
Valves inlet/outlet type	
Non-return valves	

6.6 Conveyors

Number of units	2
Drive unit	Bauer drive motor/gearbox
Kilowatt rating	1 KW & 0.75 KW
Country of origin	
Drive end Bearings and make	
Non drive end Bearings and make	
Method of greasing	
Length of belt /screw	

6.7 Compressors

Number of units	2
Model	
Make	Kaeser Kompressoren
Maximum rated pressure	10 Bar
Kilowatt rating	1.1 KW
Type of oil	
No of Cylinders	
Operating Pressure	
Country of origin	

Year of manufacture ....

Date tested ....

6.8 Belt wash effluent pump

Number of units	2
Model	
Type	Submersible
Capacity	
Size of unit	
Kilowatt rating	
Valves inlet/outlet type	
Non-return valves	

6.9 Belt presses

Number of units	2
Model	
Make	
Country of origin	
Year of manufacture	
Gearbox make	Bauer motor/gearbox
Coupling size	
Belt width	
Auxiliary equipment	
Instrumentation	
Capacity	
Kilowatt rating	2.2-2.6 KW

6.10 Strainer

Number of units	1
Type of unit	

6.11 Drain Belt

Number of units	1
Drive unit	Bauer drive motor/gearbox
Kilowatt rating	0.75 KW
Country of origin	
Drive end Bearings and make	
Non drive end Bearings and make	
Method of greasing	
Length of belt /screw	

6.12 Poly Pumps

Number of units	3
Type	Centrifugal
Make	Seepex
Model	
Capacity	
Kilowatt rating	0.75 KW
Type of coupling	
Size of coupling	
Type of drive	
Valves inlet/outlet type	

6.13 Polly Mixers

Number of units	2
Type	
Country of origin	
Model	
Kilowatt rating	0.75 KW

Type of Gearbox..... .....

Gearbox ratio/rpm..... .....

6.14 Poly Feeder

Number of units ..... 1.....

Type ....

Country of origin ....

Model..... .....

Kilowatt rating..... 0.18 KW .....

Type of Gearbox..... Elektrim motor/gearbox .....

Gearbox ratio/rpm..... .....

Drive end bearing and make..... .....

Non-drive bearing and make..... .....

7 RAW PUMPSTATION

7.1 PUMPS

Make..... Gorman Rupp.....

Type ..... Self priming .....

Size/model..... .....

Kilowatt rating..... 28 KW .....

Suction size ....

Delivery size ....

T-type of drive..... .....

Pulley sizes Drive end ....

Pulley sizes Non drive end..... .....

Coupling guards material..... .....

Taper lock bush sizes for coupling D/E..... .....

Taper lock bush size for coupling Non-D/E..... .....

V-Belt sizes..... .....

Number of belts ....

Make of belts ....

Direct coupling Yes/No ....

Fennerflex coupling size ....

Valves inlet/outlet type ....

Non-return valves type..... .....

7.2 PST`S

Number of units ..... 2.....

Type of drive..... Flender motor/gearbox .....

Make gearbox..... Flender.....

Type of oil..... .....

Capacity of oil..... .....

Kilowatt rating..... 0.37 KW .....

Centre bearing Type..... .....

Centre bearing size..... .....

Type/method of lubrication..... .....

Material type centre bearing ....

Make/type Bridge carrier wheels..... .....

Condition of Bridge walkway structure ....

Type of sludge discharge valves/sluice gates ....

Condition of outlet V-Notch plates..... .....

Type of weirs ....

Condition of centre scum/baffle plates ....

Type of scum discharge..... .....

Condition of scum removal mechanism ....

8 RETICULATION PUMP STATION

8.1 HUMUS

Number of units	2
Make	Gorman Rupp
Type	Self priming
Size/model	
Kilowatt rating	4 KW
Suction size	
Delivery size	
T-type of drive	
Pulley sizes Drive end	
Pulley sizes Non drive end	
Coupling guards material	
Taper lock bush sizes for coupling D/E	
Taper lock bush size for coupling Non D/E	
V-Belt sizes	
Number of belts	
Make of belts	
Direct coupling Yes/No	
Fennerflex coupling size	
Valves inlet\outlet type	
Non-return valves	

8.2 RECYCLING PUMP No.1

Number of units	1
Make	KSB
Type	
Size/model	
Kilowatt rating	22 KW
Suction size	
Delivery size	
T-type of drive	
Pulley sizes Drive end	
Pulley sizes Non-drive end	
Coupling guards material	
Taper lock bush sizes for coupling D/E	
Taper lock bush size for coupling Non-D/E	
V-Belt sizes	
Number of belts	
Make of belts	
Direct coupling Yes/No	
Fennerflex coupling size	
Valves inlet\outlet type	
Non-return valves	

8.3 RECYCLING PUMP No.2

Number of units	1
Make	KSB
Type	
Size/model	
Kilowatt rating	15 KW
Suction size	
Delivery size	
T-type of drive	
Pulley sizes Drive end	
Pulley sizes Non-drive end	
Coupling guards material	
Taper lock bush sizes for coupling D/E	
Taper lock bush size for coupling Non-D/E	
V-Belt sizes	
Number of belts	
Make of belts	
Direct coupling Yes/No	
Fennerflex coupling size	
Valves inlet\outlet type	
Non-return valves	

8.4 HUMUS TANK ROTATING BRIDGE No.1

Number of units	1
Type of drive	Femco motor/gearbox
Make gearbox	Femco
Type of oil	
Kilowatt rating	
Capacity of oil	
Centre bearing Type	
Centre bearing size	
Type/method of lubrication	
Material type centre bearing	
Make/type Bridge carrier wheels	
Condition of Bridge walkway structure	
Type of sludge discharge valves/sluice gates	
Condition of outlet V-Notch plates	

8.5 HUMUS TANK ROTATING BRIDGE No.2

Number of units	1
Type of drive	WEG motor/gearbox
Make gearbox	WEG
Type of oil	
Capacity of oil	
Kilowatt rating	
Centre bearing Type	
Centre bearing size	
Type/method of lubrication	
Material type centre bearing	

Make/type Bridge carrier wheels ....

Condition of Bridge walkway structure ....

Type of sludge discharge valves/sluice gates ....

Condition of outlet V-Notch plates..... .....

9 FINAL EFFLUENT PUMP STATION

9.1 Submersible/ Recycle pumps

Number of units ..... 2.....

Model..... .....

Type ..... Submersible .....

Capacity ....

Size of unit..... .....

Kilowatt rating..... .....

Valves inlet/outlet type..... .....

Non-return valves ....

9.2 Booster pumps

Number of units ..... 1.....

Make..... Franklin Electro .....

Type ..... Booster.....

Size/model..... .....

Kilowatt rating..... 1.5 KW .....

Suction size ....

Delivery size ....

Type of drive..... .....

Pulley sizes Drive end ....

Pulley sizes Non-drive end ....

Coupling guards material..... .....

Taper lock bush sizes for coupling D/E .....

Taper lock bush size for coupling Non-D/E .....

V-Belt sizes.....

Number of belts .....

Make of belts .....

Direct coupling Yes/No .....

Fennerflex coupling size .....

Valves inlet\outlet type.....

Non-return valves .....

10 ANAEROBIC DIGESTER

10.1 Mixer

Number of units ..... 1.....

Type ..... WEG .....

Country of origin .....

Model.....

Kilowatt rating..... 15 KW .....

Type of Gearbox..... motor/gearbox.....

Gearbox ratio/rpm.....

10.2 Lubricator

Number of units ..... 1.....

Type ..... WEG .....

Capacity ..... 0.88 KW .....

Make.....

Model.....

11 NIGHTSOIL SYSTEM

11.1 Pump

Number of units	1
Model	
Type	Submersible
Capacity	
Size of unit	
Kilowatt rating	15-20 KW
Valves inlet/outlet type	
Non-return valves	

19 APPENDIX C: DESIGN DATA

Design Data

Description	Value	Units
Design criteria		
Average dry weather flow	11	Ml/d
	127	l/s
Peak factor	3	
Peak wet weather flow	33	Ml/d
	1375	m3/h
	382	l/s
Raw sewage contribution (est.)	167	l/capita/d
Population equivalents (est.)	65868	
Influent sewage quality		
COD	950	mg/l
TKN	52	mg/l
P	15.3	mg/l
Suspended solids	320	mg/l
COD load	10450	kgCOD/d
TKN load	572	kgN/d
P load	168.3	kgP/d
Suspended solids load	3520	kg/d
Biofilter Plant		
ADWF	3.7	Ml/d
PST's	2	No
Diameter	15.5	m
Area (each)	188.72	m2
Upflow rate (ADWF)	0.4085	m/h
Upflow rate (PWWF)	1.2254	m/h
COD load	3515	kgCOD/d
COD removal	35	%
Suspended solids load	1184	kg/d
Suspended solids removal	67	%
Mass of primary sludge	793.28	kg/d
Mass of humus sludge	616.88	kg/d

Total sludge mass from PSTs	1410.2	kg/d

Biofilters	2	No
Diameter	30	m
Area (each)	706.95	m2
Depth	4	m
Volume (each)	2827.8	m3
Volume (total)	5656	m3
COD load	2285	kgCOD/d
Organic load	0.40	kgCOD/m3/d
Hydraulic load	2.62	m3/m2/d

Humus tanks	2	No
Diameter	20	m
Area (each)	314	m2
Upflow rate (ADWF)	0.25	m/h
Upflow rate (PWWF)	0.74	m/h
Humus sludge production	617	kg/d

Expected Effluent Quality Biofilters

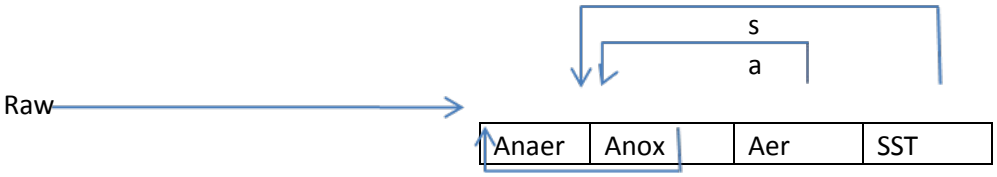
COD	72
Ammonia	4
Nitrate	25
Soluble reactive P	11
Suspended solids	15

Activated Sludge

ADWF	7.3	Ml/d
COD load	6935	kg/d
TKN load	379.6	kg/d
P load	111.69	kg/d
Anaerobic basin volume	2940	m3
Anoxic basin volume	5090	m3
Aerobic basin volume	7514	m3
Total volume	15544	m3
Retention time	2.1293	d
MLSS	2500	mg/l
Mass of activated sludge biomass	38860	kgMLSS
COD/MLSS ratio	0.1785	mgCOD/mgMLSS/d
Temperature (max)	22	C
Temperature (min)	17	C
Sludge age	20	days

A recycle	210	l/s
R recycle	170	l/s
S recycle	120	l/s

Inflow ADWF – Q	127	l/s
A/Q	1.6	
R/Q	1.3	
S/Q	0.9	



		r
SSTs	2	No
Diameter	25	m
Area (each)	490.94	m2
Upflow rate (ADWF)	0.3098	m/h
Upflow rate (PWWF)	0.9293	m/h

Expected Effluent Quality Activated Sludge

COD	74	
Ammonia	0.5	
Nitrate	9.7	
Soluble reactive P	0.3	
Suspended solids	10	

Anaerobic Digester

Total sludge mass	1410	kg/d
Sludge concentration	4	%
Volume of raw sludge produced	35	m3/d
Volume of digester	2750	m3
Retention time	78	d
Sludge mass after digestion	1128.1	kg/d
Sludge volume at 4% solids	28.203	m3/d

Sludge Drying Beds

Digested sludge volume	28.2	m3/d
Depth of sludge application	150.0	mm
Required area per day	188.0	m2/d

No of beds	20.0	
Bed length	35.0	m
Bed width	5.5	m
Total bed area	3850.0	m2
Drying period	20.5	d

20 APPENDIX D: TROUBLESHOOTING MATRIX

TROUBLESHOOTING MATRIX – PST'S, BIOFILTERS AND HUMUS TANKS

Problem/Symptom	Cause	Remedy
PST emits large bubbles with a bad smell	PST scraper mechanism stopped	Reset
	PST scraper mechanism rubber strips worn	Examine and replace
	Desludging frequency too low	Increase
Biofilter ponding	Media clogged	Rinse thoroughly
		Dig up affected area to 1m depth and clean media
		If fats are causing the problem find the source of the fats – industry responsible
Biofilter ammonias rise	COD overloading	Increase frequency of PST desludging
	Recycle pump not operating	Reset or repair
	Humus tank desludging too infrequent – solids breaking down	Increase frequency of desludging
	Scraper mechanism stopped	Reset or repair
	Scraper mechanism rubber strips worm	Inspect and replace

TROUBLESHOOTING MATRIX – DISINFECTION

Problem/Symptom	Cause	Remedy
High E coli	High ammonias	Biofilter problem – investigate further
		Activated sludge problem – too little aeration
		Accumulated solids in maturation river breaking down and releasing ammonia – measure ammonia before and after pond
	High suspended solids absorbing chlorine	Check suspended solids in effluent and determine cause – e.g. floc carryover on SST's
	Low chlorine dose	Check with chlorine comparator
	Chlorine cylinder empty	Replace
	Flow proportioning not working	Check if chlorine dose increases as flow increases

TROUBLESHOOTING MATRIX – ANAEROBIC DIGESTION

Problem/Symptom	Cause	Remedy
VFA's in excess of 200mg/l or pH less than 7.0 or no gas generated	Hydraulic overloading of digester	Reduce volumes pumped to digester
	Organic overload	Check if the strength of the sludge has increased (COD) or if high ammonia effluent has been fed to digester (blood from abattoir)
	Mixer not operating	Check and repair
If problems persist contact experienced operator to assist – methanogenisis fails below pH of 6.8 – to be avoided at all costs! Increase pH using sodium bicarbonate. Do not use lime to increase pH – it will block pipes		

TROUBLESHOOTING MATRIX – ACTIVATED SLUDGE

Problem/Symptom	Cause	Remedy
High phosphates	**R – recycle low or off**	**Check pumps for debris collection**
		Check that required number of pumps are operational
High nitrates	**A – recycle low or off**	**Check pumps for debris collection**
		Check that required number of pumps are operational
High ammonias	**Too little aeration**	**Increase DO setpoint**
		Check that outlet weir level has not been lowered by mistake
	Toxic effluent received – e.g. industrial effluent – ammonias rise very fast and wont go down	**Nitrifiers are slow growing and can take 10-14 days to recover**
	MLSS too low	**Measure and decrease wasting**
High COD	**High suspended solids carryover from SST's**	**See below**
High suspended solids carryover from SST's	**Worn RAS pump impeller**	**Check for wear and replace**
	RAS pump not operating	**Reset or repair**
	Excessive inflows into works	**Divert flow to maturation pond**
		Investigate cause of excessive flow – e.g. stormwater ingress
	Excessive MLSS concentration	**Measure and increase wasting volume**
	Scraper/siphon tripped	**Reset or repair**
	Scraper/siphon rubber strip worn	**Examine and replace**

TROUBLESHOOTING MATRIX – SLUDGE DEWATERING

Problem/Symptom	Cause	Remedy
Dewatered sludge solids low i.e. too wet	Poly incorrect	Check poly
	Poly makeup incorrect	Check an correct
	Solids measurement detector malfunction	Contact agents
	Feed sludge too thin	Investigate and correct

21 APPENDIX E: DRAWINGS