

APPENDIX 1: PARAMETERS AND ANALYTICAL METHODS REQUIRED FOR CLASSIFICATION OF SLUDGE AND MONITORING OF SLUDGE, WATER AND SOIL SAMPLES

Appendix 1.1: Analyses required for classification and characterization of sludge

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Physical characteristics	pH	Direct measurement pH on saturated paste or solution
	Total solids (TS)	Standard method 2540B ¹
	Volatile suspended solids (VSS)	Standard method 2540E ²
	Volatile Fatty Acids (VFA)	Adapted from Standard methods. The full method is detailed in Volume 1, Appendix 2.
Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
	Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
	Potassium (K)	The suggested method description has been attached in Volume 1, Appendix 2.
Metals and micro-elements	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	For land disposal the TCLP test is recommended US EPA Method 1311, 1992 Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately, especially for compounds such as Arsenic.
Microbiological quality	Faecal coliforms	Membrane filter/ m-FC medium
	Total viable Helminth ova	See recommended new method further on in this Appendix
^{1,2} Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell.		

Appendix 1.2: Sludge analyses required for monitoring purposes

Characteristic		Parameter	Guidance on methodology and/or recommended extraction method
Physical characteristics		pH	Direct measurement pH on saturated paste or solution
		Total solids (TS)	Standard method 2540B ¹
		Volatile suspended solids (VSS)	Standard method 2540E ²
		Volatile Fatty Acids (VFA)	Adapted from Standard methods. The full method is detailed in Volume 1, Appendix 2.
Chemical characteristics	Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
		Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
		Potassium (K)	The suggested method description has been attached in Volume 1, Appendix 2.
	Metals and micro-elements	Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc (Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)	For land disposal the TCLP test is recommended US EPA Method 1311, 1992 Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately.
Microbiological quality	Faecal coliforms	Membrane filter/ m-FC medium	
	Total viable Helminth ova	See recommended new method further on in this Appendix	
<p>^{1,2} Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell.</p>			

Appendix 1.3: Surface and groundwater analyses required for monitoring purposes

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Water chemistry	pH	Direct measurement
	EC	Direct measurement
	PO ₄	Standard method 4500-P ¹
	NH ₄	Standard method 4500-NH ₄ ¹
	NO ₃	Standard method 4500-NO ₃ ¹
	COD	Standard method 5220D ¹
Water microbiology	Faecal coliforms	Membrane filter/ m-FC medium ¹
	<i>E Coli</i>	Standard method 9221B ¹

¹ Standard Methods for the Examination of Water and Wastewater, 20th edition (1998) or latest, by Leonore S. Clesceri, Arnold E. Greenbert and R. Rhodes Trussell

Appendix 1.4: Soil analyses required for monitoring purposes

Characteristic	Parameter	Guidance on methodology and/or recommended extraction method
Nutrients	Total Kjeldahl Nitrogen (TKN)	The suggested method description has been attached in Volume 1, Appendix 2.
	Total Phosphorus (TP)	The suggested method description has been attached in Volume 1, Appendix 2.
Metals to assess compliance in terms of the TTV and MPL	<p>Arsenic Cadmium Chromium Copper Lead Mercury Nickel Zinc</p> <p>(Any other metal or element identified during the comprehensive characterisation detailed in Volume 1)</p>	<p>Extraction of trace elements soluble in <i>aqua regia</i> solution (see Volume 1, Appendix 2).</p> <p>International Standard ISO 11466 Method Reference number: ISO11466:1995 (E)</p> <p>Note: A semi-quantitative ICP scan would give concentrations for all mentioned metals. Remind the laboratory to manage the interferences on the ICP appropriately.</p>

Appendix 1.5: Recommended new procedure to determine Helminth ova in wastewater sludge

Note: This is a new method which was developed after Volume 1 of the New Sludge Guidelines have been published and differs from the method published in Volume 1.

Method for analyses of sludge

Note: It is always preferable to work with small sub-samples as eggs may not be as easily released from a large sample to float out of the sludge when doing the ZnSO₄ flotation technique. Rather increase the number of sub-samples than overload each test-tube in order to keep the number of tubes down.

The number of sub-samples will also be dependent on the helminth ova load expected. This will require knowledge of the epidemiology of helminths in the particular area in South Africa. Consequently, more sub-samples must be done in an area of low endemicity and less in a highly endemic area.

1. Mix the sludge sample well by swirling and stirring with a plastic rod. From the total sample take 4 x 15ml sub-samples and place them into 4 x 50ml test tubes. (If the solid content is high this should be sufficient sample. If it is low, take more 15ml sub-samples).
2. Add either a few millilitres of 0.1% Tween80 or AmBic solution to the samples, vortex and add more wash solution. Repeat this procedure until the tubes are filled to approximately a centimetre from the top.
3. Place the 150µm sieve in a funnel in a retort stand with a plastic beaker underneath to catch the filtrate. Filter the well-mixed contents of the tubes one at a time, rinsing out each tube and washing this water through the sieve as well.
4. Pour the filtrate into test tubes and centrifuge at 1389g (±3000rpm) for 3 minutes. Suction off the supernatant fluids and discard. Combine the deposits into a suitable number of tubes so that there is not more than 1ml in a 15ml tube or 5ml in a 50ml tube
5. Re-suspend each of these deposits in a few millilitres of ZnSO₄ and vortex well to mix. Keep adding more ZnSO₄ and mixing until the tube is almost full.
6. Centrifuge the tubes at 617g (±2000rpm) for 3 minutes. Remove from the centrifuge and pour the supernatant fluids through the 20µm filter, washing well with water.
7. Collect the matter retained on the sieve and wash it into test tubes.
8. Centrifuge the tubes at 964g (±2500rpm) for 3 minutes; remove & discard the supernatant fluid. Combine the deposits into one test tube, using water to recover all the eggs from the other tubes. Then centrifuge again at 964g for 3 minutes to get one deposit.
9. Once there is one final deposit, remove all of it using a plastic Pasteur pipette and place it onto one or more microscope slides. Place a coverslip over each deposit and examine microscopically using the 10x objective and the 40x objective to confirm any unsure diagnoses.

10. Each species of helminth ova is enumerated separately and reported as eggs per gram of sludge.

Note: Samples may be examined slightly differently from that described in step No. 10 above by doing the following:

The deposits are filtered through a 12µm ISOPORE membrane, which is then rinsed with distilled water. The membrane is air-dried, cut in half and placed on a microscope slide. Immersion oil is used to clear the membrane before examining under the microscope.

To test for viability:

Perform steps 1 to 8 of the procedure above and continue as follows:

9. Once there is a final deposit in the test tube, re-suspend it in 4ml of 0.1 H₂SO₄. Before incubating mark the test tube with the level of liquid and incubate at a temperature of 26°C for three to four weeks. Check the level of liquid in each one of the test tubes and add the reagent every time that is necessary, compensating for any evaporation that may occur.
10. Once the incubation time is over, homogenize the deposit and proceed to quantify the eggs. Remove all of the deposit using a plastic Pasteur pipette and place it onto one or more microscope slides. Place a coverslip over each deposit and examine microscopically using the 10x objective and the 40x objective to confirm any unsure diagnoses. Only those ova where the larva is observed are considered viable.

Equipment required and related information

1. A centrifuge with a swing-out rotor and buckets that can take 15ml and/or 50ml plastic conical test tubes.
2. Vortex mixer.
3. Retort Stand with at least 2 clamps on it.
4. Large plastic funnels to support the filters (±220mm diameter).
5. Filters / Sieves : 1x 150µm; 1x 100µm; 1x 20µm.
6. Approx. 6 Plastic beakers (500ml) & 3 Plastic wash bottles.
7. At least 4 glass "Schott" bottles (1lt, 2lt & 5lt sizes) for make-up and storage of the chemical solutions and de-ionized water.
8. Magnetic stirrer and stirring magnets.
9. 15ml and 50ml plastic conical test tubes.
10. 3 x Small glass beakers (100ml).
11. Plastic Pasteur Pipettes & Plastic Stirring Rods.
12. Glass microscope slides (76 x 26 x 1,2 mm).
13. Square & Rectangular Cover-slips (22 x 22mm & 22 x 40mm).

14. A binocular compound microscope with 10x eyepieces, a 10x objective and a 40x objective.

Working out the g-force of your centrifuge

$$\text{G-force (or g)} = (1,118 \times 10^{-5}) r s^2 = 0,00001118 \times r \times s^2$$

where : s = revolutions per minute (i.e. the speed you spin at)

 r = the radius (the distance in centimetres from the centre of the rotor to the bottom of the bucket holding the tubes, when the bucket is in the swing-out position)

Reagents

Zinc Sulphate

1. ZnSO_4 (heptahydrate) is made up by dissolving 500g of the chemical in 880ml de-ionised or distilled water.
2. A hydrometer must be used to adjust the specific gravity (SG) to 1.3, using more chemical if the SG is too low or more water if it is >1,3.

This high specific gravity facilitates the floating of heavier ova such as *Taenia* sp. (SG = 1.27). It is not critical if the SG of the ZnSO_4 solution is just over 1.3 but it should never be below this value!

Ammonium Bicarbonate

The AMBIC solution is essentially a saturated ammonium bicarbonate solution. Ammonium bicarbonate can be obtained from Merck Chemicals and is made up by dissolving 119g of the chemical in 1000ml of de-ionised water.

0,1% Tween80

1ml of Tween80 is measured out using a pipette and placed in 1000ml of de-ionized or distilled water to give a 0,1% wash solution.

Note: Tween80 is extremely viscous and it is necessary to wash **all** of it out into the water in which it is made up, by alternately sucking up water and blowing it out using the same pipette.

Appendix 1.6: Toxicity Characteristic Leaching Procedure (TCLP) extraction for sludge destined for co-disposal (USEPA Method 1311)

Summary of method

- For liquid wastes (containing <0.5% dry solid material), the waste, after filtration through a 0.6 to 0.8 μm glass fiber filter, is defined as the TCLP extract
- For wastes containing $\geq 0.5\%$ solids, the liquid, if any, is separated from the solid phase and stored for later analyses.

Apparatus

- Agitation apparatus capable of rotating the extraction vessel in an end-over-end fashion at 30 ± 2 r.p.m.
- Extraction bottles for inorganics. These may be constructed from various materials. Borosilicate glass bottles are highly recommended. Polytetrafluoroethylene (PTFE), high density polyethylene (HDPE), polypropylene (PP), Polyvinyl chloride (PVC) and stainless steel bottles may also be used

TCLP solution 1

- Add 5.7 ml glacial Acetic Acid to 500 ml of reagent quality water (double distilled water).
- Add 64.3 ml of 1N NaOH.
- Dilute to a volume of 1 litre.
- When correctly prepared, the pH of this solution will be 4.93 ± 0.05 .

TCLP solution 2

- Dilute 5.7 ml glacial acetic acid with double distilled water to a volume of 1 litre
- When correctly prepared, the pH of this solution will be 2.88 ± 0.05

Samples

- The sample must be a minimum of 100 grams.
- The sample must be able to pass through a 9.5 mm sieve, i.e. particle size of the solid must be smaller than 10 mm

TCLP extractions

Note that the TCLP test requires that a waste be pre-tested for its acid neutralization capacity. Those with low acid neutralization capacity are extracted with TCLP solution 1 (0.1M Sodium Acetate Buffer, pH 4.93 ± 0.05) and those with high acid neutralization capacity are extracted with TCLP solution 2 (0.1M Acetic Acid, pH 2.88 ± 0.05). Most sludges have a low acid neutralization capacity and will, therefore, be extracted with TCLP solution 1. After addition of lime, the acid neutralization capacity of the sludge is increased, but note that the treated sludge should be leached using the TCLP solution used for original sludge,

i.e. in most cases TCLP solution 1, so that the results are directly comparable and one can evaluate the effect of the lime treatment. This is correct even though the pre-test used in the TCLP on the lime treated sludge may indicate that TCLP solution number 2 should be used.

A. Preliminary evaluation:

This part of the extraction procedure must be performed to determine which TCLP (No . 1 or 2) solution should be used (see extraction solutions).

1. Weigh out 5.0 grams of the dry waste into a 500 ml beaker or Erlenmeyer flask.(In this exercise the particle size of the 5 grams should be 1 mm or less).
2. Add 96.5 ml of double distilled water, cover with a watch glass and stir vigorously for 5 minutes with a magnetic stirrer.
3. Measure the pH.
4. If the pH is less than 5.0, then use TCLP solution - No 1.
5. If the pH is greater than 5.0, then proceed as follows:
 - 5.1 Add 3.5 ml 1N HCL and stir briefly.
 - 5.2 Cover with a watch glass, heat to 50°C and hold at 50°C for ten minutes.
 - 5.3 Let cool to room temperature and record the pH.
9. If the pH is less than 5.0, then use TCLP solution - No 1.
10. If the pH is less than 5.0, then use TCLP solution - No 2.

B. Extraction for analysis of contaminants:

1. Weigh out 100 gram of the dry waste, which passes through a 9.5 mm sieve, and quantitatively transfer it to the extraction bottle.
2. Add two litres (2l) of the appropriate TCLP solution (No. 1 or 2 as determined by preliminary evaluation) and close bottle tightly.
3. Rotate in agitation apparatus at 30 r.p.m. for 20 hours. Temperature of room in which extraction takes place should be maintained at $23 \pm 2^{\circ}\text{C}$.
4. Filter through a glass fibre filter and collect filtrate. Record pH of filtrate.
5. Take aliquot samples from the filtrate for determination of metal concentrations.
6. Immediately acidify each aliquot sample with nitric acid to a pH just less than 2.
7. Analyse by AA or other sensitive and appropriate techniques for different metals.
8. If analysis cannot be performed immediately after extraction, then store the acidified aliquots at 4°C, until analysis (as soon as possible).

Reference: USEPA Test Methods SW-846 On-line
<http://www.epa.gov/epaoswer/hazwaste/test/pdfs/1311.pdf>

APPENDIX 2: VECTOR ATTRACTION REDUCTION OPTIONS

The following options are available to reduce the vector attraction potential. These options have been adopted from the USEPA Part 503 Rule.

Option 1: Reduction in Volatile Solids Content

Vector attraction is reduced if the fraction of volatile solids in the primary sludge is reduced by at least 38 percent during the treatment of the sludge. This percentage is the amount of volatile solids reduction that is attained by anaerobic or aerobic digestion plus any additional volatile solids reduction that occurs before the sludge leaves the treatment works, such as through processing in drying beds or lagoons, or by composting.

Digestion process efficiency can be measured by the reduction in the volatile solids content of the feed sludge to the digester and the sludge withdrawn from the digester. Anaerobic digestion of primary sludge generally results in a reduction of between 40 and 60% of the volatile solids.

O'Shaunessy's formula can be used to calculate the volatile solids (VS) reduction in a digester:

$$\text{VS reduction (\%)} = \{(V_i - V_o) / V_i - (V_i \times V_o)\} \times 100$$

Where V_i = volatile fraction in feed sludge

V_o = volatile fraction in digested sludge

Example of calculation of VS reduction

Assume volatile solids in feed sludge = 84%

Therefore volatile fraction of feed sludge = 0.84 = V_i

Assume volatile solids of digested sludge = 68%

Therefore volatile fraction of digested sludge = 0.68 = V_o

$$\begin{aligned} \text{VS reduction (\%)} &= \{(0.84 - 0.68) / 0.84 - (0.84 \times 0.68)\} \times 100 \\ &= 59\% \end{aligned}$$

Option 2: Additional Digestion of Anaerobically Digested Sludge

Frequently, primary sludge is recycled to generate fatty acids or the sludge is recycled through the biological wastewater treatment section of a treatment works or has resided for long periods of time in the wastewater collection system. During this time, the sludge undergoes substantial biological degradation. If the sludge is subsequently treated by anaerobic digestion for a period of time, it adequately reduces vector attraction. Because the sludge will have entered the digester already partially stabilized, the volatile solids reduction after treatment is frequently less than 38 percent.

Under these circumstances, the 38 percent reduction required by Option 1 may not be achievable. Option 2 allows the operator to demonstrate vector attraction reduction by testing a portion of the previously digested sludge in a **bench-scale unit** in the laboratory. Vector attraction reduction is demonstrated if, after anaerobic digestion of the sludge for an additional 40 days at a temperature between 30° and 37°C, the volatile solids in the sludge are reduced by less than 17 percent from the beginning to the end of the bench test.

Option 3: Additional Digestion of Aerobically Digested Sludge

This option is appropriate for aerobically digested sludge that cannot meet the 38 percent volatile solids reduction required by Option 1. This includes activated sludge from extended aeration plants, where the minimum residence time of sludge leaving the wastewater treatment processes section generally exceeds 20 days. In these cases, the sludge will already have been substantially degraded biologically prior to aerobic digestion.

Under this option, aerobically digested sludge with 2 percent or less solids is considered to have achieved vector attraction reduction, if in the laboratory after 30 days of aerobic digestion in a batch test at 20°C, volatile solids are reduced by less than 15 percent. This test is only applicable to liquid aerobically digested sludge.

Option 4: Specific Oxygen Uptake Rate (SOUR) for Aerobically Digested Sludge

Frequently, aerobically digested sludge is circulated through the aerobic biological wastewater treatment process for as long as 30 days. In these cases, the sludge entering the aerobic digester is already partially digested, which makes it difficult to demonstrate the 38 percent reduction required by Option 1.

The specific oxygen uptake rate (SOUR) is the mass of oxygen consumed per unit time per unit mass of total solids (dry-weight basis) in the sludge. Reduction in vector attraction can be demonstrated if the SOUR of the sludge that is used or disposed, determined at 20°C, is equal to or less than 2 milligrams of oxygen per hour per gram of total sludge (dry-weight basis). This test is based on the fact that if the sludge consumes very little oxygen, its value as a food source for micro organisms is very low and therefore micro-organisms are unlikely to be attracted to it. Other temperatures can be used for this test, provided the results are corrected to a 20 °C basis. This test is only applicable to liquid aerobic sludge withdrawn from an aerobic treatment process.

Option 5: Aerobic Processes at Greater than 40 °C

This option applies primarily to composted sludge that also contains partially decomposed organic bulking agents. The sludge must be aerobically treated for 14 days or longer, during which time the temperature must always be over 40°C and the average temperature must be higher than 45°C.

This option can be applied to other aerobic processes, such as aerobic digestion, but Options 3 and 4 are likely to be easier to meet than the other aerobic processes.

Option 6: Addition of Alkaline Material

Sludge is considered to be adequately reduced in vector attraction if sufficient alkaline material is added to achieve the following:

- Raise the pH to at least 12, measured at 25 °C, and without the addition of more alkaline material, maintain a pH of 12 for at least 2 hours.
- Maintain a pH of at least 11,5 without addition of more alkaline material for an additional 22 hours.

The conditions required under this option are designed to ensure that the sludge can be stored for at least several days at the treatment works, transported, and then used or disposed without the pH falling to the point where putrefaction occurs and vectors are attracted.

Option 7: Moisture Reduction of Sludge Containing no Un-stabilised Solids

Under this option, vector attraction is considered to be reduced if the sludge does not contain unstabilised solids generated during primary treatment and if the solids content of the sludge is at least 75% before the sludge is mixed with other materials. Thus, the reduction must be achieved by removing water, not by adding inert materials.

It is important that the sludge does not contain un-stabilised solids because the partially degraded food scraps likely to be present in such sludge would attract birds, some mammals, and possibly insects, even if the solids content of the sludge exceeds 75 percent. In other words, simply dewatering primary sludge to a 75% solid is not adequate to comply with this option. Activated sludge, humus sludge and anaerobically digested sludge can, however be dewatered to 75 % solids and comply with option 7.

Option 8: Moisture Reduction of Sludge Containing Unstabilised Solids

The ability of any sludge to attract vectors is considered to be adequately reduced if the solids content of the sludge is increased to 90 percent or greater, regardless of whether this contains primary sludge or raw unstabilised sludge. The solids increase should be achieved by removal of water and not by dilution with inert solids. Drying to this extent severely limits biological activity and strips off or decomposes the volatile compounds that attract vectors.

The way dried sludge is handled, including storage before use or disposal, can again create the opportunity for vector attraction. If dried sludge is exposed to high humidity, the outer surface of the sludge will increase in moisture content and possibly attract vectors. This should be properly guarded against.

Option 9: Sludge Injection

Vector attraction reduction can be demonstrated by injecting the sludge below the ground surface. Under this option, no significant amount of sludge can be present on the land surface within 1 hour of injection, and if the sludge is Microbiological Class A or B, it must be injected within 8 hours after discharge from the pathogen-reducing process.

Note: Microbiological class A and B can be applied to soil much later than 8 hours after discharge from the pathogen-reducing process if another vector attraction reduction option such as dewatering and/or drying is applied. The time periods referred to in Option 9 are intended for liquid sludge application of Microbiological classes A and B.

Injection of sludge beneath the soil places a barrier of earth between the sludge and vectors. The soil removes water from the sludge, which reduces the mobility and odour of the sludge. Odour is usually present at the site during the injection process, but quickly dissipates once injection is complete. This option is applicable to dedicated land disposal options only.

Option 10: Incorporation of Sludge into the Soil

Under this option, sludge must be incorporated into the soil within 6 hours of application to or placement on the land. Incorporation is accomplished by ploughing or by some other means of mixing the sludge into the soil. If the sludge is Microbiological class A or B with respect to pathogens, the time between processing and application or placement must not exceed 8 hours – the same as for injection under Option 9. See the note under Option 9. This option is applicable to dedicated land disposal options only.

Note: Practical restrictions, such as the ability of the plough to function immediately after application, could cause delays in the incorporation of the sludge within the 6 hours. This could cause the development of odours and increase risk of vector attraction. In these cases the sludge producer needs to monitor the development of odours and manage the situation diligently.

Option 11: Daily cover

This option is applicable to landfill only. Most landfill operations are based on a series of trenches or cells which are prepared to receive waste. The waste is deposited in trenches or cells, spread, compacted and covered to isolate the waste from the environment. The material to be used as cover material may be soil, builder's rubble or ash.

APPENDIX 3: SAMPLING METHODS AND PROCEDURES FOR WATER AND SOIL SAMPLES

WATER SAMPLING PROCEDURE ⁷

Sampling equipment needed

- Equipment to collect microbiological samples
 - Sterile sample bottles (see Table 14 and 15 for the type of sample bottle needed)
 - Sealed container or cool box which can be kept cool (preferably with ice)
- Equipment to collect chemical and physical samples
 - Correct sample bottles (see Table 14 and 15 for the different types of sample bottles required)
 - Cooler box with ice (if necessary)

Special precautions

- Microbiological water samples
 - Keep sample bottle closed and in a clean condition up to the point where it has to be filled with the water to be sampled.
 - Do not rinse bottle with any water prior to sampling.
 - When samples for chemical and microbiological analysis are to be collected from the same location, the microbiological sample should be collected first to avoid the danger of microbiological contamination of the sampling point.
 - The sampler (person taking the sample) should wear gloves (if possible) or wash his/her hands thoroughly before taking each sample. Avoid hand contact with the neck of the sampling bottle.
- Chemical water samples
 - Some plastic caps or cap liners may cause metal contamination of the water sample. Please consult with the laboratory on the correct use of bottle caps.
 - Keep sample bottle closed and in a clean condition up to the point where it has to be filled with the water to be analysed.
 - Never leave the sample bottles (empty or filled with the water sample) unprotected in the sun.

⁷ For more detail on the water sampling procedure, consult the following documents:
Department of Water Affairs and Forestry. Waste Management Series. Minimum Requirements for Water Monitoring at Waste Management Facilities (Latest edition).
WRC. 2000. Quality of domestic water supplies. Volume 2: Sampling Guide. WRC no TT117/99.

- After the sample has been collected the sample bottle should be placed directly in a cooled container (e.g. portable cooler box). Try and keep cooled container dust-free.

Surface water sampling technique

The following procedures should be followed when taking water samples in rivers and streams:

- At the sampling point remove cap of sample bottle but do not contaminate inner surface of cap and neck of sample bottle with hands.
- Take samples by holding bottle with hand near base and plunge the sample bottle, neck downward, below the water surface (wear gloves to protect your hands from contact with the water).
- Turn bottle until neck points slightly upward and mouth is directed toward the current (can also be created artificially by pushing bottle forward horizontally in a direction away from the hand).
- Fill sample bottle without rinsing and replace cap immediately.
- Before closing the sample bottle, preserve the sample (if applicable, see Table 14) and leave ample air space in the bottle (at least 2.5 cm) to facilitate mixing by shaking before examination.
- Label the sample
- Submit for analysis to a reputable analytical laboratory.

Composite Borehole Water Sampling

Composite water sampling is done by pumping water from a borehole. The recommended procedure for composite sampling is as follows:

- Activate the pump and remove (purge) at least three times the volume of water contained in the hole.
- Collect a water sample in a clean container (see Table 15).
- Filter and preserve the sample (if applicable, see Table 15) and submit for analysis to a reputable analytical laboratory.

Various types of pumps may be used. As a portable system, a submersible pump may be considered. Submersible pumps are generally available in South Africa. For sampling, a small submersible pump that yields 1 l/sec would be sufficient for most sampling applications.

Where low-yielding monitoring boreholes are pumped, the borehole could temporarily run dry while being purged. In such instances, samples should be taken of the newly accumulated groundwater after recovery or partial recovery of the water level in the holes. It may be necessary to sample such boreholes a day or more after having purged the hole.

SOIL SAMPLING⁸

Sampling equipment needed

- Soil auger
- Plastic sheets
- Plastic or glass containers (bottles or bags) that can be closed tightly
- Tags and a permanent marker to label the samples

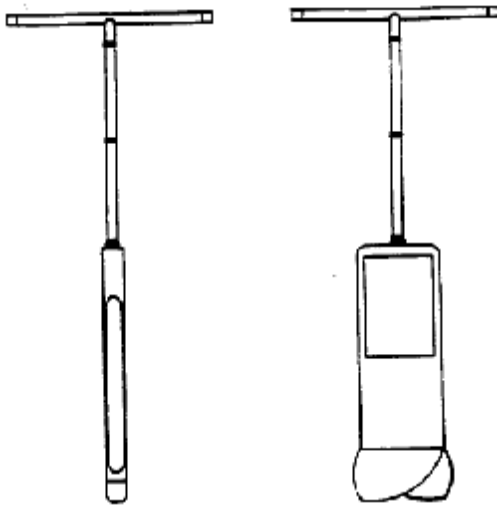


Figure 3A: Soil augers

Number of samples

For mono-fills, waste piles and lagoons at least 4 composite samples of each disposal area at each depth will be required. For DLD sites the number of samples will vary according to the size of the disposal site and different soil types present at the disposal site. At least three composite samples for each depth increment for every hectare of the DLD site are required.

Sampling procedure

The **soil auger** is used to bore a hole to a desired sampling depth, and is then withdrawn. The sample may be collected directly from the auger. The following procedure is recommended:

⁸ For more information on soil sampling procedures, consult the following documents:
USEPA Environmental Response Team. 2000. Standard operating procedures: Soil sampling
USEPA 1989. Soil sampling quality assurance: User's Guide. EPA 600/8-89/046

1. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, litter).
2. Begin augering and after reaching the desired depth, slowly and carefully remove the auger from the hole. Deposit the soil onto a plastic sheet spread near the hole. For soil monitoring at disposal sites these depths are 0-100mm, 100-200mm, 200-300mm, 300-400mm and 400-500mm.
3. Place the samples into plastic or other appropriate containers, secure the caps tightly and label the sample.
4. If composite samples are to be collected, place a sample from another sampling site into the same container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.
5. Preserve the samples as recommended in Table A3 and submit to a accredited laboratory

TABLE 3A: RECOMMENDED SOIL SAMPLE CONTAINERS, PRESERVATION AND HOLDING TIMES

Contaminant	Container	Preservation	Holding Time
Acidity	Plastic/Glass	Cool, 4°C	14 days
Ammonia	Plastic/Glass	Cool, 4°C	28 days
Sulfate	Plastic/Glass	Cool, 4°C	28 days
Nitrate	Plastic/Glass	Cool, 4°C	48 hours
Organic Carbon	Plastic/Glass	Cool, 4°C	28 days
Chromium (VI)	Plastic/Glass	Cool, 4°C	48 hours
Mercury	Plastic/Glass	Cool, 4°C	28 days
Other Metals	Plastic/Glass	Cool, 4°C	6 months

Soil samples can also be collected from a **test pit or trench excavation**. The following procedure is recommended:

1. A shovel is used to remove a one to two inch layer of soil from the vertical face of the pit where sampling is to be done.
2. Samples are taken using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose fresh soil for sampling.
3. Place the samples into plastic or other appropriate containers, secure the caps tightly and label the sample.

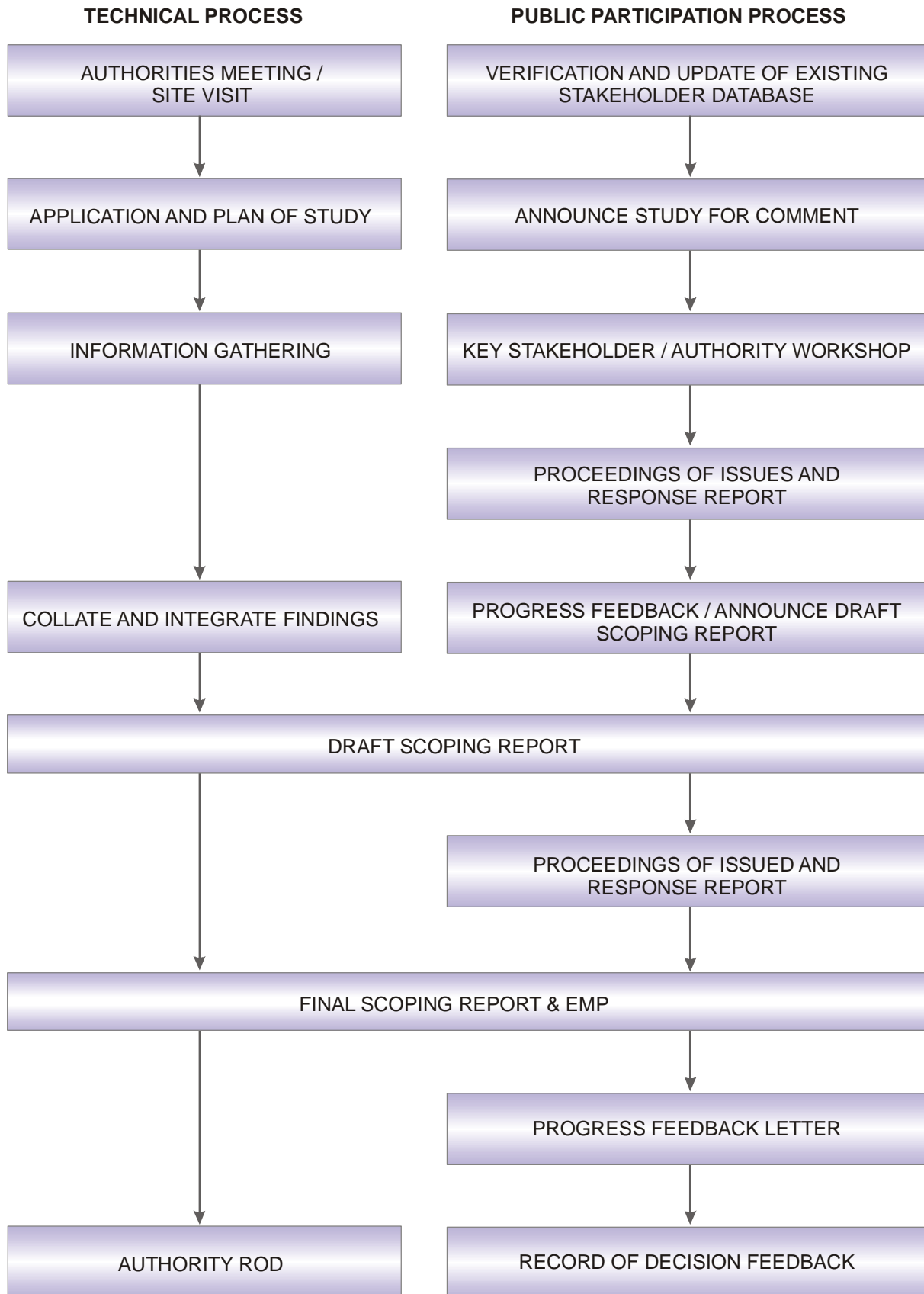
4. If composite samples are to be collected, place a sample from another sampling site into the same container and mix thoroughly. When compositing is complete, place the sample into appropriate, labeled containers and secure the caps tightly.
5. Preserve the samples as recommended in Table A3 and submit to an accredited laboratory

APPENDIX 4: LEGAL REQUIREMENTS

Appendix 4.1: Legislative framework governing the on-site and off-site disposal of sludge

Management Option	Relevant Legislation governing practice	Responsible Authority
On-site mono disposal	National Water Act, (Act No. 36 of 1998)	DWAF
	Environment Conservation Act, (Act No. 73 of 1989)	DEAT
	National Environmental Management Act, Act No. 107 of 1998)	DEAT
	Water Services Act, (Act 108 of 1997) (Specifically Section 12 & 13 related to Water Services Development Plans)	DWAF
	National Health Act, (Act No. 61 of 2003)	DoH
DLD sites	National Water Act, (Act No. 36 of 1998)	DWAF
	Waste Discharge Charge System, in terms of the National Water Act, 1998	DWAF
	Environment Conservation Act, (Act No. 73 of 1989)	DEAT
	National Environmental Management Act, (Act No. 107 of 1998)	DEAT
	National Health Act, (Act No. 61 of 2003)	DoH
Off-site co-disposal in landfill	National Environmental Management Act, (Act No. 107 of 1998)	DEAT
	Environment Conservation Act, (Act No. 73 of 1989)	DEAT
	Minimum Requirements, 2006, Waste Management Series	DEAT
Marine disposal	National Water Act, (Act No. 36 of 1998)	DWAF
	Waste Discharge Charge System, in terms of the National Water Act, 1998	DWAF
	Operational Policy for the disposal of Land-derived water containing waste to the Marine Environment, 2004	DWAF
	South African Water Quality Guidelines for Coastal Marine Waters, 1995	DWAF
	Marine Living Resources Act, (Act No. 18 of 1998)	DEAT
	Environment Conservation Act, (Act No. 73 of 1989)	DEAT
	National Environmental Management Act, (Act No. 107 of 1998)	DEAT

Appendix 4.2: Environmental impact assessment process



DEFINITIONS AND DESCRIPTION OF KEY TERMS

Acceptable exposure (AE):	The concentration of a substance that will have minimal effect on the environment or human health.
Agricultural land:	Land on which a food crop, a feed crop, or a fibre crop is grown. This includes grazing land and forestry.
Agronomic rate:	The sludge application rate (dry-weight basis) designed (i) to provide the amount of nitrogen needed by the food crop, feed crop, fibre crop, cover crop, or vegetation grown on the land and (ii) to minimise the amount of nitrogen in the sewage sludge that passes below the root zone of the crop or vegetation grown on the land to the groundwater.
Agricultural use:	The use of sludge to produce agricultural products. It excludes the use of sludge for aquaculture and as an animal feed.
Annual pollutant loading rate:	The maximum amount of a pollutant that can be applied to an area of land during a 365-day period.
Assimilative capacity:	This represents the ability of the receiving environment to accept a substance without risk.
Available metal content (Soil):	Specific to Volume 2. Metal fraction extracted with ammonium nitrate in soil samples.
Beneficial uses:	Use of sludge with a defined benefit, such as a soil amendment.
Bioavailability:	Availability of a substance for uptake by a biological system.
Biosolids:	Stabilised Sludge. Organic solids derived from biological wastewater treatment processes that are in a state that they can be managed to sustainably utilise the nutrient, soil conditioning, energy, or other value.
Bund wall:	A properly engineered and constructed run-off interception device around a waste disposal site or down slope of a waste disposal site.
Co-disposal (liquid with dry waste):	The mixing of high moisture content or liquid waste with dry waste. This affects the water balance and is an acceptable practice on a site equipped with leachate management measures.
Co-disposal (dewatered sludge with dry waste):	The mixing of dewatered sludge with dry waste in a general landfill site or hazardous landfill site without affecting the water balance of the site.
Composting:	The biological decomposition of the organic constituents of sludge and other organic products under controlled conditions.
Contaminate:	The addition of foreign matter to a natural system. This does not necessarily result in pollution, unless the attenuation capacity of the natural system is exceeded.
Controlled access:	Where public or livestock access to sludge application areas is restricted or controlled, such as via fences or signage, for a period of time stipulated by this guideline.
Cradle-to-grave:	A policy of controlling a wasteproduct from its inception to its ultimate disposal
Cumulative pollutant loading rate:	The maximum amount of a pollutant that can be applied to a unit area of land.
Cut-off trench:	A properly engineered and constructed trench to intercept and collect run-off.
Dedicated land disposal:	Sites that receive repeated applications of sludge for the sole purpose of final disposal.

Delisting:	If the estimated environmental concentration (EEC) is less than the Acceptable Exposure (AE) which is 10% of the LC ₅₀ , the waste can be delisted, i.e. be moved to a lower Hazard Rating or even disposed of at a General Waste landfill with a leachate collection system.
Dewatering:	Dewatering processes reduce the water content of sludge to minimise the volumes for transport and improve handling characteristics. Typically, dewatered sludge can be handled as a solid rather than as liquid matter.
Disinfection:	A process that destroys, inactivates or reduces pathogenic micro-organisms.
Disposal:	The discharge, deposit, injection, dumping, spilling, leaking, or placing of any waste into the environment (land, surface water, ground water, and air).
Disposal site:	A site used for the accumulation of waste with the purpose of disposing or treatment of such waste. See also Waste Disposal Site
Domestic sewage:	Waste and wastewater from humans or household operations that is discharged to, or otherwise enters a treatment works.
Dose:	In terms of monitoring exposure levels, the amount of a toxic substance taken into the body over a given period of time. See also LD ₅₀ .
Domestic waste:	Waste emanating, typically, from homes and offices. Although classified as a General Waste, this waste contains organic substances and small volumes of hazardous substances.
Dose-response:	How an organism's response to a toxic substance changes as its overall exposure to the substance changes. For example, a small dose of carbon monoxide may cause drowsiness; a large dose can be fatal.
Drying:	A process to reduce the water content further than a dewatering process. The solids content after a drying process is typically > 75%.
Dry-weight (DW) basis:	The method of measuring weight where, prior to being weighed, the material is dried at 105°C until reaching a constant mass (i.e., essentially 100 % solids content).
Dump:	A land site where wastes are discarded in a disorderly or haphazard fashion without regard to protecting the environment. Uncontrolled dumping is an indiscriminate and illegal form of waste disposal. Problems associated with dumps include multiplication of disease-carrying organisms and pests, fires, air and water pollution, unsightliness, loss of habitat, and personal injury.
<i>E. coli</i>:	A group of bacteria normally found in the intestines of humans and animals. Most types of <i>E. coli</i> are harmless, but some active strains produce harmful toxins and can cause severe illness. In sanitary bacteriology, <i>Escherichia coli</i> is considered the primary indicator of recent faecal pollution.
Ecotoxicity:	Ecotoxicity is the potential to harm animals, plants, ecosystems or environmental processes.
Emission:	The release or discharge of a substance into the environment. Generally refers to the release of gases or particulates into the air.
Emission Standards:	Government standards that establish limits on discharges of pollutants into the environment (usually in reference to air).
Environment:	Associated cultural, social, soil, biotic, atmospheric, surface and groundwater aspects associated with the disposal site that could potentially be, impacted upon by the disposal.

Environmental Impact Assessment (EIA):	An investigation to determine the potential detrimental or beneficial impact on the surrounding communities, fauna, flora, water, soil and air arising from the development or presence of a waste disposal site.
Estimated Environmental Concentration (EEC):	The Estimated Environmental Concentration represents the concentration of a substance in the aquatic environment when introduced under worst case scenario conditions, i.e., directly into a body of water. It is used to indicate possible risk, by comparison with the minimum concentration estimated to adversely affect aquatic organisms or to produce unacceptable concentrations in biota, water or sediment.
Faecal coliform:	<i>Faecal coliforms</i> are the most commonly used bacterial indicator of faecal pollution. <i>Faecal coliforms</i> are bacteria that inhabit the digestive system of all warm-blooded animals, including humans.
Freeboard:	Vertical distance from the normal water surface to the top of a confining wall.
Hazard Rating:	A system for classifying and ranking Hazardous waste according to the degree of hazard they present.
Hazardous waste:	Waste that may, by circumstances of use, quantity, concentration or inherent physical, chemical or infectious characteristics, cause ill health or increase mortality in humans, fauna and flora, or adversely affect the environment when improperly treated, stored, transported and disposed of.
Helminth ova:	The eggs of parasitic intestinal worms.
Incineration:	Incineration is both a form of treatment and a form of disposal. It is simply the controlled combustion of waste materials to a non-combustible residue or ash and exhaust gases, such as carbon dioxide and water.
Integrated Environmental Management (IEM):	A code of practice ensuring that environmental considerations are fully integrated into the management of all activities in order to achieve a desirable balance between conservation and development.
Land application:	The spraying or spreading of wastewater sludge onto the land surface; the injection of wastewater sludge below the land surface; or the incorporation of wastewater sludge into the soil so that the wastewater sludge can either condition the soil or fertilise crops or vegetation grown in the soil.
Land disposal:	Application of sludge where beneficial use is not an objective. Disposal will normally result in application rates that exceed agronomic nutrient requirements or cause significant contaminant accumulation in the soil.
Landfill:	To dispose of waste on land, whether by use of waste to fill in excavation or by creation of a landform above grade, where the term "fill" is used in the engineering sense.
LC₅₀:	The median lethal dose is a statistical estimate of the amount of chemical, which will kill 50% of a given population of aquatic organisms under standard control conditions. The LC ₅₀ is expressed in mg/l.
LD₅₀:	The median lethal dose is a statistical estimate of the amount of chemical, which will kill 50% of a given population of animals (e.g. rats) under standard control conditions.
Leachate:	An aqueous solution with a high pollution potential, arising when water is permitted to percolate through decomposing waste.
Liner:	A layer of low permeability placed beneath a landfill and designed to direct leachate to a collection drain or sump, or to contain leachate. It may comprise natural materials, synthetic materials, or a combination thereof.

Maximum available threshold (MAT):	The maximum available (NH_4NO_3 extractable) metal concentration allowed for soils receiving sludge.
Maximum permissible level:	The maximum total metal concentration allowed in soils at sludge disposal sites. Soil remediation would not be necessary except if this level is exceeded.
Minimum Requirement:	A standard by means of which environmentally acceptable waste disposal practices can be distinguished from environmentally unacceptable waste disposal practices.
Monthly average:	The arithmetic mean of all measurements taken during a given month.
Most probable number (MPN):	A unit that expresses the amount of bacteria per gram of total dry solids in wastewater sludge.
Off-site:	Sludge disposal site outside the boundaries of the wastewater treatment plant (WWTP)
On-site:	Sludge disposal site within the boundaries of the wastewater treatment plant (WWTP)
Pathogenic organisms:	Disease-causing organisms. This includes, but is not limited to, certain bacteria, protozoa, viruses, and viable Helminth ova.
pH:	The logarithm of the reciprocal of the hydrogen ion concentration. The pH measures acidity/alkalinity and ranges from 0 to 14. A pH of 7 indicates the material is neutral. Moving a pH of 7 to 0, the pH indicates progressively more acid conditions. Moving from a pH of 7 to 14, the pH indicates progressively more alkaline conditions.
Pollution:	The direct or indirect alteration of the physical, chemical or biological properties of a (water) resource so as to make it less fit for any beneficial purpose for which it may reasonably be expected to be used; or harmful or potentially harmful to the welfare, health or safety of human beings; to any aquatic or non-aquatic organisms; to the resource quality; or to property.
Primary treatment:	Treatment of wastewater prior to other forms of treatment and involving settling and removal of suspended solids.
Qualified person:	A person is suitably qualified for a job as a result of one, or any combination of that person's formal qualifications, prior learning, relevant experience; or capacity to acquire, within a reasonable time, the ability to do the job.
Receptor:	Sensitive component of the ecosystem that reacts to or is influenced by environmental stressors.
Recycle:	The use, re-use, or reclamation of a material so that it re-enters the industrial process rather than becoming a waste.
Rehabilitation:	Restoring a waste site for a new industrial function, recreational use, or to a natural state.
Remediation:	The improvement of a contaminated site to prevent, minimize or mitigate damage to human health or the environment. Remediation involves the development and application of a planned approach that removes, destroys, contains or otherwise reduces the availability of contaminants to receptors of concern.
Residue:	A substance that is left over after a waste has been treated or destroyed.
Responsible person:	A person(s), who takes professional responsibility for ensuring that all or some of the facets of the handling and disposal of Hazardous Waste are properly directed, guided and executed, in a professionally justifiable manner.

Restricted agricultural use:	Use of sludge in agriculture is permitted but restrictions apply (crop restrictions, access restrictions etc).
Risk:	The scientific judgement of probability of harm. This basic and important concept has two dimensions: the consequences of an event or set of circumstances and the likelihood of particular consequences being realised. Both dimensions apply to environmental risk management with it generally being taken that only adverse consequences are relevant.
Risk assessment:	The evaluation of the results of risk analysis against criteria or objectives to determine acceptability or tolerability of residual risk levels, or to determine risk management priorities (or the effectiveness or cost-effectiveness of alternative risk management options and strategies).
Risk management:	The systematic application of policies, procedures and practices to identify hazards, analysing the consequences and the likelihood associated with those hazards, estimating risk levels, assessing those risk levels against relevant criteria and objectives, and making decisions and acting to reduce risk levels to acceptable environmental and legal standards.
Secondary Treatment:	Treatment of wastewater that typically follows primary treatment and involves biological processes and settling tanks to remove organic material.
Sludge-amended soil:	Soil to which sludge has been added.
Sludge:	Solid, semi-solid, or liquid residue generated during the treatment of domestic sewage in a treatment works. Wastewater sludge includes, but is not limited to, domestic septage; scum or solids removed in primary, secondary, or advanced wastewater treatment processes; and material derived from wastewater sludge in a wastewater sludge incinerator. It does not include the grit and screenings generated during preliminary treatment of domestic wastewater in a treatment works.
Soil organisms:	A broad range of organisms, including microorganisms and various invertebrates living in or on the soil.
Specific oxygen uptake rate (SOUR):	The mass of oxygen consumed per unit time per unit mass of total solids (dry-weight basis).
Stabilisation:	The processing of sludge to reduce volatile organic matter, vector attraction, and the potential for putrefaction and offensive odours.
Stabilised sludge:	Organic solids derived from biological wastewater treatment processes that are in a state that they can be managed to utilise the nutrient, soil conditioning, energy, or other value.
Sterilise:	Make free from microorganisms.
Supplier:	A person or organisation that produces and supplies sludge for use. This includes a water business producing and treating sludge and processors involved in further treatment.
Surface water interception mechanism:	A mechanism placed between the disposal site and the surface water body to intercept possible run-off from the disposal site before it can reach the water body.
Sustainability:	Being able to meet the needs of present and future generations by the responsible use of resources.
Sustainable use:	The use of nutrients in sludge at or below the agronomic loading rate and/or use of the soil conditioning properties of sludge. Sustainable use involves protection of human health, the environment and soil functionality.

Total investigative level (TIL):	The total metal concentration in agricultural soils where further investigation is necessary before sludge application can commence.
Total load capacity:	The capacity of a landfill site to accept a certain substance or the amount of a substance, which can be safely disposed of at a certain site. The total load capacity is influenced by the concentration levels and mobility of the waste, and by the landfill practice and design.
Total maximum threshold (TMT):	The maximum total metal concentration allowed in agricultural soils receiving sludge.
Total metal content:	Metal fraction extracted using an <i>aqua regia</i> solution (HCl/HNO ₃ solution).
Total trigger value (TTV):	The total metal concentration in soils at disposal sites indicating that additional management options should be implemented to reduce the impact on the soil.
Toxic:	Poisonous.
Toxicity:	An intrinsic property of a substance which can cause harm or a particular adverse effect to humans, animals or plants at some dose.
Toxicity Characteristic Leaching Procedure (TCLP):	A test developed by the USA Environmental Protection Agency to measure the ability of a substance to leach from the waste into the environment. It thus measures the risk posed by a substance to groundwater.
Transporters:	A person, organisation, industry or enterprise engaged in or offering to engage in the transportation of waste.
Treatment:	Treatment is used to remove, separate, concentrate or recover a hazardous or toxic component of a waste or to destroy or, at least, to reduce its toxicity in order to minimise its impact on the environment.
Unrestricted agricultural use:	Sludge is of such good quality that it can be used in agricultural practices without any restrictions.
VAR:	Vector Attraction Reduction.
Vector attraction:	The characteristic of wastewater sludge that attracts rodents, flies, mosquitoes, or other organisms capable of transporting infectious agents.
Vectors:	Any living organisms that are capable of transmitting pathogens from one organism to another, either: (i) mechanically by transporting the pathogen or (ii) biologically by playing a role in the lifecycle of the pathogen. Vectors include flies, mosquitoes or other insects, birds, rats and other vermin.
Waste:	An undesirable or superfluous by-product, emission, or residue of any process or activity, which has been discarded, accumulated or stored for the purpose of discarding or processing. It may be gaseous, liquid or solid or any combination thereof and may originate from a residential, commercial or industrial area.
Waste disposal site:	Any place at which more than 100kg of a Hazardous Waste is stored for more than 90 days or a place at which a dedicated incinerator is located.
Waste Permit:	An authorisation in terms of the Environment Conservation Act (Act No. 73 of 1989) to establish, provide or operate any disposal site (See definition of disposal site)
Wastewater Sludge:	The material recovered from predominantly domestic wastewater treatment plants. (Also see Sludge)

Wastewater Treatment Plant (WWTP):	Any device or system used to treat (including recycling and reclamation) either domestic wastewater or a combination of domestic wastewater and industrial waste of a liquid nature.
Water Use Authorisation:	An entitlement to undertake a water use in terms of the National Water Act (Act No. 36 of 1998). An authorisation may be a water use license, permissible under a general authorisation, an existing lawful water use, or a Schedule I water use.
Wet weight:	Weight measured of material that has not been dried (see Dry-weight basis).