# Guide for management of waste stabilisation pond systems in South Africa

Philip de Souza & Unathi Jack

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# GUIDE FOR MANAGEMENT OF WASTE STABILISATION POND SYSTEMS IN SOUTH AFRICA

Report to the

Water Research Commission

by

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on behalf of Emanti Management (Pty) Ltd

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## EXECUTIVE SUMMARY

It is understood that the health of a community is significantly influenced by its water quality. The appropriate management of water systems, both the natural resource and municipal water services, is a critical requirement in municipal services provision.

## PURPOSE OF THE GUIDE

This guide has been developed with the purpose of providing assistance in terms of:

- Planning for construction of an appropriate wastewater treatment system and determining what is appropriate
- Management to understand what to expect from the contractors and/or consultants in designing a waste stabilisation ponds system
- Good operations and maintenance of waste stabilisation ponds system
- Possible re-use of treated wastewater from waste stabilisation ponds system
- Upgrading waste stabilisation ponds system.

This guide can be used in conjunction with the following Water Research Commission (WRC)/Department of Water Affairs and Forestry (DWAF) guides:

- DWAF (2004) General Authorisation
- Permissible Utilisation and Disposal of Treated Sewage Effluent, Department of Health under reference 11/2/5/3: 30 May 1976
- "South African water quality guidelines – agricultural use" DWAF 1993
- "South African water quality guidelines – industrial use" DWAF 1993
- Handbook for the operation of wastewater treatment works (2006) by Frik Schutte
- All other references at the end of the document
- A guide for operations and maintenance of waste stabilisation ponds system also developed.

## WHO SHOULD USE THIS GUIDE?

The guide has been developed in such a way that it will assist the wastewater management team to answer the following questions:

- Is a waste stabilisation pond system appropriate for us?
- What do we need to consider when designing a waste stabilisation pond system?
- Once we have constructed a waste stabilisation pond system, how do we operate and maintain the system?
- Is the treated wastewater in the waste stabilisation pond system suitable for re-use purposes?
- How do we prevent and respond to typical system failures?
- What options are available if we need to upgrade or refurbish the waste stabilisation pond system?

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**Eastern Cape** **:** Maletswai, Senqu, Buffalo City, Inkwanca, Great Kei
**Mpumalanga** **:** Emalahleni
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## ABBREVIATIONS

**COD** **:** Chemical Oxygen Demand
**EPA** **:** Environmental Protection Agency
**FC** **:** Faecal Coliform
**RBC** **:** Rotating Biological Contactor
**SS** **:** Suspended Solids

## GLOSSARY

**Aerobic** : a biological process which occurs in the presence of oxygen
**Anaerobic** : a biological process which occurs in the absence of oxygen
**Desludge** : the process of removing sediment by draining and cleaning
**Discharging** : is a process where treated wastewater is discharged of
**Effluent** : treated wastewater flowing out of the wastewater treatment system
**Grit** : solid material contained in raw wastewater (e.g. sand, gravel, food waste etc)
**Infiltration** : the process of water entering soil
**Influent** : untreated wastewater – the wastewater that flows into a wastewater treatment system
**Inlet** : opening providing a means of entrance/intake of the untreated wastewater
**Lining** : a protective covering that protects an inside surface of the pond to avoid leaching
**Nightsoil** : human excreta collected intentionally
**Organic load** : amount of Chemical Oxygen Demand (COD) per unit volume or area per unit of time; usually expressed as [kg/m$^3$/day] or [kg/m$^2$/day]
**Outlet** : opening providing a means exit of the treated wastewater
**Overflow** : flows or runs over the top or banks
**Overloaded** : loaded past/exceeds capacity of the treatment system
**Ponds** : are described as relatively shallow bodies of wastewater contained in an earthen basin
**Septage** : material removed from any part of an individual sewage disposal system
**Screenings** : the fine or coarse material removed by the screens at the inlet of the wastewater treatment system
**Screens** : a device with openings, generally of uniform size, that is used to retain course solids found in wastewater
**Scum** : filmy layer of slimy matter that forms on or rises to the surface of a pond. Scum is known to be a form or type of algae
**Sludge** : semisolid material deposited during the treatment of wastewater

# 1. BASIC CONSIDERATIONS FOR DESIGN OF A WASTEWATER TREATMENT WORKS

An understanding of the nature of wastewater (i.e. raw wastewater) is fundamental for the design of appropriate wastewater treatment works. Effluent quality is the most important factor in choosing a wastewater treatment technology. Facilities are permitted to meet certain effluent water quality standards, depending on the water quality of the receiving waters.

The ideal wastewater treatment system should satisfy the following criteria (Metcalf and Eddy, 2003; Marais, 1966)

- *Health criteria* – pathogenic organisms should not be spread either by direct contact with wastewater or indirectly via soil, water or food. The treatment system chosen should achieve a high degree of pathogen destruction.
- *Cost criteria* – capital and running costs should not exceed the community's ability to pay. The financial return from reuse is an important factor in this regard.
- *Ecological criteria* – in cases when the wastewater cannot be reused, the discharge of effluent into surface water should not exceed the self purification of the recipient water.
- *Operational criteria* – the skills required for the routine operation and maintenance of the wastewater treatment system components should be available locally or are such that they can be acquired with only minimum training.
- *Reuse criteria* – the wastewater treatment process should yield a safe effluent for reuse, preferably for aquaculture and/or agriculture purposes.
- *Nuisance criteria* – No part of the system should become odour offensive.
- *Cultural criteria* – the methods chosen for wastewater collection, treatment and reuse, should be compatible with local habits and social practice. This is dependent on issues such as location of the system, cultural value of the area etc.

Whether an existing wastewater treatment system is to be renovated or a new system built, planning in construction of a wastewater treatment facility should ensure that all the goals of treatment are considered, different options are evaluated and costs for construction and maintenance of all the options be compared. Issues to be taken into consideration include: (Qasm, 1998).

- *Local Resources*

Certain sites may be resource limited and may require specialized systems. For example an area with minimal quantities of water may require a plan of using dry sanitation methods. Grey wastewater may, in some instances, be treated onsite by septic tanks.

- *Land availability*

The size of the area available, can determine the treatment processes/operations to be used. Wastewater pond systems generally require higher areas than conventional wastewater treatment systems.

- *Economics*

In addition to the cost of the wastewater treatment unit and equipment, the capital costs include purchasing of land, equipment, plant construction and other related material. Different alternatives can be ranked based on overall costs and operation and maintenance costs (see decision trees in section 2.2 for details).

Operations and Maintenance are on-going costs that need to be budgeted for and for most treatment processes include supplies, parts, power, chemicals, operation and maintenance, labour supervision, monitoring, laboratory and report preparation. In terms of operations and maintenance waste stabilisation ponds are more cost effective as they do not require skilled personnel and power consumption and chemical use is very minimal.

- *Health considerations*

Prevention of disease transmission should be an objective of source water pollution control techniques in any treatment environment. Excessive quantities of organic material may cause rapid bacterial growth and depletion of the dissolved oxygen resources of the water body thereby impacting on the water quality.

- *Aesthetic considerations*

It is essential that the wastewater treatment systems do not infringe upon the natural, attractive, aesthetic, scientific or historical value of the area. Waste stabilisation ponds could be a nuisance if they produce odours, however if well maintained there are no odours produced.

- *Safety considerations*

The design engineer has the responsibility of incorporating as many safety features as possible into the system design. This would include the system grounds and all additional operations such as effluent structure, standby generators, etc.

- *Access/Security considerations*

Roads providing direct access to a wastewater treatment system should be constructed in a manner that minimizes accidents and should include all weather surfaces for immediate access at any time and season. The system should be enclosed by a fence to prevent people and animals from wandering into the system area and in general to deny access to the system by the public. This would include putting up “no swimming” signs.

- *Climate*

Temperature is highly important for the efficiency of the wastewater treatment processes. Temperature affects the rate of reaction of most of the biological and chemical reactions. Biological activities in waste stabilisation ponds become more active with increasing temperature thereby increasing the effectiveness of the system. Waste stabilisation ponds systems are appropriate in most of South African climatic conditions (there are no areas that are too cold and/or experience snow throughout the year).

- *Influent characteristics*

Characteristics of the wastewater to which the treatment will be applied, affects the types of processes to be used, and the requirements for proper operation. Influent types include domestic, industrial, nightsoil or a combination of these. Waste stabilisation ponds can treat a variety of these effluent types however, for influent flows greater than 1 ML/day waste stabilisation ponds system is not recommended.

- *Applicability*

The process has to be chosen according to the contaminants present, and to what quantities/concentrations they are present. Typically, past experience is used and where there is no available information or the process is new, pilot-plant studies should be used. The processes should also be chosen from information based on the expected flow rate; as processes are usually most efficient at particular flow rates.

The next step is to investigate and describe different wastewater treatment system options. It is important to describe the options not only in economic terms but also in terms of performance and other goals. The next section aims to assist in making such a decision.

# 2. SELECTING AN APPROPRIATE WASTEWATER TREATMENT SYSTEM

## 2.1 Wastewater treatment facility efficiency

The process of evaluating and selecting appropriate wastewater treatment technology usually begins with a technical feasibility study dependant on the nature of the application. This includes consideration of the area and geotechnical aspects, design considerations, local resources, economics, health factors, aesthetics, safety and access. The following tables will assist in deciding on the appropriate wastewater treatment system to utilise.

**Table 1:** Characteristics of typical wastewater treatment systems (Mara, 1976; UNEP, 1997 and Qasm, 1998)

| Treatment type | Advantages | Disadvantages |
|---|---|---|
| **Pond Systems** | | |
| Stabilisation ponds | Low capital cost.<br>Low operation and maintenance costs.<br>Low technical manpower requirement. | Requires a large area of land.<br>May produce undesirable odours. |
| Aerated ponds | Requires relatively little land area.<br>Produces few undesirable odours. | Requires mechanical devices to aerate the basins.<br>Produces effluent with a high suspended solids concentration. |
| **On-site Systems** | | |
| Septic tanks | Can be used by individual households.<br>Easy to operate and maintain.<br>Can be built in rural areas. | Provides low treatment efficiency.<br>Must be pumped occasionally.<br>Requires a landfill for periodic disposal of sludge and seepage. |
| Constructed wetlands | Claimed to remove up to 70% of solids and bacteria.<br>Minimal capital cost.<br>Low operation and maintenance requirements and costs. | Remains largely experimental.<br>Requires periodic removal of excess plant material.<br>Best used in areas where suitable native plants are available. |
| **Advanced Treatment Systems** | | |
| Filtration systems | Minimal land requirements; can be used for household scale treatment.<br>Relative low cost.<br>Easy to operate. | Requires mechanical devices. |
| Biological reactors | Highly efficient treatment method.<br>Requires little land area.<br>Applicable to small communities for local-scale treatment and big cities for regional scale treatment. | High cost.<br>Requires technically skilled manpower for operation and maintenance.<br>Needs spare parts available.<br>Has a high energy requirement. |
| Activated Sludge | Highly efficient treatment method.<br>Requires little land area.<br>Applicable to small communities for local scale treatment and to big cities for regional scale treatment. | High cost.<br>Requires sludge disposal area<br>Requires technically skilled manpower for operation and maintenance. |

The ultimate goal of wastewater management is the protection of the environment in a manner fitting public health and socio-economic concerns. Therefore the design of any wastewater treatment system should be in such a way that the final effluent produced serves this purpose.

Economic considerations in the construction of an appropriate wastewater treatment system are presented in the following section.

## 2.2 Wastewater treatment facilities economic considerations

The capital investment cost for wastewater treatment system depends on several technology driven and site driven variables. The most important factors influencing the total constructed cost of a wastewater treatment system are as follows (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006):

- The treatment system selected. Some wastewater treatment systems are more capital intensive than others.
- The available infrastructure on the site, including site services and common unit treatment processes such as screening/grit removal.
- The characteristics of the treatment system site will impact on capital cost depending on certain features such as:
    - Slope of the site will determine the number of wastewater pumping stages.
    - Ground conditions on site, specifically the presence of rock (requiring expensive excavation techniques) and problem soils (requiring specialised foundation construction).
- Discharge standards will, for example, determine the need to incorporate more capital intensive treatment infrastructure to remove Nitrogen and Phosphorus.
- Sludge disposal approach will determine the degree of sludge stabilisation and disinfection. For example, the new South African Sludge Guidelines stipulate a high level of stabilisation for certain classes of sludge, which will require additional digester facilities.
- On-site facilities required by the treatment system owner, such as laboratory facilities, staff accommodation, access roads, security fencing, etc.

Different treatment technologies have different combinations of capital investment cost and operations and maintenance costs.

Based on the issues mentioned above a decision support model for the selection of affordable and appropriate wastewater treatment technology was developed. The different wastewater treatment technologies produce different types and amounts of sludge. The sludge handling, treatment and disposal were not specifically considered in the development of the decision support model (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006).

The main criteria for selecting appropriate and affordable wastewater treatment system fall in a number of categories or groups.

- Community size and discharge standards
- Land availability
- Operational support and resources
- Maintenance support and resources
- Existing treatment infrastructure

These decision support models are intended to provide broad guidance and the outcomes always have to be adjusted by local preferences and specific site conditions. The following diagrams are extracted from a yet unpublished: (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006):

The figure below shows that ponds are normally recommended for areas with population less than 5000 persons. If the population ranges between 5000-50 000 persons, attached growth wastewater treatment system e.g. trickling filters is recommended and suspended growth wastewater treatment system e.g. activated sludge is not appropriate.

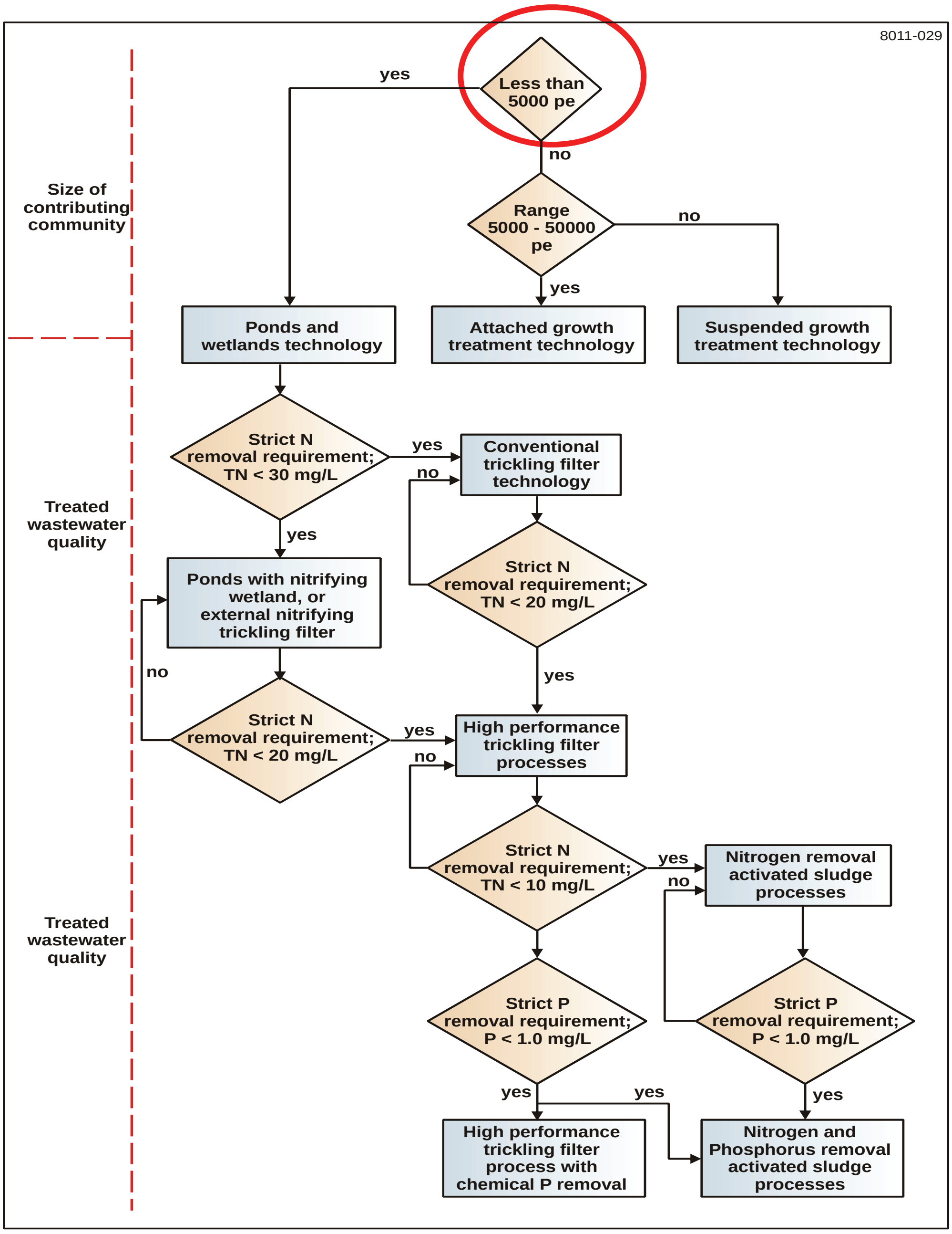



**Figure 1:** *Decision support model with respect to community size and discharge standards:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

The figure below shows that waste stabilisation ponds are normally recommended for areas with population less than 5000 persons. If the population ranges between 5000-50 000 persons, attached growth wastewater treatment system (e.g. trickling filters) is recommended and suspended growth treatment system (e.g. activated sludge) is not appropriate.

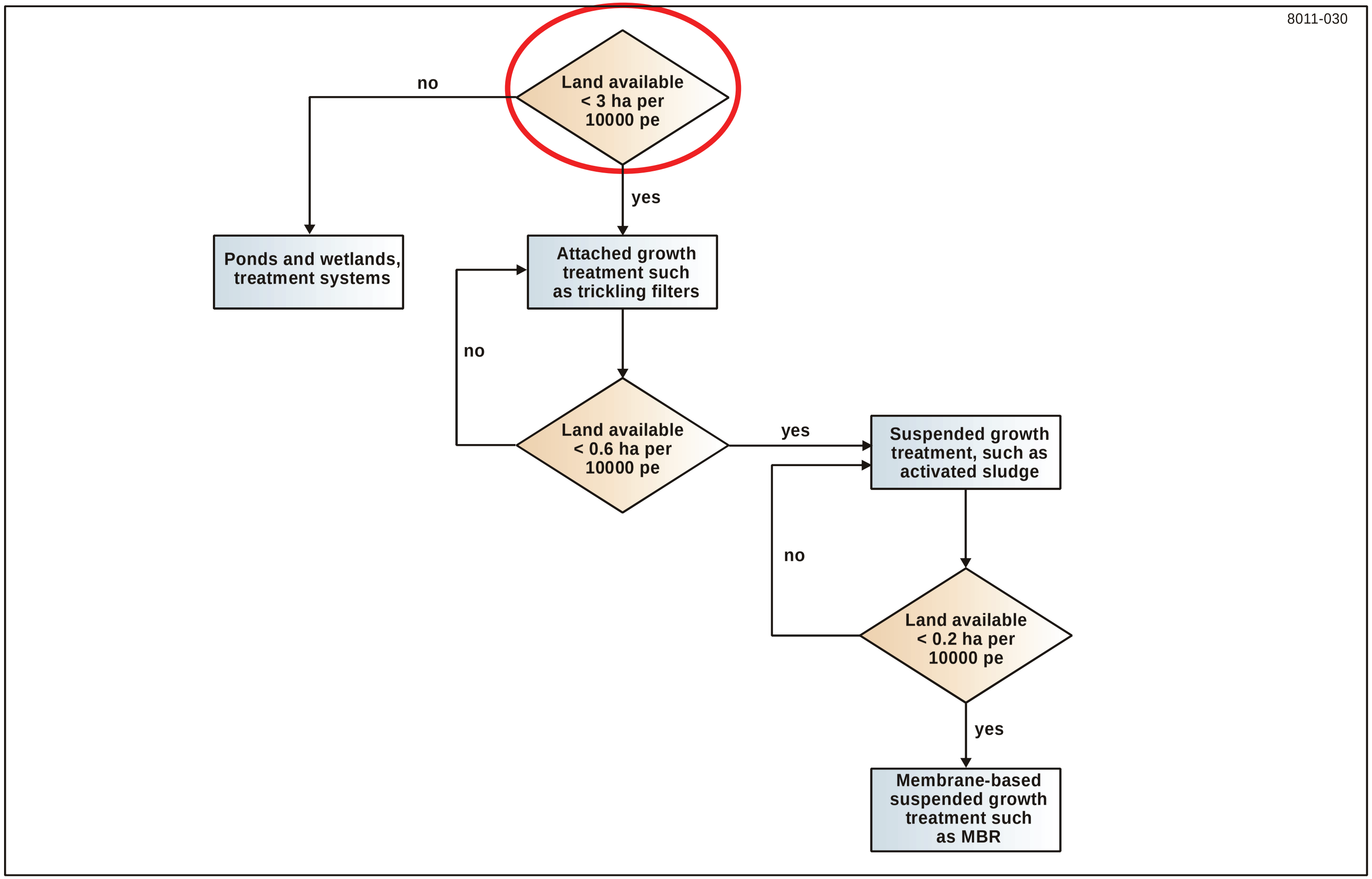



**Figure 2:** *Decision support model with respect to land availability for the system:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

The figure below shows that ponds and/or wetlands are normally recommended for areas where there is no or limited skilled operating staff. Waste stabilisation pond systems are also appropriate for areas where electricity supply is minimal.

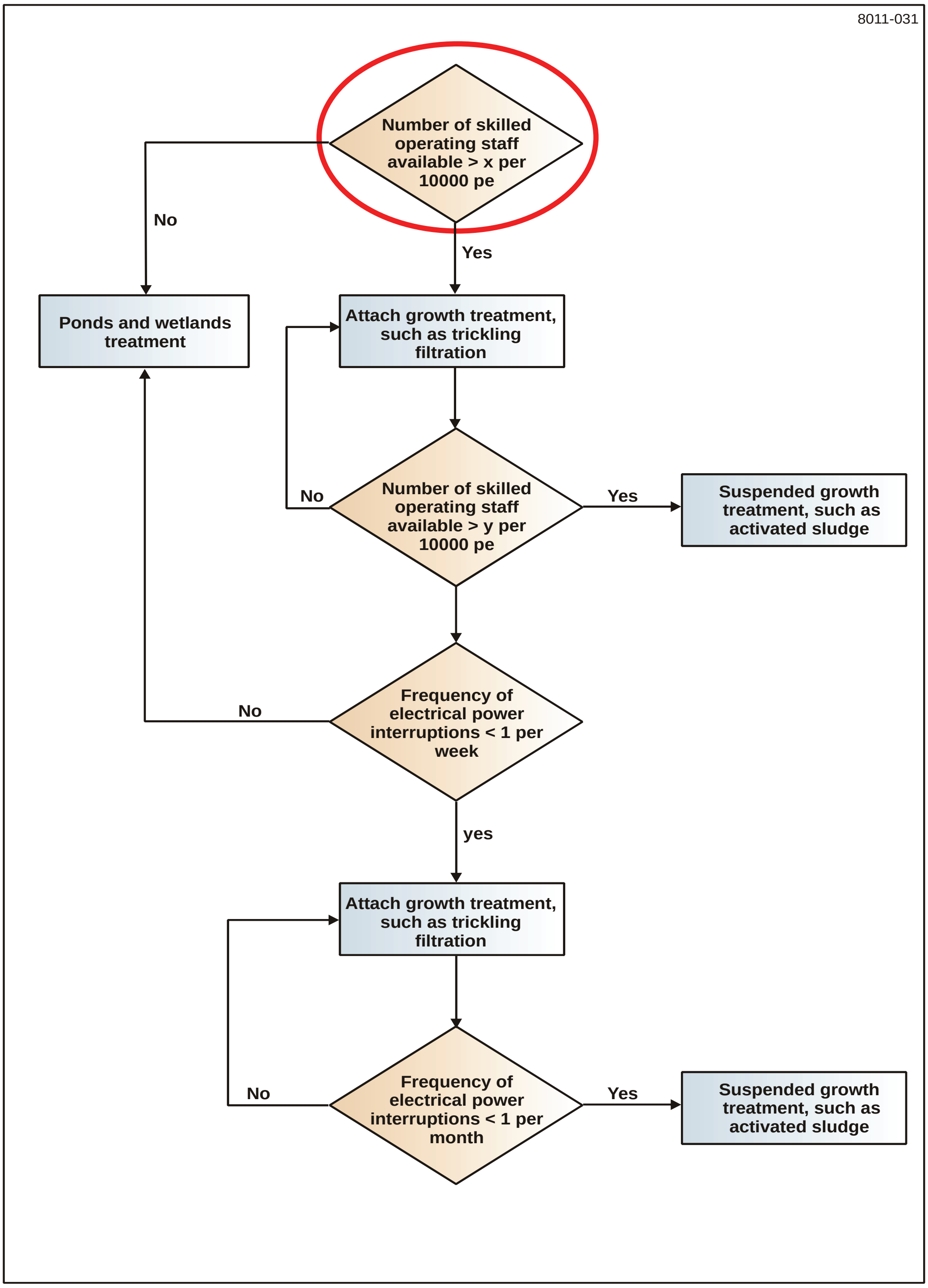



**Figure 3:** *Decision support model with respect to operational support and resources:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

The figure below shows that waste stabilisation ponds normally do not have mechanical and electrical equipment therefore access to electrical and maintenance people should not be a primary consideration. Access to mechanical and electrical maintenance personnel is more important for activated sludge systems then the trickling filter systems follow.

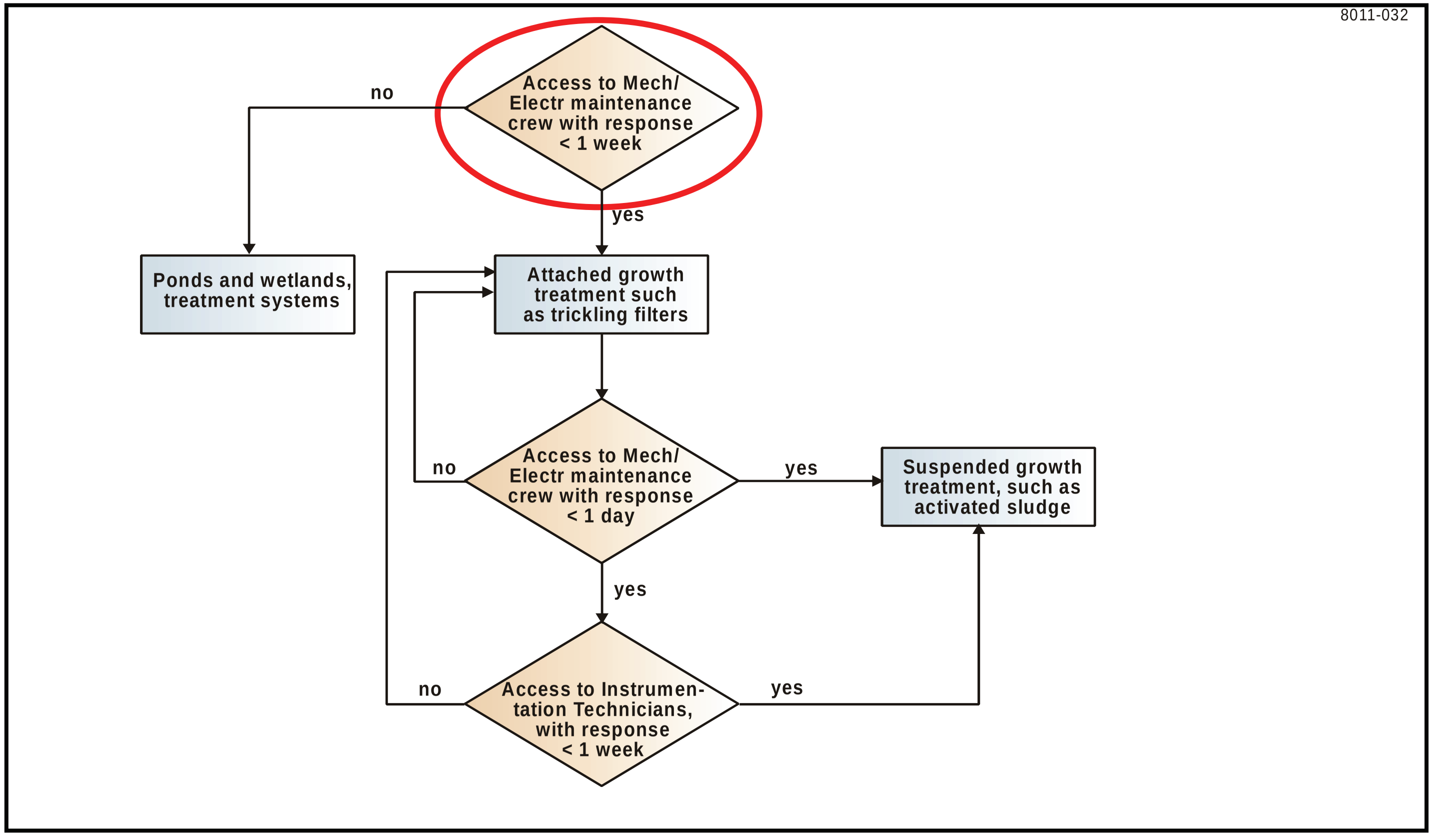



**Figure 4:** *Decision support model with respect to maintenance support and resource:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

The figure below shows what to consider when upgrading a wastewater treatment system. Where waste stabilisation ponds already exist, upgrading options could include constructing more pond basins and/or wetlands. Integrating waste stabilisation ponds with attached trickling filters and activated sludge systems could also be considered.

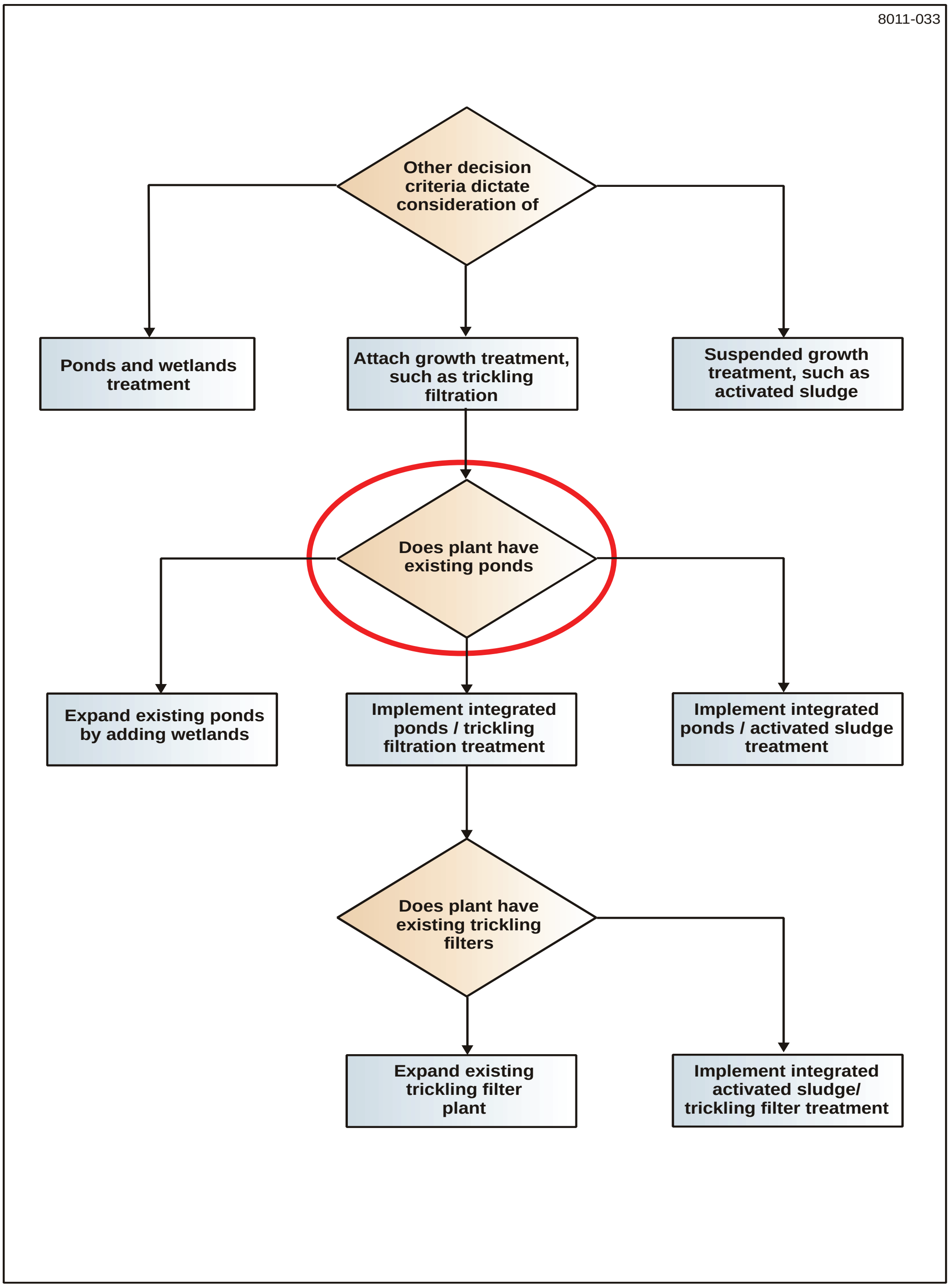



**Figure 5:** *Decision support model with respect to existing treatment infrastructure:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

Considering the aspects in the tables and figures above, a waste stabilisation pond system would be most suitable if:

- There is 30 000 $m^2$ area of land available and it is affordable
- The municipality has financial constraint in retaining and attracting highly skilled people
- Simple and cheap operation is required (therefore appropriate where there is lack of staff)
- There are no trained personnel for process control
- The area is rural therefore supply of electricity is minimal
- The community is small (say <10 000 people) and the land is flat
- Access to operations and maintenance personnel is limited
- Likelihood of groundwater contamination is less possible
- The influent received is mainly domestic, that is, no or little industrial effluent and no abattoir waste
- Located preferably 500 m from the dwellings (Mara, 1997). The General Authorization does not specify ponds location relative to the dwellings
- The potential to contaminate groundwater is limited

Some indicative capital investment costs were extracted from recently constructed wastewater treatment systems in the micro, small to medium size range. There is a substantial variation in treatment system costs due to the factors listed above and for that reason it is practical rather to give a covering of capital costs, than a single median line. The capital cost curves therefore indicate a lower 25 percentile, a median 50 percentile and an upper 75 percentile cost. The capital cost per unit of treatment capacity (R million per ML/day plant capacity) is also sensitive to the size of the plant. The larger treatment plants have a scale benefit in terms of capital investment (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006).

Although the focus is on waste stabilisation ponds, other wastewater treatment systems graphs are provided for reference.

*Integrated pond treatment* incorporating preliminary treatment, integrated ponds, polishing wetlands and side-stream nitrification Biotowers – refer to following figure.

**Note:** The cost is of a plant is expressed in R million per ML/day plant capacity. That means the cost value reflected on the graph should be multiplied by 1000.
Due to the fact stated above that there is a substantial variation in treatment system costs due to the factors listed above and that it is practical rather to give a covering of capital costs, than a single median line. The following figures show a range of capital costs that could be expected in construction of a wastewater treatment system. The 25 percentile capital cost line indicates the minimum cost, the 50 percentile capital cost line indicates an average cost and the 75 percentile capital cost line indicates the maximum cost that should be expected.

The figure below shows that for a 1 ML/day waste stabilisation ponds system, the lowest capital cost is expected at approximately R4,2 million, whilst the average capital cost is expected at approximately R5,2 million and the maximum capital cost is expected at approximately R8 million.

**Remember:** the maximum recommended waste stabilisation ponds system size should not exceed 1ML/day.

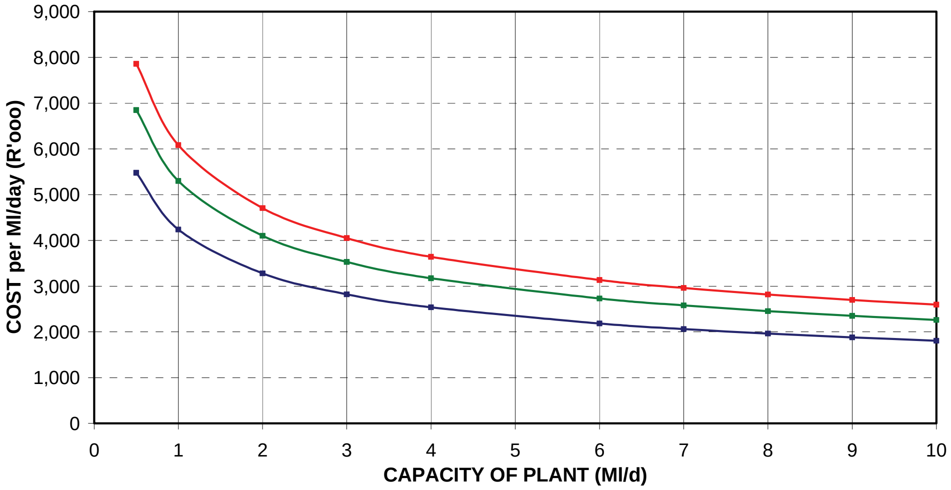



**Figure 6:** *Capital Investment Cost Curves for Integrated Ponds Treatment Systems:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

*Activated sludge treatment* incorporating preliminary treatment, BNR type activated sludge, secondary clarification, disinfection, sludge drying beds and associated plant infrastructure.

*Trickling filter treatment* incorporating preliminary treatment, primary clarification trickling filters, humus clarifiers, disinfection, sludge digestion and sludge drying beds.

The figure below shows that for a 2 ML/day activated sludge treatment system, the lowest capital cost is expected at approximately R4,8 million, whilst the average capital cost is expected at approximately R6 million and the maximum capital cost is expected at approximately R6,7 million.

For the same size (i.e. 2 ML/day) trickling filtration system, the lowest capital cost is expected at approximately R6 million, whilst the average capital cost is expected at approximately R7,8 million and the maximum capital cost is expected at approximately R8,8 million.

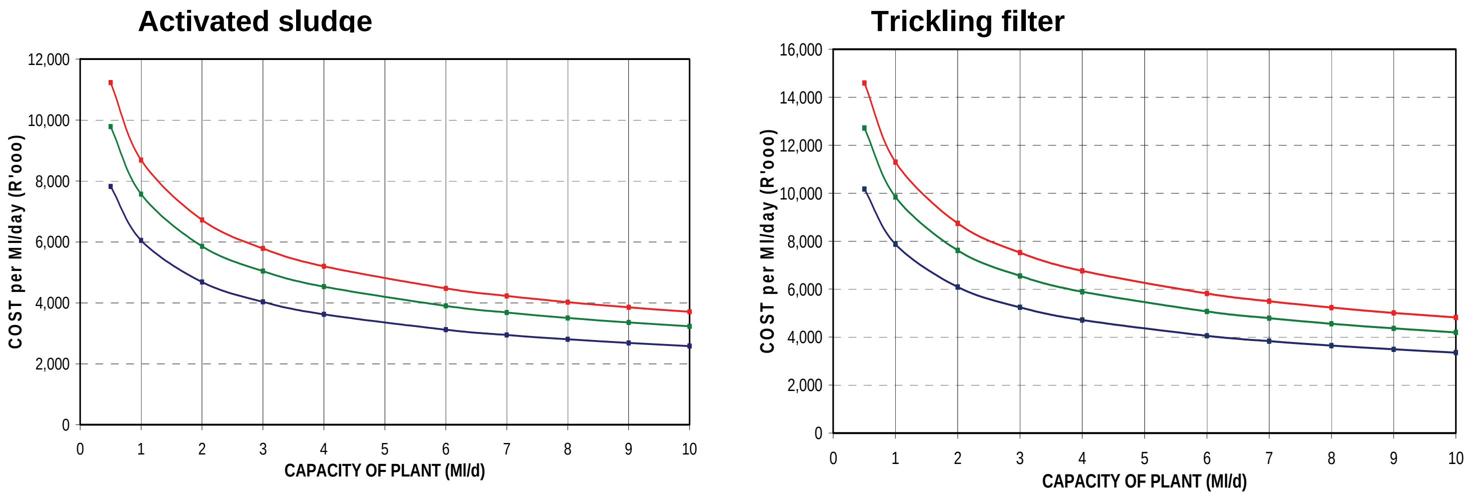



**Figure 7:** *Capital Investment Cost curves for the Activated Sludge and Trickling Filter Treatment Systems:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

### 2.3 Indicative operations and maintenance cost

The operations and maintenance cost for a wastewater treatment system would include the following components:

- Personnel and labour
- Electrical power consumption
- Chemical dosing
- Maintenance and repair
- General expenses
- Laboratory, monitoring and surveillance

The indicative operation and maintenance (O&M) cost for the different generic wastewater treatment systems are illustrated graphically in the figures below. The curves reflect a range of 50 %, 75 % and 100% utilization of the installed treatment system capacity.

The figure below shows that for a 1 ML/day waste stabilisation ponds system, operating at a 50 percent of its design capacity, operations and maintenance cost is expected at approximately 70 cents per cubic meter of water received. The same system operating at 75 percent of its design capacity, the operations and maintenance cost is expected to be approximately 79 cents per cubic meter of water received. If the system operates at 100 percent of the design capacity, it is expected to cost 90 cents per cubic meter of water received.

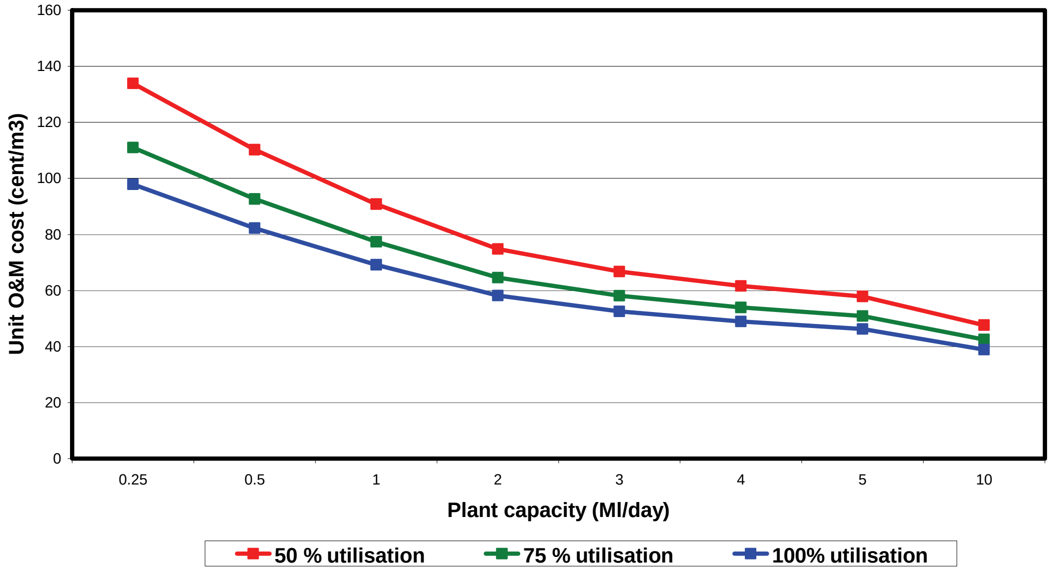



**Figure 8:** *Indicative O&M costs for Integrated Ponds and Polishing Wetlands:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

The figure below shows that for a 2 ML/day activated sludge system, operating at a 50 percent of its design capacity, operations and maintenance cost is expected at approximately 165 cents per cubic meter of water received into the system. The same system operating at 75 percent of its design capacity, the operations and maintenance cost is expected to be approximately 180 cents per cubic meter of water received. If the system operates at 100 percent of the design capacity, it is expected to cost approximately 220 cents per cubic meter of water received.

For the same size (i.e. 2 ML/day) trickling filter system, operating at a 50 percent of its design capacity, operations and maintenance cost is expected at approximately 120 cents per cubic meter of water received into the system. The same system operating at 75 percent of its design capacity, the operations and maintenance cost is expected to be approximately 140 cents per cubic meter of water received. If the system operates at 100 percent of the design capacity, it is expected to cost approximately 160 cents per cubic meter of water received.

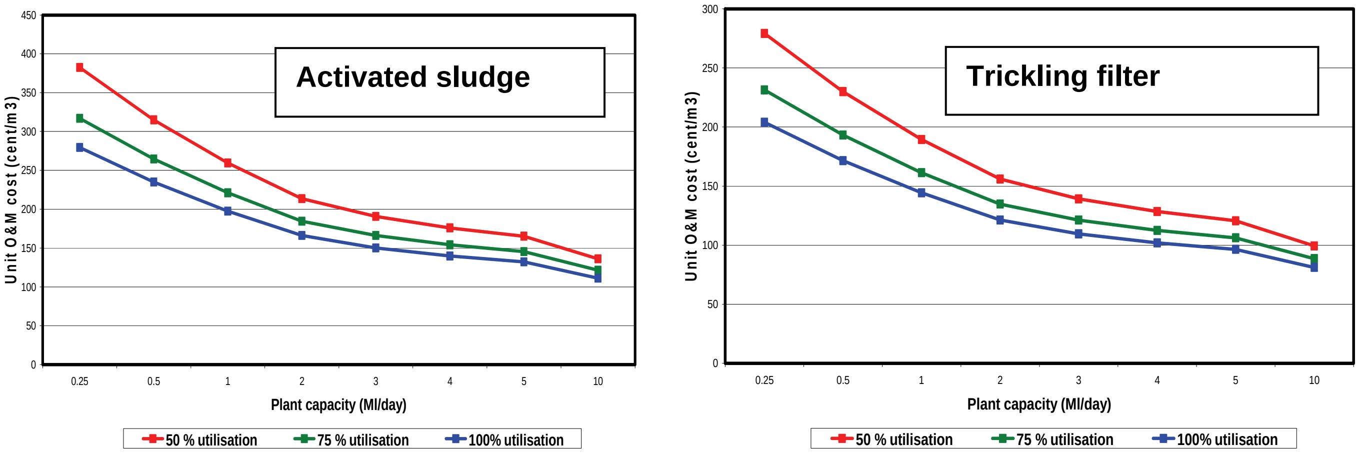



**Figure 9:** *Indicative O&M costs for Activated Sludge and Trickling Filter Systems:* (Golder Associates Africa and Zitholele consulting draft report prepared for WRC and DWAF, 2006)

Prior to detailed discussion of design, operations, maintenance etc of waste stabilisation pond systems a brief introduction to the functions of these systems is required.

# 3. TYPES OF WASTE STABILISATION PONDS

Waste stabilisation pond systems comprise a series of ponds, all of which are relatively shallow bodies of wastewater contained in an earthen basin. The basis for the classifications are type of influent (i.e. wastewater entering) and type of biological activity (i.e. functioning in presence or absence of oxygen). Two types of biological activities are anaerobic (functions without presence of oxygen) and aerobic (functions with presence of oxygen. The primary pond is often an anaerobic pond, followed by a series of aerobic ponds. Most common typical ponds setups are shown in the figures below:

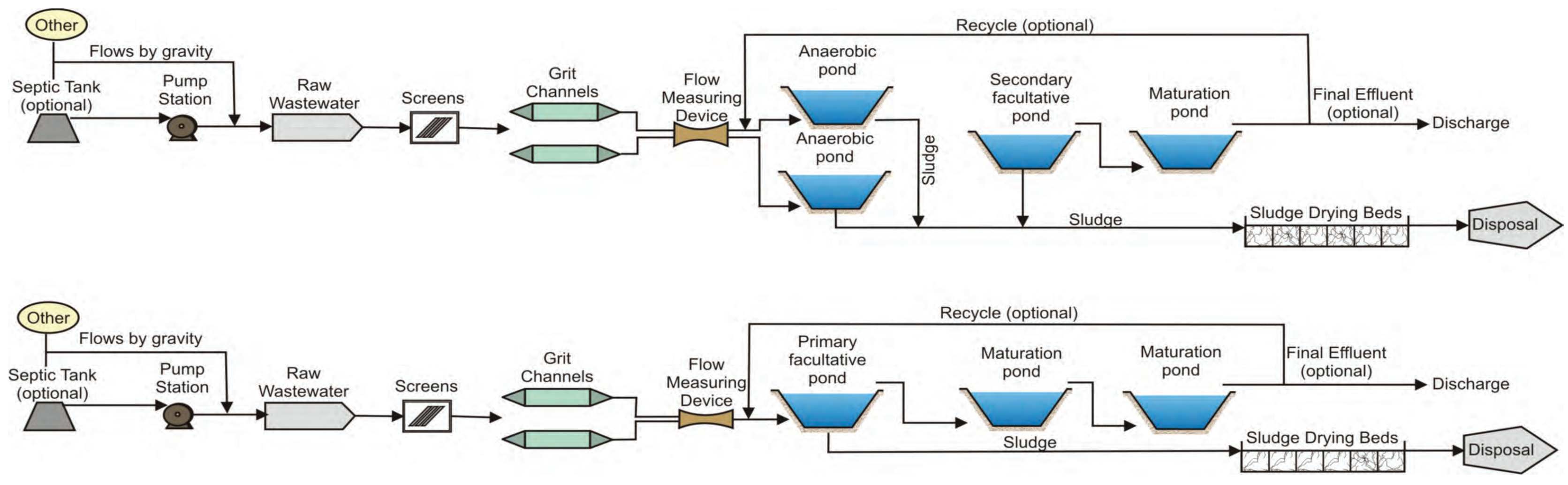



**Figure 10:** *Detailed waste stabilisation ponds configurations*

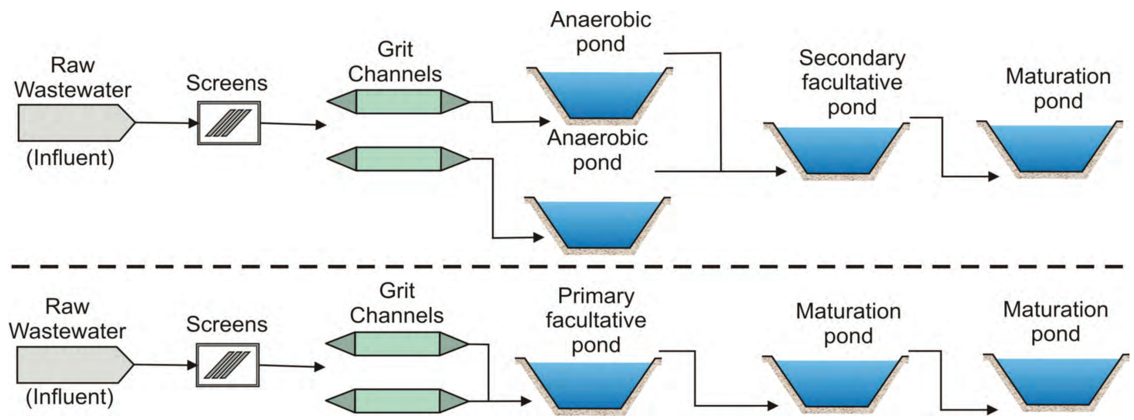



**Figure 11:** *Simple waste stabilisation ponds configurations*

## 3.1 Anaerobic ponds

Anaerobic ponds operate in the absence of oxygen. Anaerobic ponds main purpose is to provide pre-treatment as they remove organic loads and settled solids. Anaerobic ponds retention time is short, that is, 3 to 5 days at temperature greater than $20^0$C (Mara, 2005) and depth between 2-4 m. As a complete process, anaerobic pond serves to:

- Separate out solids from dissolved material as solids settle as bottom sludge
- Dissolve further organic material
- Break down biodegradable organic material
- Store undigested material and non-degradable solids as bottom sludge
- Allow partially treated effluent to pass out

Anaerobic ponds are normally characterised by:

- The influent received. Anaerobic ponds were mostly used for systems receiving nightsoil. Anaerobic ponds can be used to receive industrial waste. Now that buckets have been eradicated, the influent received is mainly domestic.
- The colour of the wastewater contained within the pond is normally dark brown to black.
- Normally contain no significant algal population. Scum layer could be found on top of the pond.

## 3.2 Facultative ponds

Facultative ponds operate with both aerobic and anaerobic zone. Aerobic conditions are generally maintained in the upper layers while anaerobic conditions exist towards the bottom. Facultative ponds are normally used as receiving ponds where domestic influent is received and the retention time is 2-4 weeks. Facultative ponds are normally characterised by:

- The effluent received: Facultative ponds are normally receiving ponds where only domestic influent is received. Facultative ponds either receive raw wastewater influent (primary facultative pond) or receive effluent from anaerobic pond (secondary facultative pond).
- The colour of the wastewater contained within the pond is normally that of the influent received. Sometimes the colour is bluish to green depending on the algal population present.

## 3.3 Aerobic ponds

Aerobic ponds operate in the presence of oxygen. Oxygen supply is totally dependent on natural conditions, principally the wind and due to algal photosynthesis. An example of an aerobic pond is called a maturation pond. Maturation ponds are used for polishing the effluent quality and the retention time is about 12 days. The primary function of maturation ponds is to remove pathogens. Aerobic ponds are similar in appearance to facultative but only differ in organic load. As a complete process, the aerobic pond serves to:

- Further treat effluent through separation, dissolving and digestion of organic material.
- Break down most remaining organic solids near the pond surface.
- Reduce the amount of disease-causing micro-organisms.
- Store residues from digestion, as well as non-degradable solids, as bottom sludge.
- Allow treated effluent to pass out into a waterway or additional treatment system (i.e. an additional pond, wetland system or for land application).
- Remove pathogenic micro-organisms by solar radiation.

Maturation ponds are characterised by:

- Normally follows a series of facultative ponds. Maturation ponds are the last ponds of the waste stabilisation ponds system.
- The colour of the wastewater contained within ponds is clear. Sometimes the colour is dark green due to algae but appears red or pink when slightly overloaded. Final effluent (if applicable) can be used for irrigation (if meets standards for irrigation) or recycled to the receiving pond.
- Normally used where there would be final effluent surface water discharge or irrigation.

Other types of waste stabilisation ponds include (Mara, 2005):

- Integrated facultative ponds or advanced facultative ponds – consists of a semi-enclosed pit operating under anaerobic conditions built within a facultative pond. Further information on this type can be found in section 7.2.1.
- High rate algal ponds – these systems are shallower than facultative pond (0.2-0.8 m) and operate at shorter retention times of around a week or less. Further information on this type of ponds can be found in section 7.2.3.
- Advanced pond systems – this system integrates an advanced facultative pond (with a built in fermentation pit) followed by a high rate algal pond. Further information on this type of ponds can be found in section 7.2.4
- PETRO (Pond Enhanced Treatment and Operation) system – uses a waste stabilisation pond as a first stage of wastewater treatment and followed by second stage which is either a trickling filter or activated sludge system.
- Aquaculture ponds – a fish or aquaculture pond is added to the end of pond wastewater treatment system. The basic principle is that the fish will graze the algae reducing solids and subsequent harvesting of the fish then provides a source of protein and a method of recovering nutrients.
- Storm-water ponds – used to treat storm-water. The need for treating storm-water has been brought forward by awareness that storm-water flushed off is not simply clean rain water, but contains contaminants such as solids and heavy metals.

# 4. WASTE STABILISATION PONDS DESIGN CONSIDERATIONS

Once a decision has been made that waste stabilisation ponds are the best system for the area the following design considerations must be taken into account. The purpose of the section below is to provide guidance to management (e.g. municipal managers, technical managers and supervisors) as to what to expect when a pond system is designed. Municipalities may appoint a service provider for construction; however it is necessary to know if legislated needs are followed and proper considerations have been made. It also provides information as to the necessary material required so as to include in the budget.

When designing waste stabilisation ponds system issues to be taken into consideration include those listed and discussed below.

- Lining
- Shape and depth
- Topography
- Inlet and outlet
- Hydraulic considerations
- Location

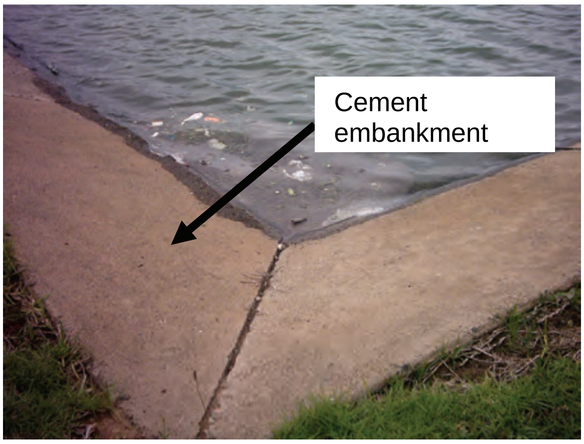
## 4.1 Pond lining

When choosing a site to construct a pond system, an area should be selected where the water table is deep (according to the DWAF General Authorization it should be above the 100 year flood line or more than 100 m from the edge of a water resource or borehole) and the soil is impermeable (the permeability in not specified). Silt or clay soils are ideal for pond foundations and construction. Ngcobo (1986), EPA Guidelines (2004) and Mississippi State Department of Health (1997) state that the following should be considered:

- Pond systems that are to be constructed in soils other than clay loam, sandy clay loam, silt clay loam, sandy clay and/or clay shall be lined with a continuous minimum 0,2 m liner or a suitable clay layer a minimum of 0,15 m thick (EPA, 2004).
- Wastewater may contain a range of pollutants, and such ponds should be lined on the bottom and sides with compacted clay and/or a synthetic membrane to minimize environmental harm.
- A clay lining should be protected from drying and cracking during construction.
- If a clay lining is used for an evaporation pond it should be protected as the liner may shrink and crack if the pond dries out. In such circumstances, synthetic liners may be required.
- Cement slabs are normally used at the edge of the ponds to avoid erosion when clay lining is used.
- Synthetic liners include PVC, polyethylene and rubber products which are used as an impermeable barrier for the construction of the pond.

During this study the observation was that only cement slabs are installed for the embankment without any other type of lining. Therefore this report will keep referring to cement embankment.

Advantages and disadvantages of different linings are presented in section 6.1



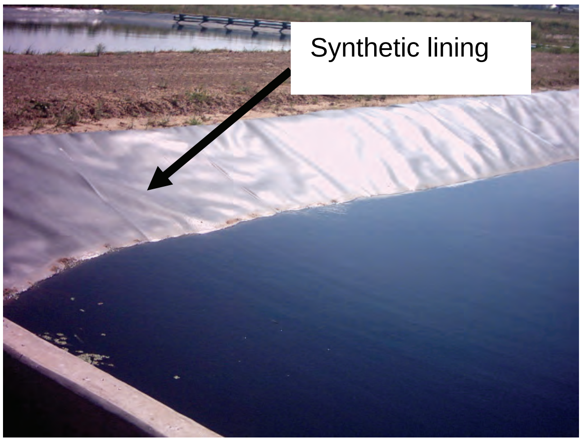




**Figure 12:** *Photographs showing lining in ponds*

## 4.2 Pond shape and depth

Potential to contaminate groundwater is significant from waste stabilisation ponds depending on the quality of construction and the depth to the water table. The use of the depths and distances does not guarantee that pollution will not be caused though; rather, it will reduce the risk of significant pollution occurring. Potential contamination sources include pit latrines, waste disposal sites located upslope from the borehole etc.

- The historical hydraulic characteristics of rectangular ponds have been found to be superior to those of square and circular ponds. Length to breadth ratios of 2 to 1 for anaerobic ponds and 3 to 1 for primary facultative ponds. For secondary facultative and maturation ponds much higher values can be used (Mara, 2005).
- The range of depth most commonly used for each type of pond is as follows (Mara, 1997):

  Facultative ponds – 1 to 2 m
  Anaerobic ponds – 2 to 4 m
  Maturation ponds – 1 to 1.5 m
- Sizing of the ponds must take into consideration the local climatic conditions and not be dictated by a set detention time. For an example anaerobic ponds are designed based on the volumetric Chemical Oxygen Demand (COD) loading which is a function of temperature (Mara, 2005) as shown in the following table:

**Table 2:** Variation of design volumetric COD loading on, and COD removal in anaerobic ponds (Mara, 2005)

| Temperature ($^0$C) | Design loading (g/m3 day) | COD removal (%) |
|---|---|---|
| <10 | 100 | 40 |
| 10-20 | 20T-100* | 2T + 20* |
| 20-25 | 10T + 100* | 2T + 20* |
| >25 | 350 | 70 |

*T = Environmental temperature

E.g. Sizing an anaerobic pond: $\lambda_v = L_iQ/V_a$ ……*Equation1:*
*where;*

- $\lambda_v$ = Volumetric COD load (g/m$^3$ day)
- $L_i$ = influent COD (g/L)
- Q = influent flow (m$^3$/day)
- $V_a$ = anaerobic pond volume (m$^3$)

**Example 1**
Worked example (for anaerobic pond):

*Assumed Specifications based on typical situation*
Influent flow (Q) =800 L/day : obtained from the inlet meter or measured manually using a parshal flume with stick method
Pond length (L) = 20 m : measured
Pond width (W) = 10 m : measured
Pond depth (D) = 3 m : measured
Influent COD ($L_i$) = 200 g/L : measured
Temperature (T) = 15$^0$C

*Calculations based on Equation 1 above:*
Pond volume $V_a$ = L(m) x W(m) x D(m) where;
L = pond length
B = pond breadth
D = pond depth

$V_a$ = 20 m x 10 m x 3 m
= 600 m$^3$
1 m$^3$ = 1000 L
Therefore 800 L/day = 0.8 m$^3$/day

$\lambda_v = L_iQ/V_a$
$\lambda_v$ = 200 g/L x 0.8 m$^3$/day / 600 m$^3$
$\lambda_v$ = 0.267 g/L day

0.267 g/L day = 267 g/m$^3$day

*Conclusion:*
Comparing the calculated COD loading and the temperature dependant loading given in table 2 above:
Design loading (g/m$^3$day) = 20T - 100 OR = 20T - 100
= 20 x 15 – 100 = 20 x 20 – 100
= 200 g/m$^3$ day = 300 g/m$^3$ day

The calculated COD loading is appropriate for ponds functioning between temperatures 10 to 20$^0$C. Therefore an anaerobic pond designed with the above specifications is expected to function well under the specified temperature conditions.

## 4.3 Pond topography

A problem common to many ponds erosion of the interior slopes. Erosion is caused by surface runoff and wind induced wave action (Metcalf and Eddy, 1991). Freeboard, the vertical height of the top of the embankment, is provided to prevent wind wind-induced waves overtopping the embankments and to allow for build-up during high flow periods. The area where the pond water surface meets the soil embankment requires protection against wave action. An all weather gravel surface around the ponds provides access for inspection and maintenance.

- Sloping ponds shall have a continuous berm around them to minimise entrance of surface water.
- The berm shall have a minimum top width of 1,8 m (Ramadan and Ponce, 2005)
- A free board of 0,5 m minimum should be maintained (EPA, 2004; Metcalf and Eddy, 1991).
- Erosion of the embankment by surface wave action can be avoided by placing concrete slabs at the top water level. The slabs stop vegetation growing down the banks and so prevent the breeding of mosquitoes.
- The capacity of the pond should be such that, in addition the stored wastewater arising from an average year's nett inflow and discharge, it can deal with rainfall runoff from 1 in 25 year storm (EPA, 2004).

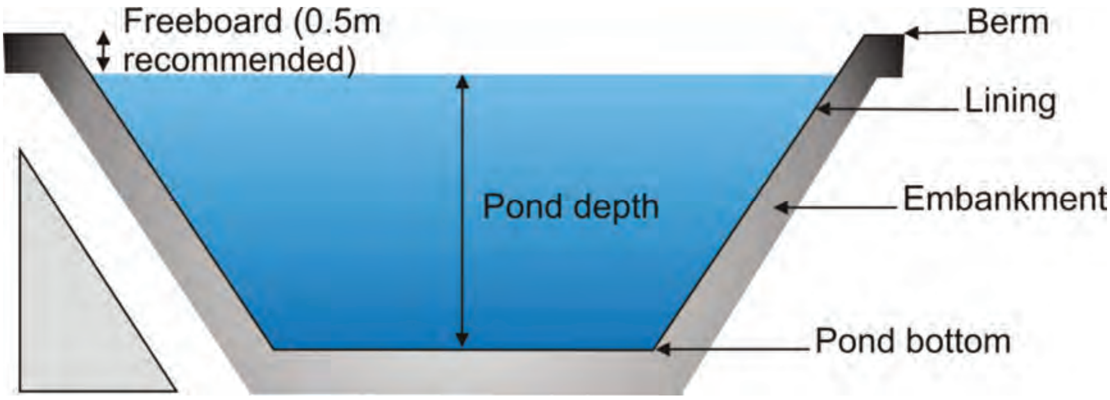



**Figure 13:** *Illustration of a pond*

## 4.4 Pond inlet and outlet

A pond should maintain a similar and reasonably well defined flow pattern through a range of different flow rates and this depends on the inlet and outlet structures. The inlet and outlet structures should permit samples to be taken easily.

- In order to facilitate maintenance it is advisable to divide the wastewater flow into two or more parallel streams which are then treated in an individual pond. The actual number of parallel units depends on the magnitude of the flow and topography of the site.

- Multiple inlets and outlets minimize short circuiting of the wastewater and allow the wastewater to be evenly spread out across each pond. An example of multiple inlets is shown in the following figure.
- To reduce short circuiting and promote mixing; the inlet to the pond should always be near the bottom, discharging in a horizontal direction away from the outlet.
- Where possible, the outlet should be windward of the inlet to avoid odours.

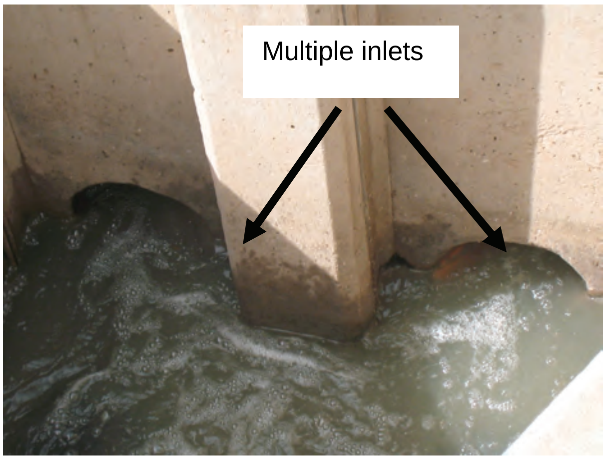




**Figure 14:** *Various pond inlets*

## 4.5 Pond hydraulic considerations

The current understanding of ponds hydraulics is still limited, however, the following observations were proven to be useful for the purpose of improving waste stabilisation ponds hydraulics, and consequently design, performance and efficiency (Mara, 2005 and Ramadan and Ponce, 2005):

- Influent should be mixed into the main body of the pond to avoid localized overloading.
- The solids deposition within the pond occurs as a result of the flow, rather than the flow being redirected as a result of the solids.
- For high load wastewaters (e.g. industrial waste), horizontal inlets may be needed to mix wastewater into the pond. Consider baffles and outlet positioning to avoid short circuiting.
- For low load wastewaters (e.g. domestic effluent), consider a manifold or baffled vertical inlet but only after consideration of wind influences.
- A pond should maintain a similar and reasonably well defined flow pattern through a range of different flow rates.
- Blood (e.g. from the abattoir) should never be allowed within a pond system.
- The retention time within a pond could be determined using the formula below (Mara, 1997).

$\Theta = V_a / Q$ ……………Equation 2: where;

- $\Theta$ = mean hydraulic retention time
- $V_a$ = anaerobic pond volume ($m^3$)
- Q = influent flow ($m^3$/day)

**Example 2**
Worked example (for anaerobic pond):

*Assumed specifications based on real situation*
Influent flow = 1 KL/day : obtained from the inlet meter or measured manually
Pond length = 20 m : measured
Pond width = 10 m : measured
Pond depth = 2.5 m : measured

Pond volume $V_a$ = L(m) x W(m) x D(m) where;

- L = pond length
- B = pond breadth
- D = pond depth

$V_a$ = 20 m x 10 m x 2.5 m
= 500 $m^3$

1 KL = 1000 L
1000 $m^3$ = 1 L
Therefore 1 KL/day = 1 $m^3$/day

*Calculation based on equation 2 above:*

Retention time = $V_a / Q$
= 500 $m^3$ / 1$m^3$/day
= 500 days

*Conclusion:*
500 days retention time is too much; therefore this shows that the pond is inappropriately designed for the specifications estimated. The size of the pond and the influent flow received are not proportional. Normally 3-5 days retention time for anaerobic pond is considered appropriate.

*Considerations:*
A pond with the given specifications could be appropriate for the following influent flow:
Say we are targeting 4 days retention time
Influent flow = 500 $m^3$ / 4 days
= 125 $m^3$/day

If the influent flow can be estimated (depending on the number of people served and their class), the volume of the pond to be constructed could be worked out as follows:
4 days retention time
depth ranging 2 – 4 m (say 3 m)
influent flow = 250 $m^3$/day

$V_a = \Theta \times Q$
$= 4 \text{ days} \times 250 \text{ m}^3/\text{day}$
$= 1000 \text{ m}^3$
Remember depth = 3 m
Therefore Area = 333,3 $m^2$

### 4.6 Pond location

Waste stabilisation ponds should be located in such a way that people and animals are discouraged from visiting the site. However, the site should be accessible by vehicles. Waste stabilisation ponds should be located:

- About 200 m from dwellings, (Mara, 1997; Ramadan and Ponce, 2005) preferably 500m. If possible waste stabilisation ponds should be located downwind from dwellings, roads and other public places.
- Above the 100 year flood line, or alternatively, more than 100m from the edge of a water resource or a borehole which is utilised for drinking water or stock watering (DWAF, 2004 a).
- Septic tanks, waste stabilisation ponds, or other component parts of the pond system shall not be located under dwellings or other permanent structures.
- The pond disposal system shall not be located in depressed areas where surface water will accumulate.

### 4.7 General

The most important parameters for waste stabilisation ponds design are:

- Temperature: the usual design temperature is the mean air temperature in the coolest month.
- Net evaporation: considered in the design of aerobic ponds, but not anaerobic as the scum layer generated on top of anaerobic ponds will prevent evaporation. Net evaporation is equal to the evaporation minus rainfall.
- Flow: a suitable flow design value is 80% (Metcalf and Eddy, 1991) of the domestic water consumption. That is if consumption is 1 ML/day (1000 $m^3$/da), assume 800

m$^3$/day of wastewater to the pond system. The design flow may be based on local experience in communities connected to a wastewater treatment system of similar socio-economic status and water use practice.

- A space for future plant expansion must be dedicated (e.g. has sufficient space surrounding pond system and avoids encroachment).
- Means and methods for sludge removal and resultant solids handling must be evaluated and installed (e.g. honey sucker for waste stabilisation ponds).
- Influent and effluent monitoring stations and facilities must be provided (e.g. v-notch, influent flume).
- Avoid sites that are likely to flood. In order to minimize the likelihood of flooding. A cut off trench or appropriate drainage should be provided (e.g. storm water drains).

Once the waste stabilisation ponds have started to operate, it is necessary to carry out continued regular routine maintenance tasks. Although simple, these tasks are essential to the good operation of the system. Simple operation and maintenance methods for the process operators on site are presented in the **guide for operation and maintenance of waste stabilisation ponds** that would be published soon.

The record sheet provided in **Appendix B** could be used by the supervisor or management to identify onsite issues and determine how frequently and how effectively maintenance is performed by the process controllers.

# 5. MANAGEMENT OF TREATED EFFLUENT

The main consideration associated with effluent reuse application is its quality therefore its suitability for that particular reuse. Some constituents in reclaimed water that are of particular significance in terms of agricultural irrigation include elevated concentrations of dissolved solids, toxic chemicals, etc. The basic types of reuse include environmental considerations (e.g. not for consumption), agricultural use (e.g. irrigation) and industrial use (e.g. cooling).

## 5.1 Environmental consideration

Environmental benefits can be gained from the use of wastewater. The factors that may lead to the improvement of the environment when wastewater is used rather than being disposed of in other ways are:

- Avoiding the discharge of wastewater into surface waters.
- Preserving groundwater resource in areas where over use of these resources in agriculture is causing high concentrations/imbalance of salt.
- The aesthetic improvement of urban conditions and recreational activities by means of irrigation and fertilisation of green spaces such as gardens, parks and sports facilities.

Benefits of wastewater reclamation include less treated wastewater and harmful nutrients flowing into our seas, less demand on traditional water resources such as groundwater and surface water.

**Strictly** speaking waste stabilisation pond systems, as noted earlier, are designed not to discharge to the environment (and in particular streams/rivers), and this is verified by the conditions attached to *Permissible Utilisation and Disposable of Treated Sewage Effluent*. A DWAF authorization in a form of a license/permit/exemption should be obtained by the municipality or any person/ industry for the operation of waste stabilisation ponds system.

As per DWAF General Authorisation, 2004 section 21 (f and h), 3.7 (i):
A person/industry intending to discharge water containing waste with either / both the quality and quantity exceeding requirements of the municipal sewer must obtain a permit/licence/exemption from the national water services regulatory institution (DWAF). The issuing of the permit/licence/exemption is necessary for those who intend to discharge water containing waste with of a quality and quantity exceeding the requirements stipulated in the General Authorisation. The issuing of the permit/licence/exemption is evaluated according to the following:

- Wastewater quality produced
- Wastewater quantity produced
- Area of disposal / irrigation

A person may discharge up to 2000 cubic metres of wastewater on any given day into a water resource that is not a listed water resource set out in table 3 provided the discharge complies with the general wastewater limit values set out in the table below.

**Table 3:** Wastewater limit values applicable to discharge of wastewater into a water resource

| **Substance/parameter** | **General limit** |
|---|---|
| Faecal coliforms | 1000/100ml |
| Chemical Oxygen Demand | 75mg/l (after removal of algae) |
| pH | 5,5-9,5 |
| Ammonia (ionised and un-ionised) as Nitrogen | 6 mg/l |
| Nitrate/Nitrite as Nitrogen (mg/l) | 15 |
| Chlorine as Free Chlorine | 0,25 mg/l |
| Suspended solids | 25 mg/l |
| Electrical Conductivity | 70 mS/m |
| Ortho-Phosphate as phosphorus | 10 mg/l |
| Fluoride | 1 mg/l |
| Soap, oil or grease | 2,5 mg/l |

**NOTE:** Ammonia may be a limiting factor as it is the most difficult to remove or satisfy in the standards.

Considering the above, it is however, important to note that this study has shown that numerous pond systems are discharging. Of great concern is where this is occurring, monitoring does not seem to be occurring. The figure below shows such systems.

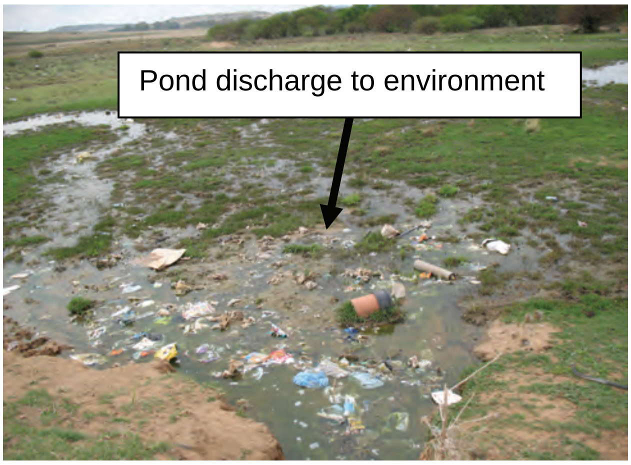



**Figure 15:** *A waste stabilisation pond system discharging to the environment*

## 5.2 Agriculture

Treated wastewater effluent can be used for irrigation of crops that are not eaten raw, irrigation of cattle feeding crops (excluding milk producing cattle) or landscape areas (e.g. parks, sports field, and lawns) and for industrial re-use, see **Appendix D** for details. With a growing human population and continued improvement of quality of life, water resources are under stress both quantitatively and qualitatively. The supply of freshwater is limited and threatened by pollution from various human activities. On the other hand, municipal wastewater and some industrial effluents which may be reused for irrigation require guidelines to estimate public health hazards (DWAF, 1993).

*Irrigation with and discharging of wastewater*

Irrigation with and discharging of sewage effluent shall be practiced in accordance with the guidelines prescribed in the documents titled “Guide: Permissible Utilization and Disposal of Treated Sewage Effluent”, issued by the Department of Health under reference 11/2/5/3 and dated 30 May 1976, or in accordance with any relevant regulations promulgated under section 26 of the Act as well as the “South African water quality guidelines – agricultural use” issued by DWAF in 1993.

As per DWAF General Authorisation (2004) section 21 (e), the final effluent of the wastewater pond systems should contain the standards reflected in the following table. Irrigation with ponds effluent is permissible if practised in the manner presented in **Appendix D** with the standards shown in the following table.

**Table 4:** Wastewater limit values applicable to irrigate with wastewater

| **Determinant** | **Quality** |
|---|---|
| Electrical conductivity | <200(mS/m) |
| pH | >6-9 pH units |
| COD | <400mg/l |
| Faecal coliforms | <100 000/100ml |
| Sodium Absorption Ratio (SAR) | <5 for biodegradable industrial wastewater |

Observations from the study were that there are a few waste stabilisation pond systems using final effluent for irrigating sports fields. This practise is permissible; however, it is essential to ensure that the final effluent quality satisfies DWAF limits for irrigation.

Irrigation in these types of landscape is permissible if the effluent contains not more than a maximum of 1000 *E. coli* count and there is no public and/or players during irrigation.

## 5.3 Industrial use of treated wastewater

Industrial reuse is highly cost effective for industries where the process does not require water of potable quality, and where secondary effluent is readily available for reuse. The most common uses of reclaimed water by industries include:

- Evaporative cooling tower, particularly for power stations
- Boiler feed water
- Process water

However, in order to fulfil requirements, pre-treatment is normally required. Typical problems that may arise as a result of change in water quality including:

- Scaling of hydraulic systems and process equipment.
- Corrosion of hydraulic systems and process equipment.
- Formation or presence of suspended solids which may interfere chemically with the process.
- Discolouration or staining of the product.

The protocol used for information gathering and development of water quality guidelines for each of the selected industries is outlined in chapter 2 of the “South African Water Quality Guidelines – industrial use” 1993.

Observations from this study were that there are no waste stabilisation pond systems using final effluent for industrial purposes.

# 6. TYPICAL FAILURES AND TROUBLESHOOTING

Waste stabilisation ponds are rarely perceived as being able to cope with high loads or being able to achieve high quality effluent standards. A temporary degradation of the final effluent quality, a regular development of offensive odours or the occurrence of operational issues are all signs that indicate to the process controller that the treatment system is operating at or over capacity. The signs of failing waste stabilisation ponds are presented below together with the upgrading options.

### Causes of failing waste water ponds and possible remedial actions

Some waste systems may not be functioning properly. Overloading can often be the result of:

- Improper process and/or physical design
- Poor design and/or operation of the inlet works; and/or
- Inadequate maintenance of the ponds.

When a pond system begins to show signs that it is no longer able to sustain its normal treatment quality, or meet the set standards a detailed plant assessment should be implemented. Hopefully inspections of the system are normally taking place. Such assessment should:

a. Review the loads coming to the plant as well as the original plant design parameters and its current conditions
b. Inflow and load data, operation and maintenance information or even general design information are often very sketchy when it comes to records from a pond This information is needed for a condition assessment of a pond and even more so for an upgrade of the same.

The following typical failures are experiences gained during the study and recommendations to attend to these are provided.

## 6.1 Lining

Observations from this study were that cement embankment and synthetic linings are the most used in South Africa. Clay lining with cement embankment is most preferably due to the fact that if well maintained (i.e. removing the grass growing on the embankment) it lasts longer compared to the synthetic lining. The cement embankment in most cases has been observed to be used as a lining with no other material (normally clay) to cover the whole pond area.

Synthetic lining covers the whole pond area and prevents erosion of the top part of the pond at the same time. Disadvantages of the synthetic lining noted are that:

- It is easily blown off if not properly installed on ponds system.
- It is damaged by animals drinking from the ponds and easy material to be torn by moles and squirrels.

- In case of fire on site, synthetic lining is more vulnerable to fire.

As noted earlier 2 m gravel around the pond to avoid plants growing and possible erosion near the banks is recommended.

Issues are shown in the figure below.


**Figure 16:** *Lining issues*

## 6.2 Inlets and outlets

If the positioning of the existing system design is such that the inlets and outlets of the ponds are in a straight line, the configuration with alternating inlets and outlets should be considered. Locate inlet close to the pond embankment. Introduce the raw wastewater below the water line to avoid splashing and odour generation. Split the inlet to distribute the raw wastewater over a wider area and avoid localized overloading. This is shown in the figure below.

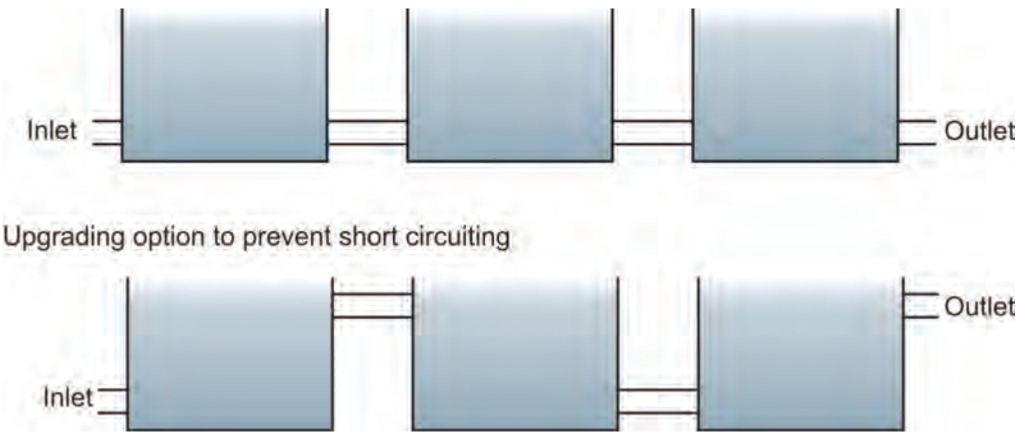



**Figure 17**: *Illustration of pond flow configuration*

Multiple inlets are recommended as experience has shown that some inlets were easily blocked (resulting in influent flowing everywhere on-site). If multiple inlets were installed, flow could be diverted to the functioning inlet. Issues are in the figure below:



**Figure 18:** *Inlet issues*

Screens should be installed at the inlet of the receiving ponds to assist with avoiding blockages at the inlet. Screenings should also be regularly removed at the inlet. It is important to know how much effluent is coming into the system, i.e. need to measure inflow using methods presented in the Guide for Operations and Maintenance of Waste Stabilisation Ponds so as to know if the system complies with the legal permit specifications for influent volumes.

Install overflow weirs between individual ponds. Protect these weirs with baffles to retain floating solids. Design the outlet weirs as flow control devices to achieve flow buffering within the pond and to avoid algae washout during storm flow events.

## 6.3 Receiving ponds

Having multiple receiving ponds provides alternative use of receiving ponds. One pond could be desludged, cleaned and/or given time to settle whilst the other pond is in use. In cases where one pond receives raw effluent it is difficult to desludge. Issues are shown in the figure below:

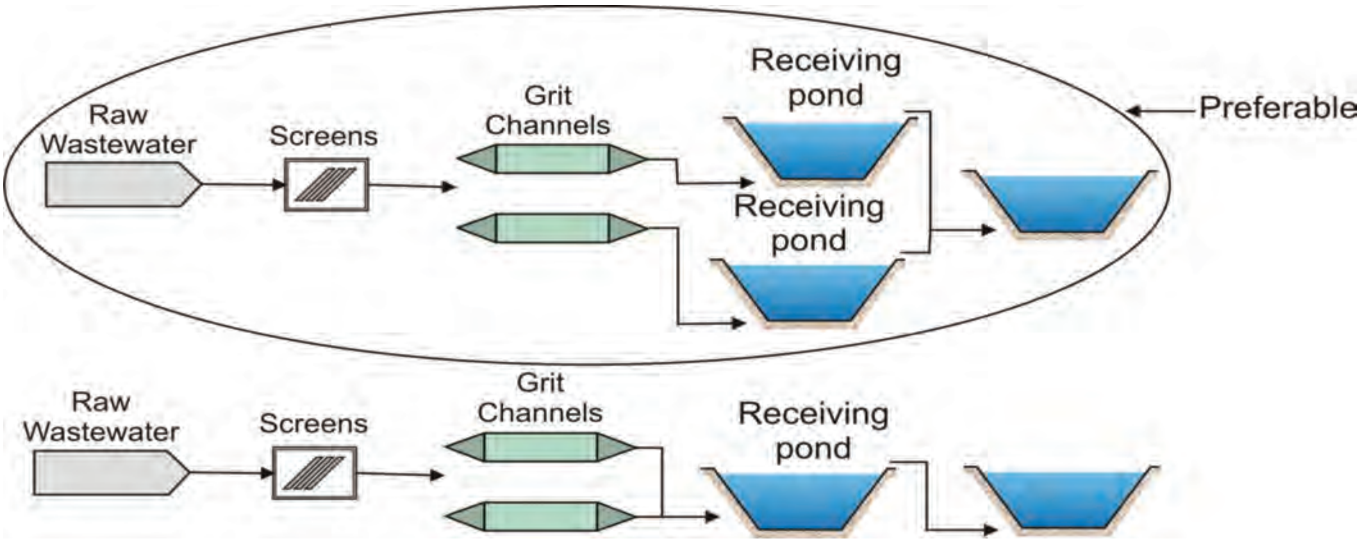



**Figure 19:** *Receiving pond issues*

## 6.4 Fencing

It is advised to raise at least a 1,8 m high razor mesh fencing to keep people and animals out of the waste stabilisation ponds system as a safety precaution. The importance of enclosing the site is to keep animals and people away from the site. It has been noted that where razor mesh is not utilised, fence theft regularly occurs.

Most of waste stabilisation pond systems assessed in this study were not enclosed (i.e. no fence or if fenced there is no gate). In many cases animals were found drinking from the ponds and occasionally drowned animals within ponds were seen. There have also been frequent reports of children are swimming in the ponds. This should be strongly discouraged as it may affect children's health and discussions/awareness within communities is essential. Issues are shown in the following figure.

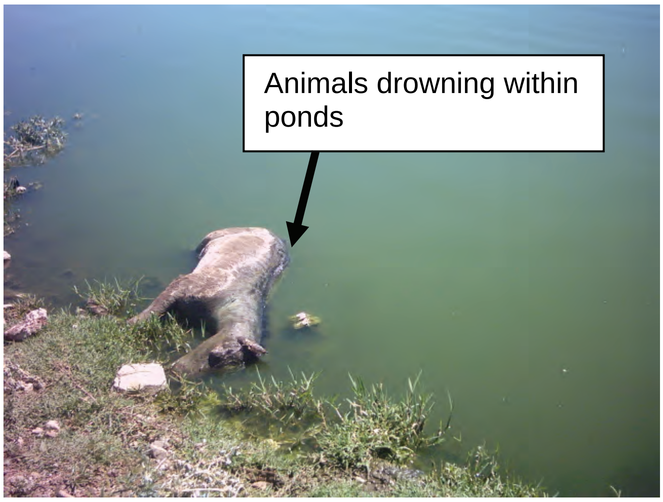




**Figure 20:** *Safety issues*

## 6.5 Supervision and Maintenance

Supervision in the waste stabilisation pond systems is important to make sure that operations and maintenance is carried out correctly. Most, if not all of these systems are Class E as per DWAF classifications see **Appendix C**. The following staff is required for Class E systems:

- One Class I process controller.
- Class V supervisor who does not have to be at the works at all times but must be available at all times.

Most of these systems are poorly maintained due to lack of supervision. A record sheet to assist maintenance personnel on-site to know what to look at and the supervisor to understand onsite issues on-site is provided as **Appendix B**.

## 6.6 Algal removal

The most appropriate technique for algal removal is a rock filter (Mara, 2005). Rock filters consist of a submerged porous rock bed which algae settle out as the effluent flows through.

The algae decompose releasing nutrients which are utilized by bacteria growing on the surface of the rocks. In addition to algal removal, significant ammonia removal may also take place through the activity of nitrifying bacteria growing on the surface of the filter medium. Rock size is important as surface area for microbial film formation increases with decreasing rock size but if the rocks are too small then problems can occur with clogging. The critical factor in design of rock filters is said to be hydraulic loading. For hydraulic loading rates less than 0.3 $m^3/m^3$ day, rock size ranging between 0,08 to 0,2 m are recommended. For hydraulic loading rates between 0,15 to 0,3 $m^3/m^3$ day, rock size ranging between 0,01 to 0,02 m are recommended.

The rock filters are known to be manmade from steel making industries. Therefore have an advantage of low construction cost and simple operation.
An alternative practical and cost effective method of removing algae is installing a U-shaped pipe towards the end of the pond. Wind direction needs to be considered when installing this as it the algal layer on top is expected to be blown by the wind towards the pipe. This kind of technique is shown in the figure below (Gaydon, personal communication 2008).

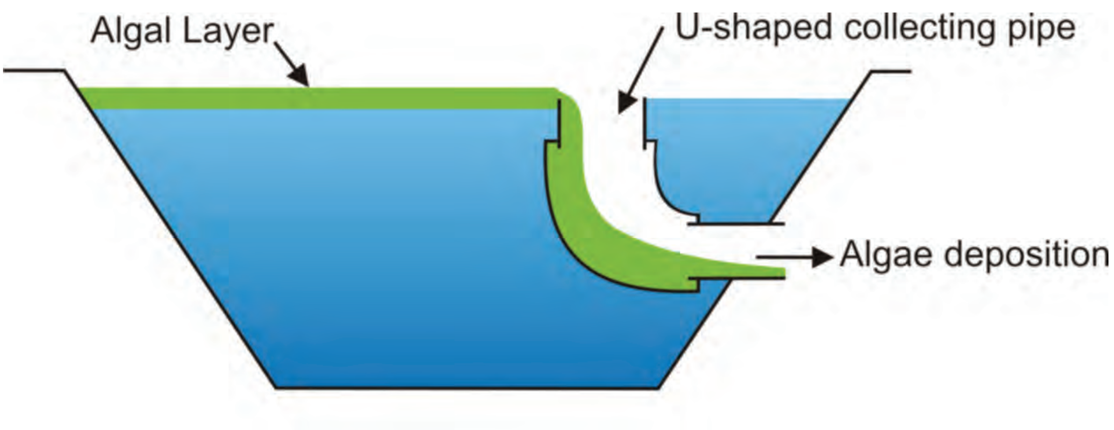



**Figure 21:** *U-shaped pipe for algae collection (Gaydon, 2008)*

Some pond systems were found to have significant algal accumulation as shown in the figure below.

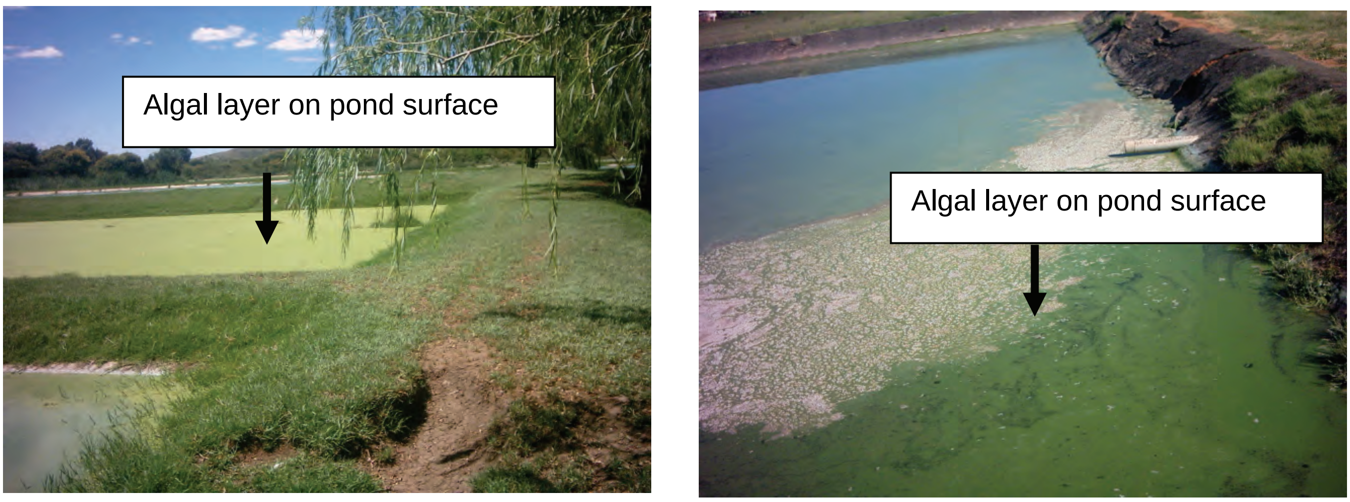



**Figure 22:** *Algal issues*

## 6.7 Odour control

The presence of industrial or agricultural wastes, particularly those with high concentrations of sulphate, may cause odour release. Odour control then becomes necessary. Odour control techniques should consider both prevention of generation and minimisation of release, and could include:

- If odours become a problem in seasons when mixing by wind is minimal, aeration or mixing should be introduced. Aerators, however, are not always effective in dealing with odour problems (Mara, 2005).
- Odours may be controlled by re-circulating the effluent from the facultative or maturation ponds to the anaerobic pond inlet in the ratio 1:6 (1 volume of effluent: 6 volumes of raw wastewater). E.g. if 6000 L/day is received within a pond as raw wastewater, 1000 L/day could be recycled from the facultative or maturation pond back to the anaerobic pond.

## 6.8 Handling excess flows

The following is suggested for handling excess flows within a pond system:

- If short circuiting is a problem, inlet and outlet configurations of the system must be re-evaluated. (See figure 17).
- Mixing (e.g. baffles, inlet and outlet location, aerators) must be able to be adjusted as it may have an impact on short-circuiting.
- Periodic measurement and removal of bottom sludge layer especially near inlet structures is important. If this is not done the inlet could be blocked and influent overflows onsite. More details on how this is practised is presented in the Guide for operations and maintenance of waste stabilisation ponds. Issues are shown in the following figure.
- More ponds must be put on line or split the flow into the ponds.
- If necessary, baffles can be installed or upgraded to improve hydraulic and treatment efficiency of the pond.
- A step feed (i.e. controlling the flow in each series of ponds) must be provided to adjust water level in each pond.


**Figure 23:** *Sludge removal issues*

## 6.9 Process controllers health

Health of the people onsite should be taken into consideration to prevent spreading of pathogenic organisms by direct contact with wastewater.

- Drinking water, shelter and sanitary facilities should be provided to process controllers.
- Process controllers must be provided with necessary equipment (e.g. rakes), washing facilities (e.g. soap, towel/tidy towel dispenser), protective clothing, and first aid kits. In systems where buckets have to be washed, waterproof clothing, gloves and masks should be provided. Protective clothing includes:
  - Gum boots
  - Long gloves
  - Masks

Personal protection equipment is shown in the following figure.


**Figure 24:** *Staff safety issues*

## 6.10 Environmental Safety: Monitoring and evaluation of pond system performance

Monitoring of the final effluent of a pond system is required to address the following needs:

- Regular assessment regarding whether or not the effluent complies with the local discharge or reuse standards, and
- Detection of any failure, or determining if the pond effluent has started to deteriorate, it also may help identify the cause of the problem and the remedial actions to be taken.

As per General Authorisation, 2004 wastewater monitoring in waste stabilisation ponds should be performed by grab sampling.
Grab sampling is when one sample (i.e. final effluent sample) is taken at a specific time. A grab sample reflects performance only at the point in time that the sample was collected, and then only if the sample was properly collected. In waste stabilisation pond systems this type of monitoring is most common. Details on how to conduct monitoring are provided in the Guide for operations and maintenance of waste stabilisation ponds.

The ponds functioning and effluent can be characterised by their colour, smell and look.

**Table 5:** Senses Characteristics in waste stabilisation ponds (Federation of Canadian Municipalities and National Research Council, 2004 and Gaydon presentation, 2008)

| **Colour** | **Characteristic** |
|---|---|
| Dark, sparkling green | Good conditions. Generally occurs with high pH and dissolved oxygen |
| Dull green to yellow | Not so good; pH and dissolved oxygen generally dropping. Blue-green algae beginning to predominate |
| Tan to brown | May relate to brown algae, which is OK. If related to silt or bank erosion can indicate physical problems in lagoon or collection system. |
| Gray to black | Very bad. Pond is septic, virtually zero dissolved oxygen |
| **Smell** | **Characteristic** |
| Rotten egg | Indicates hydrogen sulphide, bad |
| Urine or horse stable | Indicates high ammonia, bad |
| **Visual** | **Characteristic** |
| Solids | High COD (settling problems), bad |
| Cloudy | High ammonia and possibly low alkalinity, bad |

# 7. UPGRADING PONDS

A number of strategies can be used to upgrade and extend waste stabilisation ponds systems. Very simple and practical methods are provided below.

## 7.1 Additional technologies used to improve ponds

There is not much that could be done in changing the design of an existing ponds system. However ponds could be integrated into other systems (e.g. trickling filters could be introduced either before or after the ponds) to meet the required final effluent standards. If the theoretical pond capacity is found to be adequate for the new load, however the operation of the system is unsatisfactory, a review of the pond configuration should be made. Such options which could be considered are presented below.

### 7.1.1 Integrated facultative ponds (advanced facultative ponds) (Mara, 2005; Ramadan and Ponce, 2005)

Advanced facultative ponds have an advantage of integrating both anaerobic and aerobic ponds into a single pond to allow the symbiotic relationships related micro-organisms to proceed unrestrained. The advanced facultative pond is deep (i.e. exceeds its normal depth to a maximum of 4 m as an anaerobic pond) to promote sedimentation of wastewater solids and anaerobic decomposition of methane. Its most attractive feature is its high capability of wastewater total suspended solids removal, in addition to COD removal. The pond is designed so that its surface remains aerobic, thus reducing potential odour problem. This upgrading method is suitable for rural areas where land, electricity and staff skills are an issue.

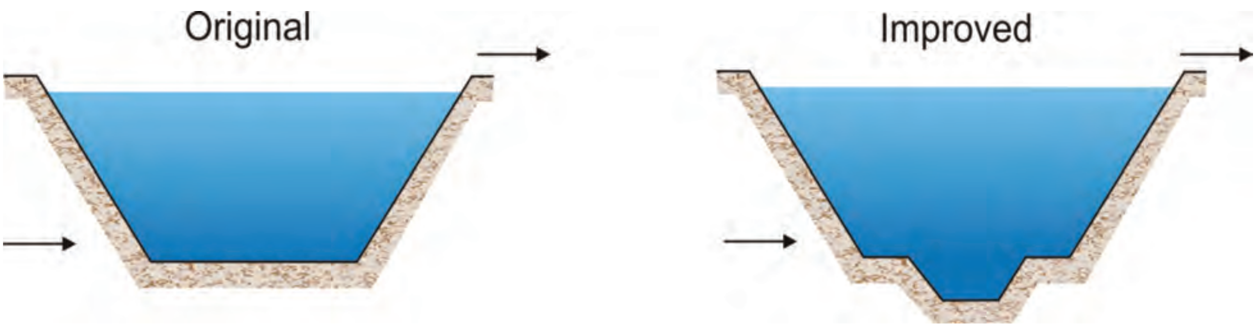



**Figure 25:** *Illustration of integrated facultative pond*

### 7.1.2 Baffle installation (Mara, 2005)

Baffles are commonly used as means of improving the hydraulic and treatment efficiency of ponds. In cases where there are numerous materials from which baffles can be built including metal, fibreglass, cement walls and plastic. Regardless of the material used, it is important to ensure that baffle is well sealed, especially at the base, and fully impermeable to avoid any leakage or short circuiting through the baffle. This upgrading method is suitable for rural areas where land, electricity and staff skills are an issue.

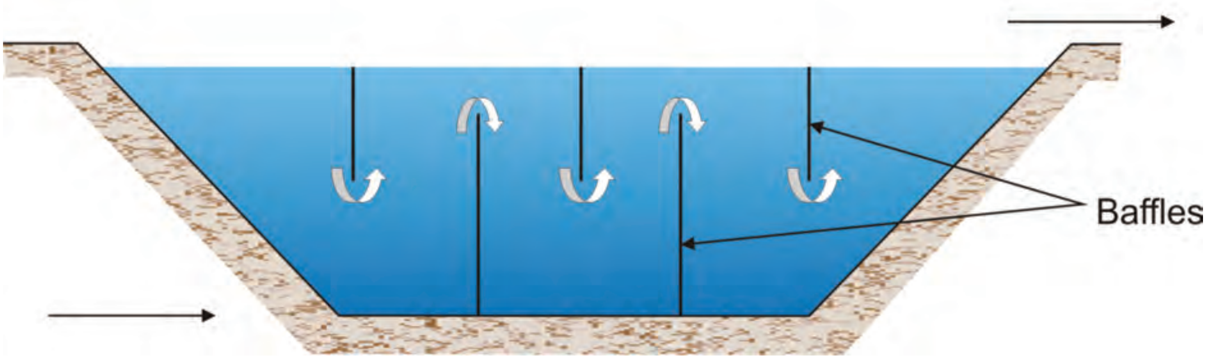



**Figure 26:** *Baffled pond*

### 7.1.3 High rate algal ponds (Mara, 2005; Ramadan and Ponce, 2005; Rose, 2006)

Depth is an important variable in the case of these ponds due to the fact that light and temperature are directly related to the depth and therefore the algal growth. The design of these systems depends on the region, that is, in regions where the water temperature is constant throughout the year. A paddlewheel normally is incorporated to provide efficient mixing within the pond. In areas where there is no electricity supply and algal harvesting (i.e. staff skills) would be a problem this should not be considered.

### 7.1.4 Advanced integrated wastewater pond system (Mara, 2005, Ramadan and Ponce, 2005)

Advanced integrated pond is a shallow (0.1 to 1m deep) continuously mixed meandering channel with a residence time between 2 to 8 days. The mean velocity (0,15 m/s) (Mara 2005) prevents thermal stratification and keeps algae uniformly suspended. The gentle mixing is most provided by a slow rotating paddle wheel which is used to separate the influent and effluent pipes of the pond to minimise short circuiting as shown in the following figure. These types of ponds are designed to minimize the accumulation of sludge and to maximise the production of oxygen through algal photosynthesis. Algal photosynthetic efficiency is improved by gentle mixing and by maintaining an optimum depth for light penetration to ensure that the algal cells receive maximum exposure to solar radiation.

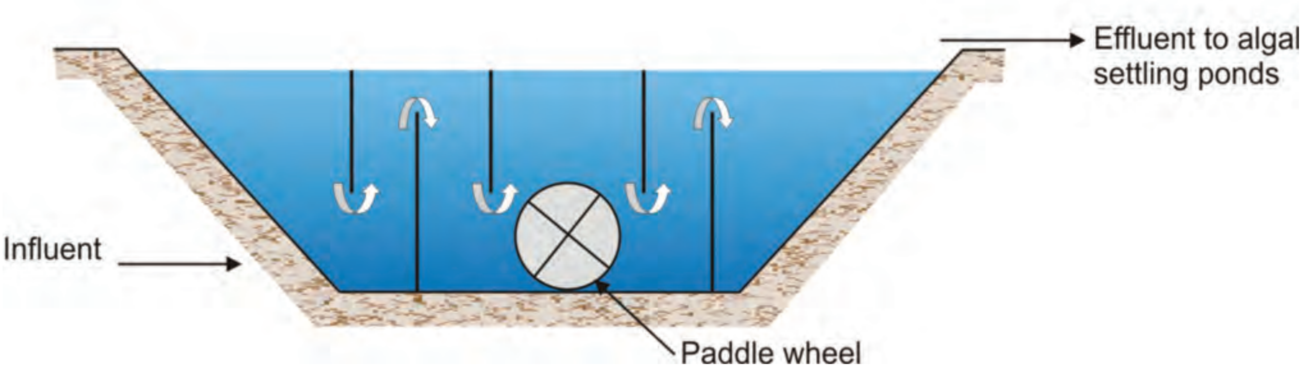



**Figure 27**: *Integrated waste stabilisation ponds system*

### 7.1.5 Active Filter (Shilton, 2006)

Active filter as means of phosphorus removal is a residual from steel making processes. Active filters are currently being researched. The advantages of using active filters over rock filters are that:

- They remove Phosphorus at the same time function as filters. That is they provide media for Phosphorus attachment.
- They do not require additional land
- Though they have limited life span, researches on regeneration and increasing the surface area by breaking up the media are being done.

**Summary**

The maintenance requirements of waste stabilisation pond systems is generally very simple, but they must be carried out regularly otherwise there will be serious nuisance issues. A further key observation is that little or no supervision and guidance is provided for the maintenance personnel on-site.

Management should be able to understand and provide guidance to process controllers in terms of the following:

- Understand when a waste stabilisation ponds system is appropriate.
- Understand what to expect from the contractors and/or consultants in designing a waste stabilisation ponds system.
- Understand when and how final effluent reuse could be practiced.
- Provide operational guidance to process controllers including:
  - Providing operations and maintenance record sheet.
  - Providing calculation examples that are expected from the process controllers.
  - Providing necessary equipment (e.g. rake, wheelbarrow, scooping net, etc)
  - Guiding process controllers on how and where to dispose sludge and screenings.
  - Provide monitoring equipment

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# APPENDIX A

## Waste Stabilisation Ponds Assessment Tool

The waste stabilisation ponds assessment tool is web enabled based and accessible through electronic water quality management system (eWQMS). Details on how to fill in the questionnaire on the eWQMS are presented in the guide on How to Use eWQMS Waste Stabilisation Ponds Tool. Questions entailed are presented in the following table.

| **Design** |
|---|
| Are the ponds lined/fully covered? |
| What kind of lining is used? |
| Is the anaerobic pond depth as per the recommended depth of 3m? |
| Is the oxidation pond/s depth as per the recommended depth of 1m-1.5m? |
| Do you know the size of the ponds (volume)? |
| What is the size/volume of the ponds (please specify units)? |
| What population size is served by the pond system? |
| Is the pond system appropriately sized for this population? |
| Is the population served lower, middle or upper class? |
| Is there a flow meter at the inlet? |
| Is the flow meter at the inlet functional? |
| Is there space available for future upgrades/expansion? |
| Are there any fluctuations in input load (e.g. seasonal variations)? |
| Are the fluctuations frequent? |
| Any further comments? |
| |
| **Maintenance** |
| Do the ponds appear to be well maintained (grass cut, screenings removed, ponds not blocked/overflowing)? |
| Is there a responsible person assigned to cut grass/weeds around the ponds? |
| Are screenings regularly removed? |
| Are the screenings discarded appropriately? |
| Are there prescribed maintenance procedures for process controllers? |
| Is there algal growth or slime layer removal from the ponds? |
| Have the ponds ever been desludged? |
| How frequently are ponds desludged |
| Is any mechanical equipment used for performance enhancement (e.g. aerators)? |
| Is the mechanical equipment in good working condition? |
| Any further comments? |
| |
| **Operation and Performance** |
| Do you measure the influent flow? |
| What is the effluent type treated by the ponds system? |
| Do the ponds receive water contaminated with farm chemicals (pesticides, herbicides, etc)? |
| Do the ponds receive abattoir waste? |
| Is there any odour release on-site (i.e. the site smells poor)? |
| Is dilution water available for nightsoil dumping? |
| Is the interconnection between the ponds clear (can see flow from one pond to the next)? |
| Is the sludge layer at the bottom of the ponds measured from time to time to determine if sufficient capacity is available? |
| Are the ponds overflowing? |
| Is there population growth in the area? |
| Any other comments? |

| |
|---|
| **Safety** |
| Is the site enclosed (fences, gates and locks)? |
| Are there "no trespassing" and health warning signs? |
| Are prescribed health and safety procedures adhered to? |
| Do staff have necessary safety clothing and equipment? |
| Do you feel that there is public awareness of safety aspects related to pond systems (i.e. do not enter site, don't swim, etc)? |
| How far are the ponds located from community dwellings? |
| Are there regularly animals on-site (e.g. cattle grazing)? |
| Are there sanitary facilities on-site (e.g. toilet, wash basin)? |
| Is there a room on-site (shelter, storage of equipment, eating)? |
| Is a drinking water tap available on-site? |
| Have there been any cases of vandalism (e.g. fence stealing) |
| Any other comments? |
| |
| **Supervision and Management** |
| Have responsibilities for the supervision of the site been assigned? |
| Is the responsible process controller appropriately trained? |
| Is a checklist/logbook regularly completed or updated? |
| Is a report highlighting issues of concern regularly produced? |
| Are the findings discussed at appropriate meetings? |
| Are required actions timeously implemented? |
| Any other comments? |
| |
| **Water Quality Monitoring** |
| Is the quality of the influent to the ponds monitored? |
| Is the quality of the final effluent leaving the ponds monitored? |
| What happens to the final effluent from the pond system? |
| Are there any boreholes in use near the ponds? |
| If there are boreholes near the pond systems, are the boreholes regularly monitored? |
| Any further comments? |
| |

# APPENDIX B

## PONDS OPERATION AND MAINTENANCE RECORD SHEET

Operation and maintenance record sheet is recommended to be used as a reporting and/or recording system. Some sections of the record sheet are expected to remain unchanged every time the record sheet is filled (e.g. name of the system, number of ponds and type, etc). These sections could be filled in by a supervisor in all record sheets prior the process controller.

| | |
|---|---|
| Ponds system name | |
| Date and time of inspection | |
| Influent flow (specify units): | |
| Population size served by ponds: | |
| Influent colour (green, brown, grey, red, milky) | |
| Influent nature (domestic, industrial, buckets, combination) | |
| Season (summer, winter, etc) | |
| Screenings removed at the inlet (yes, no) | |
| Screenings buried or burnt ((buried, burnt) | |
| Grit removal (yes, no) | |
| Total number of ponds and types | |
| Number of ponds with effluent | |
| Number of ponds discharging effluent or overflowing | |
| State of embankments in all ponds (erosion, vegetation etc) | |
| Water level within ponds (full, empty, etc) | |
| Odour onsite (state which pond) | |
| Scum/ foam on anaerobic ponds | |
| Final effluent flow (state units or none) | |
| Final effluent reuse (state or none) | |
| Sampling conducted (yes, no) | |
| Fence (security) available/no signs of vandalism | |
| GENERAL OBSERVATIONS | |
| Signature | |

**Ponds operation and maintenance record sheet**

# APPENDIX C

## CLASSIFICATION OF WASTEWATER TREATMENT WORKS AND STAFF QUALIFICATIONS

The regulations are presented in the Water Services Act of 1997. The document is in a process of review. To note is that there is not much difference in the classification system but rather the additions in the process controlling skills regulation side.

SCHEDULE II

## REGISTRATION OF A WATERWORK USED FOR THE TREATMENT OF WASTE AND THE DISPOSAL OR RE-USE OF THE TREATED WASTE

**Rating**

| **Class of works** | **E** | **D** | **C** | **B** | **A** |
|---|---|---|---|---|---|
| **Range of points** | **<30** | **30-39** | **40-59** | **60-70** | **>70** |

Points to be awarded at the discretion of the Director – General in accordance with the following criteria:

| | | | Maximum |
|---|---|---|---|
| **Infrastructure** | **Design Capacity in kilolitres per day (kℓ/d)** | 0 to 500……………………………………………………………… | 1 |
| | | 500 to 5 000………………………………………………………… | 2 |
| | | 5 001 to 20 000……..……………………………..………………….. | 4 |
| | | 20 001 to 50 000…………………………………………………… | 6 |
| | | 50 001 [Actual volume: __________Kℓ/d] ………………… | 8 |
| | | >250 001.…………..……………………………..…………………….. | 10 |
| | **Installed power (kilowatts of installed power to operate)** | 0- 5 kW……………………………………………….……………. | 1 |
| | | 5-100 kW……………………………………………………………. | 3 |
| | | 101-1000………………………………………….……………………. | 5 |
| | | >1000 kW……………………………..……….……………………. | 10 |
| **Quality of intake water** | | Domestic.………………………………………………………………. | 0 |
| | | Conservancy/Night soil……..……………………………………….. | 1-5** |
| | | Industrial effluent……………………………………….……………. | 1-5** |
| | | Internal recycle e.g. filtrate/centrate, supernatant , etc.………………………………………………………………………… | 2 |
| | | Leachate……………………………….…………………………….. | 1-3** |

| | | | |
|---|---|---|---|
| **Process parameters** | **Primary Treatment** | Handraked screens……………………………………………… | 1 |
| | | Automatic screens……………………………………………….. | 2 |
| | | Hand/mechanical grit removal………………………………….. | 1 |
| | | Automatic grit removal………………………………………… | 2 |
| | | Flow balancing…………………………………………………. | 2 |
| | | Primary sedimentation………………………………………… | 2 |
| | | Sludge fermentation…………………………………………… | 4 |
| | **Secondary Treatment** | Oxidation ponds ……………………………………………… | 2 |
| | | Biodiscs………………………………………………………... | 3 |
| | | Biofilters (Biof)……………………………………………… | 4 |
| | | Activated sludge: full nitrification……………………………….. | 6 |
| | | Activated sludge: partial denitrification………………………… | 8 |
| | | Activated sludge: Biological Excess phosphate removal……. | 10 |
| | | Chemical Addition……………………………………………... | 4 |
| | **Tertiary Treatment** | Maturation ponds ……………………………………………... | 1 |
| | | Reedbeds……………………………………………………… | 1 |
| | | Sand filters …………………………………………………….. | 2 |
| | | Disinfection (e.g.. Chlorination, ammonium bromide, ozone and UV 1-2)*..…………………………………………………… | 1-3* |
| | | Chemical De-chlorination……………………………………….. | 2 |
| | | Desalination/Membrane filters………………………………… | 4 |
| | | Treated water containing waste re-use for industrial purposes…………………………………………………………... | 2 |
| | | Treated water containing waste re-use for potable purposes (this section of the plant must then be registered in terms of Schedule I)……………………………………………………... | Nil |
| | **Sludge Treatment** | Anaerobic Digestion – <30 days retention……..…………… | 4 |
| | | – >30 days retention……..………… | 2 |
| | | Mechanical or physical/chemical sludge treatment including thickening, stabilisation and/or dewatering……………..……… | 7 |
| | | Aerobic digestion……………………………………………… | 2 |
| | | Sludge drying beds/lagoons…………………………………….. | 1 |
| | | Thermal sludge treatment……………………………………… | 6 |
| | | Sludge heating………………………………………………… | 3 |
| | **Additional Factors** | Gas engines, incineration, boilers…..…………………………. | 1-3* |
| | | On-site steam generation……………………………………….. | 3 |
| | | Partial to full plant automation………………………………….. | 1-5* |
| | | Odour control…………………………………………………... | 1-3* |
| | | Standby power………………………………………………… | 1-3* |
| | | 24 hour telemetry monitoring…………………………………… | 3 |

| | | | |
|---|---|---|---|
| **Control Processes** | **Maintenance** | None by process controllers……………………..……………….. | 0 |
| | | Basic maintenance by process controller…………………….. | 1 |
| | | Specialised maintenance by process controller……………… | 4 |
| | **Lab services** | Reading with instrumentation by process controller………... | 2 |
| | | Full lab service on site but not done by process controller, although still a management function………………………….. | 3 |
| | | Chemical analyses done by process controller……………..... | 4 |
| | **Administration** | Record Readings………………………………………………… | 1 |
| | | Calculate daily flows and stock taking…………………….…... | 2 |
| | | Calculate dosing and generate reports………………………… | 4 |
| | | Work on computer (not just check screen)…………………… | 5 |
| | **Trade Effluent by-laws** | Trade effluent by-laws exist and are implemented………….. | 0 |
| | | No trade effluent by-laws………………………………………... | 5 |
| **Sensitivity of water resource into which treated water containing waste is discharged** | | Low – e.g. oxidation pond with irrigation, evaporation pond, marine discharge………………………………………………… | 2 |
| | | Medium – e.g. all discharges to any river or stream except in specially identified areas……………………………………… | 4 |
| | | High – e.g. Special standard or where a receiving water quality standard is prescribed and estuaries…..……………….. | 6 |

*points scored according to complexity of process – needs to be motivated and 1 additional point is then added per motivation.

** Points scored according to % of night soil, industrial effluent or leachate being discharged to the waterwork making the process more complex. This motivation must include the Chemical Oxygen Demand concentrations.

## SCHEDULE III

### WATER WORK PROCESS CONTROLLER REGISTRATION

This Schedule must be read in conjunction with the Qualifications registered with the South African Qualifications Authority on the National Qualifications Framework. The qualifications include Water and Wastewater Process operations and control and industrial water treatment support and control operations.

| EDUCATIONAL REQUIREMENTS | Years appropriate experience per Class of Process Controller | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Grandparented** | **In Training** | **I** | **II** | **III** | **IV** | **V** | **VI** |
| ▪ None | **5** | | | | | | | |
| ▪ Std. 6 | | 0 | - | - | - | - | - | - |
| ▪ Std. 6 plus Maintenance Workers Certificate<br>▪ NQF 1 GETC: Water Services | | 0 | 4 | - | - | - | - | - |
| ▪ Std. 7 plus Maintenance Workers Certificate<br>▪ NQF 1 GETC: Water Services plus Core from Appropriate NQF 2 Qualification | | 0 | 3 | - | - | - | - | - |
| ▪ Std. 8 (or NTC I) plus Maintenance Workers Certificate<br>▪ Std. 8 (or NTC I) plus Water and Wastewater Treatment practice NI<br>▪ Std. 8 (or NTC I) plus Core from Appropriate NQF 2 Qualification<br>▪ Appropriate NQF 2 Qualification | | 0 | 2 | 5 | - | - | - | - |
| ▪ NTC I in Water and Wastewater Treatment practice | | 0 | 1.5 | 4 | - | - | - | - |
| ▪ Std. 8 (or NTC I) plus Operators certificate<br>▪ Std. 8 (or NTC I) plus core from Appropriate NQF 3 Qualification | | 0 | 1 | 3 | 9 | - | - | - |
| ▪ Std. 9 (or NTC II) plus Operators certificate<br>▪ Std. 9 (or NTC II) plus core from Appropriate NQF 3 Qualification<br>▪ NTC II in Water and Wastewater Treatment practice<br>▪ Appropriate NQF 3 Qualification | | 0 | 0.5 | 2 | 7 | 15 | - | - |

| EDUCATIONAL REQUIREMENTS | Years appropriate experience per Class of Process Controller | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Grandparented** | **In Training** | **I** | **II** | **III** | **IV** | **V** | **VI** |
| ▪ Matric (or NTC III) plus Operators certificate<br>▪ Matric (or NTC III) plus Water Treatment practice N3<br>▪ Matric (or NTC III) plus wastewater Treatment practice N3<br>▪ Matric (or NTC III) plus core from Appropriate NQF 4 Qualification<br>▪ NTC III in Water Treatment practice<br>▪ NTC III in wastewater Treatment practice<br>▪ Appropriate NQF 4 Qualification | | | 0 | 0.5 | 3 | 8 | 15 | - |
| ▪ National Diploma or National Technical Diploma or NTC VI or 3 year BSc (all in appropriate field)<br>▪ Appropriate NQF 5 Qualification | | | | | 0 | 2 | 6 | - |
| ▪ Higher National Diploma or 4 year BSc (both in appropriate field)<br>▪ Appropriate NQF 6 Qualification | | | | | | 0 | 4 | 15 |
| ▪ Professional Engineer (Act 81 of 1968) in appropriate field; Natural Scientist (Act 55 of 1982) in appropriate field; Corporate member of IWPC (now WISA) | | | | | | 0 | 3 | 12 |

**NOTES ON SCHEDULE III**

1. APPROPRIATE NQF QUALIFICATIONS

NQF qualifications are revised every three years and updated if necessary. Certificates issued for the following qualifications and any previous or updated versions thereof will be recognized, as indicated in Schedule III above.

1.1 NQF LEVEL 1

GETC: Water Services

1.2 NQF LEVEL 2

1.2.1. National Certificate: Water and Wastewater Process Operations

1.2.2. National Certificate: Industrial Water Treatment Support Operations

1.3 NQF LEVEL 3

1.3.1. National Certificate: Water and Waste Water Process Control

1.3.2. National Certificate: Industrial Water Treatment Plant Operation

1.4 NQF LEVEL 4

1.4.1 Further Education and Training Certificate: Water and Waste Wastewater Process Supervision

1.4.2. National Certificate in Industrial Water Treatment Control Operations

1.5 NQF LEVEL 5

1.5.1 A generic qualification in management that includes as electives a selection of registered water related unit standards at the NQF 5 level

1.6 NQF LEVEL 6

No unit standard based qualifications have yet been developed at this level for the water industry but are foreseen in the future. Equivalent whole qualifications are provided by tertiary education institutions.

Re-evaluation of present operator classification in terms of Government Notice No. R. 2834 of 27 December 1985 may be requested. Process Controller registration in terms of Schedule III is only an indication of the persons' level of competency and in no way obliges the employer to amend a salary or create a new position for such persons.

**SCHEDULE IV**

**MINIMUM CLASS OF PROCESS CONTROLLER REQUIRED PER SHIFT, AND SUPERVISION, OPERATION AND MAINTENANCE SUPPORT SERVICES REQUIREMENTS AT A WATERWORK**

| WORKS CLASS | CLASS OF OPERATOR PER SHIFT | SUPERVISION* | OPERATIONS AND MAINTENANCE SUPPORT SERVICES REQUIREMENTS* |
|---|---|---|---|
| E | Class I | Class V* | THESE PERSONNEL MUST BE AVAILABLE AT ALL TIMES BUT MAY BE IN-HOUSE OR OUTSOURCED<br>- electrician<br>- fitter<br>- instrumentation technician |
| D | Class II | Class V* | |
| C | Class III | Class V* | |
| B | Class IV | Class V | |
| A | Class IV | Class V | |

NB. Fluoridation – for any class works, minimum operator classification should be class III

**NOTES FOR SCHEDULES IV**

*does not have to be at the works at all times but must be available at all times. If the owner of a waterworks has no person of this class employed on that work, a contractor/consultant with the required qualifications as prescribed in Schedule III in respect of that particular class of persons, shall be appointed to visit the work weekly.

# APPENDIX D

## GUIDE FOR RE-USE AND DISCHARGE OF TREATED WASTEWATER FROM A POND SYSTEM

**GUIDE: PERMISSIBLE UTILISATION AND DISPOSAL OF TREATED SEWAGE EFFLUENT, 30 MAY 1978**

*REFERENCE: 11/2/5/3*

This guide sets out the present policy of the Department and replaces all previous relevant guides. Any person intending to use treated effluent must obtain prior permission to do so from the Regional Director concerned.

This guide is applicable only to treated sewage effluent which is mainly of domestic origin and contains little or no industrial effluent.

The Regional Directors have been empowered to relax the requirements specified in this guide or to impose additional or more stringent requirements in the light of special circumstances in specific cases.

This guide defines the following:

A. Classification of treated effluents

B. Directives for the use of treated effluent for irrigation purposes.

C. Directives for other uses of treated effluents.

D. Methods of disposal and discharge of treated effluents.

E. General directives and precautionary measures.

<table>
<tr><th>CLASSIFICATION OF TREATED EFFLUENTS<br>(SEWAGE PURIFICATION WORKS)</th><th></th></tr>
<tr><td>

**PS – PRIMARY AND SECONDARY TREATMENT – HUMUS TANK EFFLUENT**

Conventional sewage purification according to accepted design criteria#. This includes screening and primary settling followed by biological purification such as the biological filterbed process or activated sludge process. Secondary treatment also includes the settling or clarification after biological or alternative purification methods.

PST – PRIMARY, SECONDARY AND TERTIARY TREATMENT

Final effluent complies with the GENERAL STANDARD*, with the *E. coli* count relaxed to a maximum of 1000 *E. coli* /100 ml

In addition to the above-mentioned primary and secondary or equivalent treatment one or more tertiary treatments, viz. land treatment, maturation pond, filtration, chlorination or other types of disinfection, etc., should be applied.

**STD – PRIMARY, SECONDARY AND TERTIARY TREATMENT**

(Compare with PST)

Final effluent complies with the GENERAL STANDARD* viz. inter alia NIL *E. coli*/100 ml

**SP-STD – ADVANCED PURIFICATION**

Final effluent complies with at least the SPECIAL STANDARD* and the quality compares favourably with that recommended for drinking water

In addition to the above-mentioned primary, secondary and tertiary treatment, advanced purification also includes special physico-chemical purification or other advanced techniques.

</td><td>

**OD – OXIDATION POND SYSTEM**

Final effluent contains a maximum of 1 000 *E. coli*/100ml

The pond system should be designed according to a recognised standard# and operated in a nuisance-free manner. The combined retention time of the primary pond and approximately 4 secondary ponds should usually be at least 45 days. This system should drain into an irrigation dam of which the reserve storage capacity during dry weather conditions is at least 12 days. Unless sufficient space is available and the ponds are sufficiently remote from built-up areas, this system is not recommended for communities with a population exceeding 5 000.

Every oxidation pond system which is not able to deliver effluent of the above-mentioned quality should, for the purpose of this guide, be regarded on its merits as no more than equivalent to PS.

**SEPTIC TANK EFFLUENT**

(Primary settling and limited biological purification)

This effluent must undergo further secondary and tertiary or equivalent treatment before it may be utilised for the purposes indicated in this guide.

For the direct use or disposal, only nuisance-free land treatment or irrigation of fenced-in plantations will be permitted on its merits.

</td></tr>
</table>

* GENERAL AND SPECIAL STANDARD # DESIGN CRITERIA

| DIRECTIONS FOR THE UTILISATION OF TREATED EFFLUENTS FOR IRRIGATION | |
|---|---|
| **IRRIGATION OF** | **OD – OXIDATION POND SYSTEM** |
| VEGETABLES AND CROPS CONSUMED RAW BY MAN (3 EXCLUDED)<br><br>LAWNS AT SWIMMING POOLS, NURSERY SCHOOLS, CHILDREN'S PLAYGROUNDS | NOT PERMISSIBLE |
| CROPS FOR HUMAN CONSUMPTION WHICH ARE NOT EATEN RAW (VEGETABLES, FRUIT, SUGAR-CANE)<br><br>CULTIVATION OF CUT FLOWERS (SEE ALSO 6) | ANY TYPE OF IRRIGATION PERMISSIBLE ON ITS MERITS<br><br>EFFECTIVE DRAINING AND DRYING BEFORE HARVESTING IS ESSENTIAL |
| FRUIT TREES AND VINEYARDS: FOR THE CULTIVATION OF FRUIT WHICH IS EATEN RAW BY MAN (SEE 2 – FRUIT WHICH IS NOT EATEN RAW) | FLOOD, DRIP AND MICRO-IRRIGATION PERMISSIBLE ON THEIR MERITS PROVIDED FRUITS ARE NOT DIRECTLY EXPOSED TO SPRAY<br><br>EFFECTIVE DRAINING AND DRYING BEFORE FRUITS ARE HARVESTED<br><br>FALLEN FRUIT IS UNSUITABLE FOR HUMAN CONSUMPTION |
| **IRRIGATION OF** | **OD – OXIDATION POND SYSTEM** |
| GRAZING FOR CATTLE EXCLUDING MILK PRODUCING ANIMALS (SEE 5) | ANY TYPE OF IRRIGATION PERMISSIBLE BUT NOT DURING GRAZING<br><br>GRAZING ONLY PERMISSIBLE AFTER EFFECTIVE DRAINING AND DRYING – NO POOLS<br><br>NOT PERMISSIBLE AS DRINKING WATER FOR ANIMALS |
| GRAZING FOR MILK PRODUCING ANIMALS (DEFINITION OF MILK – SECTION I(XV) OF THE HEALTH ACT 1977 (ACT 63 OF 1977) | NOT PERMISSIBLE |
| CROPS NOT FOR GRAZING, BUT UTILISED AS DRY FODDER<br><br>CROP CULTIVATED FOR SEED PURPOSES ONLY<br><br>TREE PLANTATIONS<br><br>NURSERIES – CUT FLOWERS EXCLUDED (SEE 2)<br><br>ANY PARK OR SPORTSFIELD ONLY DURING DEVELOPMENT AND BEFORE OPENING THEREFOF | ANY TYPE OF IRRIGATION PERMISSIBLE (SEE ALSO 4 AND 5) |
| **IRRIGATION OF** | **OD – OXIDATION POND SYSTEM** |
| (iii) SPORTSFIELDS WHERE CONTACT IS OFTEN MADE WITH THE SURFACE, E.G. RUGBY FIELDS, ATHLETICS TRACKS, ETC.<br><br>SCHOOL GROUNDS<br><br>PUBLIC PARKS – SPECIAL CHILDREN'S PLAYGROUNDS EXCLUDED (SEE 1 | ONLY FLOOD IRRIGATION PERMISSIBLE<br><br>SPRINKLER IRRIGATION NOT PERMISSIBLE<br>NO OVER-IRRIGATION AND NO POOL FORMING |

| IRRIGATION – GENERAL REMARKS AND PRECAUTIONS |
| --- |
| a) In order to obviate the irrigation system causing a nuisance in time, evidence must be produced that the type of soil and the size of the surface as well as the type of crop concerned are suitable for irrigation with the proposed quantity and quality of effluent.<br><br>b) The piping used for effluent be markedly different from the piping used for drinking water in respect of colour, type of material and construction. This precaution is necessary in order to obviate accidental cross-coupling of piping.<br><br>c) In order to prevent persons from unwittingly drinking effluent water or washing with it, the taps, valves and sprayers of the irrigation system must be so designed that only authorised persons can open them or bring them into operation.<br><br>d) Every water point where uninformed persons could possibly drink effluent water must be provided with a notice in clearly legible English, Afrikaans and any other appropriate official languages, indicating that it is potentially dangerous to drink the water.<br><br>e) The expression 'after effective draining and drying" in the above-mentioned table means that the particular act may take place only when no pools or drops of effluent are evident in the irrigation area concerned.<br><br>f) All possible precautions should be taken to ensure that no surface or underground water is contaminated by the irrigation water, especially where the latter does not comply with the General Standard. Excessive irrigation must therefore be avoided and the irrigation area protected against stormwater by means of suitable contours and screening walls<br><br>g) Sprinkler irrigation shall be permitted only if no spray is blown over to areas where, such irrigation is forbidden. In this connection the quality of the effluent, the use of such adjoining area and its distance from the irrigation area must be taken into consideration before sprinkler irrigation is permitted. |

| METHODS OF DISPOSAL AND DISCHARGE OF TREATED EFFLUENTS | |
| --- | --- |
| **METHODS OF DISPOSAL AND DISCHARGE OF EFFLUENTS** | **OD – OXIDATION POND SYSTEM** |
| DISCHARGE INTO RIVERS AND WATER COURSES, EXCLUDING ESTUARIES, DAMS AND LAGOONS | NOT PERMISSIBLE |
| DISCHARGE INTO ESTUARIES, DAMS, LAKES, LAGOONS OR OTHER MASSES OF WATER | NOT PERMISSIBLE |
| DISCHARGE INTO THE SEA | PERMISSIBLE ON MERITS AS FOR PS AND PST |

GENERAL DIRECTIONS AND PRECAUTIONARY MEASURES

a) The sewage purification works must be efficiently operated by adequately trained personnel at all times and must, as far as is reasonably practicable, not be overloaded.

b) The person or authority in charge of the purification works must satisfy himself that the quality of the final effluent will at all times be in accordance with the directives as set out in this guide.

c) Regular control tests of representative final effluent samples must be made at least quarterly and records must be kept of such tests.

d) The person or authority in charge of the works must ensure that the quality of the final effluent and the use thereof comply with the directives set out in this guide – also when such effluent is utilised by another person or body. The supply and utilisation of effluent must be terminated if the directives set out in this guide are not complied with.

e) A person or body using the final sewage effluent for a purpose set out in this guide, but not undertaking the purification himself, must satisfy himself that only permissible utilisation practices are maintained and must forthwith discontinue the use thereof should he become aware of any deviation from the directive contained in this guide.

f) Compliance with the requirements for the utilisation of purified sewage effluent as set out in this guide is the individual and joint responsibility of both the supplier and the user of the final effluent.

g) In the case of a use qualified in this guide as permissible on merit, it will be necessary for the relevant uses and methods of use to be thoroughly motivated and investigated. The majority of such cases, stricter supervision and control of the system as well as the quality of the effluent will be required in order to prevent the development of any nuisance or conditions dangerous to health.