DISPOSAL OF SEWAGE AND FAECAL SLUDGES BY BURIAL IN THE GROUND

WISA BIENNIAL CONFERENCE

28th May 2014

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PARTNERS IN DEVELOPMENT
PID
(Pty) Ltd
CONSULTING ENGINEERS & PROJECT MANAGERS

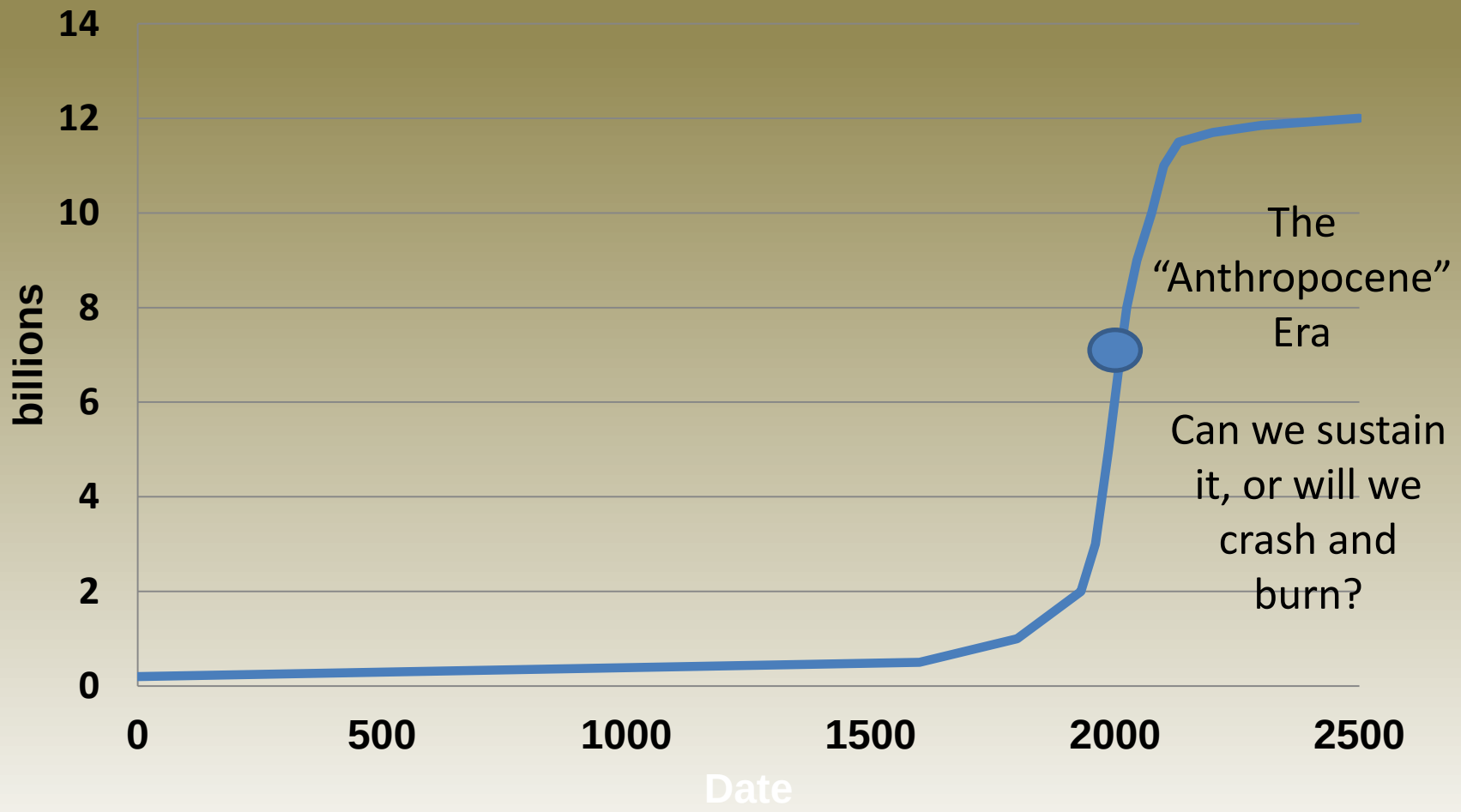
WATER RESEARCH COMMISSION

Disposal of sludge by burial – research questions

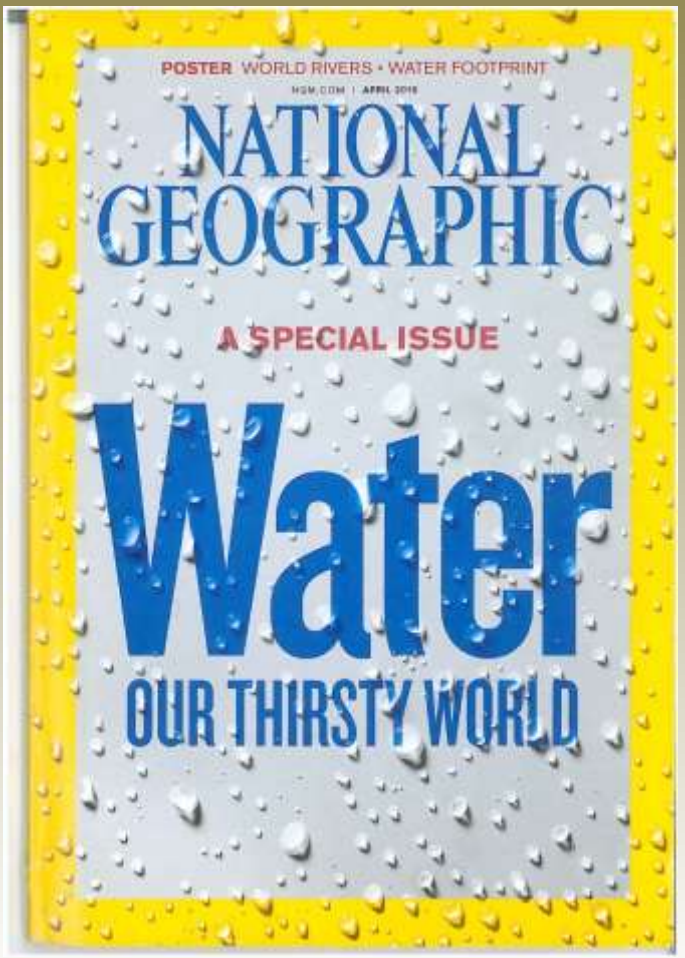
- Has this method of sludge disposal been tried before?
- What is the fate of pathogens which are buried in the ground?
- How does sludge change after it is buried in the ground?
- What is the fate of the nutrients in the sludge after it is buried in the ground?
- How should one go about burying sludge in the ground and what will this cost?
- Can one make use of the nutrients in the buried sludge, and what might such use be worth?
- What are the alternatives to this method of sludge disposal, and what do such methods cost?
- If one wishes to use this method for sludge disposal, how should one go about acquiring authorisation from the relevant authorities?

The demographic transition

World population in billions



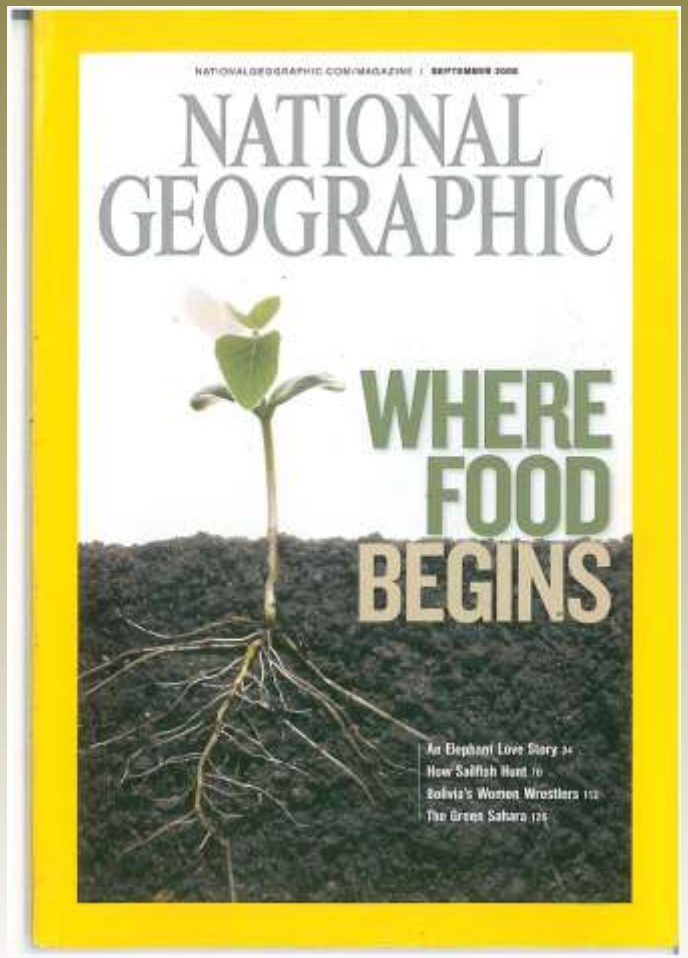
What do you need to feed the world?



70% of the world's fresh water resources are already used for agriculture

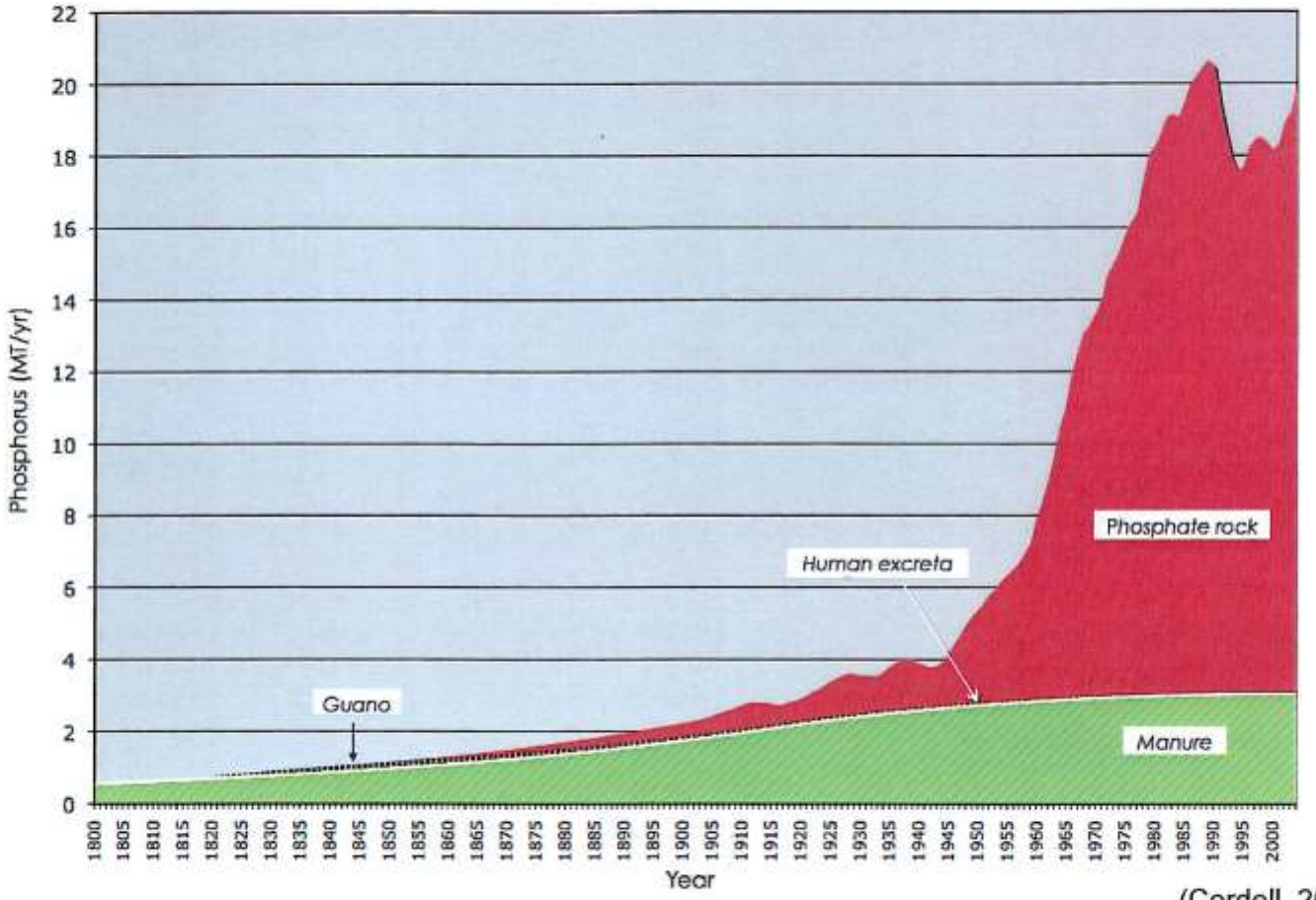
Without using energy, we can't make more of it

What do you need to feed the world?

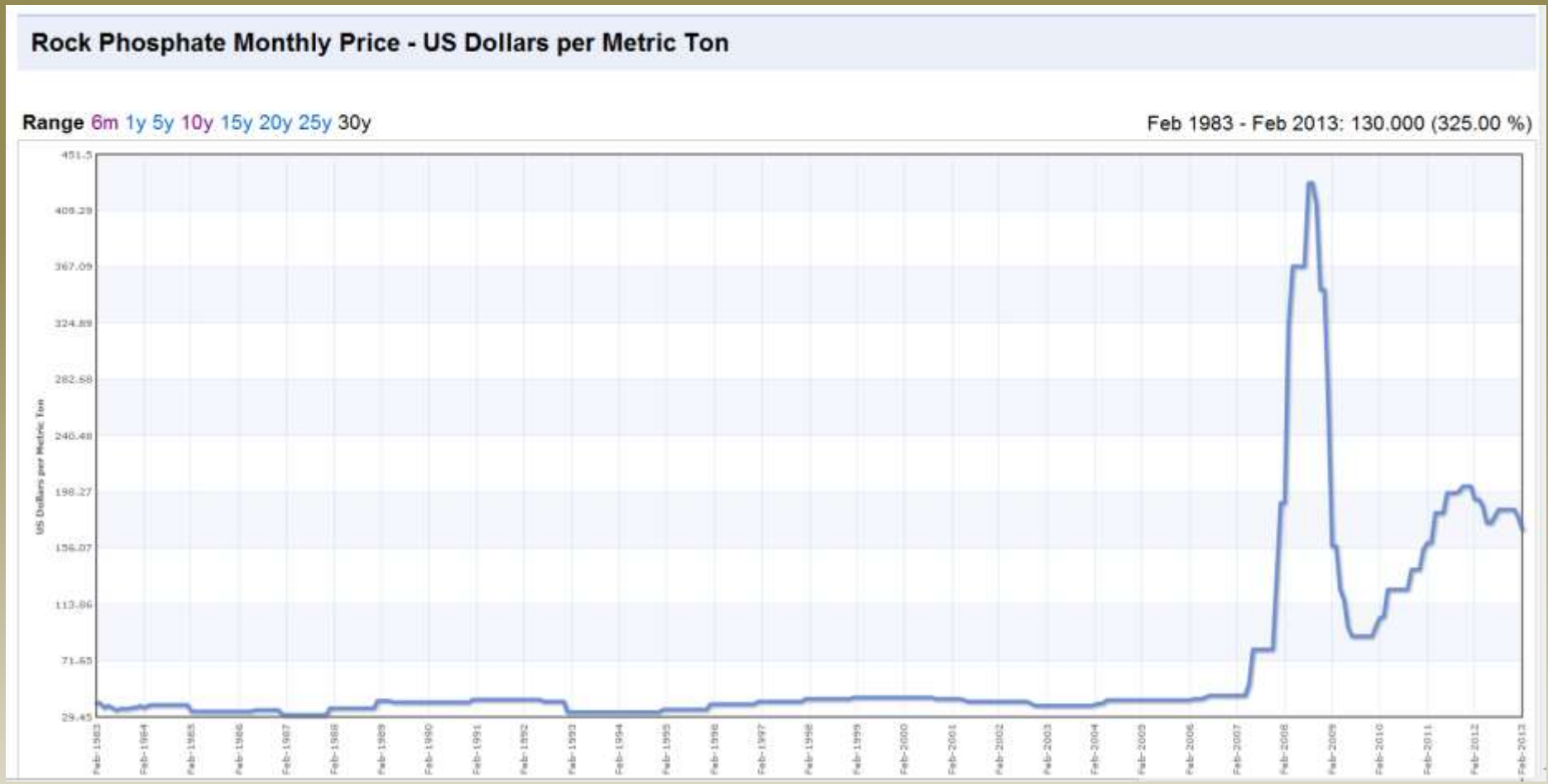


Soil is where food begins – to grow food you need healthy soil with nutrients

Historical global sources of phosphorus fertilizers (1800-2000)



(Cordell, 2009)



ROCK PHOSPHATE PRICE

1983 30 – 40 USD/tonne

2008 420 USD/tonne

2013 170 USD/tonne

How long will our known phosphate rock reserves last?

- **172 years projecting current trends**
- **126 years assuming rising standards of living (esp. Africa)**
- **48 years if world obtains 10% of energy supply from biofuel**

Human excreta – a neglected treasure!

N = 2,8 kg
P = 0,4 kg
K ~ 1,3 kg
Per person
per year

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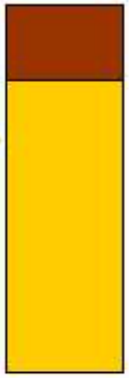
P = 0,4 kg
K ~ 1,3 kg
Per person
per year



≈

Urea = 6 kg
TSP = 2 kg
KCL ~ 2,6 kg

Enough fertiliser for 300-400 m^2 of crops

Options for sludge disposal

- Landfill
- Irrigation
- Pelletisation
- Co-composting with organic matter
- Shallow burial – soil conditioning

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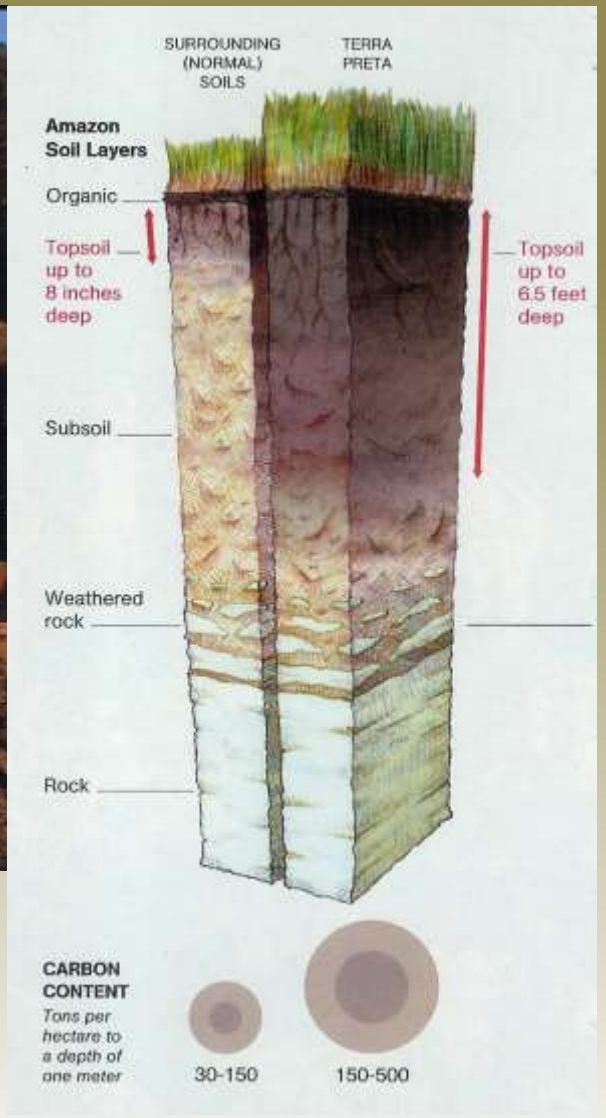
Pelletizing pit sludge - Durban

Fertilizer value from human waste

- **Organic fertilizer retails for R10/kg**
- **Fertilizer value in pellets from eThekwini pits is approx 1/3 compared with commercial organic fertilizer, but ratios NPK not optimal**
- **Conservatively work on R1 per dry kg, then the fertilizer value per full VIP is approx. R1 000 (compare value of a bakkie load of kraal manure)**
- **If 5 000 VIPs are being filled per annum, the fertilizer value is approx. R5 million**
- **Cost to produce pellets is 3 x fertilizer value**



Tera Preta Soils – Amazon basin, use of domestic waste to enrich soils practiced for thousands of years

Pit emptying is not so bad when the sludge is matured

Sludge – close up.

Sludge burial research site - Umlazi

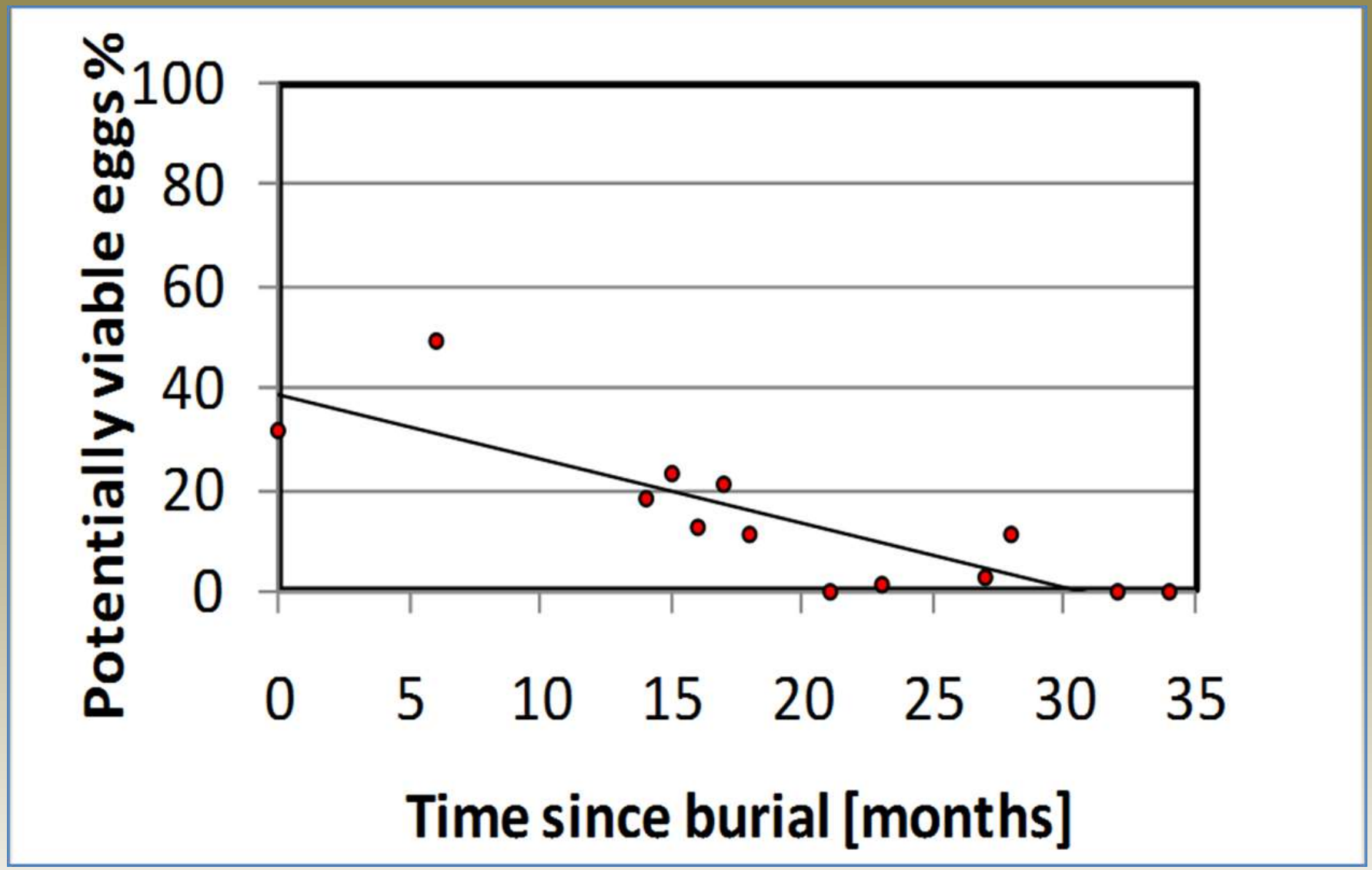

Umlazi Trial
– sludge
burial Jan
2009

26 January 2012 –
three years after planting


Sludge January 2013

Monitoring of groundwater

- E-coli
- Heterotrophic plate count
- Nitrate
- Ammonium
- Chloride
- Sodium
- Conductivity
- Chemical Oxygen Demand



Fate of pathogens after burial

Controlled trials at UKZN – after 6 months
Tree on left irrigated with fertiliser, tree on right planted over core of sludge

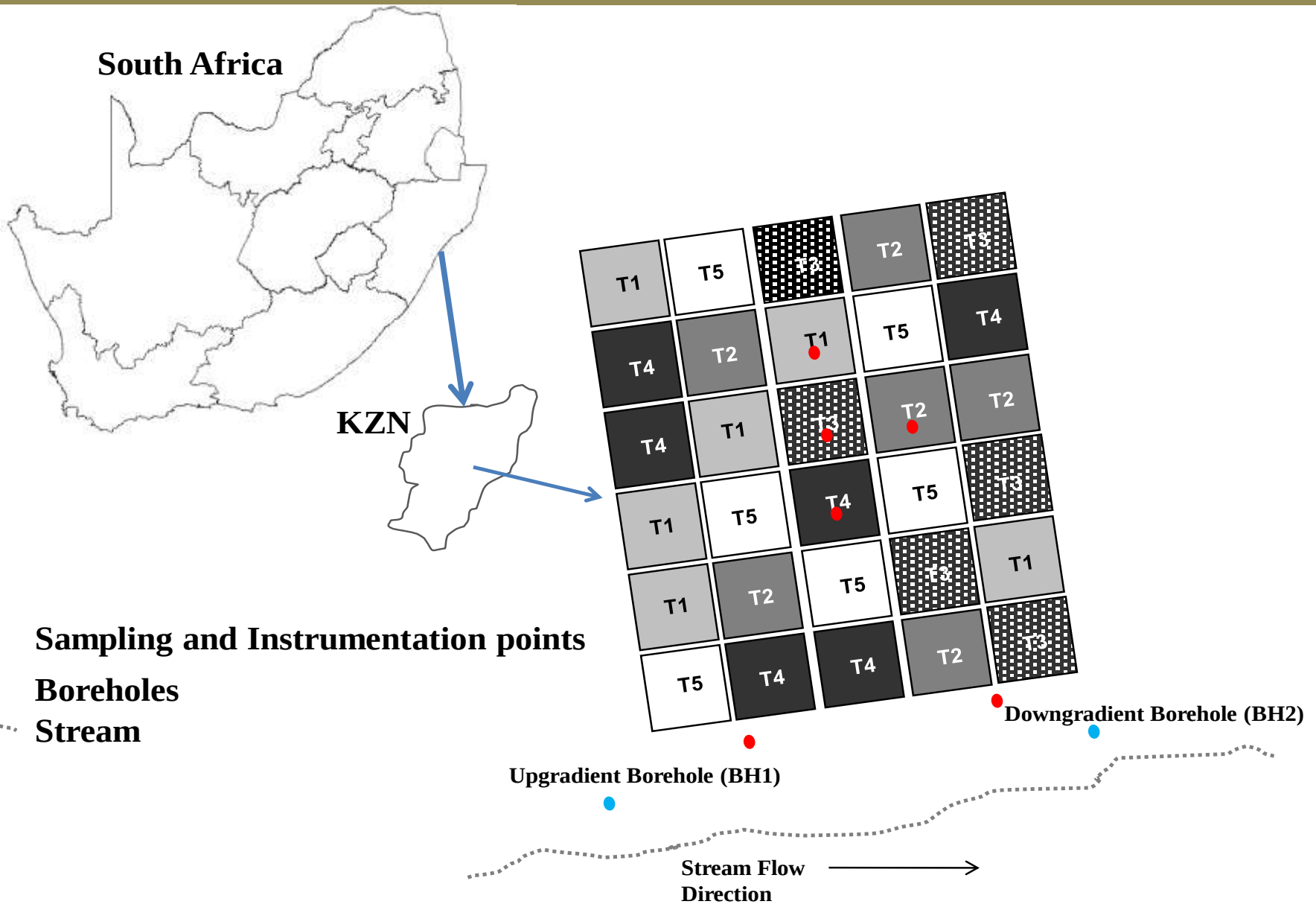
Do the tree roots avoid the sludge?

Controlled tower trial with VIP sludge, after 6 months

Sappi site

10 km west of Howick on Karkloof rd


PLANT HIRE
346 2111
220


South Africa
KZN
T1
T5
T3
T2
T3
T4
T2
T1
T5
T4
T4
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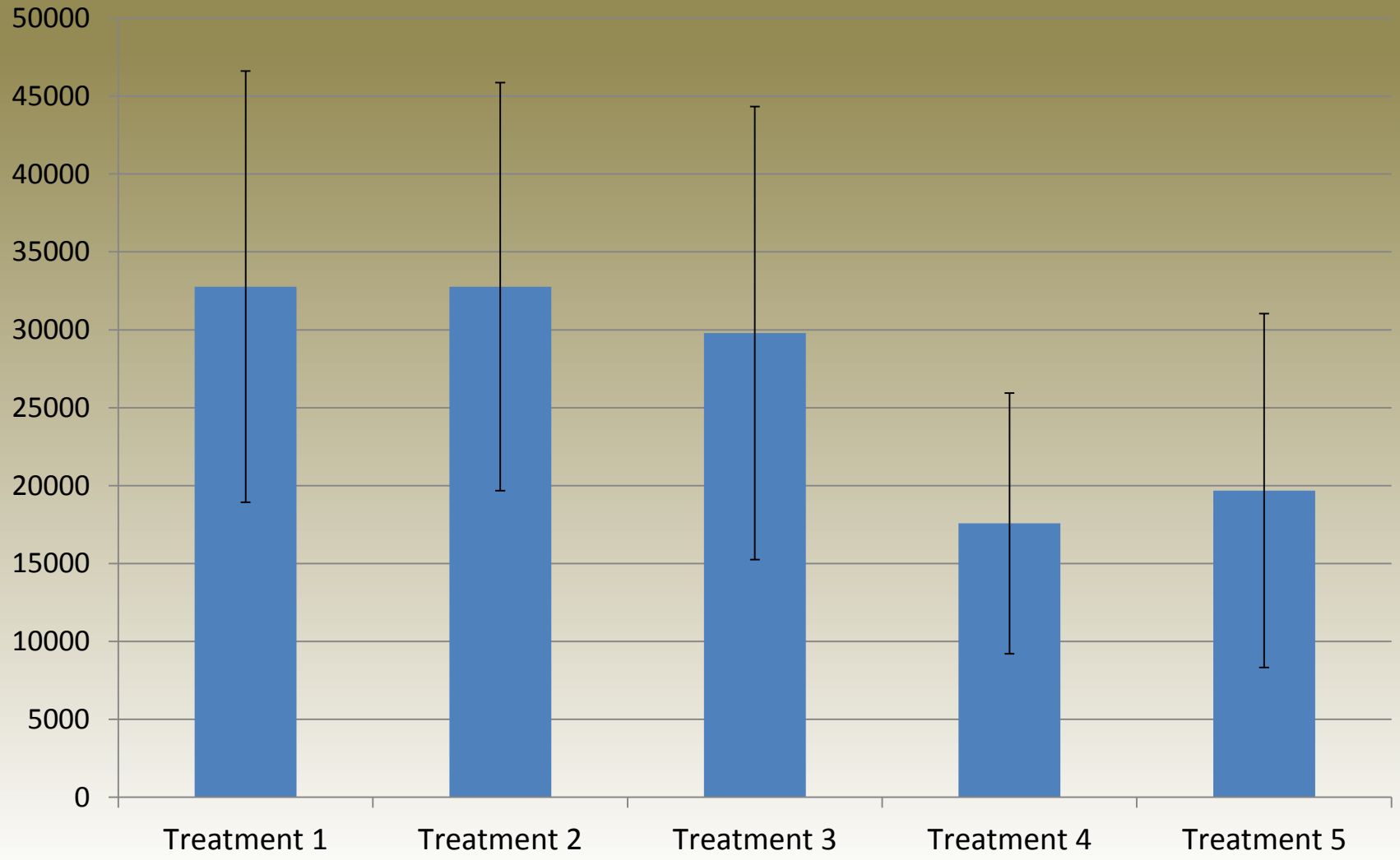
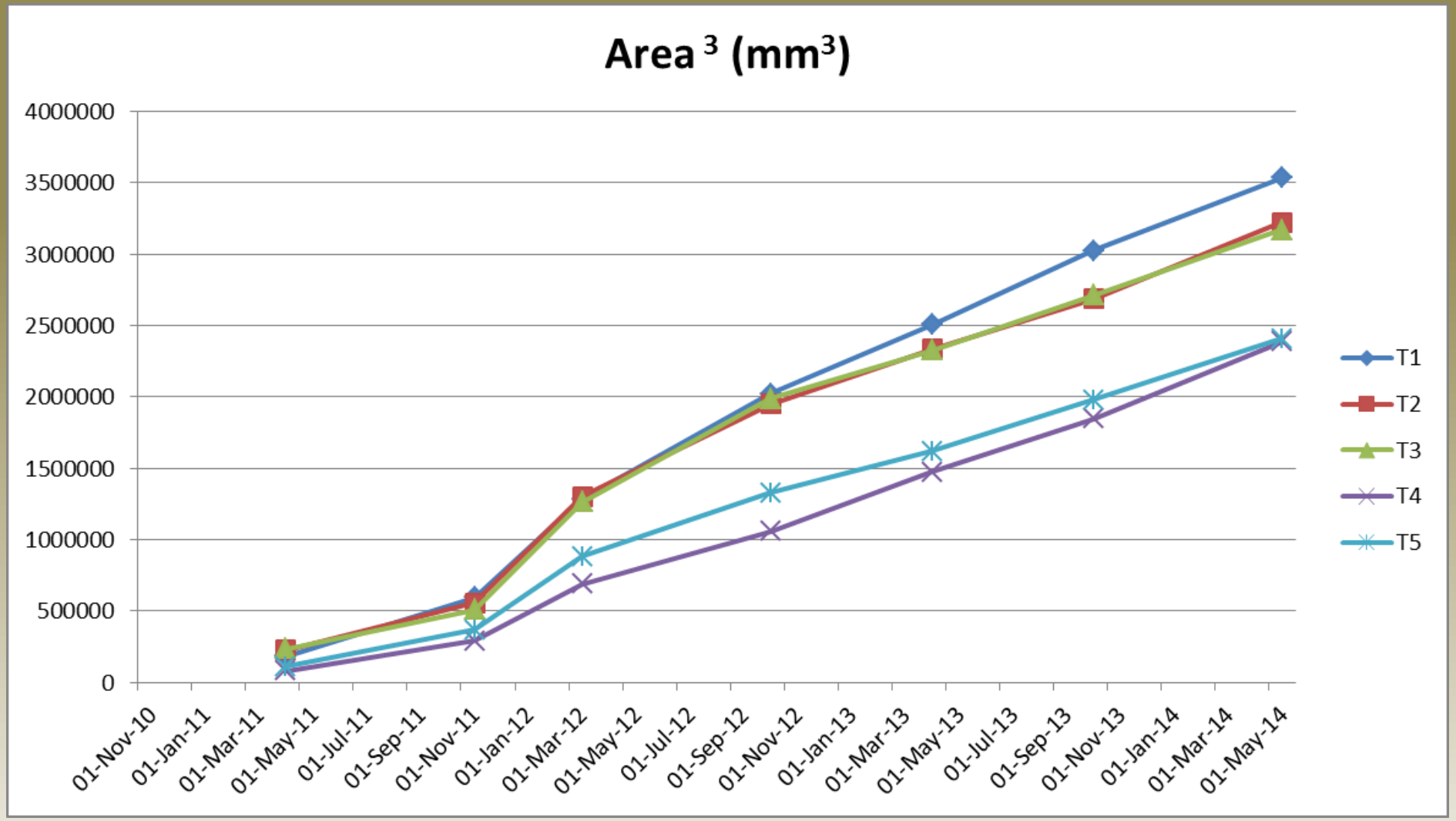
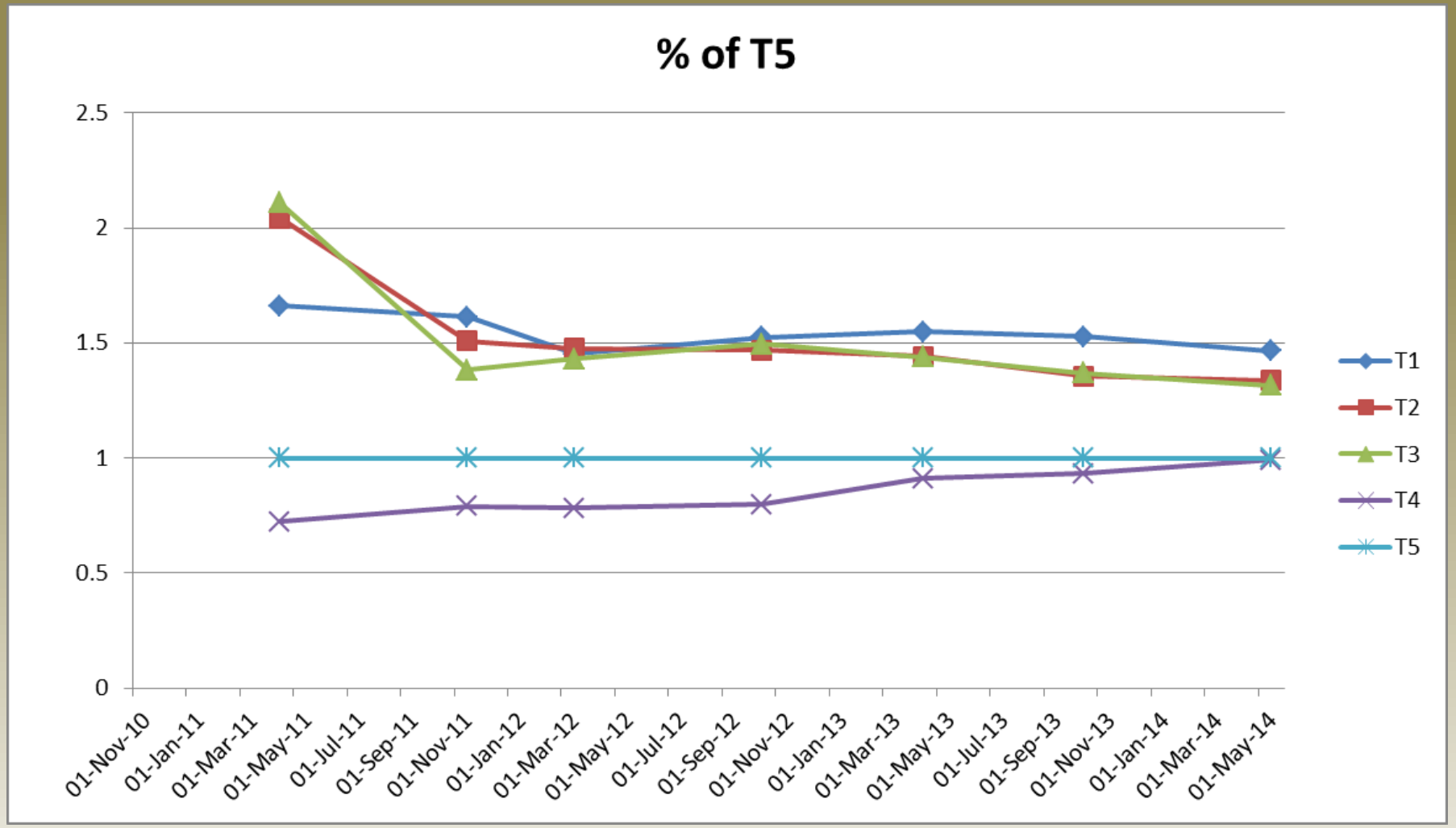
T3
T2
T2
T1
T5
T4
T5
T3
T1
T5
T2
T5
T3
T1
T5
T4
T4
T2
T3
Sampling and Instrumentation points
Boreholes
Stream
Downgradient Borehole (BH2)
Upgradient Borehole (BH1)
Stream Flow Direction

Relative Volumes for different treatment methods, including dead trees

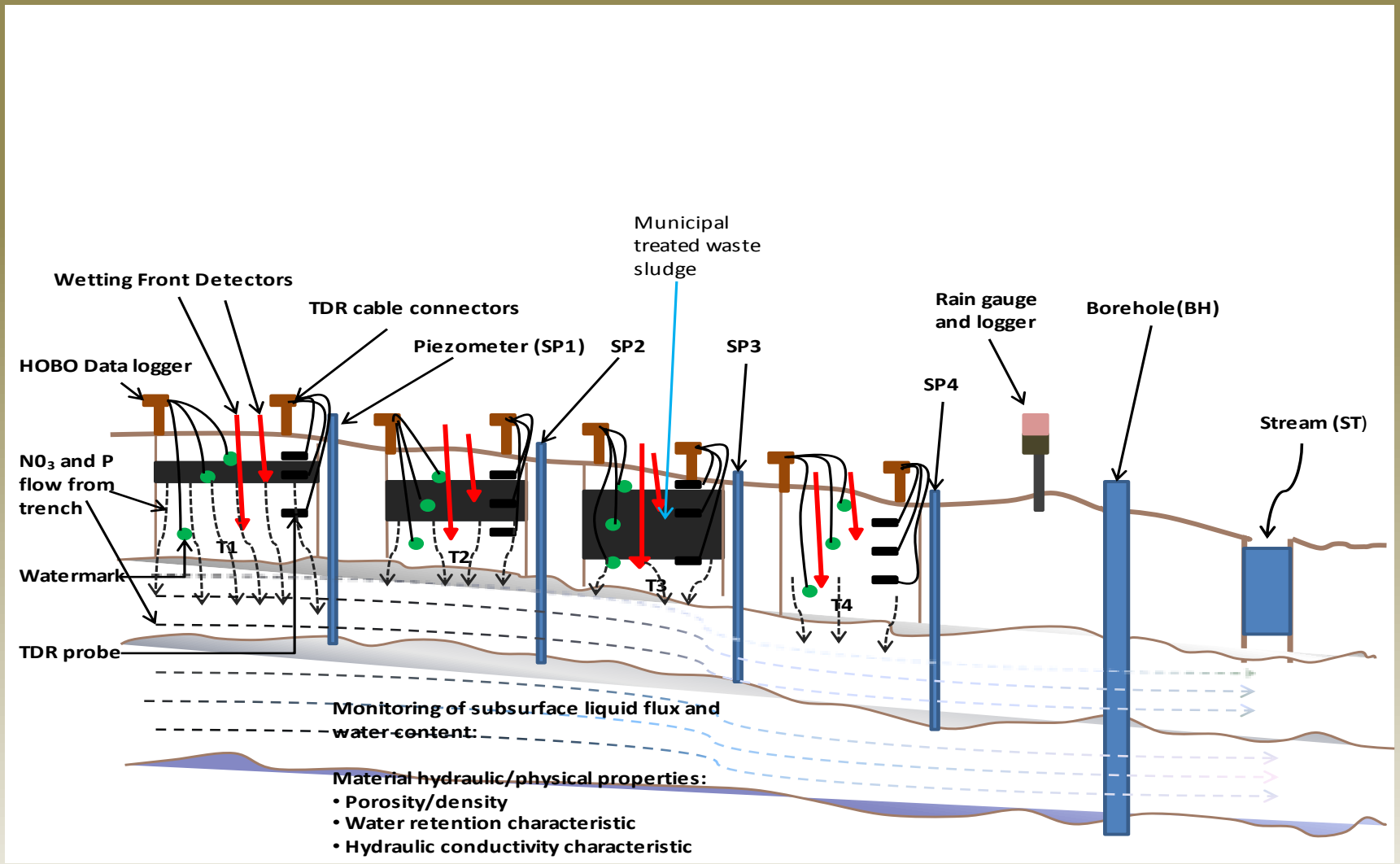


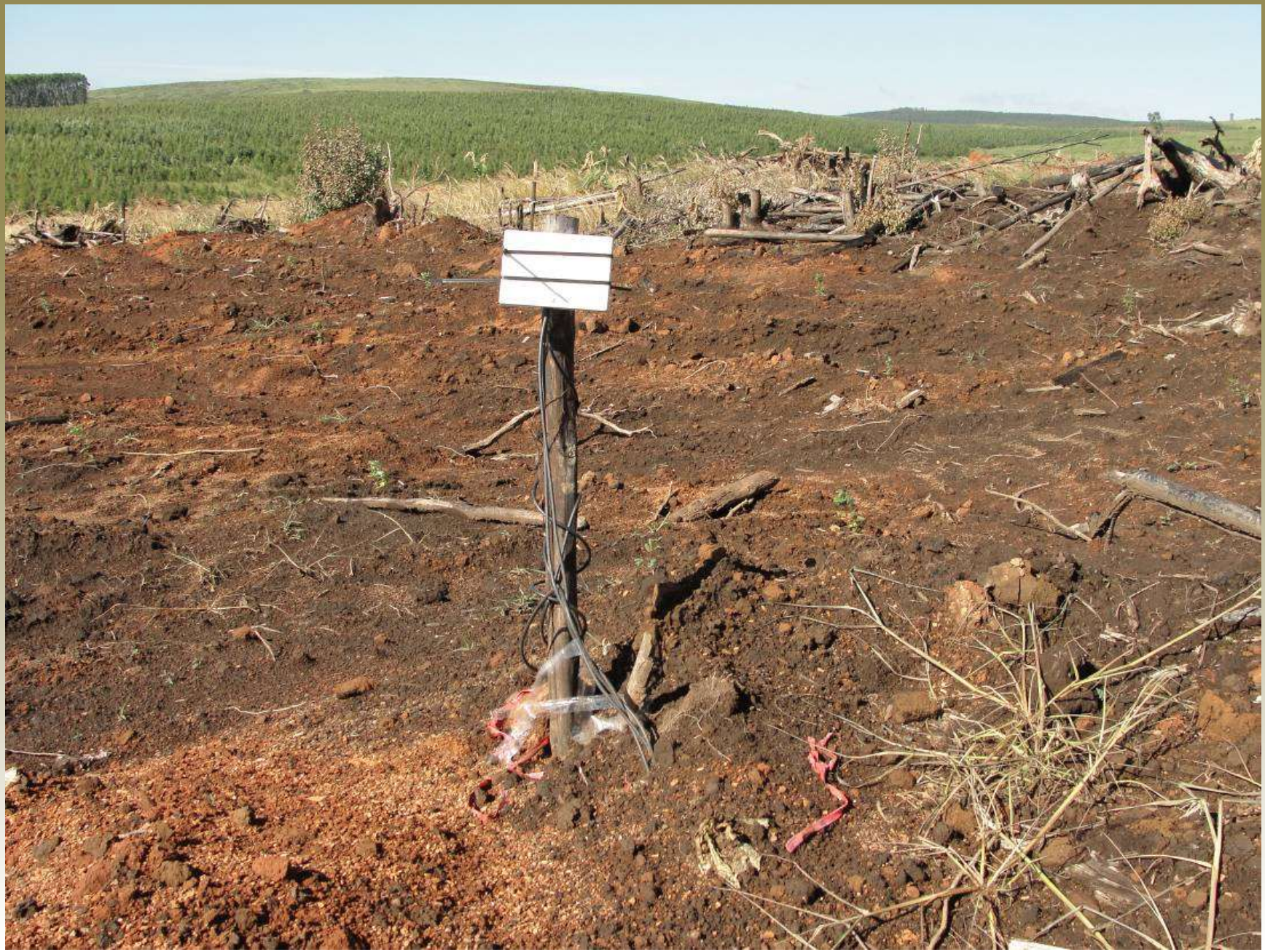


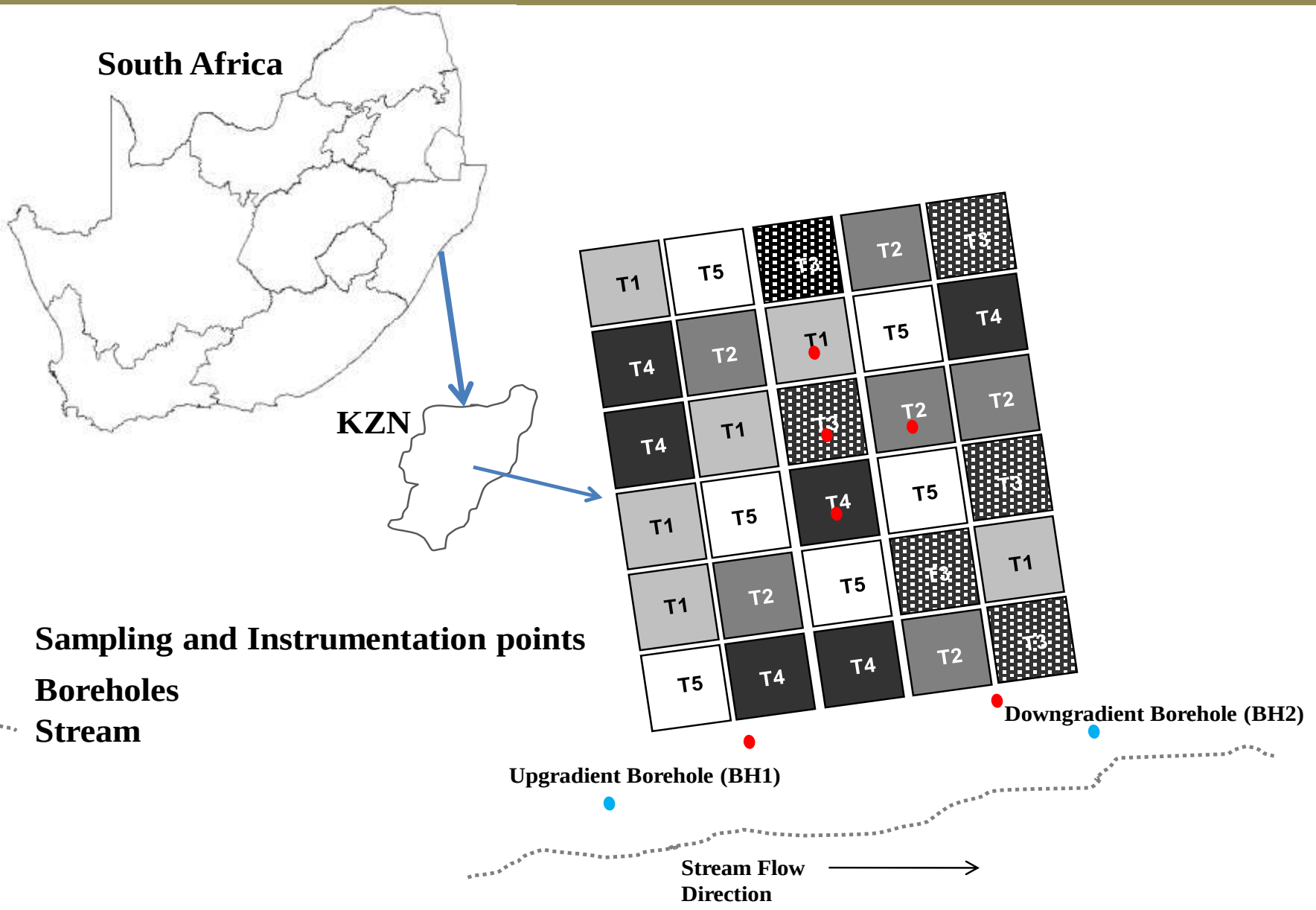
Relative change in tree volume over time



Comparative change in tree volume over time


Municipal
treated waste
sludge
Wetting Front Detectors
TDR cable connectors
Piezometer (SP1)
SP2
SP3
Rain gauge
and logger
Borehole(BH)
HOBO Data logger
SP4
Stream (ST)
N0$_3$ and P
flow from
trench
T1
T2
T3
T4
Watermark
TDR probe
Monitoring of subsurface liquid flux and
water content:
Material hydraulic/physical properties:
• Porosity/density
• Water retention characteristic
• Hydraulic conductivity characteristic




South Africa
KZN
T1
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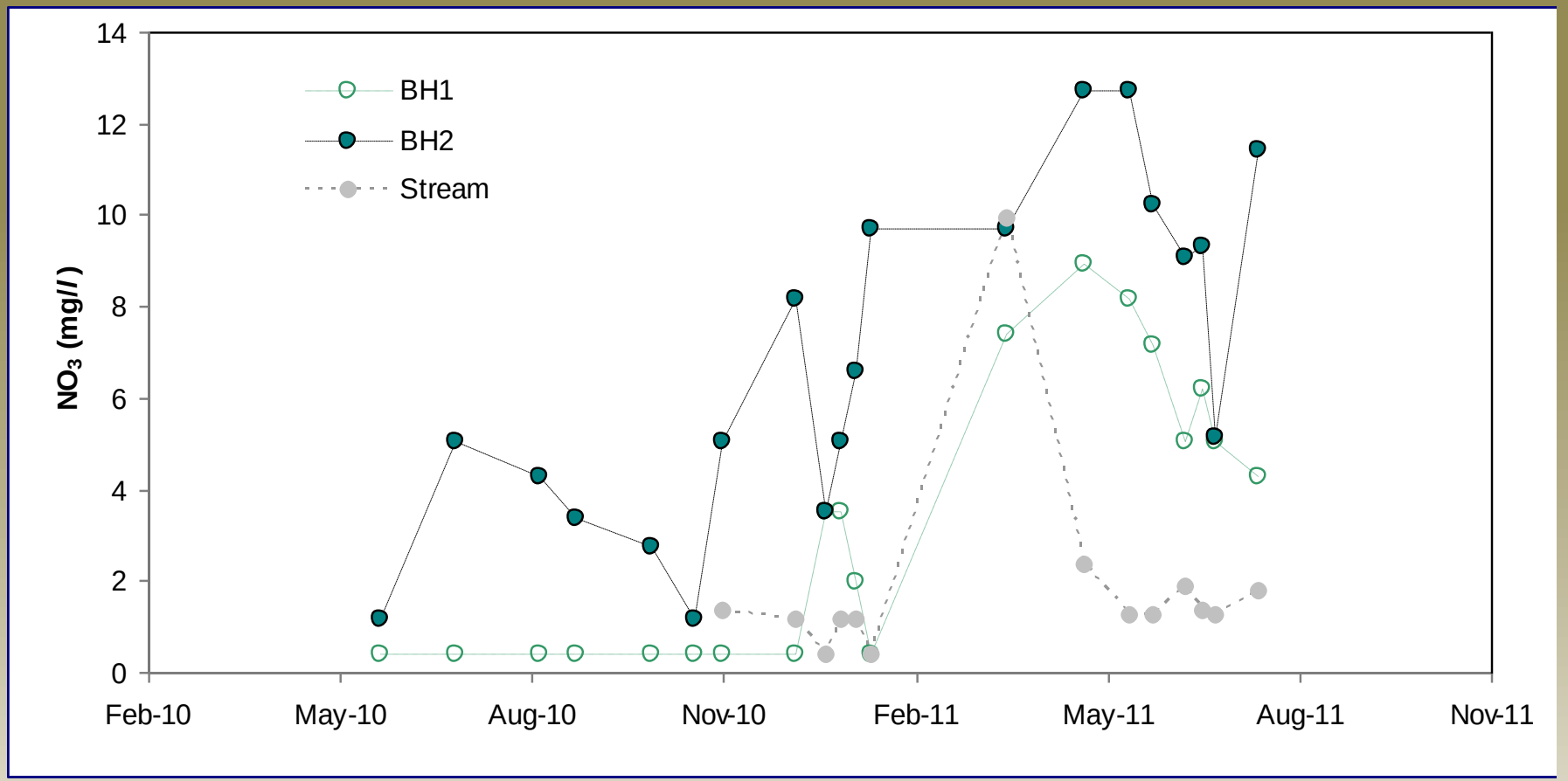
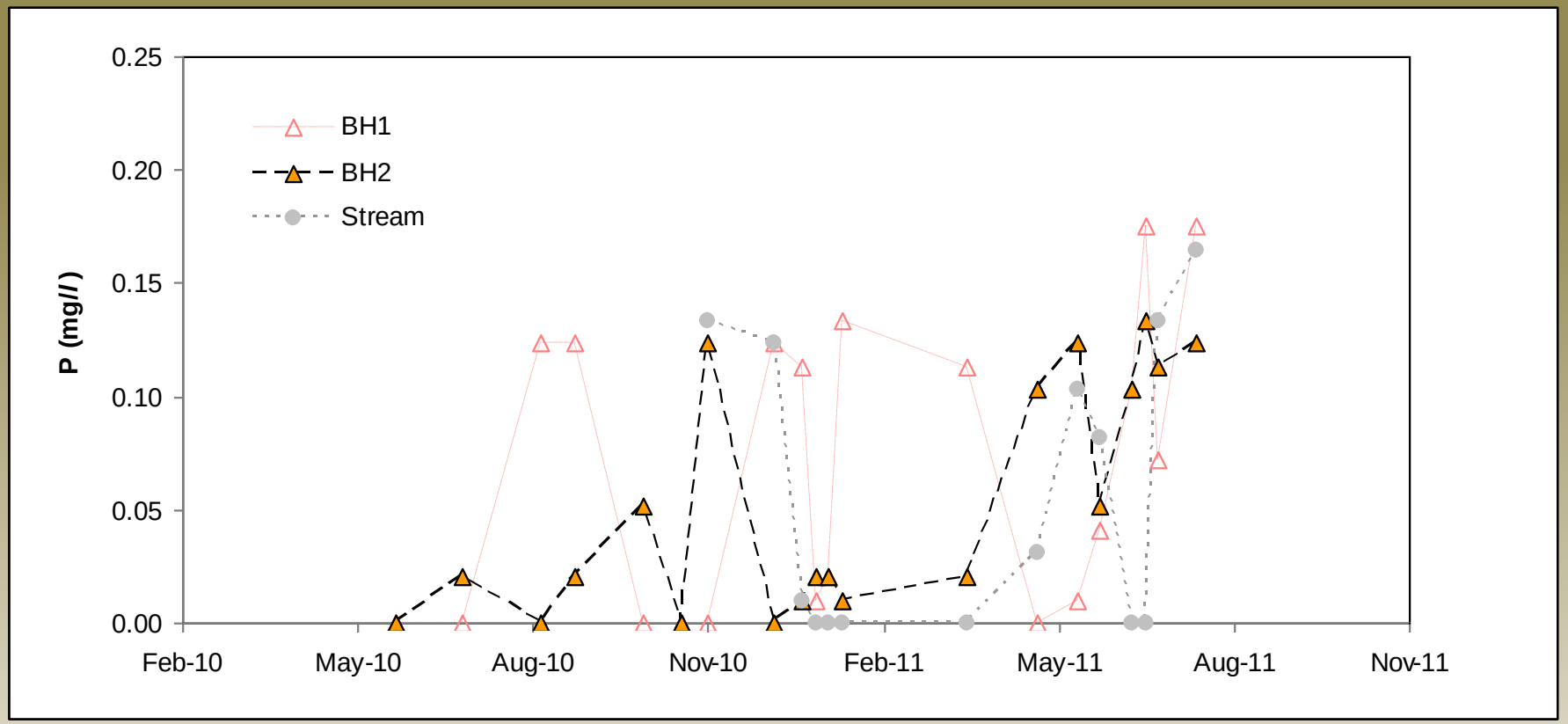
Stream Flow Direction


14
12
10
8
6
4
2
0
NO3 (mg/l)
BH1
BH2
Stream
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11


0.25
0.20
0.15
0.10
0.05
0.00
P (mg/l)
BH1
BH2
Stream
Feb-10
May-10
Aug-10
Nov-10
Feb-11
May-11
Aug-11
Nov-11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Roofkote

Controlled leachate monitoring trial, November 2013 - ?

Cumulative N and P mass leached after 6 months

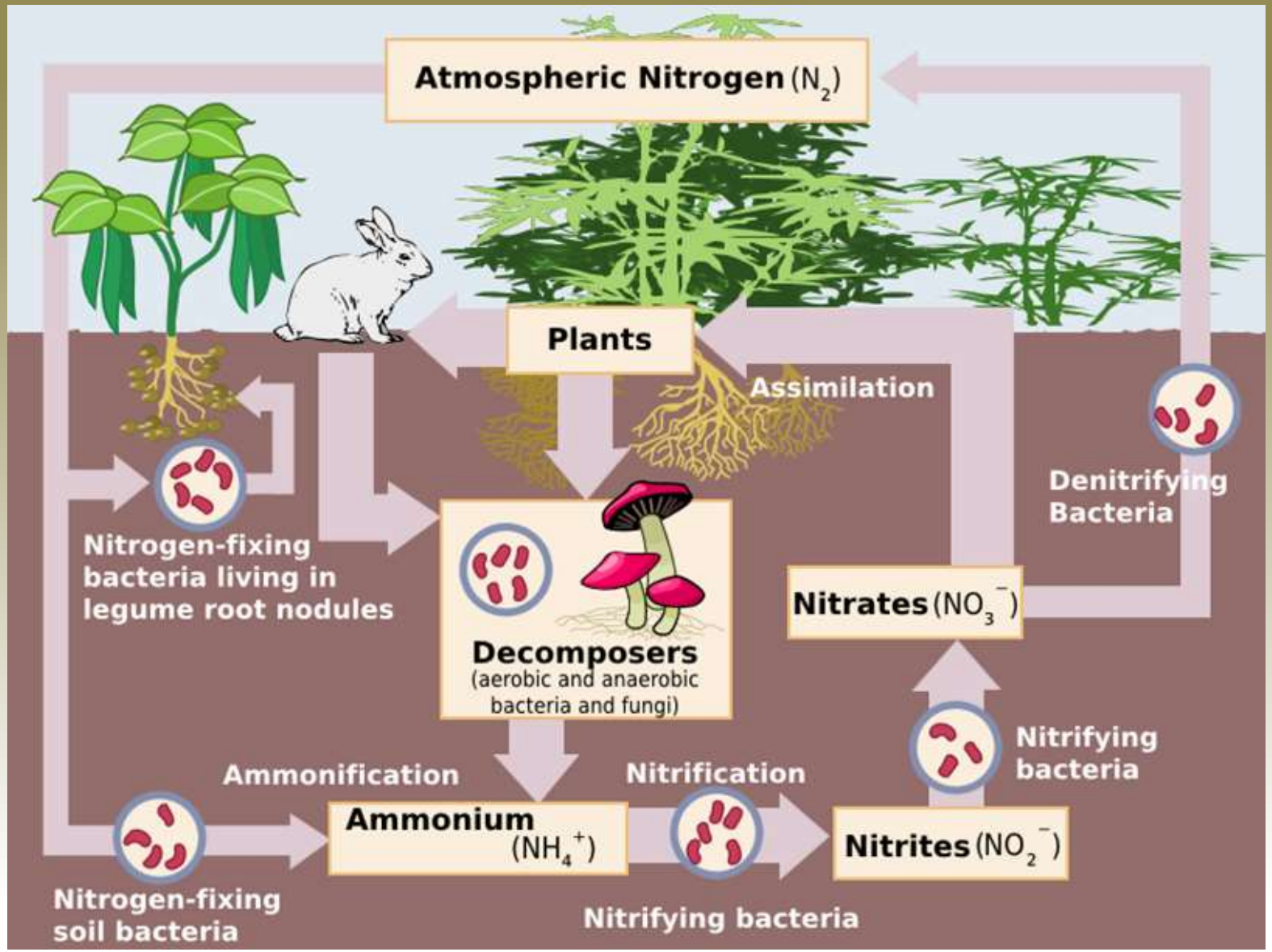
N Ave 0.16% Median 0.051%

Parameter	Block-1		Block-2		Block-3	
	T1	T2	T1	T2	T1	T2
Applied Kg- Total N/ha	4169	1599	6138	2349	3005	1439
leached-Kg (NH_4+NO_3)-N/ha	0.055	1.4	0.44	5.2	0.39	8.7
% N-leached	0.001	0.088	0.007	0.221	0.013	0.605

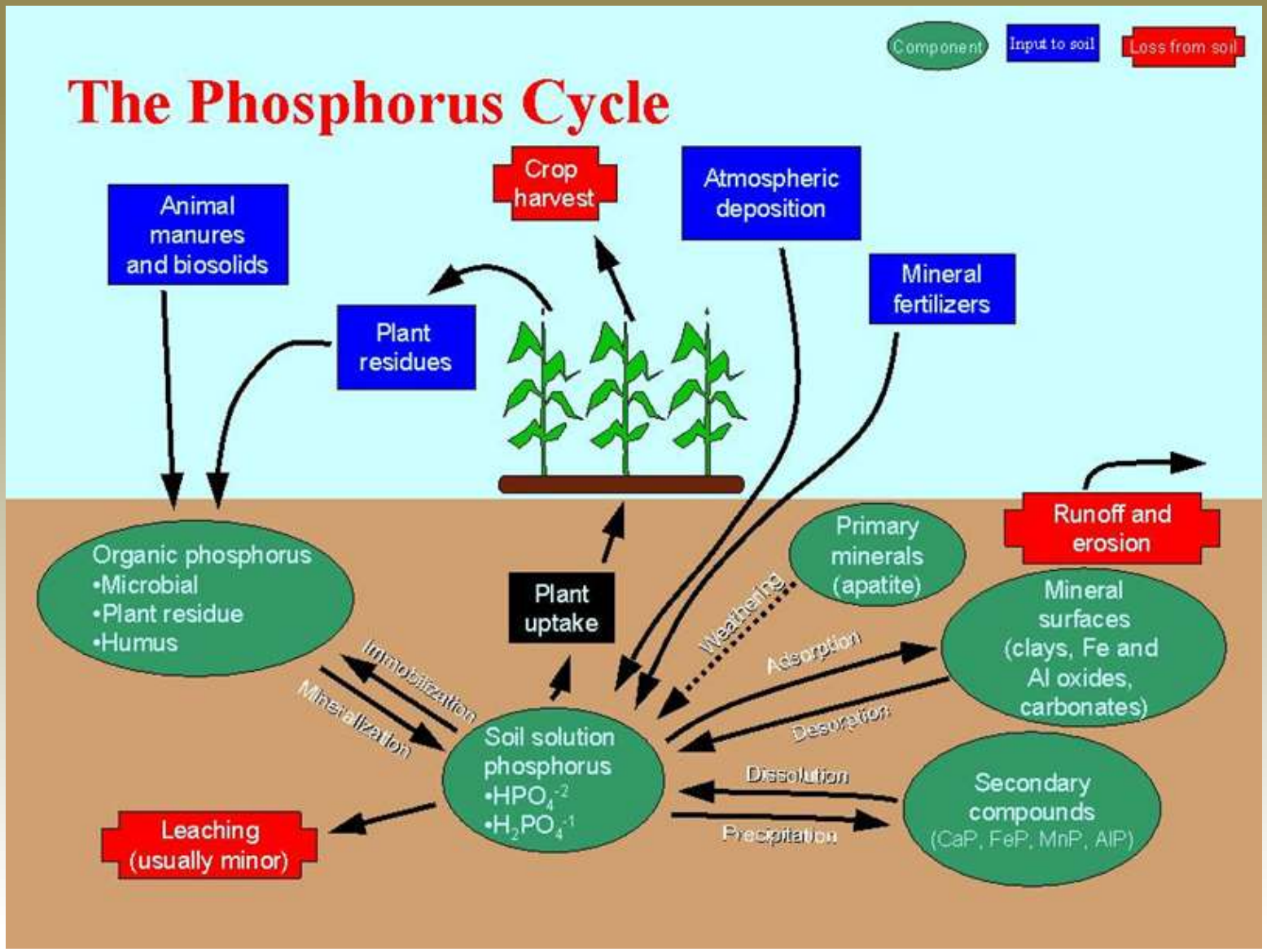
(b) **P** Ave 0.0035% Median 0.0015%

Parameter	Block-1		Block-2		Block-3	
	T1	T2	T1	T2	T1	T2
Applied Kg-Total P/ha	1498	575	2194	839	1375	659
leached-Kg PO_4-P/ha	0.000072	0.0013	0.005	0.022	0.21	0.018
% P-leached	0.000	0.000	0.000	0.003	0.015	0.003

Where does all the N go?



Where does all the P go?



Sludge burial – environmental impact

- In the ground, sludge decomposes by natural biological processes and after a few years is barely distinguishable from the surrounding soil.
- After three years even the hardiest pathogens such as *Ascaris* die off.
- Despite high loading rates no significant impact on groundwater has been observed in the trials to date over four years of monitoring.

Disposal by burial – is the benefit worth it?

- Net Standing Value of Eucalyptus is in range of R200 – R300/tonne (i.e. after deducting harvesting, haulage and milling costs)
- Mean Annual Increment of Eucalyptus in the 15 to 25 tonne/annum range (water, sun and soil dependent)
- Typically harvest after 10 years growth, tonnage about 200 tonne per hectare, i.e. NSV after 10 yrs is approx. R50 000/ha
- i.e. if we increase NSV by say 40%, value is approx. R70 000/ha
- At what cost?

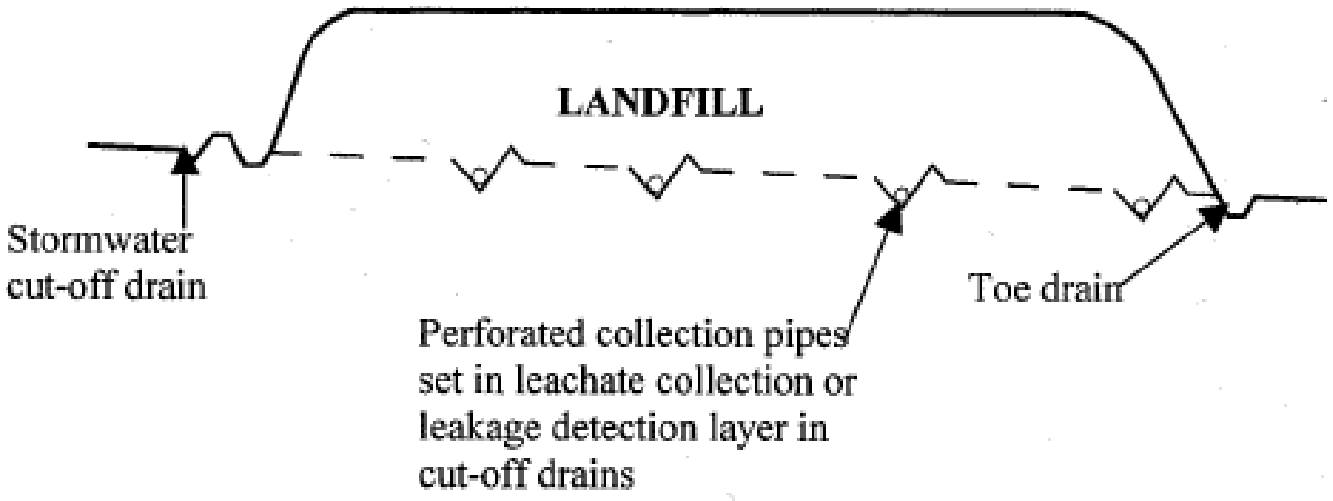
Disposal by burial – what's the cost?

- **With trenches 3 metres apart ,100 m long, 300 mm wide by 400mm deep with 250 mm sludge depth, you can bury 248 m^3 of sludge in one hectare**
- **This requires long haul of sludge (R2/tonne.km) and**
- **Short haul of sludge (R30/m^3) and**
- **Excavation and backfill – 1.6 m^3/m^3 sludge at R60/m^3 soil or R100/m^3 sludge**
- **So cost to bury 248 m^3 sludge is approx. R32 000 excluding long haul.**
- **Margin for long haul then about 50 km, but**
- **Monitoring and OHSA costs not taken into account**

Disposal by burial – what's the alternative?

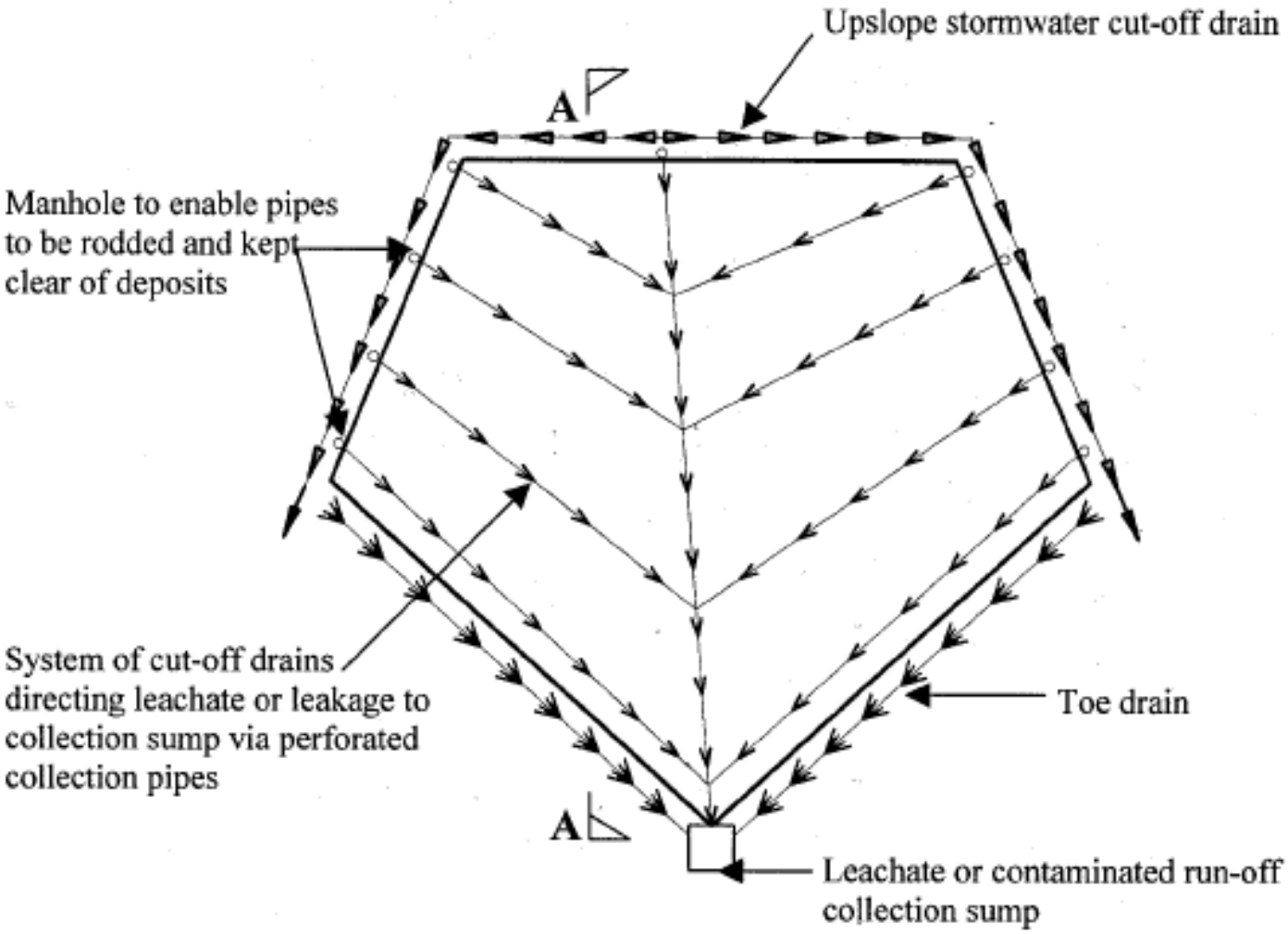
- **Surface application, class A sludge only, limited to favourable topography and hydrology**
- **Composting – makes sense where there is a ready supply of co-composting material e.g. woodchips and sawdust, but not cheap and quality control may be hard**
- **Status Quo - Landfills**

Landfills 101.1



Section A-A through landfill

Landfills 101.1



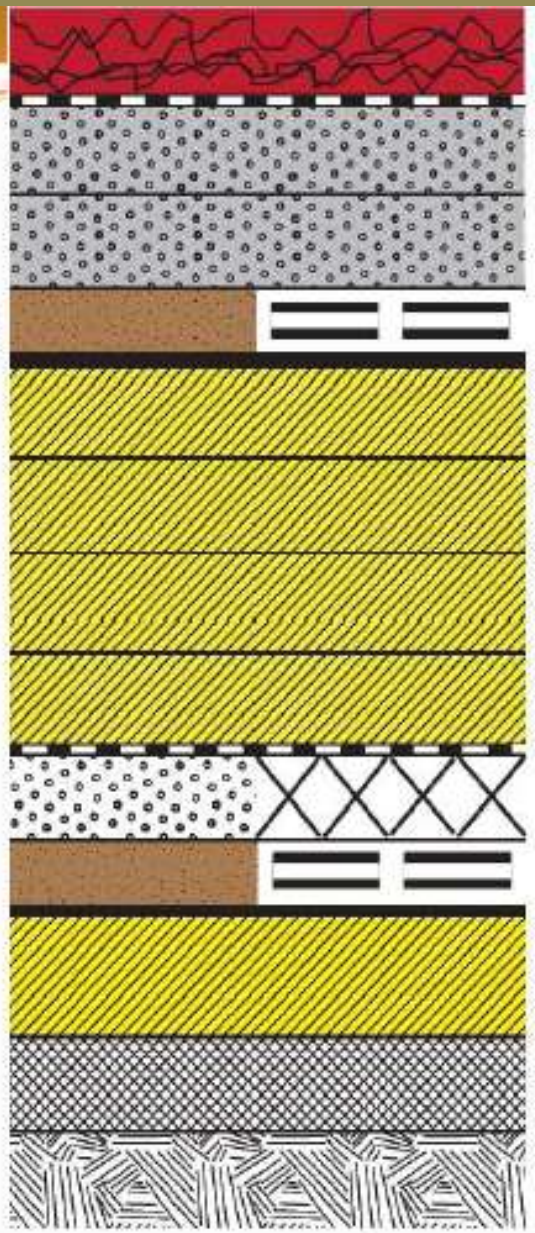
Landfill acceptance Criteria

Waste Risk Level	Disposal Requirements
Type 0: Very High Risk	Disposal **not allowed**. The waste must be treated first and then re-tested to determine the risk profile for disposal.
Type 1: High Risk	Disposal only allowed at a landfill with a **Class A** or **Hh/HH** containment barrier design.
Type 2: Moderate Risk	Disposal only allowed at a landfill with a **Class B** or **GLB+** containment barrier design (or Class A).
Type 3: Low Risk	Disposal only allowed at a landfill with a **Class C** or **GLB+** containment barrier design (or Class B or A).
Type 4: Inert Waste	Disposal allowed at a landfill with a **Class D** or **GSB-** containment barrier design.
Non-hazardous Waste (Pre-classified)	Disposal only allowed at a landfill with a **Class B** or **G S/M/L B-/B+** containment barrier design.

Permitted landfills may accept wastes in any currently operating cells, but the design and operation of future cells must be upgraded to the new containment barrier designs.

Landfills 101.1

Class A Containment Barrier Design



Waste body
Geotextile

300 mm Stone leachate collection system

100 mm Protection layer of silty sand
or a Geotextile of equivalent performance
2 mm HDPE Geomembrane

600 mm Compacted clay liner (in 4 x 150 mm layers)

Geotextile layer
150 mm Leakage detection system of granular material or geosynthetic equivalent
100 mm Protection layer of silty sand
or a Geotextile of equivalent performance
1,5 mm HDPE Geomembrane

200 mm Compacted clay liner

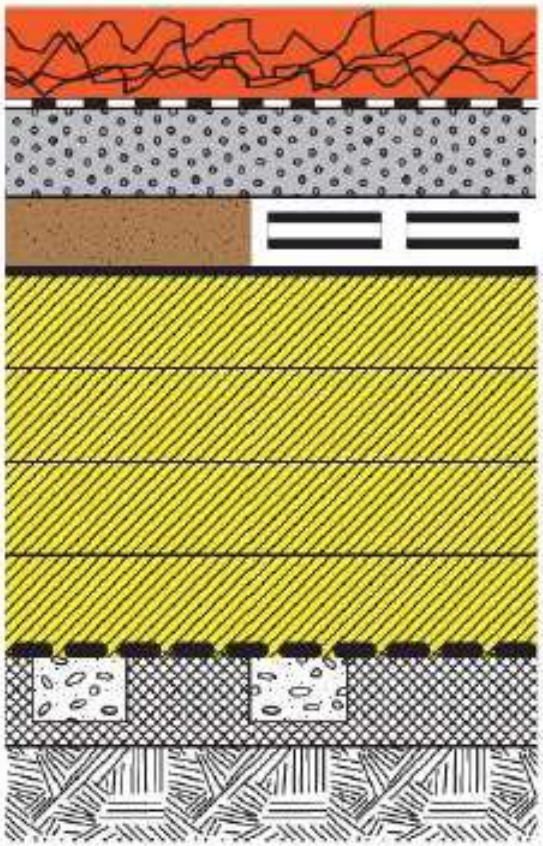
150 mm Base preparation layer

In situ soil

environmental affairs
Department:
Environmental Affairs
REPUBLIC OF SOUTH AFRICA

Landfills 101.1

Class B Containment Barrier Design



Waste body

Geotextile
150 mm Stone leachate
collection system

100 mm Protection layer of silty sand
or a Geotextile of equivalent performance
1,5 mm HDPE Geomembrane

600 mm Compacted clay
liner (in 4 x 150 mm layers)

Under drainage and monitoring system
and 150 mm Base preparation layer

In situ soil

environmental affairs
Department
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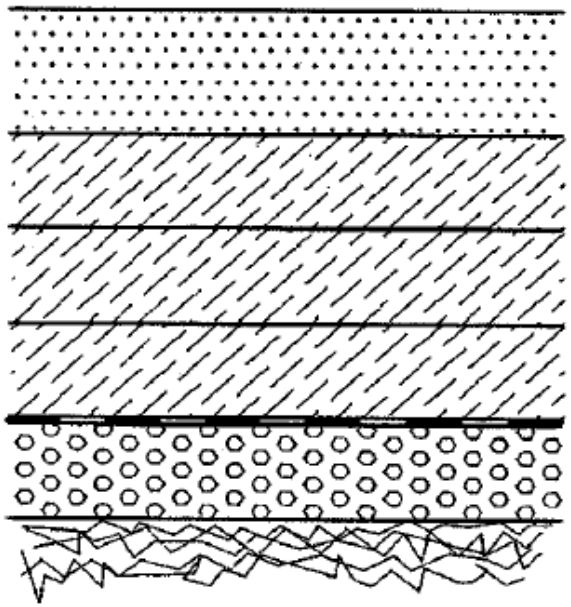
Landfills 101.1 - capping

G:M:B^{+} , G:L:B^{+} and Hazardous Landfills



What to do with sludge from on-site sanitation - conclusions

- Disposal on site into a nearby pit or a trench is the simplest, cheapest and most practical option
- Plant a tree or trees over the sludge to gain some advantage from the nutrients in the sludge
- If you don’t want to or can’t bury the sludge, compost it

What to do with sewage sludge - conclusions

- Cheapest option is surface application – has to be Class A sludge, erosion potential must be limited
- Composting makes sense if there is a ready source of organic waste for co-composting and if it can be well managed
- Shallow burial in conjunction with non-food crops (cane, timber) makes a good deal more sense than landfill

Caution: there are obstacles to large scale sludge burial in South Africa

- Faecal sludge is classified in terms of legislation as a *hazardous waste* due to the pathogen content – this has implications for handling and transport
- A large scale burial site (more than a few hundred m^3) is classified as a landfill – this has extensive implications in terms of permission and monitoring
- However, productive use of "biosolids" in the forestry sector in other parts of the world is well established - can be done. With more pilot scale research the risks can be better assessed and defined.

Thankyou