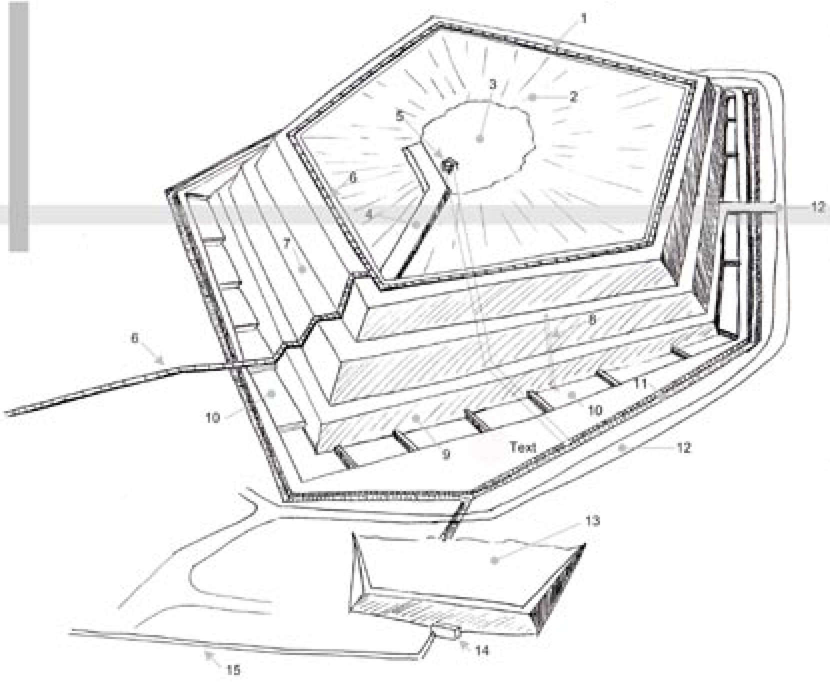
# BASELINE

# TYPICAL SYSTEM

## ELEMENTS OF A TAILINGS DISPOSAL FACILITY

TYPICAL SYSTEM ELEMENTS
SLOPE AND PROFILE ANALYSIS
SLOPE CONFIGURATION
DEPOSITION METHODS
TAILINGS CHARACTERISTICS
WATER BALANCE
VISUAL PERCEPTION

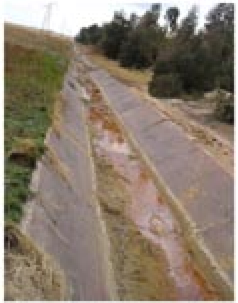
DIAGRAMMATIC REPRESENTATION OF A TYPICAL TDF (CHAMBER OF MINES OF SOUTH AFRICA 1996)



1 Daywall
2 Beach
3 Pool
4 Catwalk
5 Penstock
6 Delivery pipe
7 Bench
8 Bench penstock
9 Starter wall
10 Catchment paddock
11 Toe drain/solution trench
12 Access road
13 Return water dam
14 Pump station
15 Return water pipeline

SURFACE CHANNEL

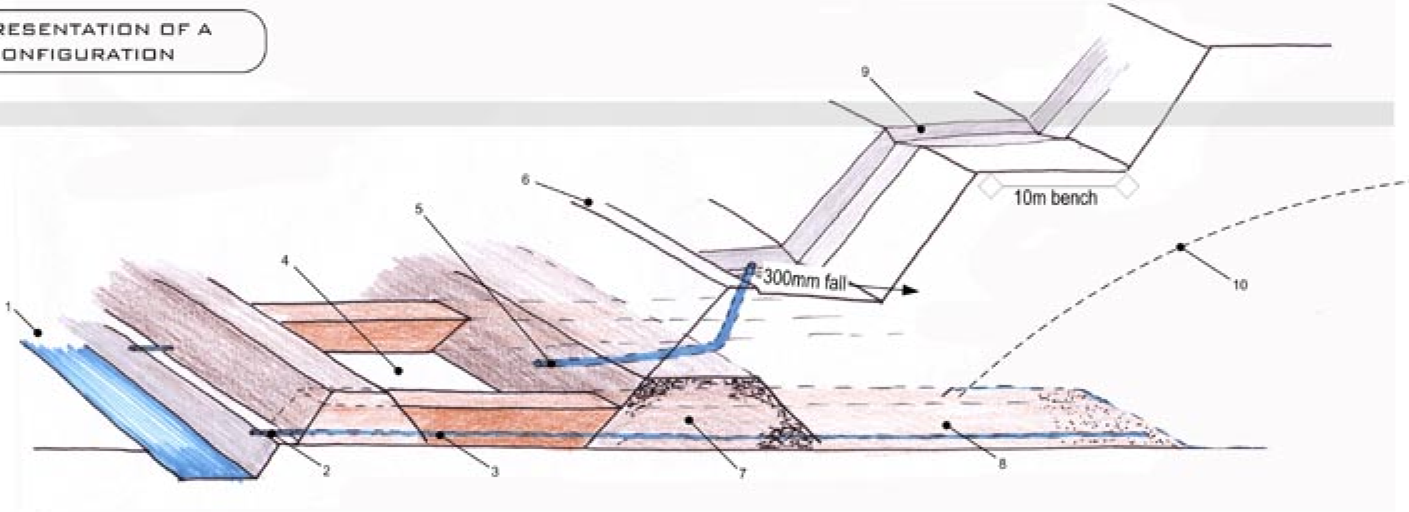
BLANKET DRAIN OUTLET



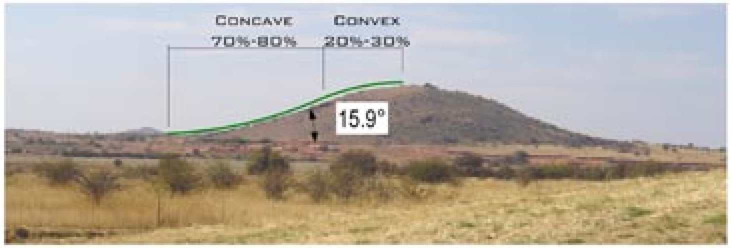
SOLUTION TRENCH

DIAGRAMMATIC REPRESENTATION OF A TYPICAL SLOPE CONFIGURATION

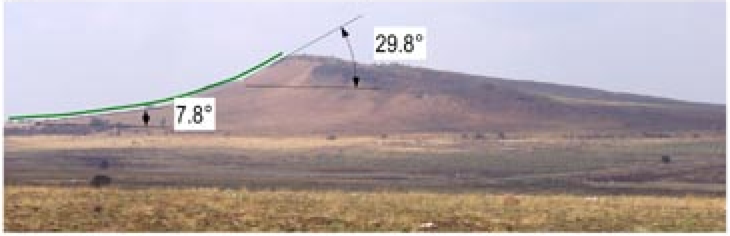
1 Solution trench
2 Blanket drain outlet
3 Geo-pipe
4 Paddock
5 Bench penstock outlet
6 0.5 m bund wall
7 Starter wall
8 Blanket drain
9 Surface channel
10 Phreatic surface



$^3$6 NATURAL SLOPE PROFILE 1



$^3$7 NATURAL SLOPE PROFILE 2



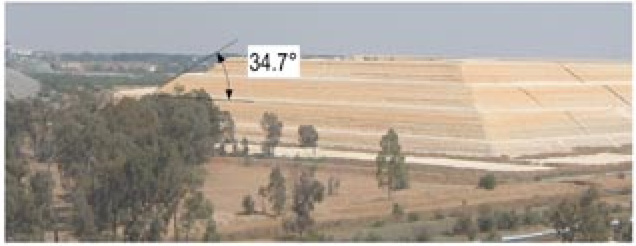
### Natural slope profile

An analysis of natural slopes reveals that four basic slope forms are identifiable; straight, convex, concave and s-shaped slopes. Smooth S-shaped slopes usually indicates long-term stability and a state of equilibrium among slope forces. Such slopes rarely exceed 45° inclination and are usually secured against heavy erosion by a substantial plant cover (Marsh 1991). A natural slope is usually a complex combination of these four slope forms.

A principle applied in coal mine overburden rehabilitation is to create a S-shaped profile with the upper 20%-30% being convex and the lower 70%-80%, concave, thus simulating a natural, stable profile (fig $^3$-6). This shape is a result of erosion and deposition until stability is achieved (fig $^3$-13). The catchment area at any point on the slope is a function of the slope length above it. As one progresses down the slope, the catchment area increases as well as the volume of runoff derived from a rainfall event (Hannan 1984).

"Over geological time the forces of erosion and deposition have acted upon natural slopes until an angle is reached which, for a given soil type, is in equilibrium with the effects of *catchment area*, *runoff volume* and *vegetative cover*. This results in a slope which becomes progressively flatter towards the bottom so that flow velocity is maintained at a roughly constant, non-erosive value." (Hannan 1984:22) (fig $^3$-7)

$^3$8 TDF SLOPE PROFILE-OPERATION



$^3$9 TDF SLOPE PROFILE-REHABILITATED

### Constructed slope profile

Side slopes of TDFs are generally constructed at 33º. However, 33º angle is about the optimum angle for erosion (Chamber of Mines of South Africa 1996), thus resulting in severe erosion problems and rehabilitation difficulty as well as with ongoing maintenance and repair (Blight & Amponsah-Dacosta 1999).

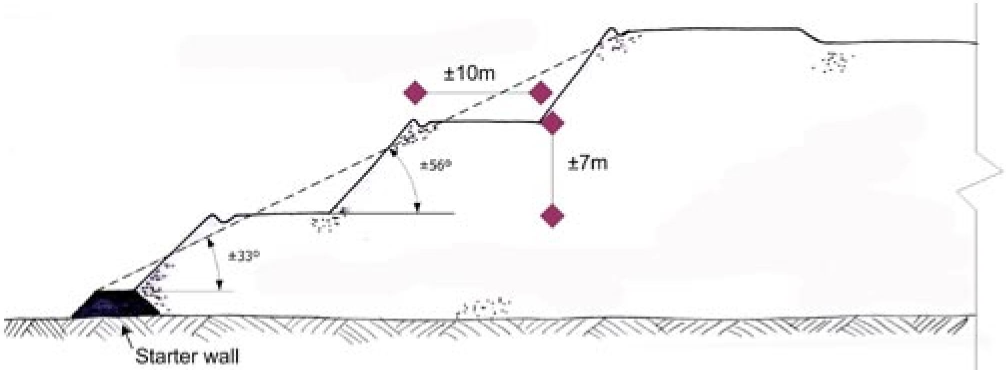
Benches are introduced to break a continuous slope length. This reduces the overall slope angle and improves erosion control.

During the rehabilitation phase, slopes are often flattened to a 18º-25º gradient (fig $^3$-9). Slopes are vegetated for the purpose of erosion control and to satisfy visual requirements. A common problem is that vegetation cover is often unsatisfactory due to the draughty nature of the growth medium (tailings). Water retention is poor and most water is either lost through infiltration or runoff, causing erosion.

In conclusion, it seems that rehabilitation must aim at simulating a slope profile that represents the tailings material's natural erosion resistant gradient. This optimum slope angle has not been determined yet by associated research. A comparison to sand dune profiles reveals that 9º slopes exist on windward slopes and 33º on leeward slopes (Blight & Amponsah-Dacosta 1999).

Angles steeper than 18º will not be adopted for this project as field surveys has proven steeper gradients unsuccessful.

$^{3}$10 CONVENTIONAL SLOPE CONFIGURATION

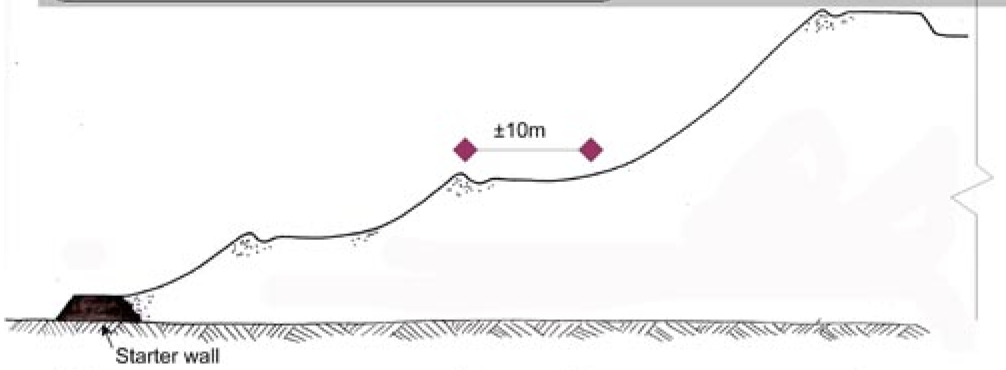


## Conventional slope configuration

A conventional slope configuration is presented in figure $^{3}$-10. A uniform rise and tread (bench) is consistent from toe to crest. Benches provide access and assist in run-off and erosion control. Sediment from erosion accumulates on the benches, thus reducing the loss of material off the site. The slope length corresponds with the volume of runoff that can occur during a specific frequency rain event. Runoff is conveyed via surface channels to selected down-points on the benches.

The distribution of light on a slope with this configuration, creates sharp shadows and contribute negatively to the visual impact of the TDF as a whole (fig $^{3}$-12).

$^{3}$11 PROPOSED REHABILITATED CONFIGURATION

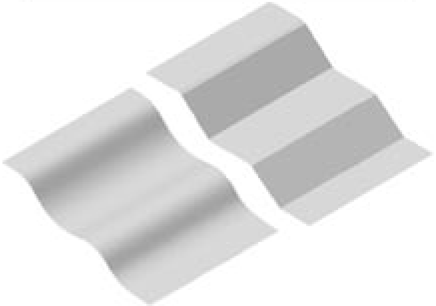


## Proposed rehabilitated configuration (fig $^{3}$-11)

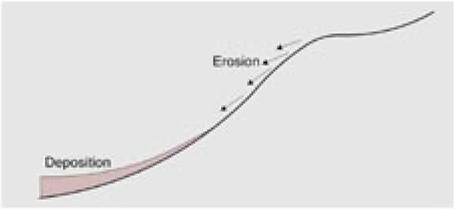
An S-shaped profile is noticeable of a stable slope (Hannan 1984). Erosion of top sections are deposited at the bottom until a stable scenario is achieved (fig $^{3}$-13). One can pursue the argument that less erosion will occur on a slope with this profile and an increase in stability is possible.

A concave/convex slope distributes light evenly over the length of the slope. It is softer on the eye and it could be argued that visual impact is reduced (fig $^{3}$-12).

$^{3}$12 LIGHT DISTRIBUTION OVER VARIOUS SLOPE CONFIGURATIONS



$^{3}$13 EROSION AND DEPOSITION EQUILIBRIUM



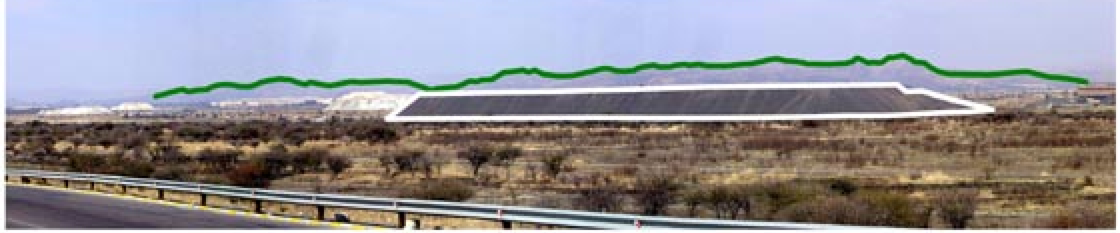
# SLOPE CONFIGURATION

## Profile comparison

14 PROFILE COMPARISON

━ Profile of mountains in the background
━ Profile of typical Mine Residue Deposit

The stark contrast in form, line, colour and texture, confirms the high visual impact. The flat top, steep uniform side angles and sharp corners, are elements of concern.



## Natural landform slope analysis

15 NATURAL LANDFORM SLOPE ANALYSIS

A slope analysis of one of the prominent natural landforms in the region, indicates the variety in slope angles of this particular slope configuration.

The diversity of slope gradients correlates with a diversity in habitat conditions, water availability, plant distribution and soil depths.

The focus is on plant distribution and the associated conditions.

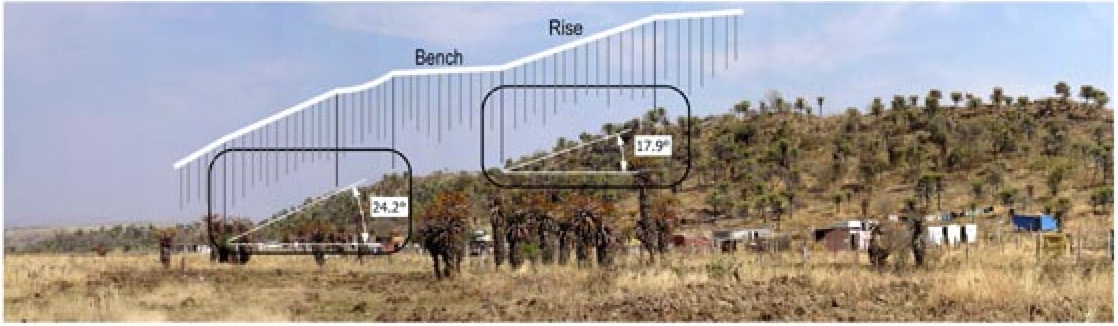
## Natural landform profile analysis

16 NATURAL LANDFORM PROFILE ANALYSIS

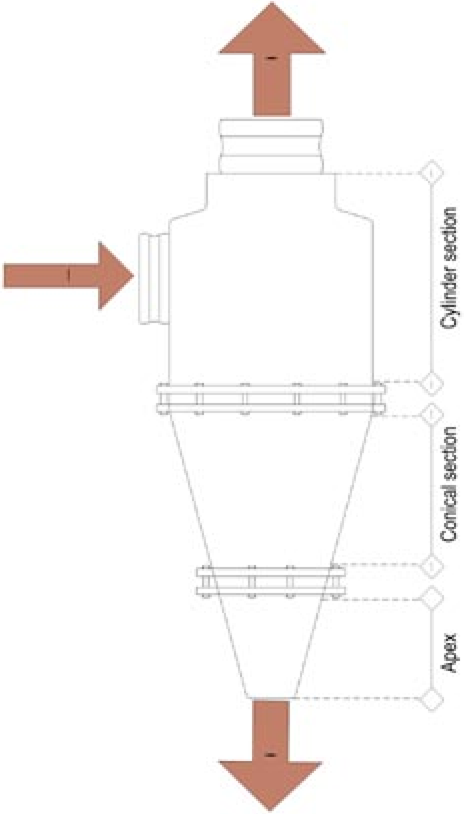
This is a profile analysis of a relative small landform in the region. The variation in side slope configuration is the focus of this analysis.

The white line is a simplified profile resembling similarities of TDF side slopes. The bench and rise are clearly identified in the profile.

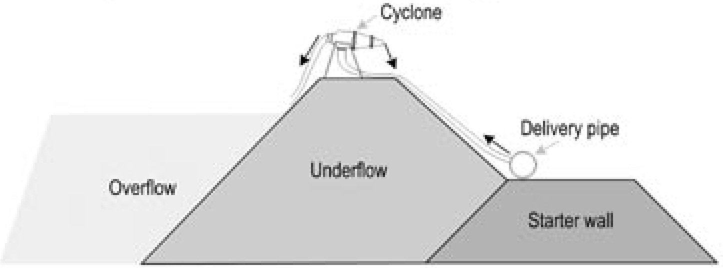
1:2 = 50% = 26.5°
1:3 = 33% = 18.5°
1:6 = 17% = 9.5°
1:9 = 11% = 6°



$^{3}$17 CYCLONE DEVICE (Vick 1983)



$^{3}$18 EMBANKMENT CONSTRUCTION VIA CYCLONE DEPOSITION



## Introduction

Alternative tailings deposition methods exist in the mining industry. The two main methods, commonly used in South Africa is cyclone and spigot deposition. Cyclone deposition requires a relatively high initial capital cost but is justified by the quick rate-of-rise. A safe rate-of-rise of approximately 9 m per year is possible compared to a 2.5 m resulting from spigot deposition (Chamber of Mines of South Africa 1996).

## Cycloned tailings

The use of cycloned tailings in embankment construction presents an attractive alternative design option when other suitable soils or quantities are unavailable. A significant cost advantage may occur if it is considered to substitute imported soils with the sand fraction of the tailings. The sand fraction is easily separated from the bulk with little added cost. The resulting cycloned sand has a high effective strength and permeability, making it an ideal material to construct embankments and facilitate the necessary drainage to control the phreatic surface (Vick 1983).

Another advantage is the reduction of 10%-30% of the bulk of tailings discharged, depending on impoundment configuration and embankment type. Due to the separation and the deposition of only the fine material, the total permeability of the discharge is less, thus reducing vertical seepage through the impoundment and subsequent contamination of groundwater (*ibid*).

Cyclones are simple devices that function on a centrifugal separation principle. The pressurised tailings slurry from the plant enters a cylindrical feed chamber. The coarse particles in the slurry spiral downward through the conical apex at the bottom (*underflow*) and the finer fraction along with most of the water rise to the outlet as *overflow (ibid)*. (fig $^{3}$-17)

***On-dam cycloning*** (fig $^{3}$-18)
On-dam cycloning is probably the most preferred cycloning method. Generally, many small cyclone devices are arranged on the embankment crest on small towers or scaffolds. Underflow from each cyclone is discharged towards the embankment face and overflow slimes is deposited to the inside of the impoundment. The cyclones are periodically raised as the embankment height increases.

The overflow is allowed to flow as a thick slurry, consisting of approximately 70%-75% solids, directly onto the embankment. At this pulp density, the sands assume a natural angle of repose of 1:3 (18.5°) to 1:4 (14°). (*ibid*)

***Stationary cycloning***
This method entails that the coarse and fine fraction is separated at a single high-capacity cyclone station, often near the location of deposition. The embankment is mechanically constructed by conventional earth-moving equipment and the overflow is conveyed to the impoundment via a separate slimes delivery line (*ibid*).

# CYCLONE DEPOSITION

**Embankment construction** (fig $^{3}$-19 to $^{3}$-22)

The conical shape deposited of each cyclone requires periodical movement of cyclones in order to ensure an even distribution of tailings over the embankment. A daily management of the delivery and deposition is necessary to keep the rise of the embankment balanced with the deposition rate.

Water in the coarse fraction is allowed to seep down to the catchment paddocks situated at the toe of the TDF or on the benches. Water is encouraged to evaporate from the paddocks.

As previously mentioned, the slurry (coarse fraction) accepts a natural angle of repose of 1:3 to 1:4. Research indicates that erosion of the tailings at this angle is very high and rates of soil loss in the region of 500 tons per hectare per year on gold residue dams was recorded (Chamber of Mines of South Africa 1996).

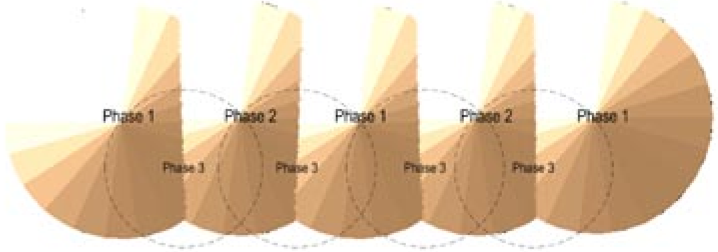
**Flattened side slopes as an erosion control measure**

A logical approach is to flatten the side slope angles in order to reduce erosion. It has to be noted that flattened slope angles require greater land acquisition costs in order to deposit the same volume of tailings at the same rate during the life-of-mine and still maintain safety and stability. Due to the increase in footprint size, an enlarged zone of pollution is possible.

It is possible to maintain the same footprint area and still retain safety and stability by reducing the deposition rate approaching the end of the life-of-mine. This will be an economic-influenced decision due to the fact that the rate of mineral extraction also need to diminish near the end of the operational phase.

Advantages associated with the reduction of side slope angles is the instant increase in stability as well as the reduction of erosion. Water infiltration encourage successful vegetation establishment.

$^{3}$19 CYCLONE DEPOSITION PHASING - PLAN



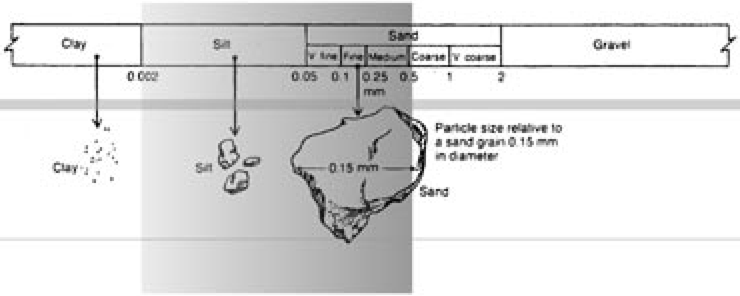
$^{3}$20 CYCLONE DEPOSITION PHASING -ELEVATION

$^{3}$21 CYCLONE DEPOSITION PHASING -SECTION

$^{3}$22 CYCLONE DEVICES IN OPERATION

TYPICAL SYSTEM ELEMENTS
SLOPE AND PROFILE ANALYSIS
SLOPE CONFIGURATION
DEPOSITION METHODS
TAILINGS CHARACTERISTICS
WATER BALANCE
VISUAL PERCEPTION

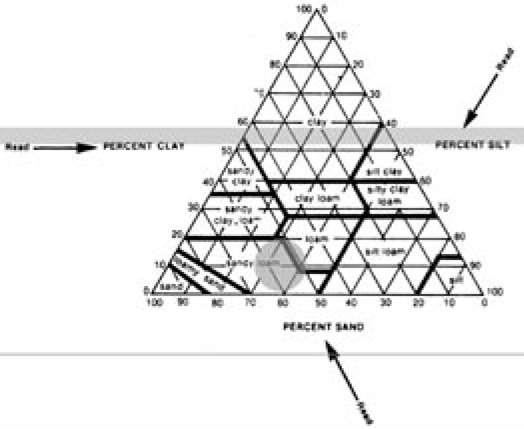
23 PARTICLE SIZE (MARSH 1991)



## PARTICLE SIZE

The particle size for platinum tailings typically vary between 0.002mm - 0.6mm. The coarse fraction commonly used to construct the embankments occur in the upper range of the distribution (sand fraction). The silt and clay size particles with most of the water is discharged inside the impoundment.

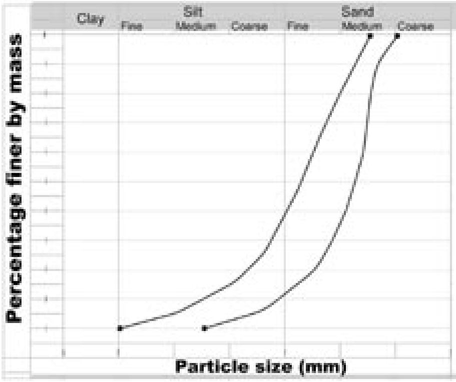
24 SOIL TEXTURE (MARSH 1991)



## SOIL TEXTURE

On the soil textural triangle, platinum tailings bear characteristics of a sandy loam textured soil. If analyzed the tailings consist of 10%-40% silt fraction, 60%-90% sand fraction and a negligible clay fraction. Natural soils with similar characteristics, are colluvium deposits at the toe of slopes formed by slides and runoff (Marsh 1991:72). These soils usually drain very well and have a low slope gradient due the relative high erosion potential.

25 PARTICLE SIZE ENVELOPS FOR PLATINUM RESIDUES (CHAMBER OF MINES OF SOUTH AFRICA 1996)



## SOIL COMPOSITION

**Natural soil generally comprises of four components:**

- Mineral particles (50%-80%)
- Organic matter
- Water
- Air (Marsh 1991)

Tailings are deprived of organic matter confirming the lack in moisture absorption and retention capability as well as microbial activity. To improve and ameliorate the tailings, a topsoil capping of 300mm to 500mm is often applied. This implies stripping of topsoil prior to construction, or massive amounts of topsoil need to be imported for the re-vegetation phase. Both these practices require high mechanical energy and are detrimental to the environment in some respect.

The aim is to enhance water retention, reduce evaporation and encourage a sufficient, self-sustaining nutrient cycle by the establishment of both pioneer and climax vegetation species.

# ERODIBILITY

## PARTICLE DISTRIBUTION

(26) TYPICAL PARTICLE DISTRIBUTION THROUGH A TDF
(ADOPTED FROM CHAMBER OF MINES OF SOUTH AFRICA 1996)

## ERODIBILITY

The Universal Soil Loss Equation and supporting studies have indicated that a steeper slope gradient and long slope lengths increase water erosion considerably (Dorren & Blight 1986). Arising from this research, the construction of benches on the slopes was implemented thus reducing slope lengths as well as vegetating of side slopes. To increase the erosion resistance of the side slopes, it is necessary to reduce the slope gradient as well as amend the surface conditions to increase vegetation establishment and reduce the erosive effect of both water and wind.

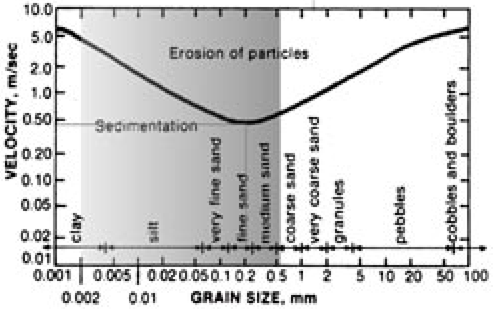
| **The following factors influence soil erosion:** | **Current practice circumstances** |
|---|---|
| Vegetation density | Negligible vegetation cover |
| Soil type | Sandy loam |
| Slope length | Approximately 12m |
| Slope gradient | 1:1,5 (33°) to 1:3 (18,5°) |
| Frequency and intensity of rainfall events (Marsh 1991) | Dependent on region |
| | (Chamber of Mines of South Africa 1996) |

## EROSIVE POTENTIAL

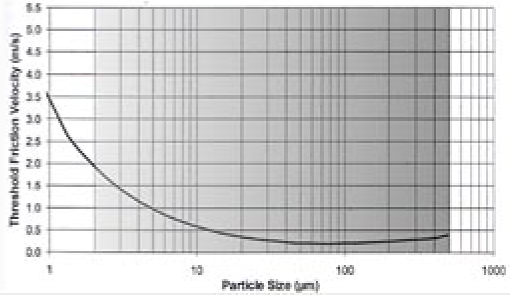
Losses from unprotected slopes of gold tailings in South Africa of over 500 tons/ha/year are quite common, while vegetated slopes can reduce erosion rates to 200 tons/ha/year. These results are due to both wind and water forces.

It is apparent that the sand fraction's erosion threshold gives away at the lowest flow velocities (water erosion), giving it the highest erosion potential. This is of great concern as the outer slopes consist mostly of the sand fraction and is also the material most exposed to the erosive forces of water. Due to a higher resistance to dislodgement as a result of water movement, waste rock is often placed on outer slopes to reduce erosion.

The threshold wind friction velocity is defined as "...the minimum friction velocity required to initiate particle motion" (Scorgie & Randell 2001). Particles with a diameter of <60µm requires an increasingly high threshold friction velocity to be dislodged due to the increasingly strong cohesion forces connecting the particles. Consequently, the outer slopes are subject to high wind erosion due the low threshold level of the particles.



(27) WATER EROSION THRESHOLD VELOCITIES (MARSH 1991)



(28) WIND EROSION THRESHOLD VELOCITIES (SCORGIE & RANDELL 2001)

### Toxic leaching potential

A composite sample of the tailings was tested at Lakefield Research in Johannesburg for the following analysis:

- Acid Base Accounting (ABA)
- South African Acid Rain Test (SAAR)
- Toxicity Characteristic Leaching Procedure (TCLP)
- Total Digest
- 10% aqueous solution (Hudson 2002)

The results indicates that the material is likely to be non-acid generating. It must be noted that a risk factor does exist as a single sample laboratory test would not be sufficient and comprehensive enough to assess the potential of ARD over a longer time period. The potential is likely to be of a low level but appropriate measures should be implemented to monitor and treat if necessary (*ibid*).

The TCLP results indicates that some of the metals present in the tailings could be released into the environment in mildly acidic conditions. Of particular note is chrome III, chrome VI, manganese and zirconium, copper and iron.

29 SOLUTION TRENCH CONVEYING CONTAMINATED WATER

30 SULPHATE PRECIPITATION FROM TAILINGS

### The formation of Acid Rock Drainage (ARD)

The formation of ARD is primarily a function of the geology, hydrology and mining technology employed for the mine site. AMD is formed by a series of complex geo-chemical and microbial reactions that occur when water comes in contact with pyrite (iron disulfide minerals) in the overburden of a mine operation. The resulting water is usually high in acidity and dissolved metals. The metals stay dissolved in solution until the pH raises to a level where precipitation occurs. (DEP 1996)

### Treatment of AMD

Chemical treatment / Active treatment

Acidity is buffered by the addition of alkaline chemicals such as calcium carbonate, sodium hydroxide, sodium bicarbonate or anhydrous ammonia. These chemicals raise the pH to acceptable levels and decrease the solubility of dissolved metals. These chemicals are expensive and the treatment system requires additional costs associated with operation and maintenance as well as the disposal of metal-laden sludge (*ibid*).

Passive treatment

The concept behind passive treatment is to allow the natural occurring chemical and biological reactions that aid in AMD treatment to occur in a controlled and managed environment, and not releasing it in the receiving environment before satisfactory results is achieved. Passive treatment offers many advantages over active treatment systems. Virtually no chemical additions and energy consuming treatment processes is needed, thus reducing cost. Also, operation and maintenance requirements is considerably less than for active treatment systems (*ibid*).

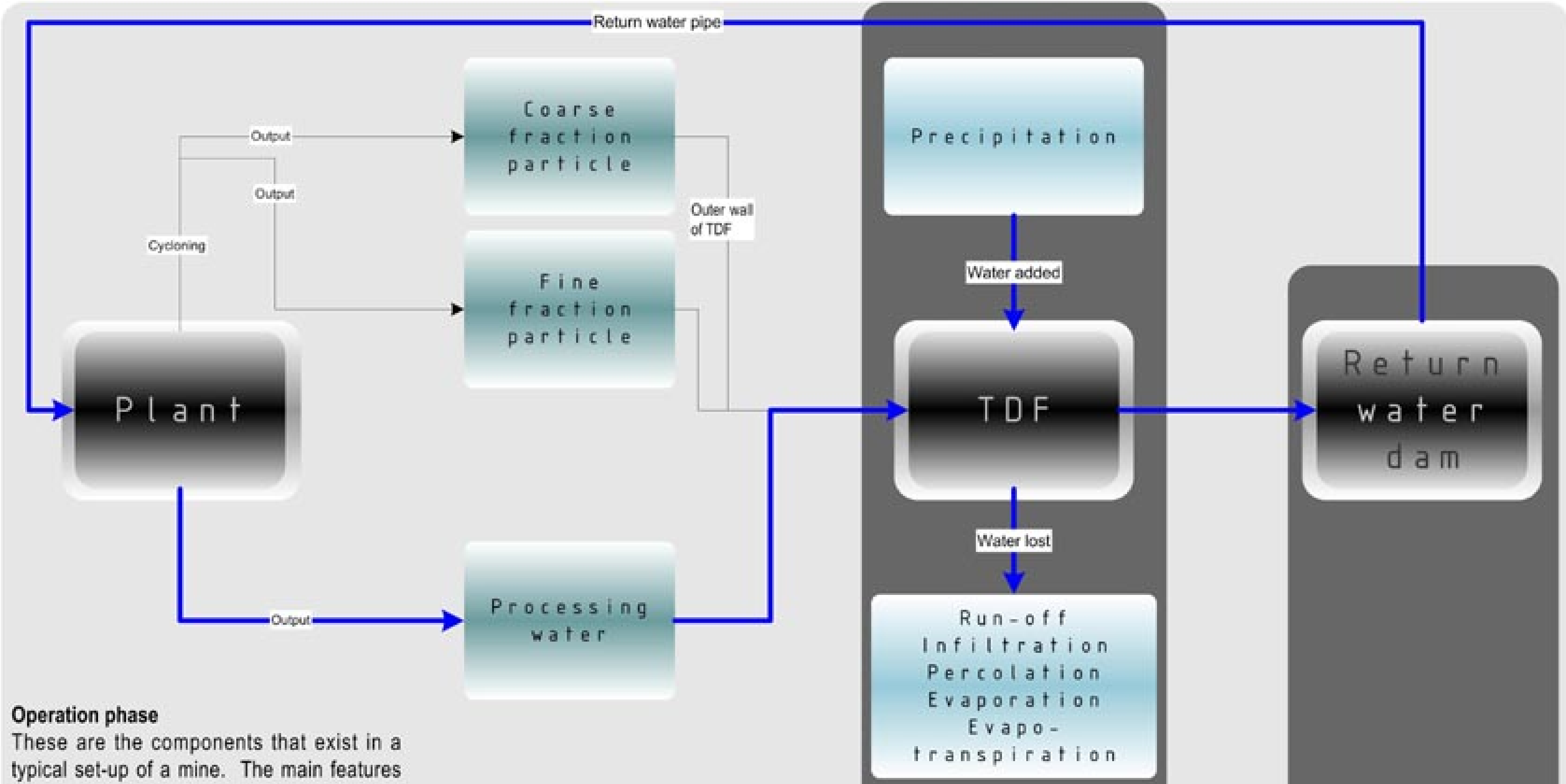
Passive treatment alternatives include the following systems:

- Aerobic wetlands
- Compost and anaerobic wetlands
- Open limestone channels
- Diversion wells
- Anoxic limestone drain
- Vertical flow reactors
- Pyrolusite® process (*ibid*)

In many cases a combination of a few of the above alternatives can be applied, depending on the significance of pollution.

# PATH OF WATER THROUGH A TYPICAL PLATINUM PLANT

(fig $^3$31)



Return water pipe

Output

Output

Cycloning

Coarse fraction particle

Fine fraction particle

Outer wall of TDF

Plant

Output

Processing water

Precipitation

Water added

TDF

Water lost

Run-off
Infiltration
Percolation
Evaporation
Evapo-transpiration

Return water dam

**Operation phase**
These are the components that exist in a typical set-up of a mine. The main features described in this study, are the plant, TDF and return water dam. The plant and any other associated infrastructure are disassembled subsequent to decommissioning and removed off the site. The TDF and return water dam are the only elements that are permanent and are subject to rehabilitation according to legislation.

A normal ring-dyke impoundment construction makes use of the coarse fraction of the tailings to build the impoundment wall. The fine fraction and water are deposited within these constructed envelopes. The separation of the fractions occur via cycloning.

**Post-closure phase**
The TDF and associated waste rock dumps are all that's left of the original system, after decommissioning of the plant. The TDF should now function as a safe and stable, independent and self-sustaining landform, free of long-term maintenance. The TDF should be able to uphold an ecology that is regenerative in its nature and support life.

The rehabilitated system should be able to operate following the withdrawal of water from the plant. The only water supplementing the system is from precipitation.

**Post-closure phase**
The return water dam can either be demolished or function as an integrated element in the normal hydrological cycle of the site. If the decision requires it to fulfill a long-term role, it should be designed appropriately, prior to the operational phase.

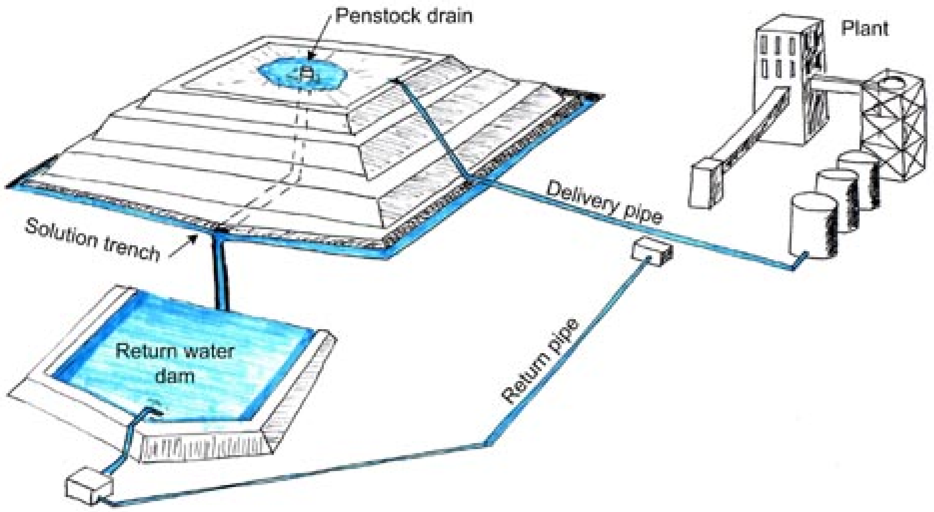
**Water addition:**

***Plant*** - Water from the operation plant is the greatest percentage of water added to the system. The volume is dependent on the rate of deposition and the water concentration in the tailings.
***Precipitation*** - In the Rustenburg area, average rainfall ranges from 630mm - 740mm annually.

**Water loss**:

***Runoff*** - The system is designed to dispose of surface water off the TDF as quick as possible. Surface water can potentially cause erosion gullies as well as increase the phreatic surface to hazardous levels
***Infiltration*** - Infiltration is usually discourage to reduce the risk of instability or subsequent failure due to a raised phreatic surface
***Evaporation*** - Mean evaporation rates in the Rustenburg area is approximately 5.6mm per day resulting in higher evaporation rates than precipitation rates. Evaporation results in a loss of recyclable operation water thus increasing the demand for additional water. Surface water is encourage to evaporate by the use of a paddock system.
***Percolation*** - Contaminated water is lost to the natural groundwater aquifer. The presence of a natural or synthetic liner reduces percolation.
***Evapo-transpiration*** - Evapo-transpiration from a TDF is negligible due to the absence of vegetation
***Internal drainage*** - Penstock drains decant water from the top surface and blanket drains drain internal seepage water. Water is conveyed via a solution trench to the return water dam

32 ILLUSTRATION OF AN OPERATIONAL DISPOSAL SYSTEM



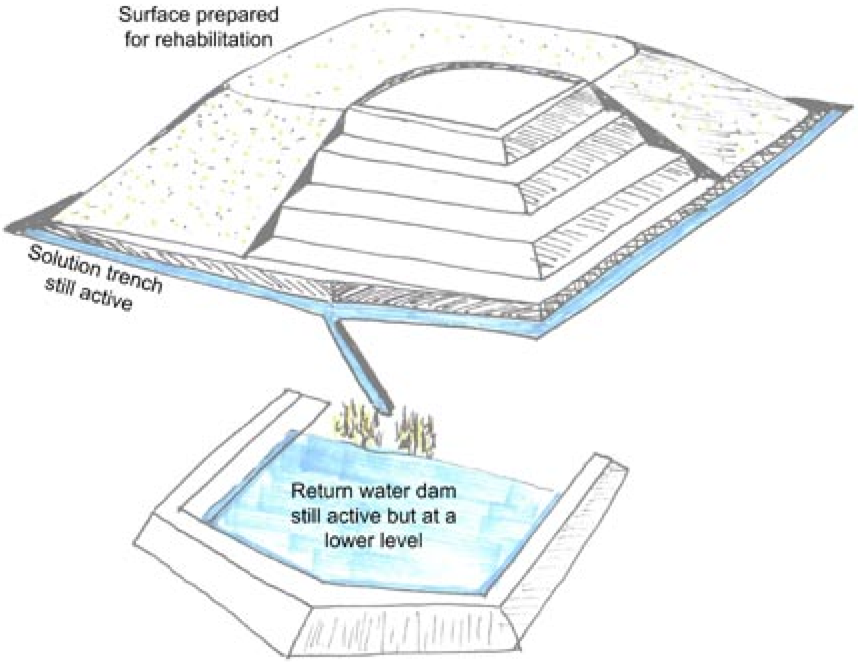
**Water addition:**

***Plant*** - Water addition from the plant has ceased due the decommissioning of the mine
***Precipitation*** - Precipitation stays constant in the 630mm - 740mm per year range with isolated hazardous storm events

**Water loss:**

***Runoff*** - Water retention should occur in the root zone to improve vegetation establishment. Runoff is encouraged to be absorbed and retained in the top layer instead of causing possible erosion gullies
***Infiltration*** - Infiltration should only occur in the top layer. Too much infiltration will raise the phreatic surface and jeopordise safety and stability of the TDF. This principle is a store- and-release approach
***Evaporation*** - Evaporation stays high and the aim is to establish a cover as fast as possible to reduce evaporation to an acceptable level and stabilise the surface
***Percolation*** - Percolation decreases due to the decline of water addition to the whole system after decommissioning
***Evapo-transpiration*** - Evapo-transpiration becomes significant when the whole surface is vegetated. Too little water in the system will cause stress on the vegetation and subsequent poor surface stabilisation
***Internal drainage*** - Internal drainage is still active in order to lower the phreatic surface to a safe level. Rates at which a phreatic surface in a dam subsides have been observed to be as low as 0.3m per year (Chamber of Mines of South Africa 1996)

33 ILLUSTRATION OF A REHABILITATED TDF



TYPICAL SYSTEM ELEMENTS
SLOPE AND PROFILE ANALYSIS
SLOPE CONFIGURATION
DEPOSITION METHODS
TAILINGS CHARACTERISTICS
WATER BALANCE
VISUAL PERCEPTION

D&C
OPERATIONAL PHASE
CLOSURE PHASE
POST-CLOSURE PHASE
DESIGN AND CONSTRUCTION

**Water addition:**

***Precipitation*** - Precipitation stays constant in the 630mm - 740mm per year range. Maximum recorded annual rainfall - 1206mm. Abnormal rain events can cause severe damage to the surface especially when vegetation cover is still immature and drainage systems are insufficient.

**Water loss**:

***Runoff*** - Runoff is often still high due to steep side slopes and poor vegetation cover, causing erosion gullies. The sediment that is lost during erosion, collects in the solution trenches and subsequently silts up the return water dam. In most cases gullies also occur adjacent to the TDF and return water dam

***Infiltration*** - Infiltration is dependent on the absorption capability of the surface material. Steep slopes impede infiltration and increase runoff. A rough surface cover and dense vegetation cover encourages infiltration

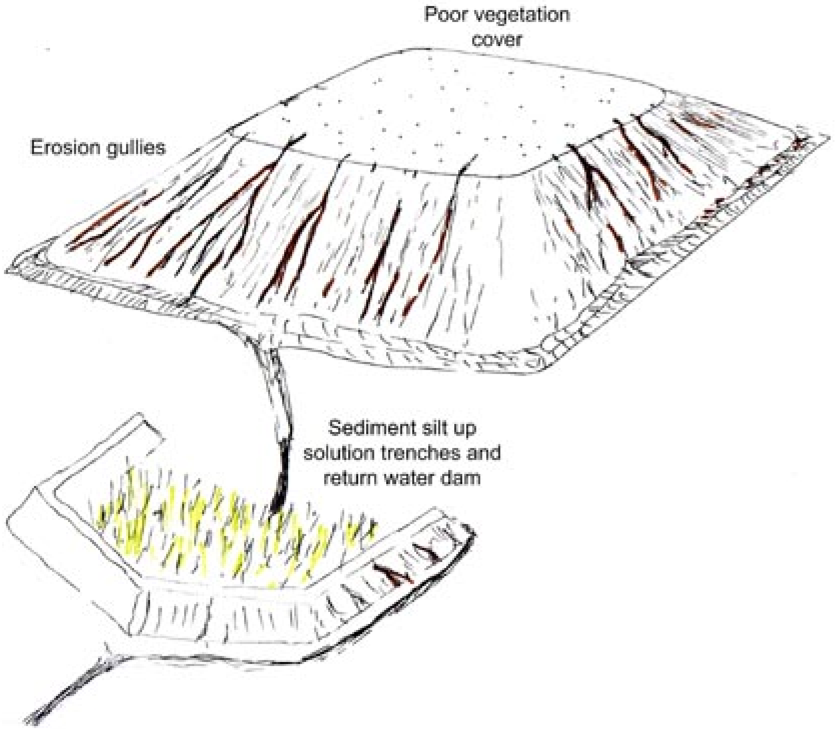
***Evaporation*** - A bare surface has a great evaporation rate. A mulch layer or vegetation cover reduces evaporation

***Percolation*** - Percolation will stabilise at some point when the water table has stabilised

***Evapo-transpiration*** - Evapo-transpiration directly correlates with vegetation cover. Water that is not taken up by plants, either evaporates, infiltrates or are disposed via runoff

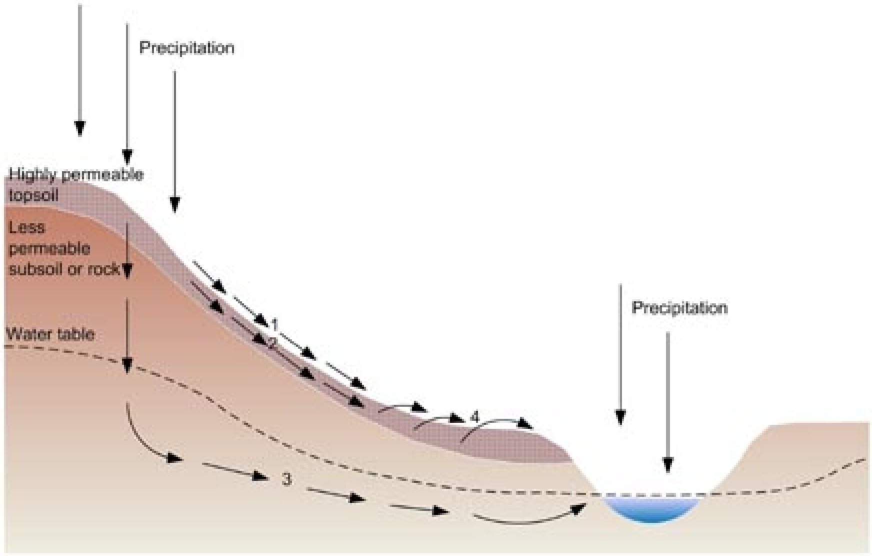
***Internal drainage*** - The internal drainage system will stay active until it is sealed or when it automatically clogs up

34 ILLUSTRATION OF POST-CLOSURE SCENARIO



# WATER BALANCE IN A NATURAL SYSTEM

35 POSSIBLE PATHWAYS OF WATER MOVING DOWNHILL (ADOPTED FROM DUNNE&LEOPOLD 1978)



**Water balance in the Rustenburg Region** (fig 3-36)

Average annual rainfall: 630-740mm
Maximum annual rainfall recorded: 1206mm
Evaporation rate: 7mm per day
infiltration rate: sandy loam = 25 mm/hr
Surface runoff: Q=A*C*I
Percolation: k-factor for material
Evapo-transpiration rate: dependent on vegetation cover & species

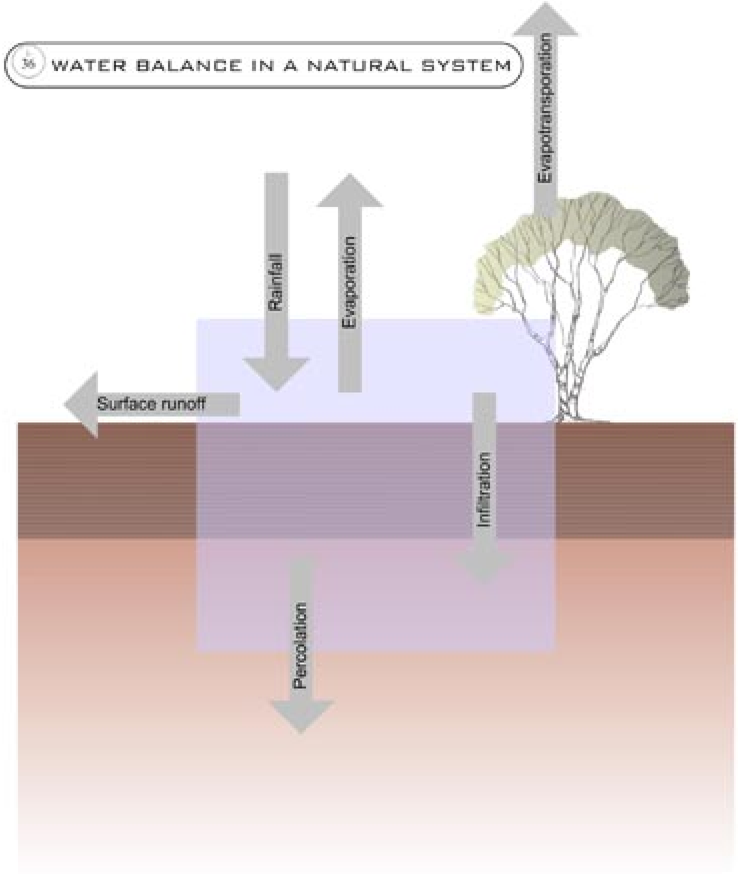
In a stable natural system, an equilibrium is achieved between water received and water lost. This equilibrium is essential for sustaining healthy vegetation growth, an equilibrium not often achieved on re-vegetated TDFs. The challenge lie in providing a topsoil layer capable of absorbing water, releasing it as the demand increase.

**Possible pathsways of water moving downhill** (fig 3-35)

| | |
|---|---|
| Path 1: | Overland flow |
| Path 2: | Shallow sub-surface storm flow |
| Path 3: | Ground water flow |
| Path 4: | Saturated overland flow composed of direct precipitation in the saturated area plus infiltrated water that returns to the ground surface (From Dunne & Leopold 1978) |

The obvious aim is to reduce as much runoff as possible and subsequent loss to the system as well as increase infiltration in the topsoil layer. This can be achieved by applying a cover to increase surface roughness. This cover can be a stone mulch, vegetation or any organic mulch.

36 WATER BALANCE IN A NATURAL SYSTEM



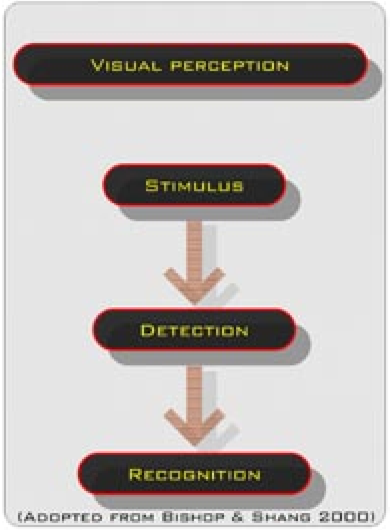
## Introduction

The author was involved in a study concerning the visual perception of TDF's in the South African context. It forms part of a PhD degree study currently undertaken by Mr. Brain Rademeyer under endorsement of the University of Pretoria, Department of Bio-systems and Civil Engineering in collaboration with the Department of Architecture, Landscape Architecture and Interior Architecture.

The study is concerned with the visual perception of tailings impoundments as landforms. This research is aimed at the determination of critical threshold distances where a tailings impoundment landform is visually perceived as a natural landform after applying mitigation. The effectiveness of mitigation will be evaluated according to its capability to merge the landform with its environment and to reduce the viewer-distance of *recognition* as a tailings impoundment within the landscape.

Once this is established it could be argued that the zones of *recognition* will also be the outer limit of the zone of influence, i.e. the negative visual impact zone. The inclosing zone of negative visual impact could potentially sterilise the land of uses such as tourism, residential or agriculture. It is further postulated that the assessment of the change in land-use will disclose a quantitative monetary value of the visual impact.

3-37 VISUAL PERCEPTION



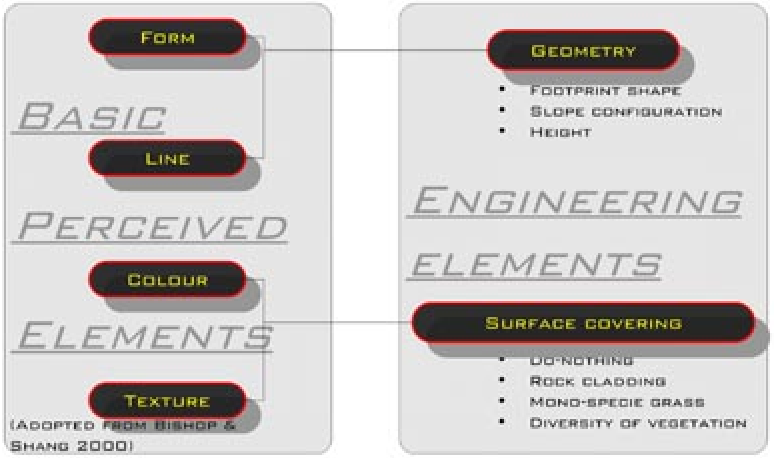
(ADOPTED FROM BISHOP & SHANG 2000)

## Visual perception

Humans are dependent on senses to attain awareness from their environment. The smell, taste and tactile senses are utilised in conjunction with the others to familiarise ourselves with our immediate surroundings. Our visual and auditory senses are much more developed and are capable of perceiving both immediate and distant environments.

Our senses are rarely used in isolation, but in some cases we deliberately rely on our visual sense to make reason of what is perceived (Bell 1999), due to the fact that the other senses are incapable of adding clarity to the perceived element/s. This usually happens when distance between the observer and the observed element/s is so great that information gained by the other senses become redundant due to their lack of competence in this particular instance. In this case we rely purely on our visual sense to acquire the necessary information needed to recognise the element/s.

3-38 BASIC PERCEIVED ELEMENTS



(ADOPTED FROM BISHOP & SHANG 2000)

The sub-conscious mind progress through a series of stages when a scene is visually perceived (Bishop & Shang 2000)(fig $^{3}$-37). A scene consists of different elements, each with its own character in terms of shape, colour and texture (fig $^{3}$-38). If one focus specifically on one of the elements, for example a tree, the tree would be the stimulus in the scene.

The first stage of perception is the detection of the stimulus in its environment. It could be that the tree is undetectable due to the distance between the observer and the tree, or merely due to the lack of contrast with its environment. This is not to say that there is no stimulus, it is just not detectable.

The second stage is the recognition of the detected stimulus. If the stimulus is a familiar object, like a tree, recognition is effortlessly obtained and the sensory experience was successful. The detected stimulus was compared and matched with a similar object in the human memory.

If it was an unusual stimulus for this specific scene, it could be unrecognisable or misinterpreted. This often happens when distance becomes greater than the ability to accurately perceive a specific

TYPICAL SYSTEM ELEMENTS
SLOPE AND PROFILE ANALYSIS
SLOPE CONFIGURATION
DEPOSITION METHODS
TAILINGS CHARACTERISTICS
WATER BALANCE
VISUAL PERCEPTION

element for what it truly is. Also, the contrast-factor could be insufficient to distinguish the element from its environment. Camouflage is nothing else as the reduction in contrast to such a level that recognition and even detection is disabled. If distance is added, the effectiveness of camouflage increases, hence making the stimulus either undetectable or unrecognisable.

The quantity of information and knowledge we receive depends on the diversity and degree of contrast of the sensory data we obtain and the ability to differentiate between them (Bell 1999). If the information is too little and our curiosity is stirred, we tend to want to move closer in order to increase the level of detail, thus enhancing the probability of accurate recognition.

**Conclusion**

One can assume that by altering certain design features of a TDF, it could be possible that the TDF will be unrecognisable and thus the zone of visual influence can be reduced. If the perception is of that of a natural landform, there is no detection or recognition of the TDF for what it truly is (fig $^{3}$39). This is only possible if the TDF is designed to look and function as a natural landform. The design aspects that can be altered are the overall geometry and surface covering.

**Mitigation**

It is often relied on mitigation to reduce impacts to an acceptable standard. It is also a common miss-conception that mitigation is a remediative endeavour attempting to resolve negative impacts succeeding its detection. The true value of mitigation can only be appreciated when it is part of an iterative process during the project planning and design phases.

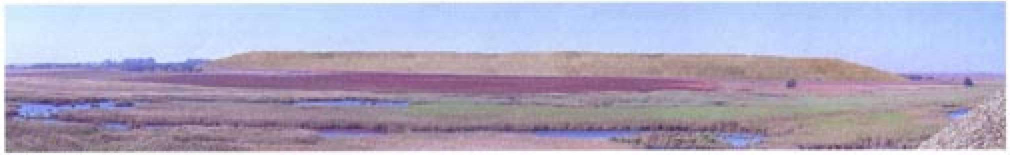
"The purpose of mitigation is to *avoid*, *reduce* and where possible *remedy* or *offset* any significant adverse effects on the environment arising from the proposed development."(Landscape Institute 2002:43)

Any development should be seen as an addition the landscape and should respect the environment in which it is placed. As it is common practice to amend negative impacts after its occurrence, it is necessary to critically assess the lifecycle of a mine and focus specifically on the planning and design phase in an attempt to avoid or reduce predicted impacts prior to occurrence.

39 VISUAL SIMULATIONS WITH DIFFERENT TEXTURES

Existing scenario
At 2km distance

Rock cover
At 2km distance



Vegetated - Mono specie grass
At 2km distance

Vegetated - Diversity of species
At 2km distance