07
Technification

7.1 Introduction

The following technical investigation is aimed to give expression to the main concepts of alternative corpse disposal, local grounding, as well as designing spaces that express the narrative told throughout the site.

This chapter addresses water systems, ecology, human compostings, and the technification of the human composting chambers.

7.2 Water systems

7.2.1 Surface water

The overall approach to the water is providing clean water for recreational use and for animal consumption.

The Nekrotopio burial site is located in the southern half of the degraded Diepsloot Nature Reserve. As proposed in the landscape vision in Chapter four, the nature reserve status of the site will be regained through proper site boundaries, rubble removal, grassland rehabilitation, and the addition of game such as antelope and zebras. In order to accommodate the proposed wildlife, water suitable for animal consumption has to be provided. The Diepsloot stream runs through the site, Figure 95, and will be used to provide the animals with fresh water. Unfortunately, the entire Diepsloot township is located in the stream's catchment area, Figure 95. The stream is polluted with silt, floating debris, and other pollutants flushed into the stream from the township. Figure 96 illustrates some of these contaminants. To ensure clean water on site, purification interventions will have to be implemented upstream in the township. Figure 97 shows the proposed water strategy. This water strategy can be divided into two phases.

7.2.1.1 Phase one: Diepsloot township

Diepsloot township is a densely populated informal settlement. Diepsloot's central stream divides the township in two. It is difficult to cross. Figure 98 shows locations of worst rubbish build up. It often correlates with informal circulation paths. Poor connectivity has resulted in the breakdown of the refuse collection system and has made collection of the litter impossible. The existing connectivity of Diepsloot is mapped in Figure 98. There are only two formal crossing points over the stream. Improved connectivity between the west and east of Diepsloot will enable refuse collection. Figure 98 maps the proposed improved connectivity

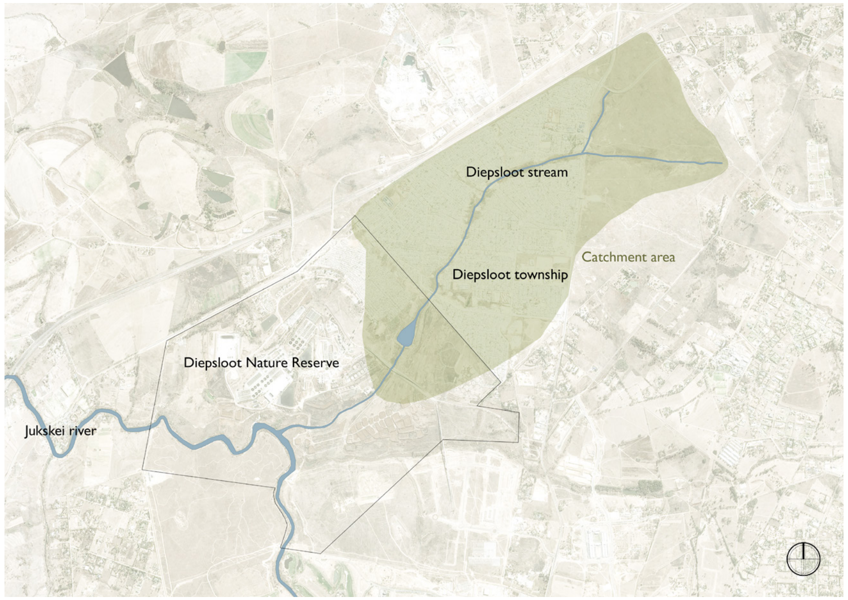


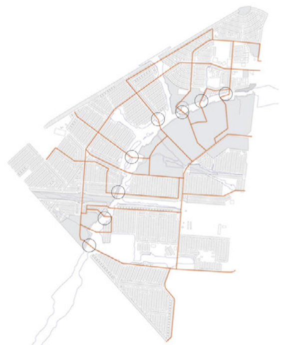
Figure 95. The Diepsloot stream's catchment area consists mainly of the Diepsloot township (Author 2015).

Figure 96. Collage of Diepsloot stream contaminants (Tyrell 2007).

Figure 97. Diepsloot Nature Reserve water strategy (Author 2015).

Areas of extreme litter due to poor connectivity

Existing connectivity



Proposed connectivity

Figure 98. Diepsloot litter and connectivity analysis (Author 2015 adapted fromTyrell 2007).

in the settlement as well as across the stream. The ten points crossing over the stream is a series of vehicle and pedestrian bridges. These bridges form part of the first layer to improve the Diepsloot stream.

Figure 99 illustrates the layered strategy in Diepsloot to improve the stream's water quality.

Layer one: Trash trap bridges

The above-mentioned improved connectivity of Diepsloot involved the addition of bridges over the stream. These do not only connect to eastern and western sides of Diepsloot, they function as trash traps. Although the proposed connectivity should improve the refuse collection system, it is a management solution, not a designed solution. There is not guarantee that the litter will not enter the stream, thus a series of garbage traps are proposed to prevent the floating debris from flowing down stream.

In addition to collecting floating debris, the proposed bridges improve the safety of the informal settlement's residents. The stream often floods during summer due to the large amount of storm water runoff caused by erosion.

Layer two: Water management

The second layer of Figure 99 shows the proposed water management strategy. The dark blue areas form a series of

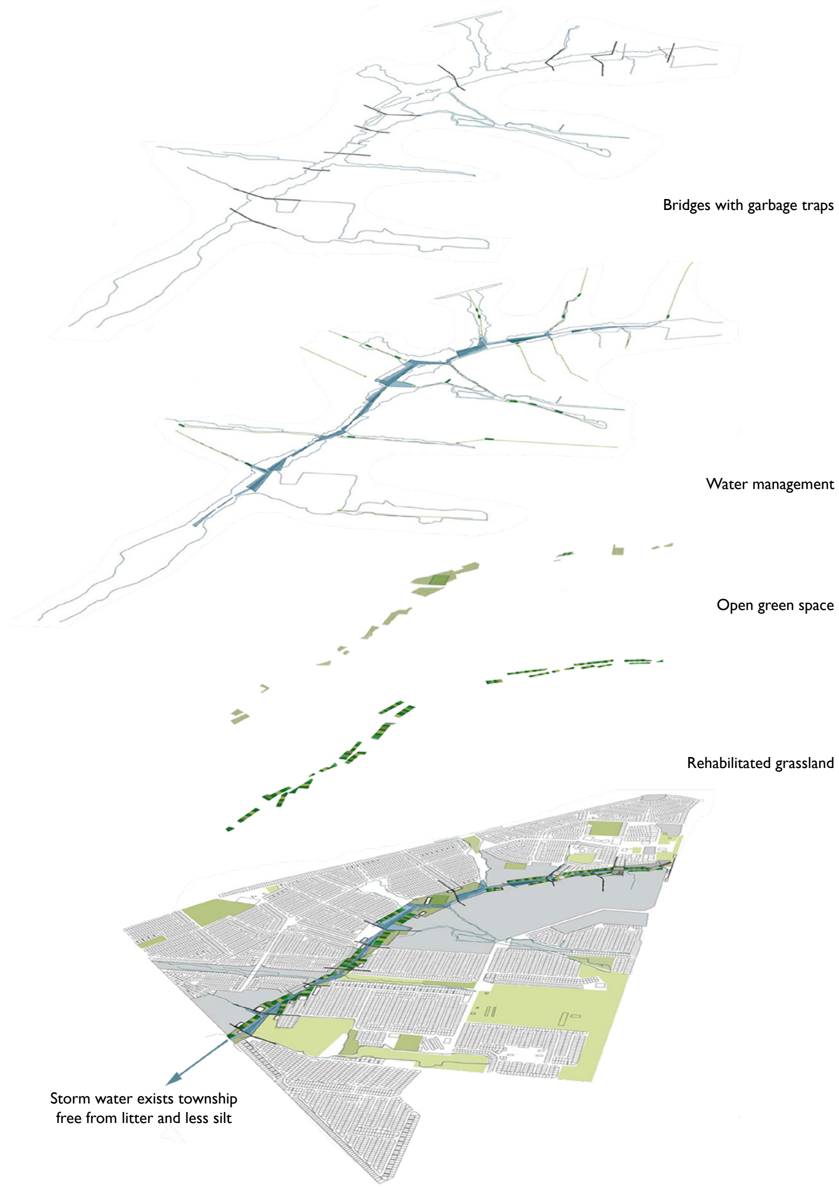


Figure 99. Phase one: Diepsloot stream strategy (Author 2015 adapted fromTyrell 2007).

perennial surface wetlands. Lighter blue areas indicate ephemeral wetlands that will only be inundated during the summer rainfall season. The remainder of the year these areas will be masses of sedges and wetland grasses.
The green arrows indicate the most appropriate locations for bio-swales. These locations are based on the topography as well as the limited open space between the informal dwellings. The bio-swales slow down and treat water before it reaches the wetlands and eventually the stream. They also improve the microclimate within the township and reduce erosion (Tyrrell 2008).

Layer three: Open green spaces
The third layer illustrates proposed parks and public open spaces as illustrated in Figure 99. These spaces relate directly to the proposed bridges and strive to create community nodes at these points.

Included in the open spaces are soccer fields. Not only can the community enjoy this, the fields become detention dams during large rainfall events. Other spaces are large enough for many formal and informal recreational uses. The community would generate such programs (Tyrrell 2008).

Layer four: Rehabilitated grassland
Due to the large amount of storm water runoff during summer as well as the lack of paved walkways large areas next to the stream have been eroded, leaving the soil bare. The fourth layer proposes the reimplementation of grassland vegetation in areas outside the proposed community open spaces. The establishment of grassland vegetation will stabilize the soil, prevent further erosion and reduce the amount of silt in the stream.

Through the implementation of this first phase with its four layers, the water exiting Diepsloot via the stream should be free of floating debris, have low amounts of silt in it, and contain minimal contaminants due to the bio-swales and wetlands.

7.2.1.2 Phase two: Post Diepsloot treatment
Once the water exits Diepsloot, the stream flows through a series of silt traps to catch any remaining silt. From this the water flows into a natural existing retention pond. Water from this pond is gravity fed to the site to irrigate the promession forest. From this pond, the stream continues through a surface wetland into the site. The stream should now be aesthetically clean, contaminant free, and safe for animals consumption. The stream follows through the site and flows into the Jukskei river.

This two phased water strategy should provide the Nekrotopio with clean water for recreational use and for animal consumption.

7.2.2 Ground water

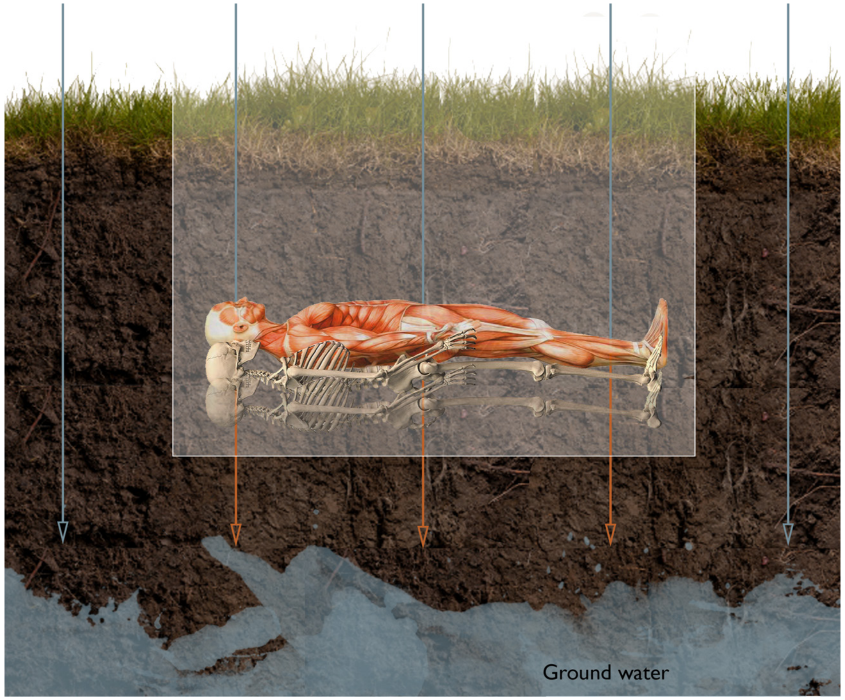


Figure 100. Buried corpses could potentially pollute water (Author 2015).

Nekrotopio is a burial site; in certain areas, corpses are buried in the soil. This raised the question: what impact, if any, does burial sites (cemeteries) have on ground water?

According the Department of Water Affairs and Forestry (DWAF 2007), certain members of the public believe that cemeteries pollute ground water. This perception is incorrect, and the following policy, which have been formulated and sanctioned by the Minister will clear up the matter:

The risk of pollution posed by cemeteries to the quality of the water resource, especially the quality of drinking water, is regarded as acceptable, and in most instances negligible, for the following reason:

A corpse's disease-causing bacteria cannot survive long outside a living human body. They perish within days from burial, before it comes into contact with groundwater or even surface water. If a corpse is exposed to ground water, it will therefore have a low risk of containing disease-causing bacteria and, although high in nutrients, will be small in volume when compared with waste from improper sewage management, chemical fertilizers, pesticides, illegal disposal of medicine and medical waste, and industrial runoff.

The risk of pollution posed by cemeteries is very low. Notwithstanding the above, the Department of Water Affairs and Forestry do recognise the potential for pollution caused by poorly sited cemeteries. Based on previous assessments funded by DWAF and conducted by specialists, amongst others the CSIR, the following measures have been put in place to address this potential risk:

In accordance with the definitions contained in the National Water Act, No 36 of 1998 (NWA), a cemetery constitutes a water use in terms of s21(g) of the NWA, which need to be authorised. However, due to the low pollution potential from cemeteries, very broad general authorisations are currently under preparation for the purpose of such authorisation.

The table in figure 101 proofs that in terms of sections 22(3) and 22(4) of the NWA, that Nekrotopio meets the cemetery placement requirements of the Department of Water Affairs and Forestry.

For the complete Policy refer to Appendix B.

To conclude: The burial of corpses on site will not pollute groundwater. Correct measures were taken to ensure the location of the burial is acceptable and safe with regard to users and the environment.

National water act requirement	Nekrotopio
Located above the 1 in 50 year flood line of a river/ stream	Burial and composting of corpses happen above the 1 in 50 year flood line.
Not situated in unstable areas like fault zones, seismic zones, dolomitic or karst areas where sinkholes and subsidence are likely	The site is underlain by transported sandy and gravel soils overlying strongly cemented residual soils that are underlain by weathered granite belonging to Halfway House Granite Dome of Archaean Age.
Not situated in a ecologically sensitive areas;	Although the burial site is located in the Diepsloot Nature Reserve, it is situated ontop of old agricultural fields, a completely disturbed area of the reserve. In addition, the site is rehabilitated using grassland species in the burial site instead of the traditional lawn and exotic trees.
Not situated in areas characterised by steep gradients, or shallow bedrock with little soil cover, where stability of slopes could be a problem	The areas where corpses are buried has been either cut or filled to create a stable surface with a mild slope. The area is slightly sloped to prevent the burial veldt from turning into a detention pond during summer. Corpses submersed in water will not decompose, because composting is an aerobic process.

Figure 101. Nekrotopio meets NWA requirements regarding cemetery placement (Author 2015).

7.3 Ecology (Planting)

The overall approach to the planting is rehabilitation. Areas where rehabilitation is not reasonable, planting is used to strengthen the burial site's narrative. The planting for this thesis can be divided into three sections:Rehabilitation: Most of the site is rehabilitated to enrich the nature reserve.

- Green Burial veldt grasses: Rehabilitation is not feasible where new corpses are buried every ten years. Thus, grasses appropriate to the Egoli Granite Grassland are planted to enrich the narrative.
- Promession Forest: The forest forms part of the site's narrative, as well as a sustainable method of corpse disposal. Indigenous trees were selected for this area. They convey the narrative and aid in the rehabilitation of the nature reserve.

7.3.1 Rehabilitation

The Diepsloot Nature Reserve forms part of the Egoli Granite Grassland region.

The GM 10 Egoli Granite Grassland has moderately undulating plains and low hills with *hyparrhenia hirta* dominant grasslands. Some woody species can be found in rocky outcrops and well as some scattered shrub groups (Mucina & Rutherford 2006).
Due to agricultural activities, sewage drying pans, a motorcycle racetrack, illegal dumping, and the extension of the informal settlement into the reserve, some areas are disturbed, as discussed in chapter three: Site analysis.

The strategy for the larger DNR is to rehabilitate the site. Rehabilitation means to improve the current situation, while restoration means to restore it to its original state. The areas of rehabilitation is inicated in Figure 102. The four rehabilitation phases are as follows:

1. Site clearing: The existing rubble needs to be removed and a proper barrier to demarcate the reserve needs to be erected.

2. Eradicate invasive flora: Alien invasive species need to be removed. The phases of eradication is initial control, follow up control and maintenance control. In the control phase, the smaller plants are hand pulled and larger trees frilled. In the remaining phases, the site is regularly checked for regrow and eradicated again if necessary.

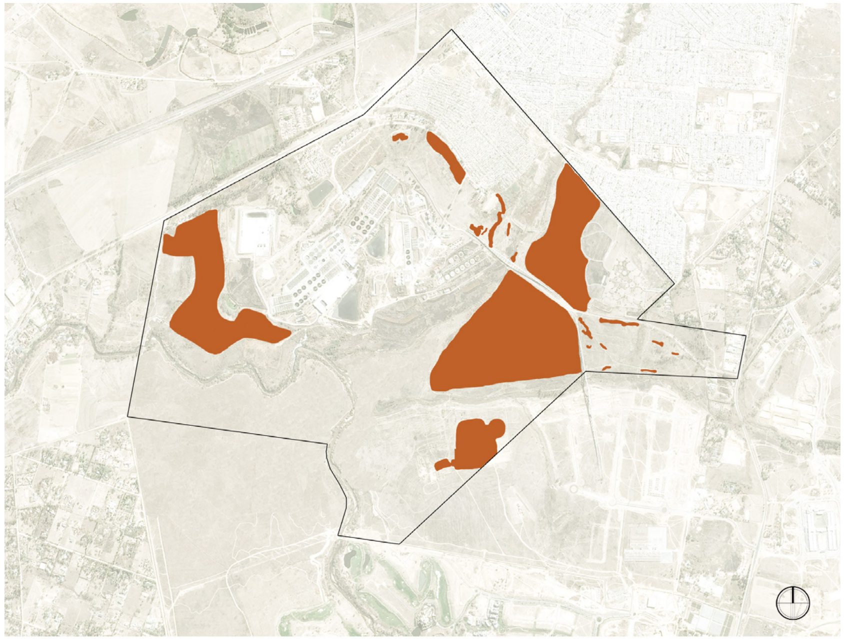


Figure 102. Areas of proposed rehabilitation (Author 2015).

3. Establishment of pioneer species: Following the eradication pioneer species are established. The suggested pioneers are *Eragrostis teff, Melinis repens*, and *Sporobolus festivus.*

4. Procession: After the establishment of the pioneers, climax grasses such as *Melinis nervelomis*, *Miscanthus junceas* and *Setaria megahulla,* and herbs and succulent like *Diantis molensis, Stagis natalensis, Colombaria sp.* , *Dicana sahiri* and *Dicana anomda* can be planted in-between the pioneers (Wentzel 2015).

7.3.2 Green Burial veldt grasses

In the green burial veldt graves are reused every ten years when the corpses have completely decomposed. The soil is thus disturbed every decade. This makes grassland rehabilitation on top of the graves unfeasible. Instead of attempting to make the burial veldt look undisturbed, the veldt is planted in a stripe pattern, highlighting the rows of graves, Figure 103. The selected grasses, figure 104, were

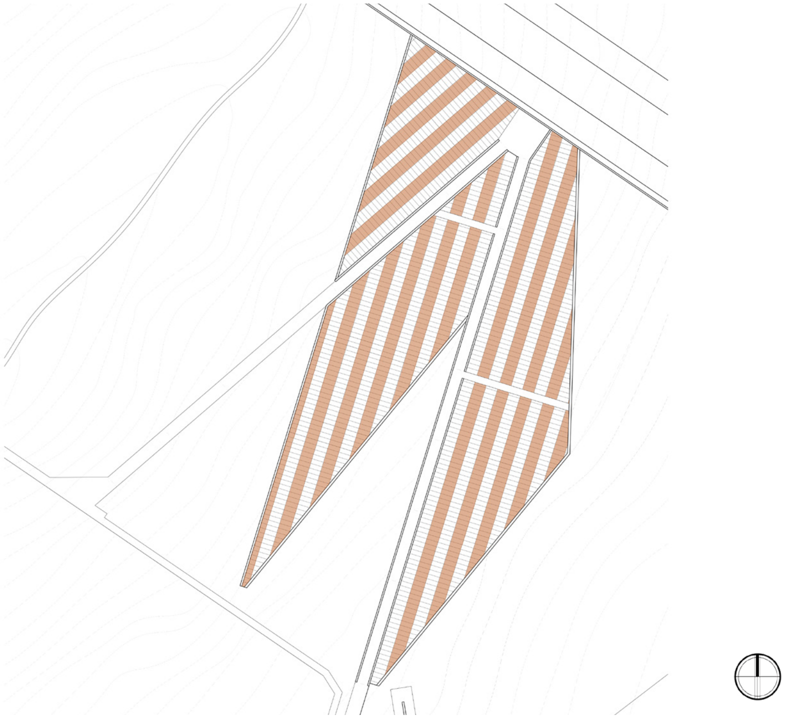


Figure 103. Stripe veldt grass pattern derived from the graves layout (Author 2015).

Figure 105. Different grasses arranged according to height (Author 2015).

selected based on their height, Figure 105, winter foliage, and summer foliage and arranged accordingly. Each grass strip is a different colour in summer and winter, Figure 106. Throughout the year the veldt will always be changing colour. This idea of a dynamic landscape fits into the circle of life theme. According to the Phenomenology of grief, nature teaches people the facts of life and death. Nature provides people with an intellectual frame of reference for death and dying, reminding them that death is a natural phenomenon that they can neither escape nor ignore (Grover 2013). With the grass strips changing colour throughout the year, the user sees the results of the death, decay, and rebirth that is inherent to holism and the cycles of life. It makes intuitive sense that a closer connection to ever-changing nature may help people come to terms with death and the grieving process (Grover 2013). In an article on nature awareness as a healing therapy, Dr. Dyer explains the role nature plays in grief and acceptance:

> *"Being in nature one becomes aware of the infinite circle of life. There is evidence of decay, destruction, and death; there are also examples of rejuvenation, restoration, and renewal. The never-ending cycle of birth, life, death and rebirth can put life and death into perspective and impart a sense of constancy after experiencing a life changing loss or a death".*
> (Dyer 2002)

The green burial veldt is not only a place where corpses are buried or where the user realizes that nothing of the human body remains, it is also a place where the user starts to come to terms with death through nature.

7.3.3 Promession Forest

In the promession forest, a corpse's ashes are placed in an eco-urn with a tree seedling and compost, and are placed in the promession forest. The deceased's family has five trees to choose from: *Dombeya rotundifolia* var. *rotundifolia*, *Erythrina humeana*, *Ziziphus mucronata* subsp. *mucronata*, *Vachellia rodusta* subsp. *robusta*, and *Combretum molle*. These trees were selected because they are suitable for the environment: they are all hardy, frost resistant, fast growing, easily cultivated from seed, and have low water requirements. They were also selected for their shape, they all have relatively rounded crown without any low branches or multiple stems, thus the user will be able to walk underneath the crowns. According to the narrative, the forest is the third event. This space is entered into after the user has been made aware of their own morality and the fact that their bodies disintegrate after death. Upon entering the forest, the user should feel safe. Light is filtering

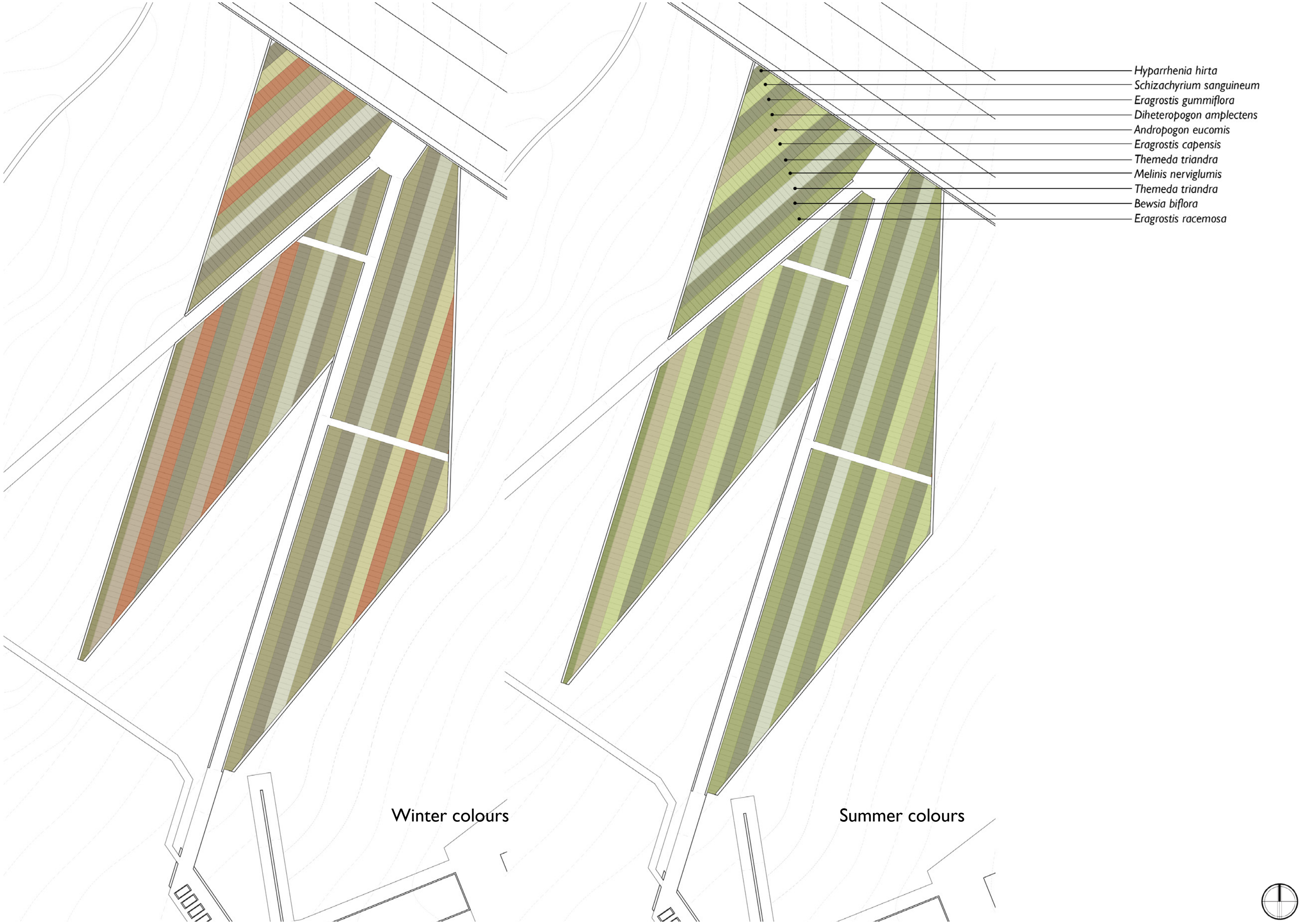
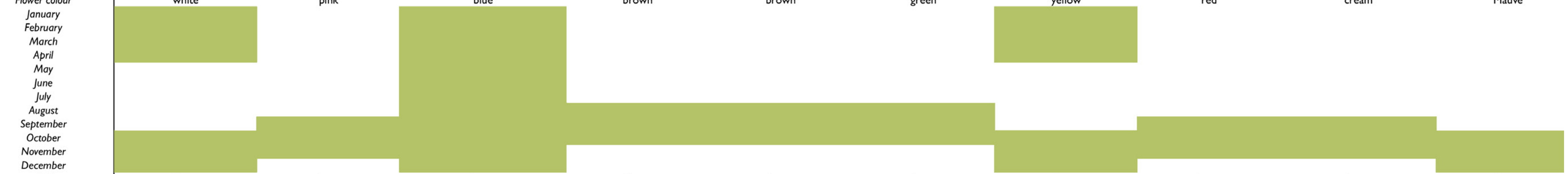


Figure 106. The green burial veldt changes colour as the seasons change, creating an ever-changing stripe pattern in the landscape(Author 2015).

Botanical name	*Andropogon eucomis*	*Bewsia biflora*	*Diheteropogon amplectens*	*Eragrostis capensis*	*Eragrostis gummiflua*	*Eragrostis racemosa*	*Hyparrhenia hirta*	*Melinis nerviglumis*	*Schizachyrium sanguineum*	*Themeda triandra*
Common name	Snowflake Grass	False love grass	Broad-leaved blue stem	Heart -seed love grass	Gum grass	Narrow heart love grass	Thatching grass	Bristle leaved red top	Red autumn grass	Red grass
Size (m)	0.5 - 1	0.5	1	0.5	1	< 0.3	2	0.5	1	0.5
Shape	clump forming	clump forming	clump forming	clump forming	climber	clump forming	clump forming	clump forming	clump forming	climber
Texture	fine	fine	broad leaf	very fine	fine	medium	very fine	fine	medium	medium
Hardiness	very	very	very	very	very	very	very	very	very	very
Water requirements	water wise	water wise	water wise	water wise	water wise	water wise	water wise	water wise	water wise	water wise
Growth rate	fast	fast	fast	fast	fast	fast	fast	fast	fast	fast
Position	sun	sun	sun	sun	sun	sun	sun	sun	sun	sun
Evergreen	deciduous	deciduous	deciduous	deciduous	deciduous	deciduous	deciduous	deciduous	deciduous	deciduous
Summer Foliage	dark green	light green	blue green	faded green	dark green	green	green	green	green	green to red
Winter Foliage	green	light brown	light brown	light brown	brown	light brown	straw yellow	brown	red	grey
Flower colour	white	pink	blue	brown	brown	green	yellow	red	cream	Mauve



Soil	loam	loam	loam	loam	loam	loam	loam	loam	loam	loam
Habitat	moist areas	grassveld	grassland	moist areas	grassland	moist areas	grassland	grassland	moist areas	grassland

Figure 104. Selected grasses for the green burial veldt (Author 2015).

through the trees, birds are singing and animals can be spotted. In the forest, the user should realize that each tree represents a life. Each tree grew from the remains of a person. So even though people are mortal and their bodies are temporary, from death comes new life. The trees in the forest provide food and shelter to other life forms. In order to have such a dynamic forest, the selected trees attract a lot of insects, birds and animals, Figure 107.

The role of nature in grief is also pulled through into the forest: deciduous tree with attractive changing foliage and interesting fruit or flowers were selected to ensure that the forest is visually dynamic. Like the grass strips, the trees are also planted in a pattern to highlight certain aspects of certain trees during the year.

Botanical name	*Dombeya rotundifolia var. rotundifolia*	*Erythrina humeana*	*Ziziphus mucronata subsp. Mucronata*	*Vachellia robusta subsp. Robusta*	*Combretum molle*
Common name	Bushveld bride	Dwarf Coraltree	Buffalo-thorn	Broadpod Robust Thorn	Velvet Bushwillow
Classification	small tree	medium shrub/ small tree	medium tree	small tree	medium tree
Size (m)	6 x 4	3 x 2,5	9 x 10	7 x 6	9 x 10
Shape	rounded (sparse open texture)	long narrow (sparse open texture)	rounded (sparse open texture)	rounded (dense)	contorted to rounded
Root system	not aggressive	not aggressive	not aggressive	aggresssive	not aggressive
Drough resistant	yes	yes	yes	yes	yes
Hardiness	very	half-hardy	very	very	very
Water requirements	low	low	medium	medium	low
Growth rate	fast	fast	moderately fast	fast	moderately fast
Position	sun	sun	sun	sun	sun
Evergreen	deciduous	deciduous	deciduous	deciduous	deciduous to evergreen
cultivation	easy from seed	easy from seed	easy from seed	from seed	easy from seed
Bark colour	dark brown to black	grey-green	dark brown	blackish brown	dark brown to blackish
Bark texture	very coarse and fissured	prickly with vertical grooves	grooved	rough with deep grooves	rough and fissured
Summer Foliage	dark green (appears after flowering)	green (appears with flowering)	dark green (appears with flowering)	dark green (appears with flowering)	green (appears after flowering)
Leaf shape	broadly ovate to round	triangularly lobed and pointed	ovate or broadly ovate	bipinnate	elliptic to obovate
Leaf texture	thick, rough and hairy	shinny and smooth	leathery	fine	soft velvety
Autumn foliage	lemon yellow before falling	brown and dies back	golden yellow before falling	brown before falling	yellow to red before falling
Flower colour	creamy-white then golden-brown	red	yellow green	yellow	yellow
Flowering time:					
January					
February					
March					
April					
May					
June					
July					
August					
September					
October					
November					
December					
Fruit/pod	almost round hairy fruit	long sickle-shaped pod.	shiny and leathery round berry	leathery/woody pods, straight or sickle	attractive, four-winged fruit
colour	cream	purplish-black pods with orange-red seeds	ripens to yellow, then dark red or brown.	brown	red-brown
Soil	most soils	humus rich soils	all soils	most soils	most soils
Habitat	open bushveld	mountainsides in bushveld	variety (bushveld to forest)	dryish bushveld/ grassland	bushveld
Other	Attracts useful insects, game browses leaves and porcupines are fond of the bark	Sunbirds, white-eyes and bulbuls feed on the nectar produced by the flowers, it also attracts useful insects	flower's nectar attracts bees, butterflies and beetles. Guineafowl and other birds consume fruit. Game browses leaves and fallen fruit. Rock rabbits climb the tree	Flowers, pods and leaves eaten by game. Lures a large number of insects and thus insectivorous birds	Attracts insects and the Guine-fowl butterfly. Antelopes browse the leaves

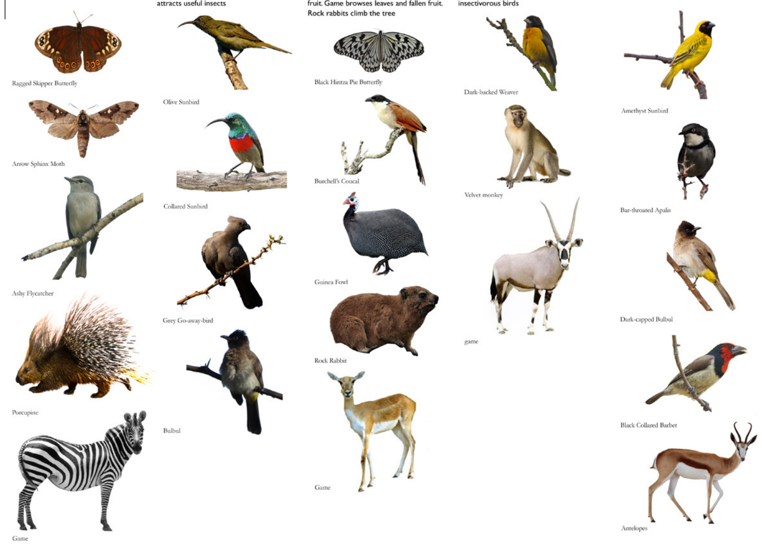


Figure 107. Selected trees for the promession forest (Author 2015).

7.4 Composting system

In the selected area of detailing, the composting chambers, corpses are composted in vertical enclosed structures. Each corpse is placed in the chamber with straw. The amount of straw required has to be calculated. In order to do so, the process and mechanics of composting need to be understood.

Haug (1993) defines composting in The Practical Handbook of Compost Engineering as:

> *"The biological decomposition and stabilization of organic substrates, under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens, and can be beneficially applied to land."*

Rodale (1960) manages to state it a bit more eloquently when he argued that compost is more than a fertilizer or a healing agent for the soil's wounds. It is a symbol of continuing life.

Composting is a process that involves the cultivation of microorganisms that degrade and transform organic materials in the presence of oxygen, Figure 108. When properly managed, meaning the compost heap has the correct nitrogen to carbon ratio, the compost becomes heavily populated with thermophilic microorganisms. Microorganisms combine carbon with oxygen through a chemical reaction that produces carbon dioxide and energy in the form of heat. This exothermic reaction kicks off the composting process. Following this, the organic material is converted to humus through a series of stages by micro (invisible) and macro (visible) organisms.

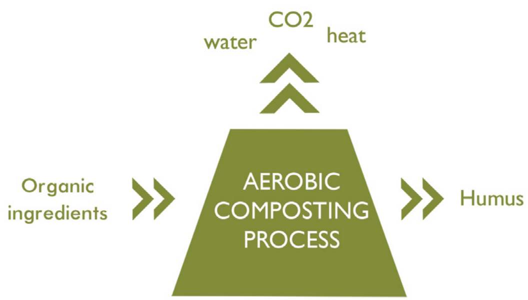


Figure 108. Thermophilic aerobic composting process (Author 2015).

7.5 Return to nature through composting

All organic material contains stored energy. Everything from a leaf to a corpse holds a certain amount of heat and light. According to Sides (1991) in the cycle of light, producers (plants) convert solar energy into food for primary consumers (humans). Through the consumption of the producer, the energy is transferred to the primary consumer. When the primary consumer dies, the energy should be returned to the soil in order to generate new producers. The cycle of solar energy is one of the reasons why composting of corpses is crucial. Corpses should not longer be seen as waste, but as sunlight on the move from one form to another (Sides 1991). This energy is returned to the soil in the form of humus.

Through the composting of a corpse and other organic material, humus is created. Humus is a brown substance resulting from the decay of organic refuse. Humus is a stable product that does not attract insects or nuisance animals. It can be handled and stored without fear of carrying pathogens. Not only does it accelerate plant growth, it also holds moisture, thus increasing the soil's capacity to absorb and store water. Furthermore humus aerates the soil, balances the soil pH and slow-releases essential plant nutrients, such a Nitrogen, making it less susceptible to leaching than chemical fertilizers (Haug 1993). The humus is added to soil, to restore fertility and create rich topsoil. Without the addition of humus to the soil, building topsoil is a centuries long process.

Through the process of corpse composting, the energy and nutrients in a human body is returned to the soil to complete the circle of life.

7.6 Four necessities for successful corpse composting

1. Balanced ingredients
A proper blend of organic materials (a good nitrogen : carbon balance) is required for a successful, thermophilic, and odor free compost pile. Without a sufficient N:C ratio, the organic materials will not compost. Corpses are nitrogen (N) based (they contain more nitrogen than carbon) thus without the addition of a carbon based material, it will not compost, only rot. A good N:C ratio for a compost pile is between 1:20 and 1:35. The optimum ratio is 1:30, Figure 109. For every 30 parts of carbon there has to be only one part nitrogen (Stoner 1977).

Microorganisms' main energy source is carbon, but nitrogen is needed for protein, genetic material, and cell structure. A balanced diet for a compost microorganism is 30 parts carbon for every one part nitrogen they consume. If a compost pile contains too much nitrogen, the microorganisms cannot consume all of it and the excess it lost in the form of foul smelling ammonia gas. Nitrogen is extremely valuable to plants, thus losing it to the atmosphere is wasteful (Rodale 1960).

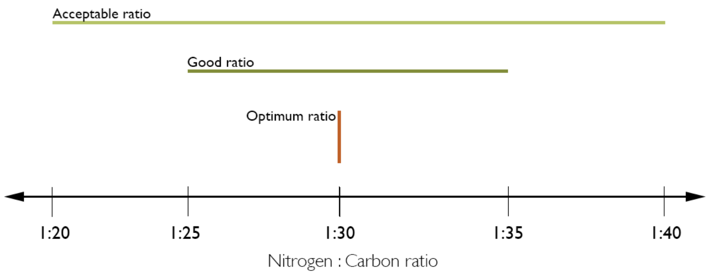


Figure 109. Required Nitrogen: Carbon ratios for successful compost (Author 2015).

The two ingredients of corpse composting are the corpses and straw/dried veldt grass (carbon based material). A human corpse consists of 18.5% carbon and 3.2% nitrogen. Although the percentage of nitrogen might seem low, in comparison to the carbon percentage, a corpse has a N:C ratio of 1:6. This is far from the required 1:30 ratio needed for composting. Straw consists of 40% carbon and 0.288% nitrogen and has a N:C ratio of 1:140. Combining the corpse and straw in the correct proportion will result in a balanced N:C ratio.

2. Moisture

Without sufficient moisture, organic material will not compost. Moisture is required at the initial stage when the exothermic reactions take place. During the composting process a lot of moisture evaporates, causing the pile to shrink with 70%. The lack of moisture will result in a dried out composting and bring the process to a halt (Rynk 1992). In extreme cases, the moisture content of a compost pile can dwindle from 65% to 20% in just a week.

Water does not needs to be added as an ingredient. The ingredients (corpse and straw) all contain moisture and if balanced correctly no extra moisture will be necessary.

Both ingredients have a moisture percentage. Carbon based materials like straw, dry veldt grass, sawdust, etc. consist of 20% H20. Corpses vary in moisture content because humans die at different ages. As a human ages, the moisture content of the body decreases.. Figure 110 indicate that newborns have a moisture content of 75%, a one year old to a teenager a 65%, an adult 55 - 60% and an elderly person only 50% (Forbes 1987). The moisture content as well as the weight of the corpse will influence how much straw is needed to balance the compost pile.

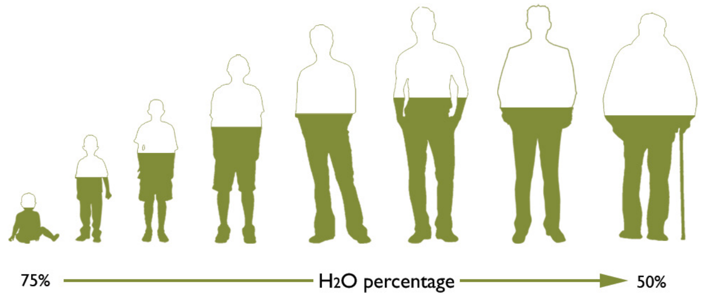


Figure 110. The moisture percentage of a human body decreases with age (Author 2015).

3. Oxygen

Composting is an aerobic process that requires the cultivation of oxygen loving bacteria in order to ensure thermophilic decomposition. Minute interstitial air pockets can be created by adding airy, non-compacted, bulky material (straw) to the corpse (Jenkins 2005).

Bacterial decomposition can take place anaerobically; this however, is much slower, not thermophilic, and releases undesirable odors. Proper healthy aerobic compost does not smell bad; good carbon bulking material, like straw, traps oxygen in the pile and prevent odors.

4. Temperature

Composting is an exothermic chemical reaction. In order to compost the organic materials properly, the pile has to reach a certain temperature. Without a correct N:C ratio, the compost pile is too hot or not hot enough. Figure 111 illustrates that if the N:C ratio is 1:40 the pile will only reach a temperature of 60°C, while a 1:60 ratio only reaches 45°C. With a correct N:C ratio the compost pile should reach temperature between 70 and 77 °C. If this is not reached, the decomposition is less effective and takes a lot longer.

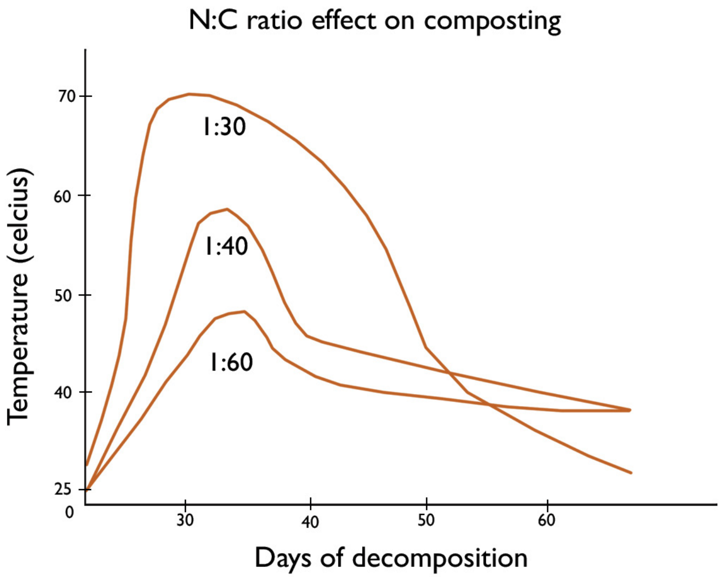


Figure 111. Incorrect N:C ratio will result in insufficient heating of the compost heap (Author 2015).

The person compiling the compost heap can easily manage the above-mentioned necessities. Once these are in place, thermophilic microorganisms can start the composting process.

7.7 The composting process

7.7.1 Preparing the chamber

Prior to composting, the pile needs to be built.

1. The pile should be contained in a constructed chamber instead of just sprawling over the soil; this will reduce the surface area where heat loss happens.

2. The pile needs to stand on top soil to allow macroorganisms, like earthworms, to move from the soil into the pile and back. If the soil underneath the pile were compacted, macroorganisms would not be able to enter the pile, which would bring the process to a halt.

3.The chamber should not be entirely exposed to full sun. Solar heat would externally overheat the pile, killing the micro and macroorganisms and cause the pile to rot, rather than compost.

4. The materiality of the chamber needs to be considered. Timber or cement/ masonry can be used, timber may be preferred as it will insulate the pile and prevent heat loss. If timber is used it should be kiln dried and may not be soaked in toxic chemicals. Kiln drying timber removes the air, which makes it too dense to decompose (Jenkins 2005).

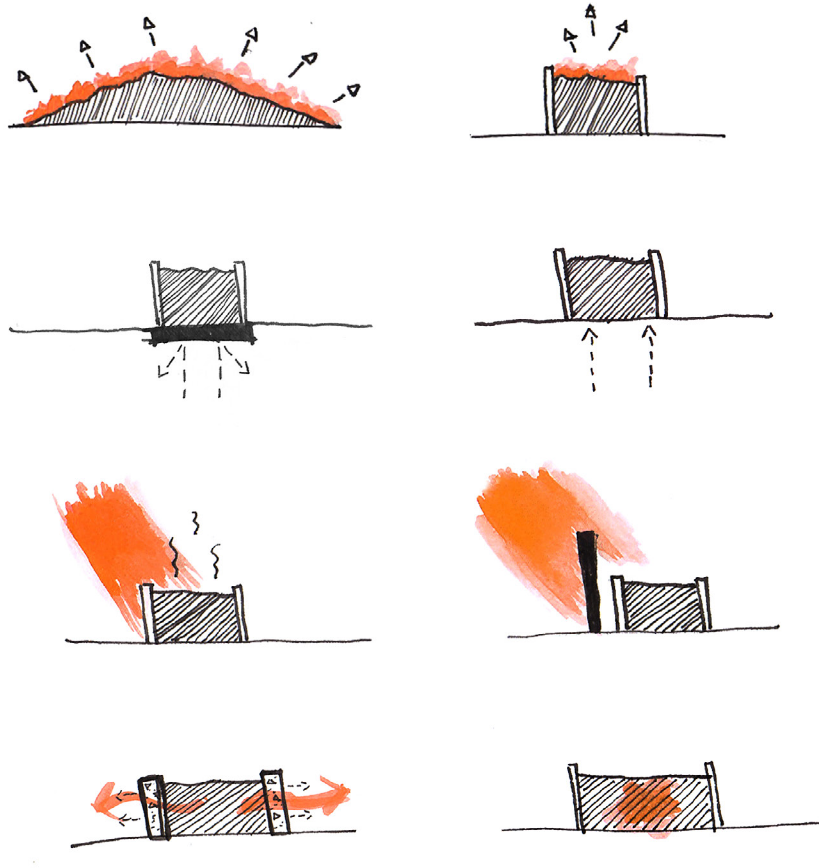


Figure 112. Incorrect vs correct composting pile construction (Author 2015).

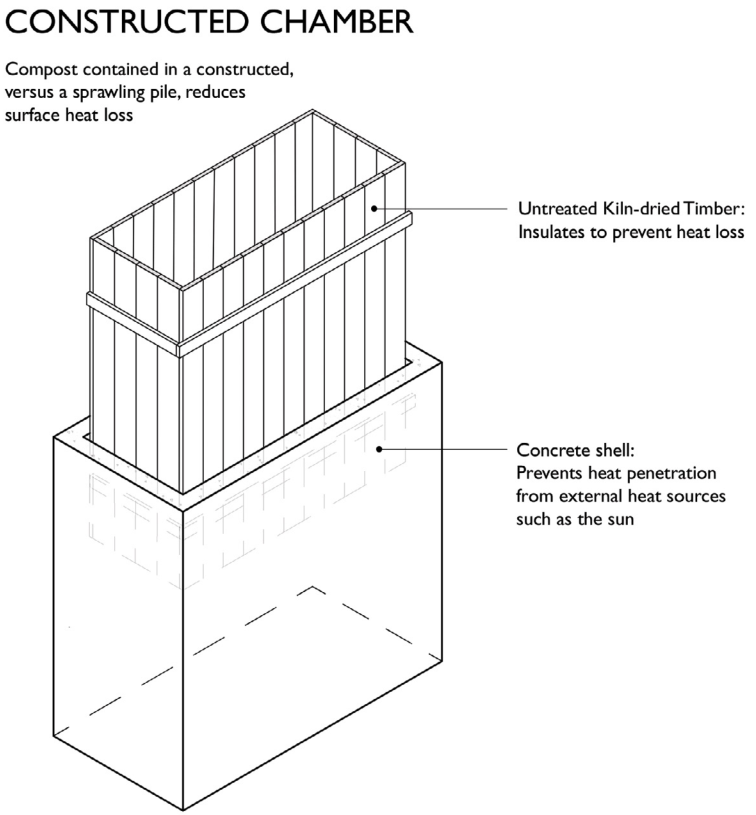


Figure 113. Proposed constructed composting chamber's materiality and shape (Author 2015).

7.7.2 Preparing the corpse

Before placing the corpse in the composting chamber, the corpse has to be prepared, Figure 114, to ensure proper composting. Everything in the human body can decompose; teeth however take exceptionally long due to its high calcium concentration. The decay of teeth can take as soon as 50 to 100 years. The teeth should rather be pulled out and turned to ash through promession, as it will not compost within two months. Next, the corpse may not be embalmed at all. Embalming fluid will prevent decomposition and will poison the compost pile. Lastly, the corpse may not be placed in a wooden or metal coffin. Only decomposable straw woven caskets are allowed. The corpse may also be wrapped in cotton instead of placed in a casket.

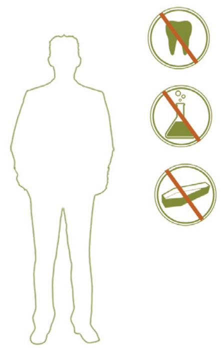


Figure 114. Composted corpses my not be embalmed or be placed in timber caskets. Their teeth are also pulled prior to composting as dental decay takes between 50 - 100 years (Author 2015).

Once the chamber is constructed and the corpse has been prepared, the corpse and straw can be placed inside. The corpse, which is placed in a woven casket or wrapped in cotton, is lowered onto 40% of the straw and then covered with the remaining 60%. It is crucial that the nitrogen-based material is covered with the carbon-based material; it prevents foul corpse odors.

7.7.3 Four phases of composting

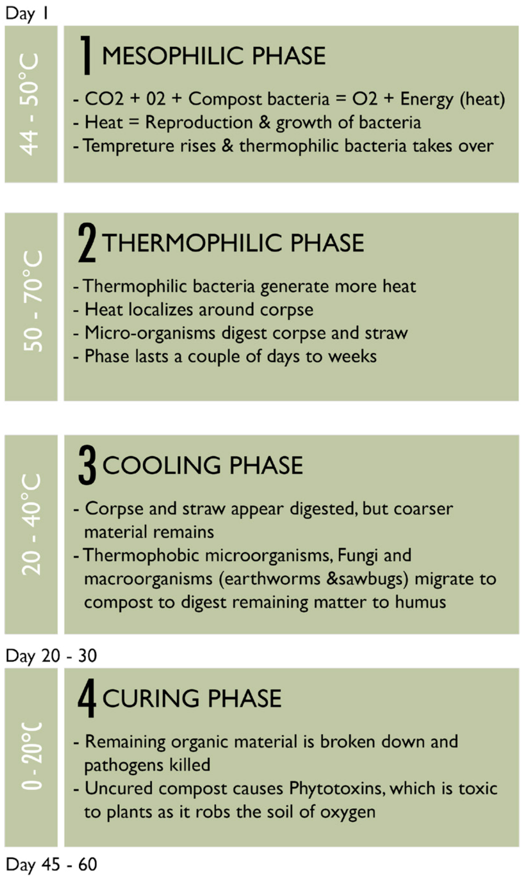
When the corpse and straw is placed in the chamber, Figure 115, the four stages of composting commence. Figure 116 illustates the four phases of composting.

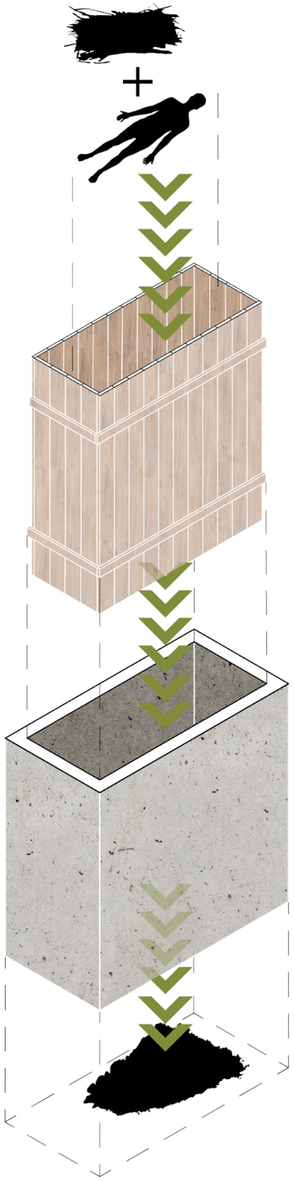
7.8 Calculating the N:C ratio

Efficient and pathogen destroying thermophilic composting only takes place if the nitrogen-based and carbon-based organic materials are balanced. The perfect N:C ratio is 1:30. In order to calculate the N:C ratio, the nitrogen, carbon, and water percentage of each material is needed. Whilst calculating the ratio, it is also crucial to calculate the size of the pile. This is done in cubic meter and will determine the size of the compost chamber.

7.9 Composting calculation example

Each corpse will require its own N:C ratio calculation. The age of the person who died, as well as their weight influences the amount of sawdust needed. As an example the calculation will be done for a 45 year old male who weighed a 100kg.





LEFT Figure 116. Four phases of composting (Author 2015).
RIGHT Figure 115. Ingredients are placed into the chamber and reduced to humus through composting (Author).

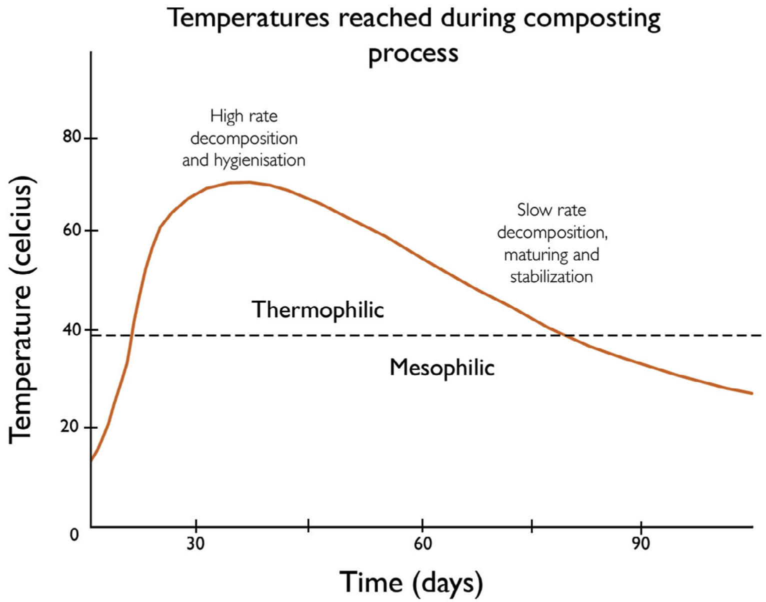


Figure 117. Temperatures reached during composting process (Author 2015).

Figure 118 illustrates his, and the straw's biological statistics. The information in is translated into a table.

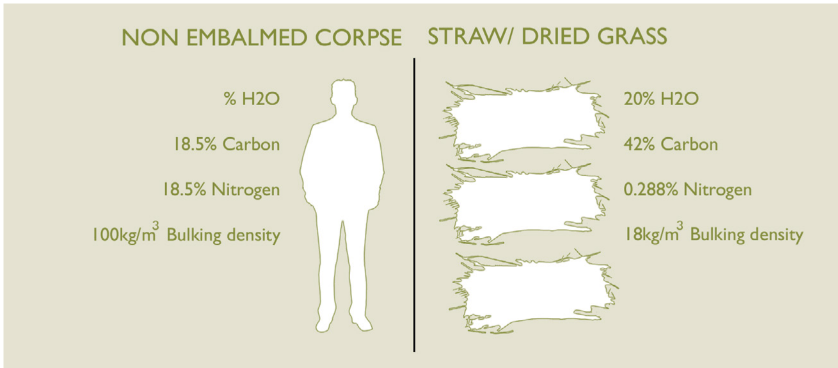


Figure 118. Biological and chemical statistics of a corpse and straw (Author 2015).

Organic material	Weight (kg)	Volume (m^3)	% H20	% Carbon	Carbon average	% Nitrogen	Nitrogen average	N:C ratio
Corpse	100	0.1	60	18.5	7.4	3.2	1.28	1:6

The volume of the corpse is calculated as such:

volume (m^3) = weight (kg) / density (kg per)

(Greenwood & Earnshaw 1997)

The density of a human corpse is 1000kg per m^3 and the corpse in this example weighs 100kg. Thus, the volume of the corpse would be 0.1.

$$v = w/p$$
$$v = 100 / 1000$$
$$v = 0.1\ m^3$$

Following this calculation, the amount of carbon needed to balance the nitrogen-based corpse has to be calculated. The chemical statistics of straw is illustrated in Figure 118. This information is translated into the table.

Organic material	Weight (kg)	Volume (m^3)	% H20	% Carbon	Carbon average	% Nitrogen	Nitrogen average	N:C ratio
Corpse	100	0.1	60	18.5	7.4	3.2	1.28	1:6
Straw	120	5	20	42	40.32	0.288	0.276	1:122
Total	**220**	**5.01**			47.72		1.556	**1:30**

With the information in the table, the weight and volume can be calculated. For a deceased person of 45 years and 100kg, 120kg (five cubic meter) of straw is needed to compost the corpse. Also indicated in the table is the total volume of the compost pile; to compost this corpse the chamber will need to be at least 5.01 cubic meter.

7.10 Timing and final product

Human corpse composting is not practiced anywhere in the world. The author designed the system based on the biological properties of the organic elements and chemical processes of composting. Although humans are not composted, the composting of livestock carcasses on farms has become popular amongst farmers. The increase of composting large animal carcasses is due to the high cost to dispose of the carcasses through incineration, bio-digestion, or chemical digestion (Auvermann *et al* 2006).

According to Auvermann *et al* (2006), the cattle carcasses are covered with sawdust, Figure 119, to ensure a N:C ratio of about 1:30. Phase one to three takes about two months for a 250kg calf. For human corpse composting, the Author has divided this time in half, due to corpses being smaller and lacking a thick coarse skin, and fur.

After the first three phases, all soft tissue has degraded, only the carcass bones have not fully composted. The pile is left for another two months for allow phase four to take place (Auvermann *et al* 2006). Once again this time can be reduced for human corpses. After all four phases are completed, some larger bone fragments remain, Figure 120, but they are hollow and brittle and will easily degrade once applied to the land (Auvermann *et al* 2006). If larger bone fragments are undesired, it can be turned to ashes using an industrial blender.

Figure 119. Nitrogen-based cattle carcass is placed in and over with sawdust (Author 2015).

Figure 120. After the Curing phase brittle bone fragments remain (Author 2015).

To conclude, the composting of a human corpse takes about one and a half to two months. The mass of the organic materials is reduced to about 30% of the original volume within the first 20 to 30 days. The final product of composting is a nutrient rich, safe to handle humus, which may contain some bone fragments.

7.11 Focus area: Human composting chambers

The area selected for detailing, figure 121, is the first event of the burial site's narrative: the composting chambers.

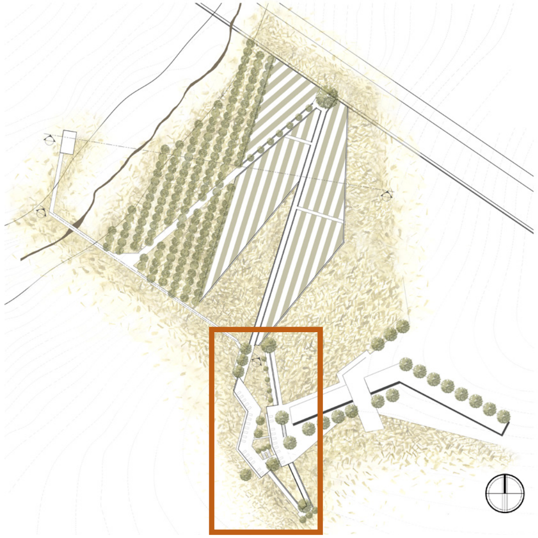


Figure 121. Sketch plan/ focus area for technification (Author 2015).

7.12 Approach to technification of the composting chambers

The area was selected because it is important to the site's narrative and demonstrates a unique alternative method to sustainably dispose of corpses through composting. At the composting chambers, the user is made aware of his own morality. On the upper level of the chambers, the user witnesses the corpses being lowered into chambers. This makes the burial feel very traditional up to this point. However, once the user is on the lower level moving past the composting chambers, it goes from tradition to unconventional. On the upper level the experience is about the user bidding farewell to a loved one, while on the lower level is it about the user's own mortality. On the lower level the user realizes that they, like the person composting in the chamber next to them, is mortal. Although the corpses cannot be seen or smelled, the idea of it makes one very aware of the temporality of human life, and of your own mortality. This is a powerful, serious, formal and important space; not only is it a place where someone says goodbye to a loved one, it is also a space where the user is confronted with death. The design and materiality of the space should reveal this.

The space should not feel informal, cheerful, or lighthearted, so the architecture should not either. Tectonic structures often feel light and relaxed. An example of such is the viewing tower at the end of the narrative. After the user moved through the narrative the genus loci changes from serious to lighthearted. The architecture reflects this change in atmosphere by also being light, open, and tectonic like the viewing tower at Vecht riverbank in Dalfsen, Figure 122.

Figure 122. Tectonic viewing tower at Vecht riverbank in Dalfsen (Author 2015).

In juxtapose, the architecture of the composting chambers needs to be solid, strong, and formal. The architecture has to reveal a place of importance. It is place where the body of a person is returned to the greater cosmos. It is a place where a person watches as their loved one is lowered into a chamber. It is a place where people are confronted with death.

To achieve this the architecture has to be heavy and powerful. An example of such a place is the Voortrekker monument, Figure 123. This iconic granite building is extremely powerful, it conveys the message that it is a place of importance and permanence. If the Voortrekker Monument were instead a light steel frame with glass panels, it would not have conveyed the same message. If the sarcophagus and interior of the monument had not been polished granite, but timber, the space would not have felt as sacred. The composting chambers needs to have a similar stature to it. The place has to be stereotomic: a solid shape with spaces carved into it. Peter Zuthor's Thermal Baths in Switzerland, Figure 124, is a great stereotomic example of how spaces are created through voids or negative space. The success of this project also lies in the simplistic material choice: granite is used on the exterior and interior walls as cladding and as large tiles on the floor. This enables the space to read as a single mass from which has been cut. Like the Voortrekker Monument, the Thermal Baths is also a strong granite structure (even though it is cladding), which makes the space read as a mighty sanctuary. The intention of Zumthor was to create a space that felt like a cave with natural hot springs (Betsky

Figure 123. Voortrekker monument, Pretoria, is a strong stereotomic structure. The architecture reveals that it is a place of permanence and importance (Aspeling 2013 & Author 2015).

Figure 124. Thermal baths, Switzerland, by Peter Zumthor. Spaces are created through carving it from a solid structure (Betsky 2002).

Figure 125. Tidal swimming pool, Portugal, by Alvaro Siza feel like the architecture was carved out of the natural rock (Balters 2011).

2002). Finallly, the composing chambers need to sit in the landscape, although stereotomic, it should not feel like a box stuck onto the landscape. Where the natural site ends and where the constructed chambers start should not be visible. A highly successful example of this is the Tidal swimming pool in Portugal by Alvaro Siza, Figure 125.

7.13 Material selection

To achieve all of the above-mentioned, the material selection for the composting chambers needs to be powerful, yet simplistic.

Granite
Granite is the main material, it is used in the form of tiles and cladding to, as the for-mentioned examples, give stature to the space and read as one volume. Even though granite is a non-renewable resource, the mining amount is restricted to avoid depletion of the resource. Unlike most quarried or mined materials, natural stone has a relatively low impact on our environment. The extraction process does not require the use of any chemicals. Only water is used at quarry sites to cool and lubricate diamond abrasives to cut the stone. Natural stone quarries do not produce toxic waste piles that can pollute the surrounding environment.

Granite also has a memory connection. Granite and marble is used for tombstones and cremation wall plaque without exception all over South Africa. It is tradition to engrave a person's name on a precious stone. It gives their memory a sense of permanence (Moodley 2007). Even in the poorest of settlements, loved ones buy the most expensive granite slab they can afford; it is a sign of respect and love towards the deceased. An example of this is seen in an illegal cemetery just outside the Diepsloot township. Even though the family of the deceased could not afford a grave in a municipal cemetery, every grave is marked with a granite tombstone, Figure 126.

This thesis is not about changing people's culture or traditional believes regarding death or burial. The aim is to preserve and respect the traditions, but deal with corpses in a sustainable and ecologically friendly manner within these believes. Thus, the tradition of using granite in a place where people are laid to rest and remembered is retained.

The selected granite colour is Niagara Gold, Figure 127. This stone, crystalline in

Figure 126. Illegal cemetery in an open field next to Diepsloot township. Each grave is marked with a grainte slab or tombstone (Author 2015).

Niagara gold granite

Diepsloot Nature Reserve

Figure 127. Niagara gold granite will fir in the DNR seamlessly to strenghten the notion of cutting into the landscape and carving out of it (Author 2015).

formation, is a combination of vibrant bordeaux reds, creams, golds, and greys that resembles the colour of the Diepsloot Nature Reserve soil and landscape, Figure 127.

Corten (weathering) steel
Weathering steel is used for lighter elements such as balustrades. It is used instead of stainless steel or galvanized steel because of its earthly texture and colour. Stainless steel has an undesirable clinical quality; while weathering steel has a

warmer quality and blends in with the natural landscape. To prevent rust residue from the weathering steel it is treated and sealed. The steel is sand blasted and oxidised to activate rust. The rusting is brought to a halt and the steel is sealed with marine.

Concrete

Smooth finish concrete is used sparsely to not compete with the granite; it is used in service areas and on the ceilings. The colour and texture blends well with the Nigara Gold granite.

Figure 128. Selected material: concrete, granite, and weathering steel (Author 2015).

7.14 Sketch plans

The composting chambers are terraced into the landscape of the Diepsloot Nature Reserve. The design consists of three levels, as illustated in Figure 129.

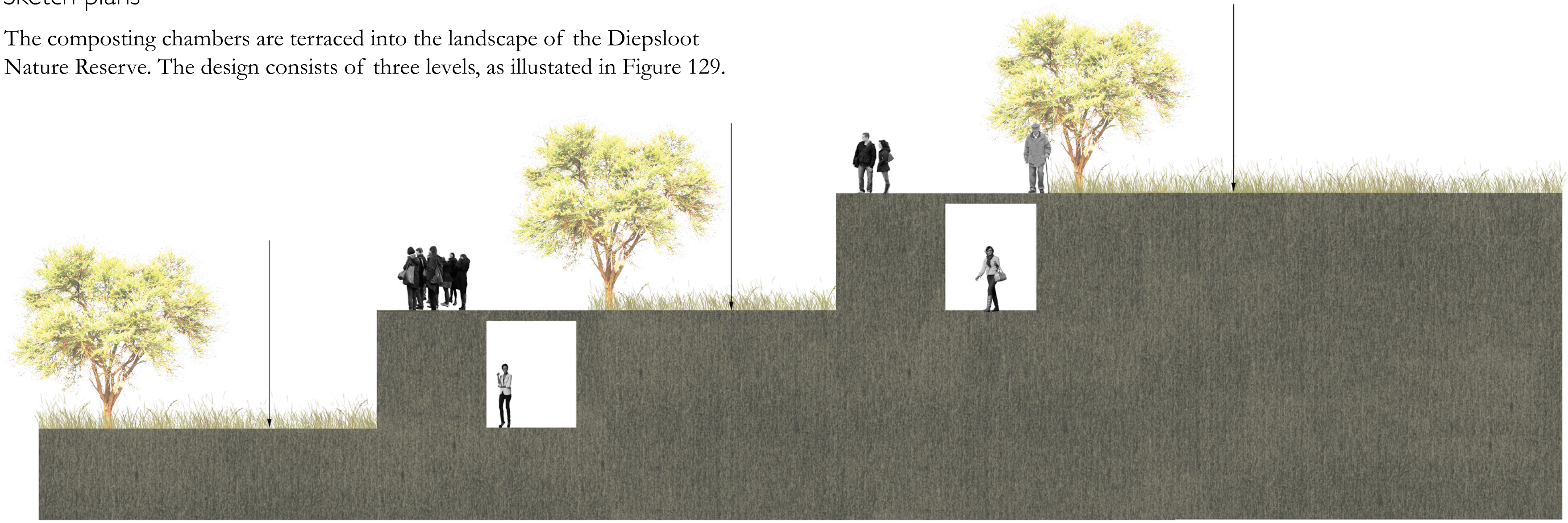
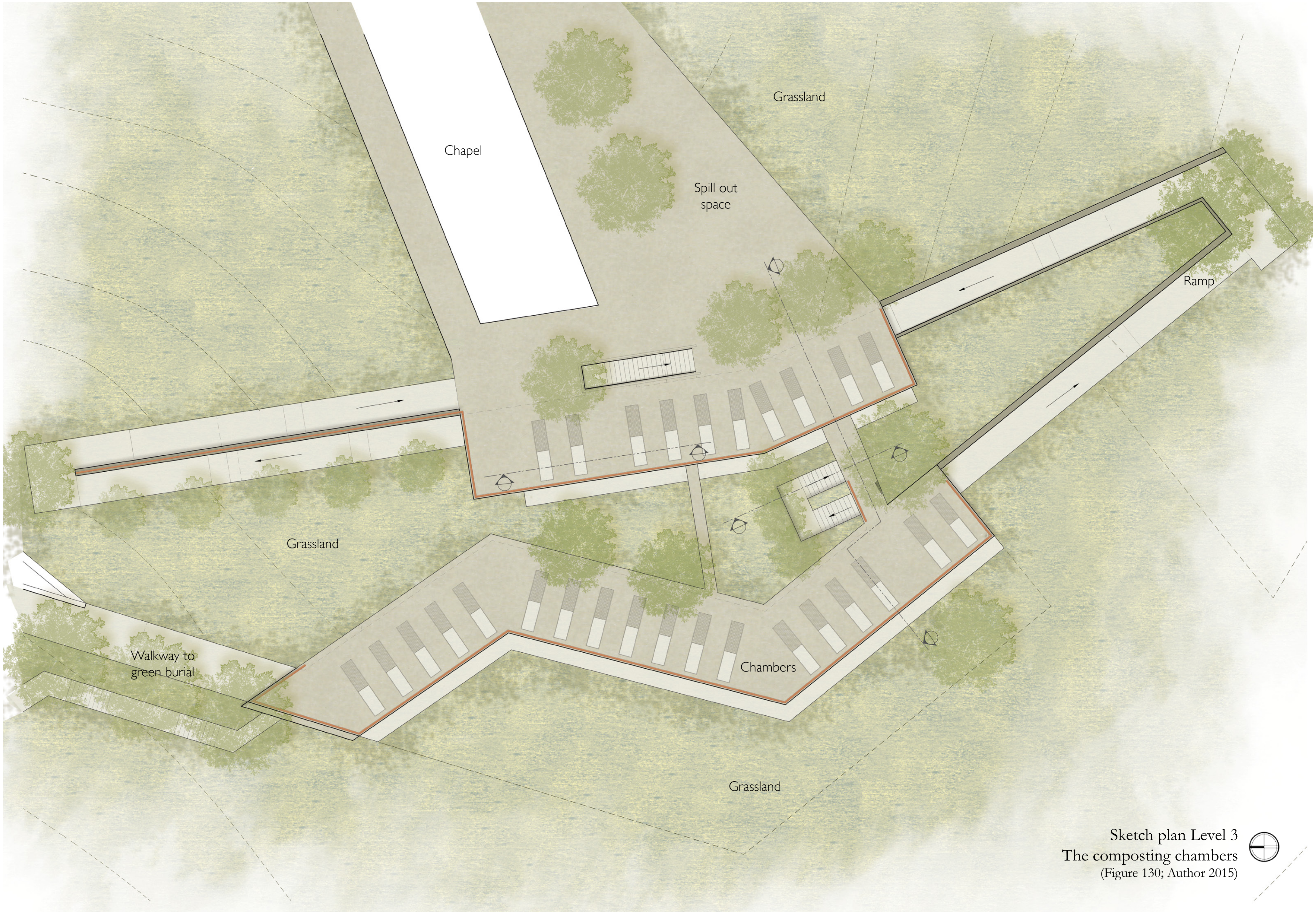
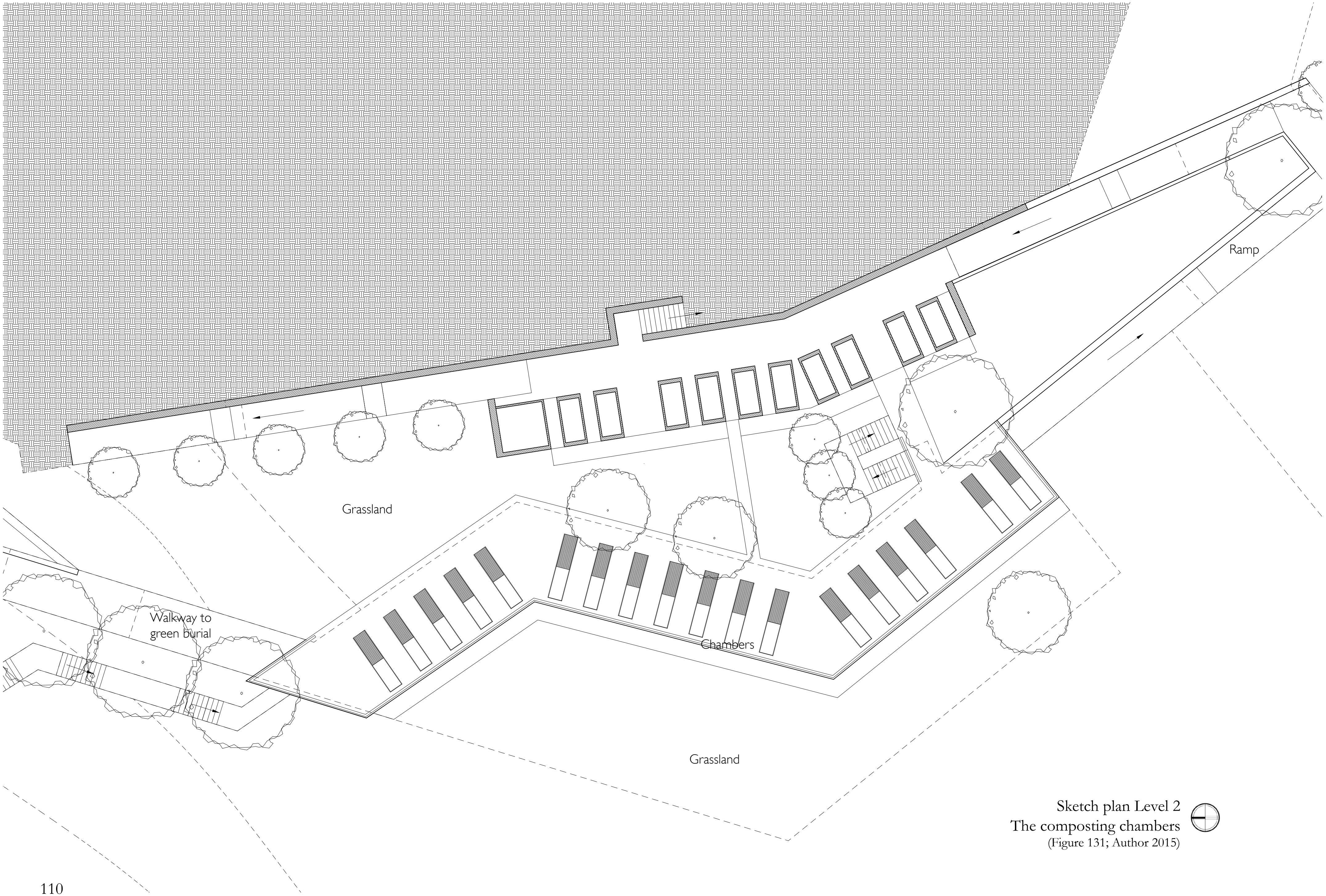


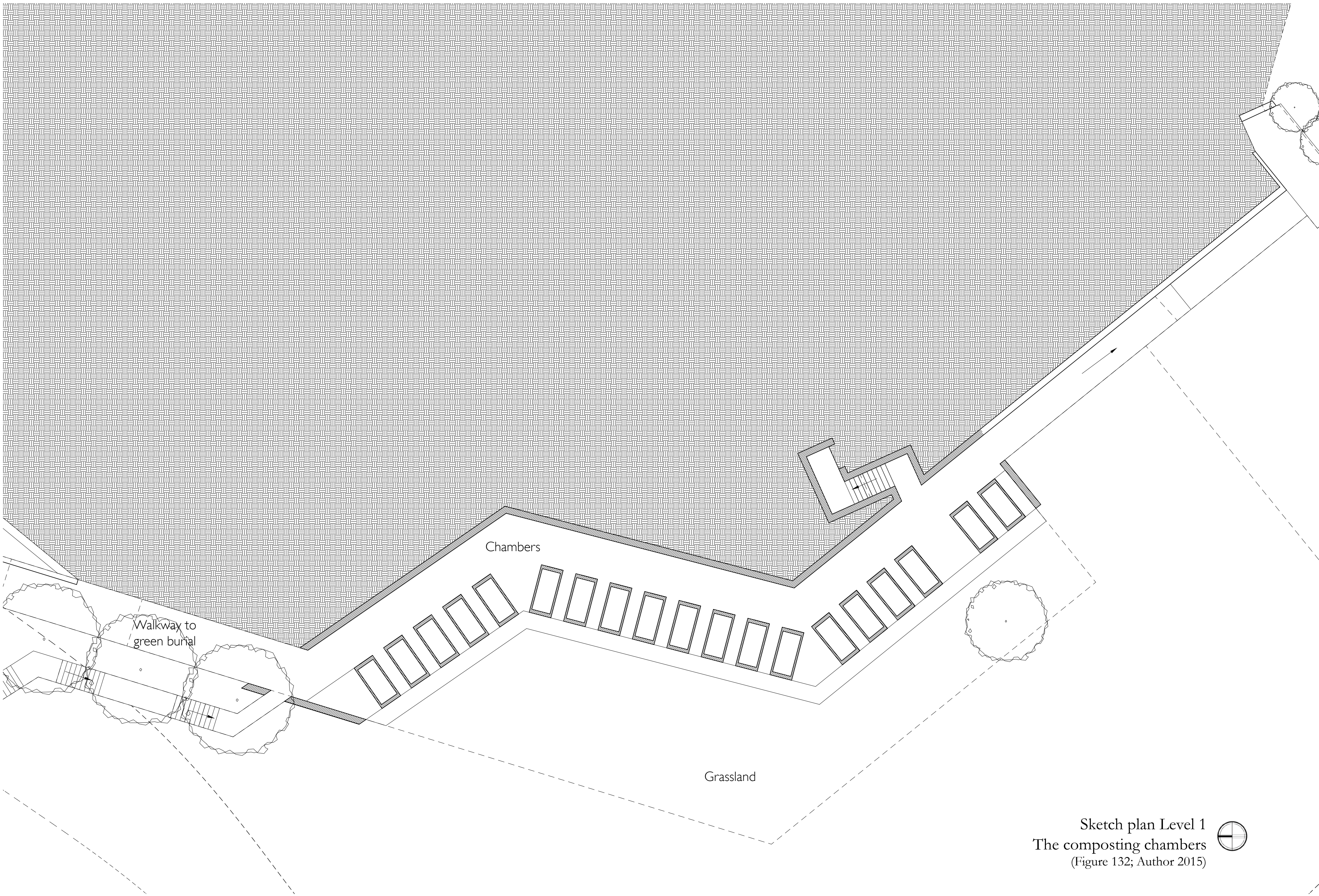
Figure 129. The three levels of the terraced composting chambers (Author 2015).



Sketch plan Level 3
The composting chambers
(Figure 130; Author 2015)

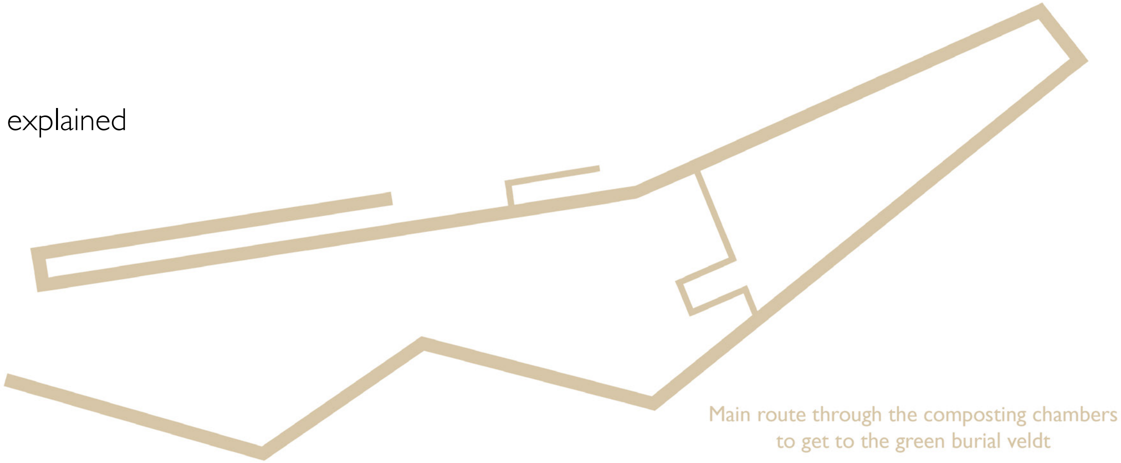


Sketch plan Level 2
The composting chambers
(Figure 131; Author 2015)

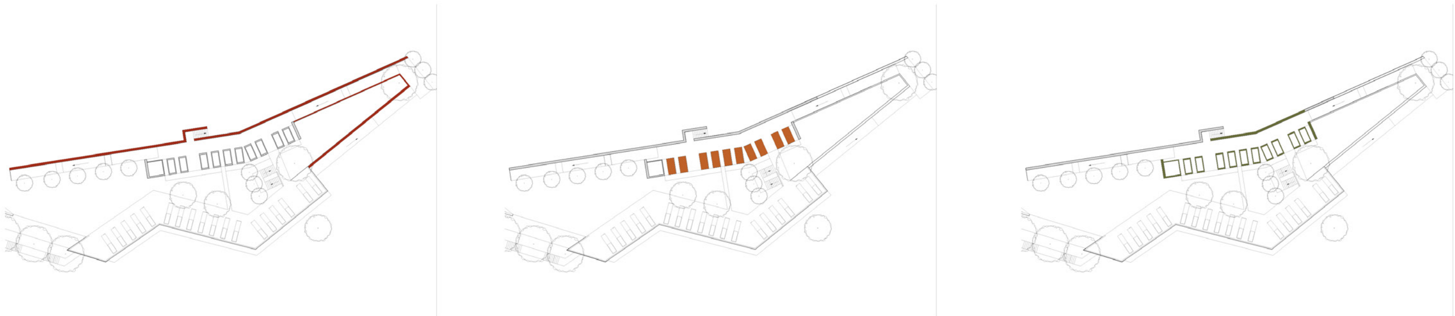


Sketch plan Level 1
The composting chambers
(Figure 132; Author 2015)

7.15 Composting chambers explained



Level 2

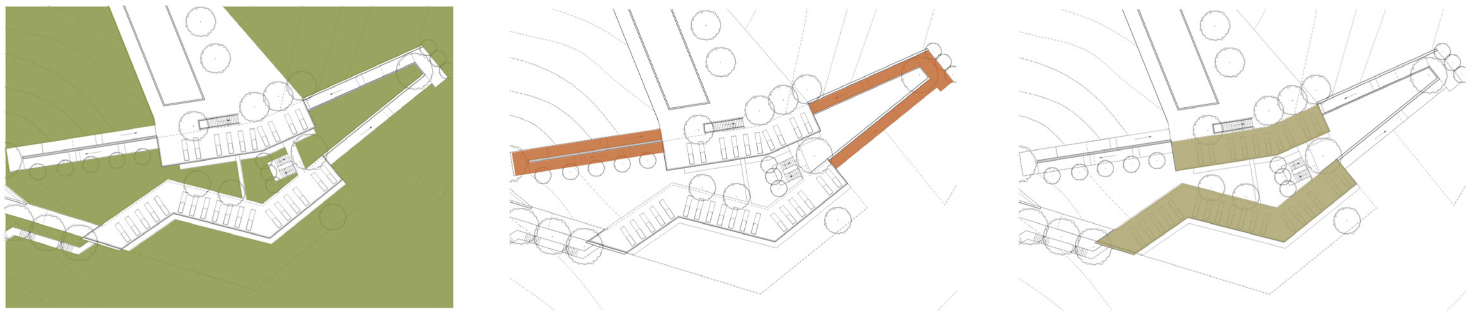


Retaining wall creating terracing of composting chambers

Composting chambers

Walls supporting upper platform

Level 3



Rehabilitated grassland

Ramp for wheelchair users, moving of corpses, and maintenance

Two platforms where corpses are lowered into the composting chambers

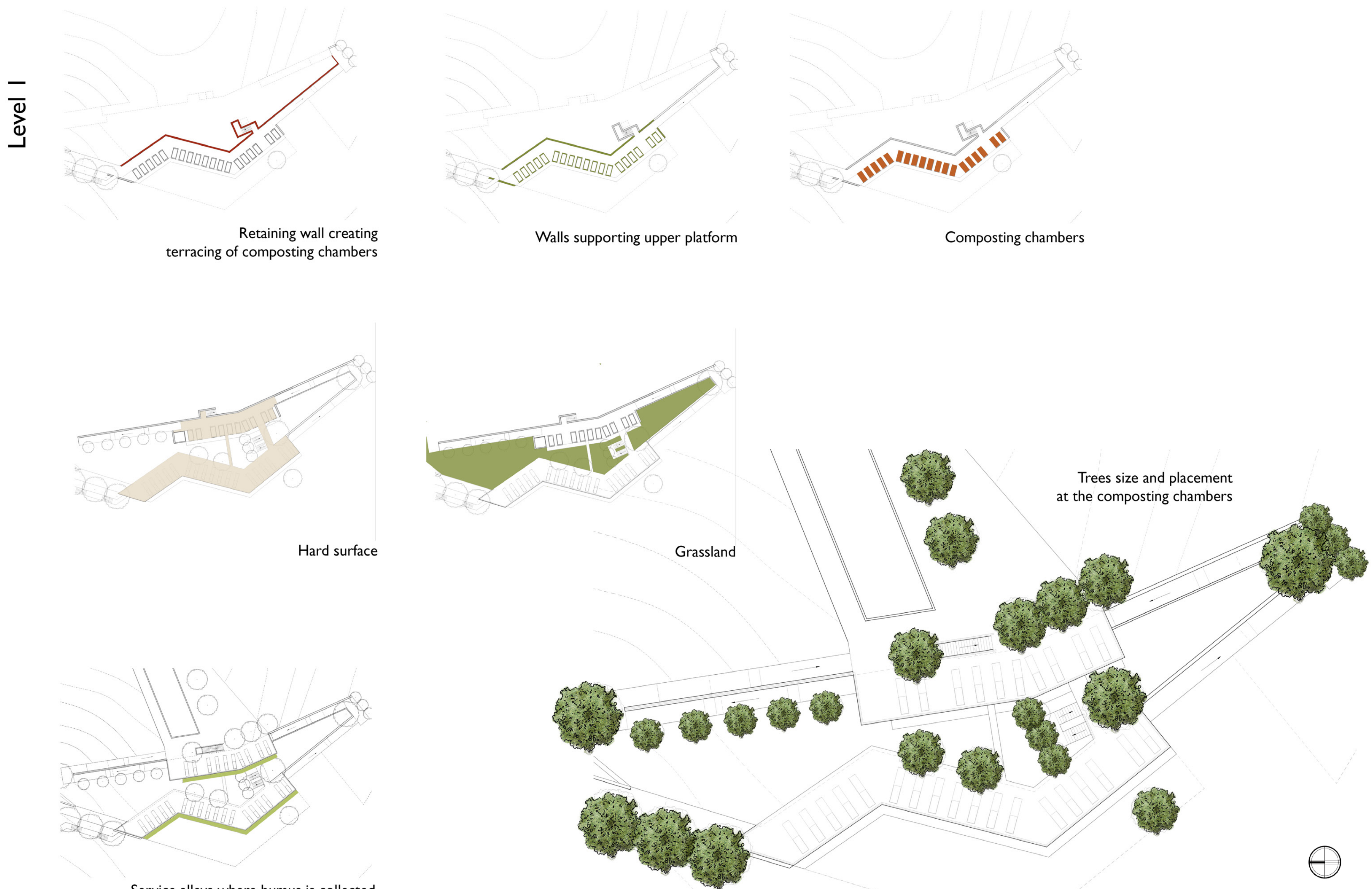


Figure 133. Composting chamber design deconstrcuted (Author 2015).

7.16 Perspectives

Figure 134. Users descend a ramp to get to the second series of comosting chambers. Catherine Dee's refuge and prospect theory was applied by having a high retaining wall on the right and a vast view of the landscape on the left. (Author 2015).

Figure 135. The names of the deceased is engraved on the chamber in which their human remains were reduced to compost. The slits between the chambers allow light to filter into the space. This balance between light and dark is a metaphor for two other contrasting elements of the thesis: Life and Death. (Author 2015).

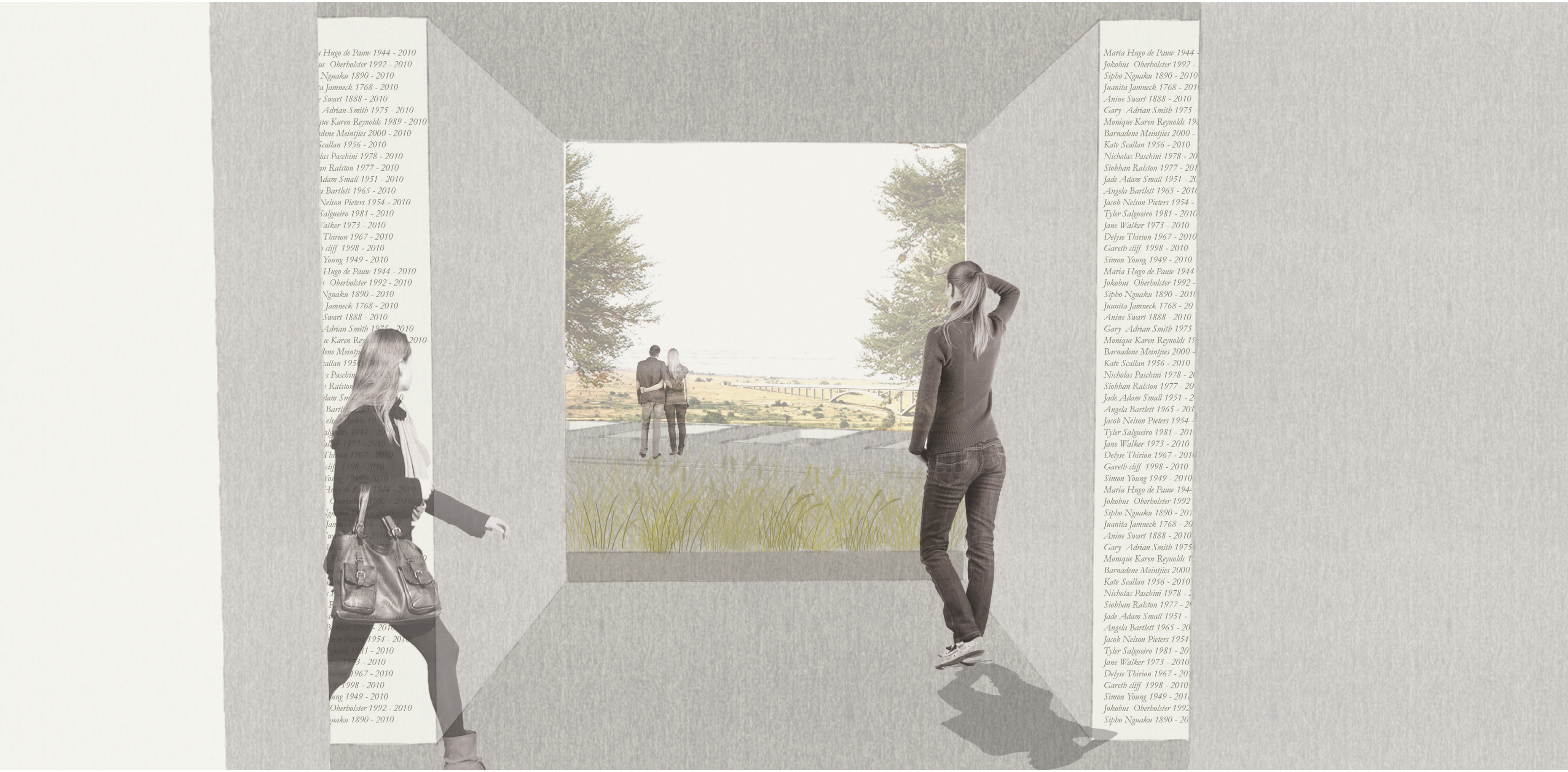
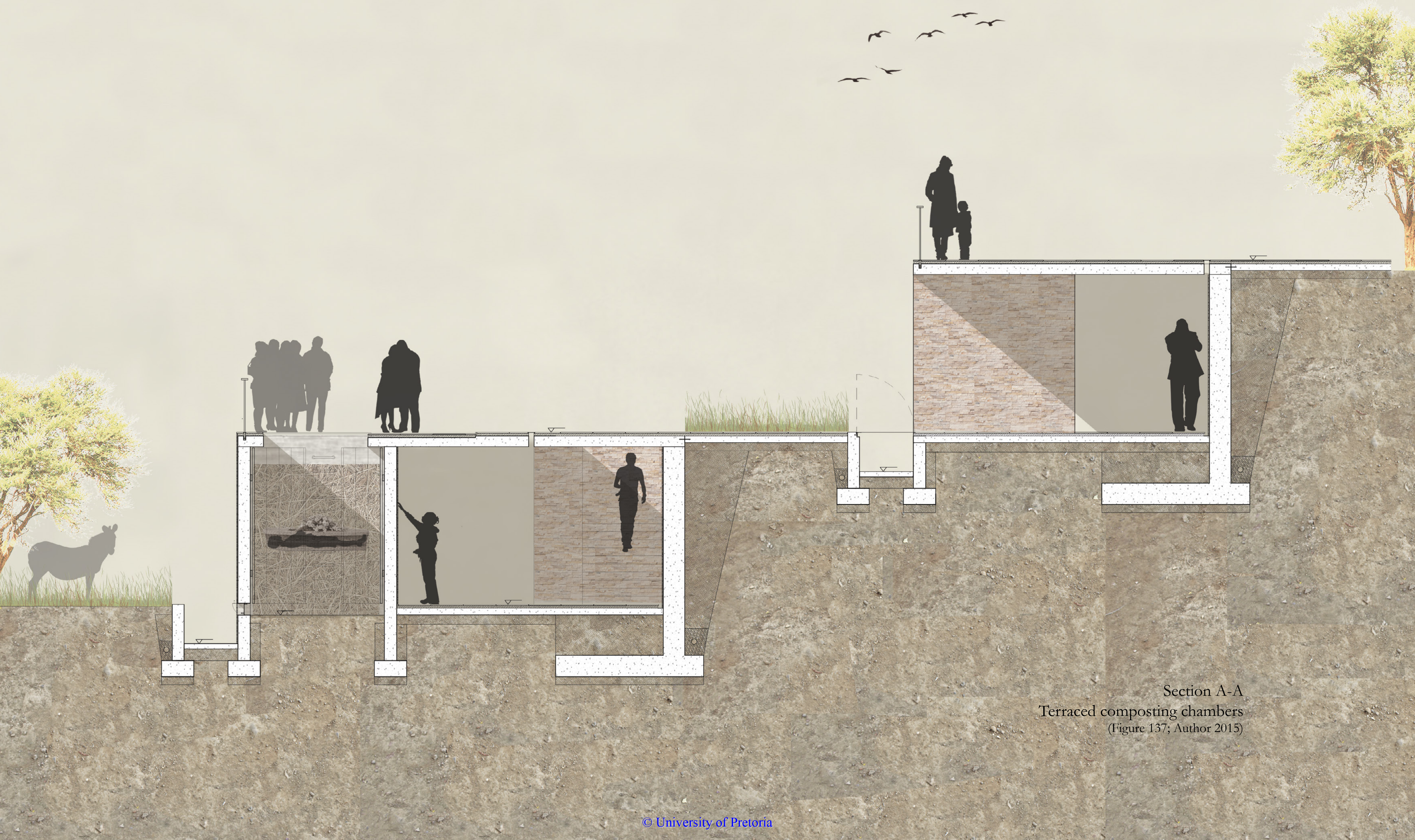
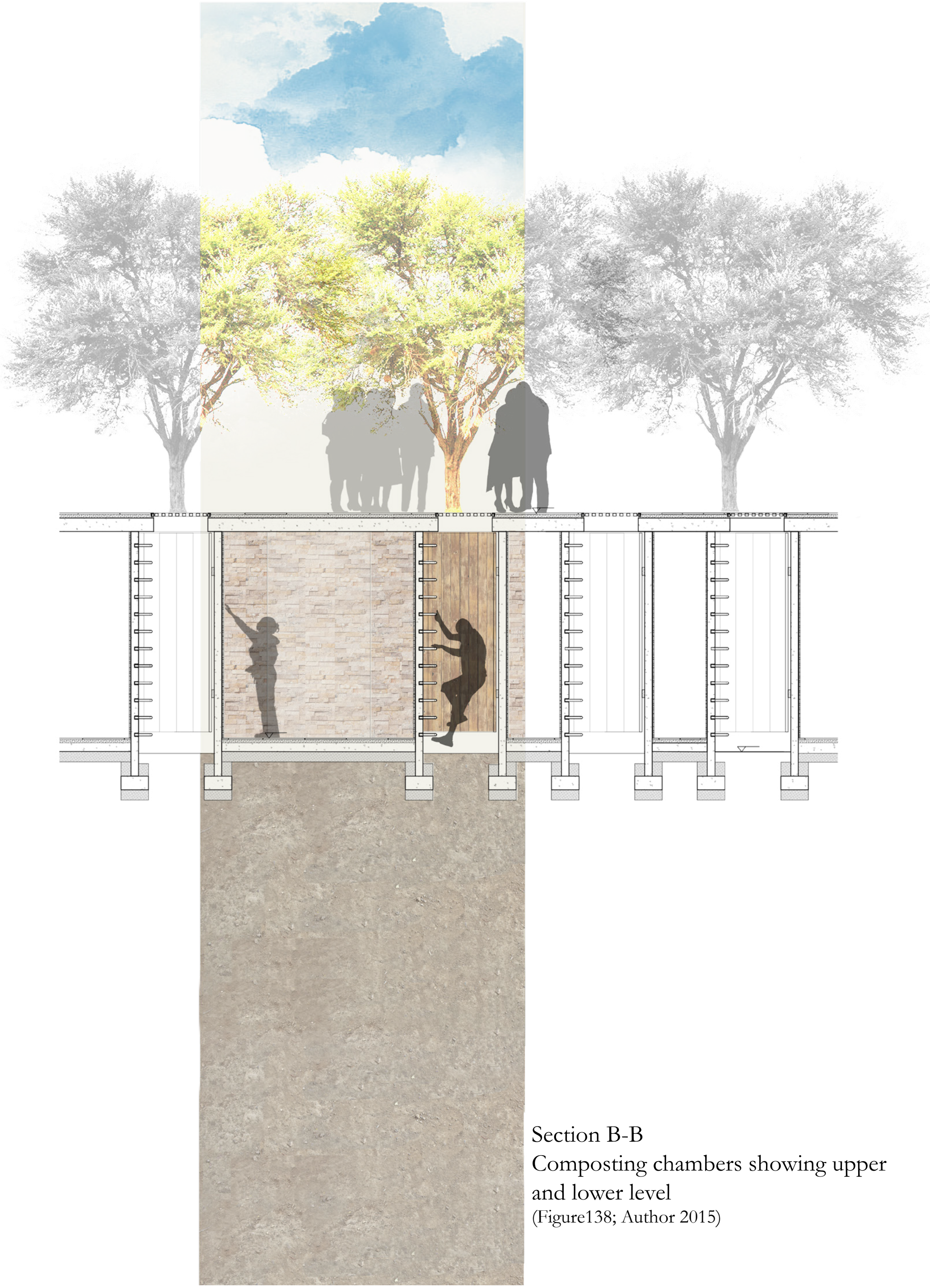


Figure 136. Some slits between chambers are larger to create a moment of intensity. The view is framed and the space is receased to allow for user contemplation. (Author 2015).

7.18 Sections



Section A-A
Terraced composting chambers
(Figure 137; Author 2015)



Section B-B
Composting chambers showing upper and lower level
(Figure138; Author 2015)

Section C-C
Level change from level two to one via stairs
(Figure 139; Author 2015)

7.18 Chamber isometric

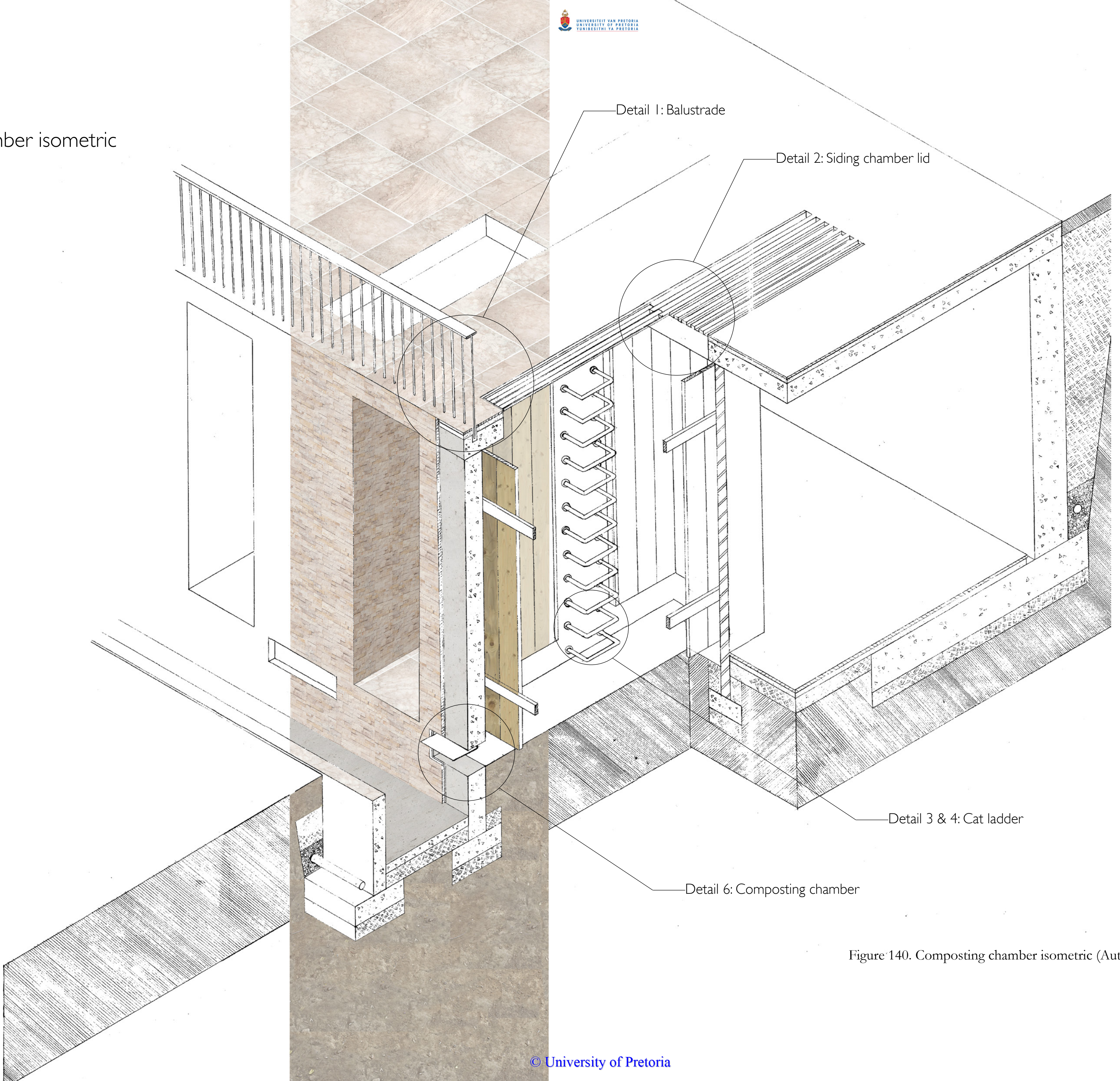


Figure 140. Composting chamber isometric (Author 2015).

7.18 Details

7.18.1 Detail 1: Balustrade

The balustrade strongly resembles the one by Peter Zumthor at the Thermals Baths. The thin corten balustrade juxtaposes the heavy stereotomic structures and emphasizes it. The balustrade is elegantly fixed to the platform without exposed bolts.

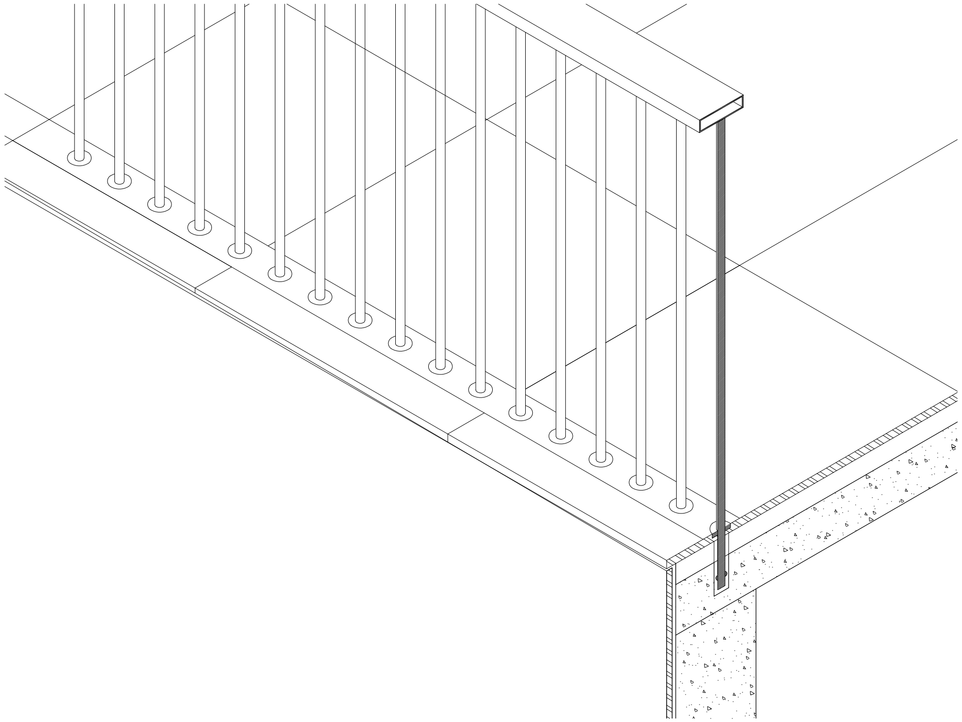


Figure 141. Balustrade isometric (Author 2015).

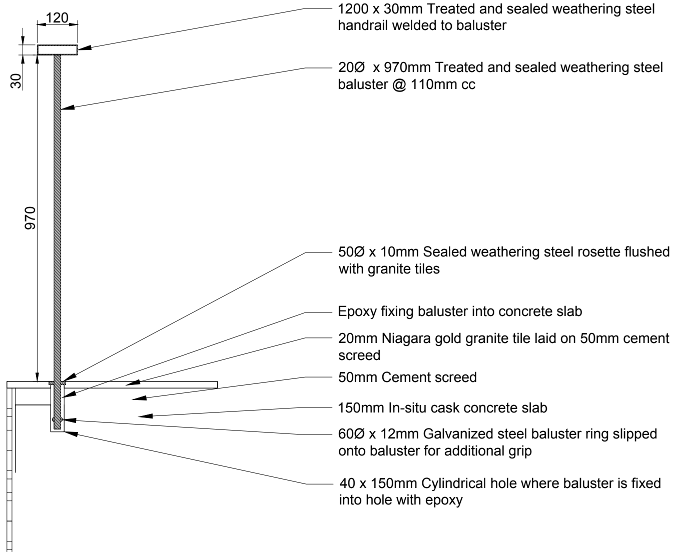
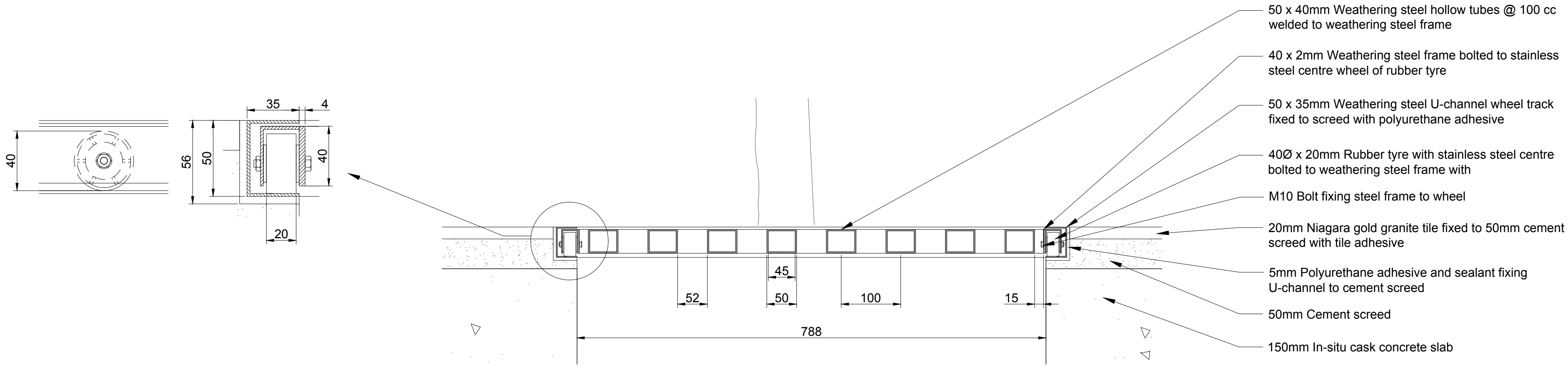
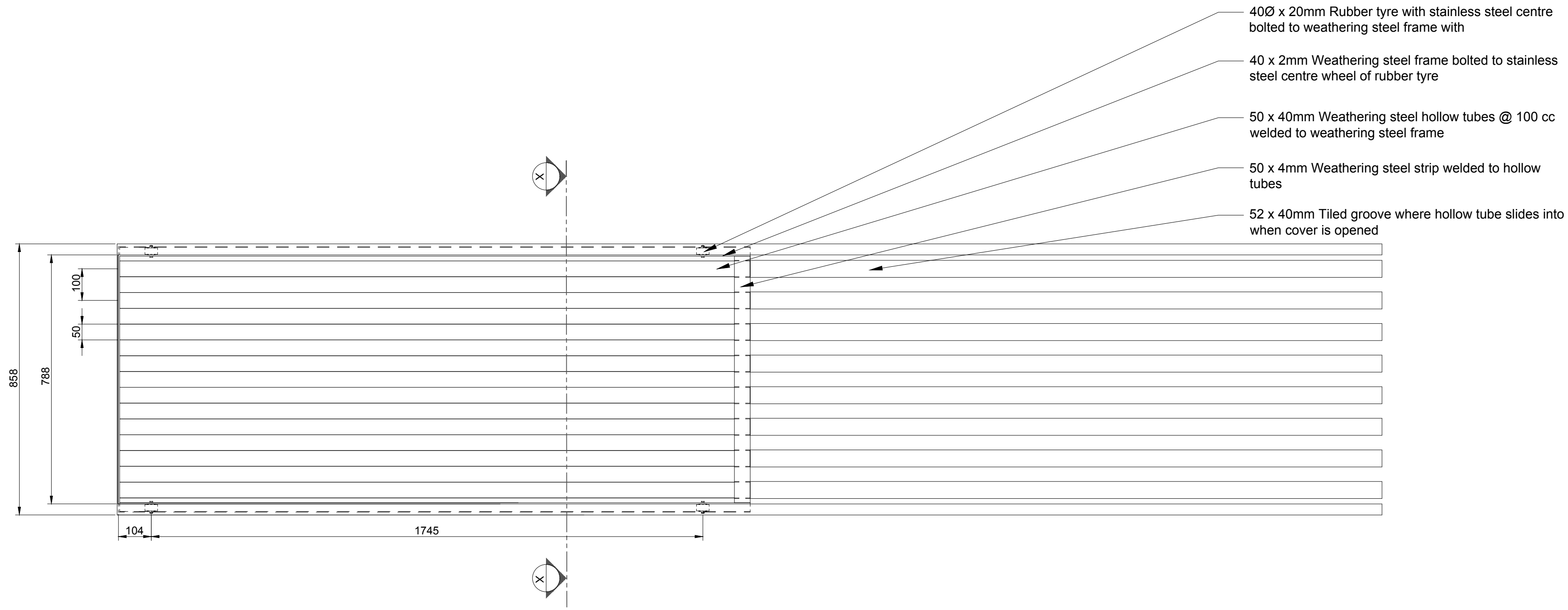


Figure 142. Detail 2: Balustrade technical detail (Author 2015).

7.18.2 Detail 2: Sliding chamber lid

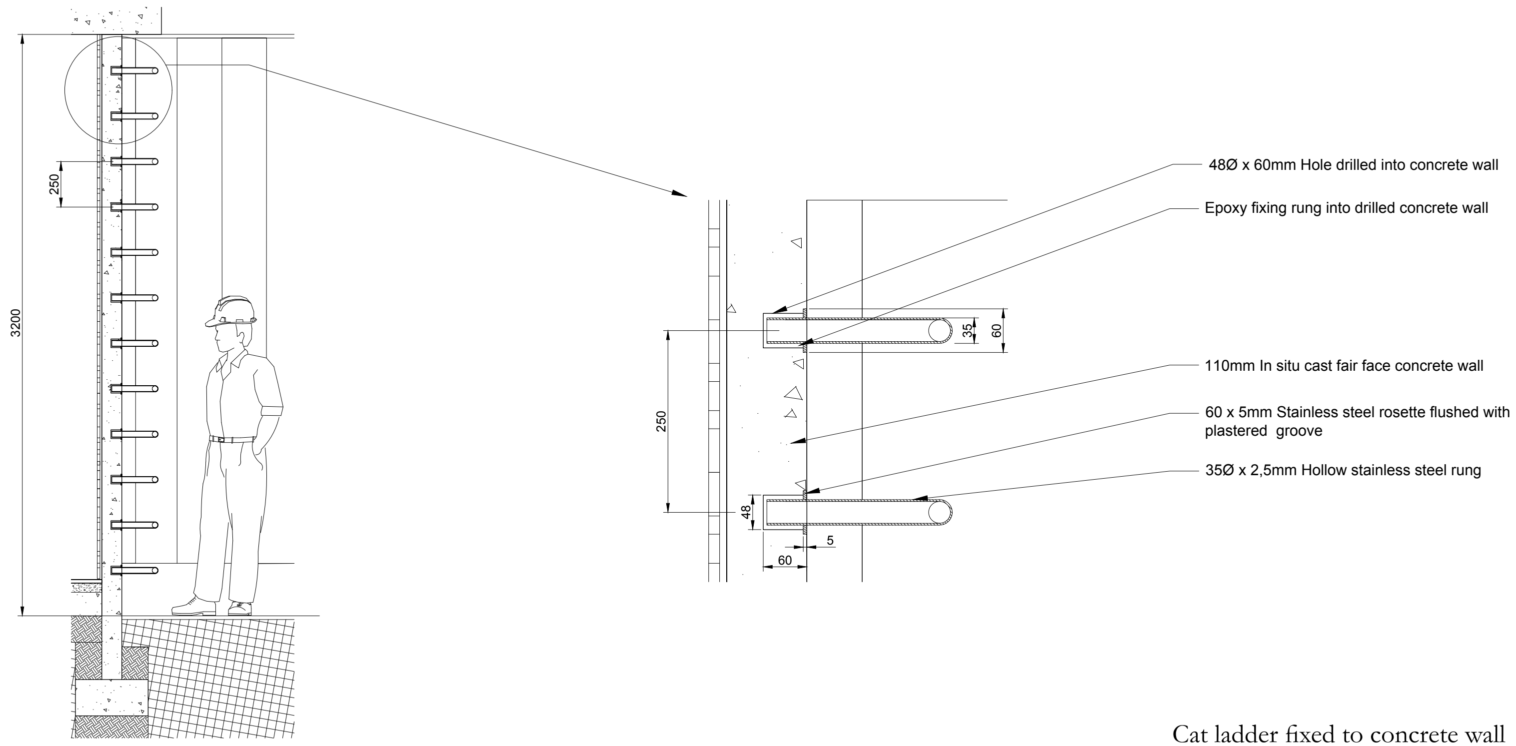
The composting chamber rquires a suitable lid: it has to be permeable enough to allow for ventilation and rain during summer, but also closed to prevent a user on the upper level from falling into the chamber. The initial idea was a removable lid, however this felt too industrial and resembled a manhole cover. The final lid designed is a weathering steel (corten) frame with steel bars that slide on wheels into the paving when open and slides closed once the corpse has been placed inside. It opens and closes easily, allows for ventilation and users can walk over it when it is closed.





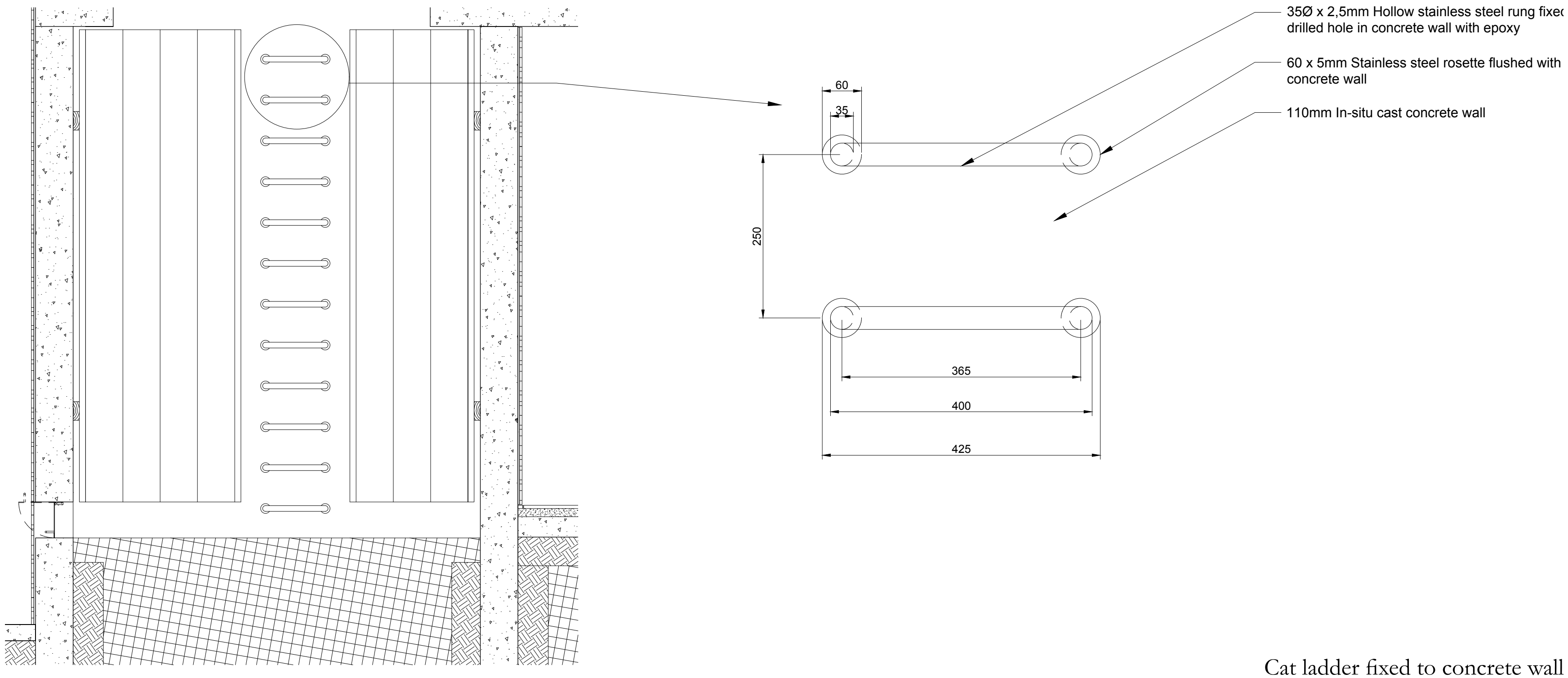
7.18.3 Detail 3 & 4: Cat ladder

The cat ladder on the inside of the chamber provides the employees access to the humus. The material for the ladder is stainless steel to keep it as hygienic as possible for the person climbing into the chamber and to simplify cleaning. It is fixed to the concrete wall with epoxy



Cat ladder fixed to concrete wall

OPPOSITE PAGE Figure 143. Detail 2: Sliding chamber lid technical detail (Author 2015).
Figure 144. Detail 3: Cat ladder inside of composting chamber (Author 2015).



Cat ladder fixed to concrete wall

Figure 145. Detail 4: Cat ladder inside of composting chamber (Author 2015).

7.18.4 Detail 5: Service alley

After the corpse and straw have been reduced to humus, the humus is swept out of the chamber through a cavity in the outer wall into the wheelbarrow in the service alley. The service alley is designed like a haha; it is at a lower level than the walkway and vegetation, visually hiding it from the users. At some points users van can walk over the service alley on a steel platform. When humus is being collected, the steel platform hinges up to allow the wheelbarrow to pass.

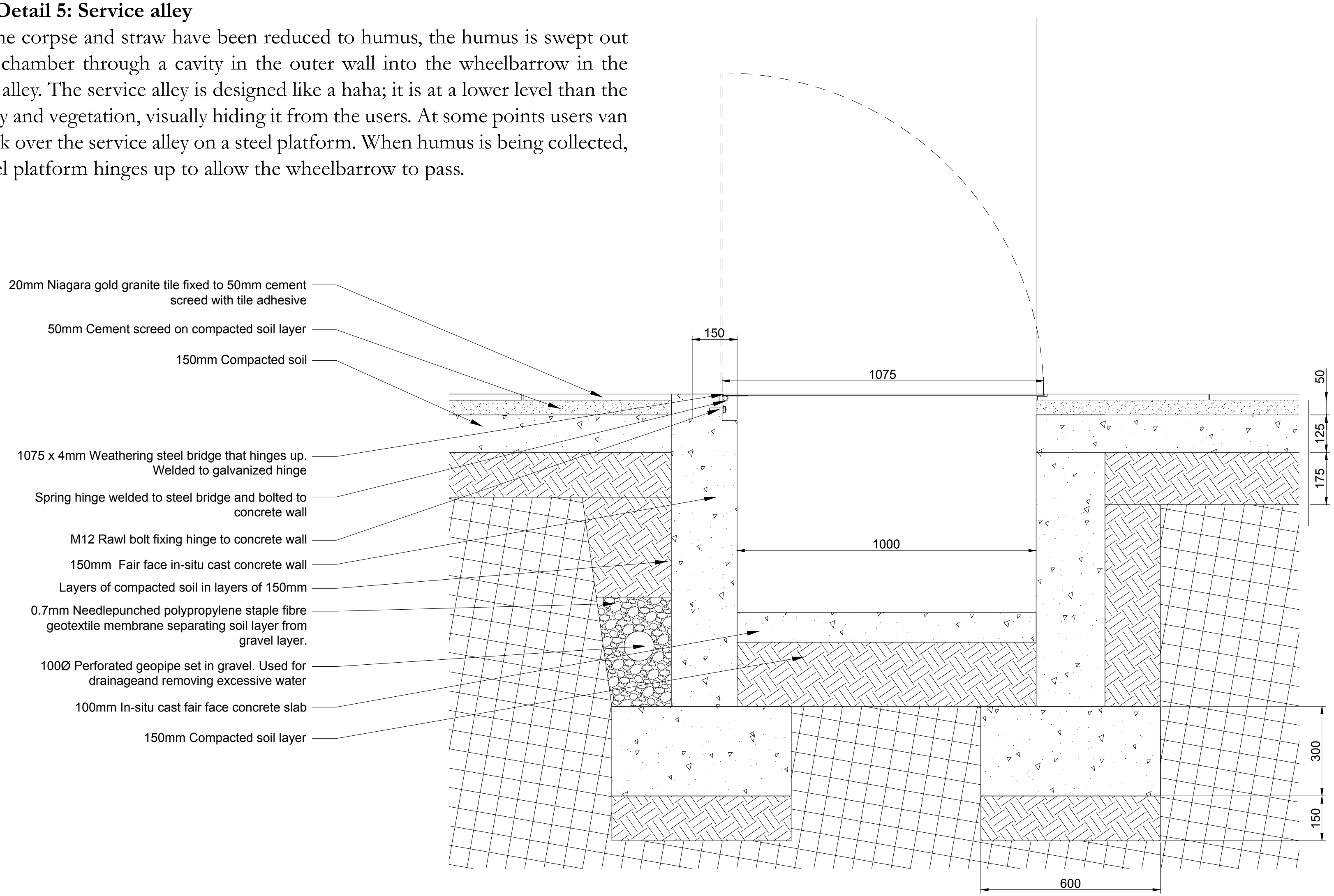


Figure 146. Detail 5: Service alley for removal of humus after the composting process is complete (Author 2015).

7.18.5 Composting chamber

The chamber has a concrete shell and timber cladding on the inside. The timber prevents heat loss and has to be kiln dried and may not be treated with any chemicals. The floor of the chamber is aerated top soil so micro and macro organisms can transfer between the soil and the compost pile during the process. The composting chamber is designed with an input at the top, and an output at the bottom. The corpse and straw/dry grass is placed into the chamber at the upper level. After two months, all that remain is the humus at the bottom of the chamber. This is access via a cat ladder. Once inside the employee sweeps and rakes the humus into a pile and pushes it through a cavity in the wall (which is covered with a steel lid during composting) into the service alley.

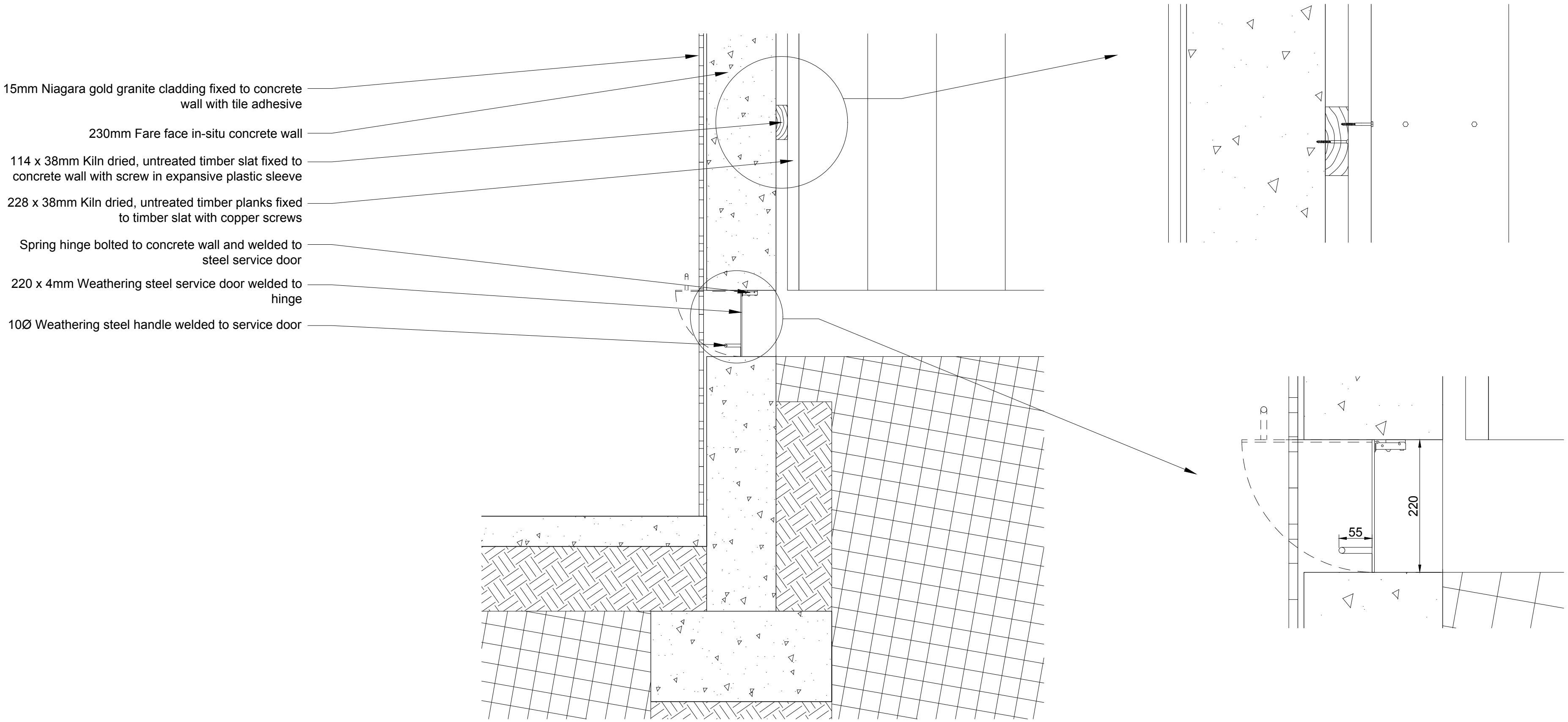


Figure 147. Detail 6: Composting chamber exterior wall detail (Author 2015).

OPPOSITE PAGE Figure 148. Perspective showing materiality (Author 2015).

7.18 Materiality perspective

7.19 Sustainability rating

The SITES (Sustainable land design and development rating for initial design) sustainability rating system was used to evaluate Nekrotopio and the rest of the Diepsloot Nature Reserve. Due to the unique nature of the thesis it is difficult to evaluate it based on a formula developed to assess general landscape interventions.

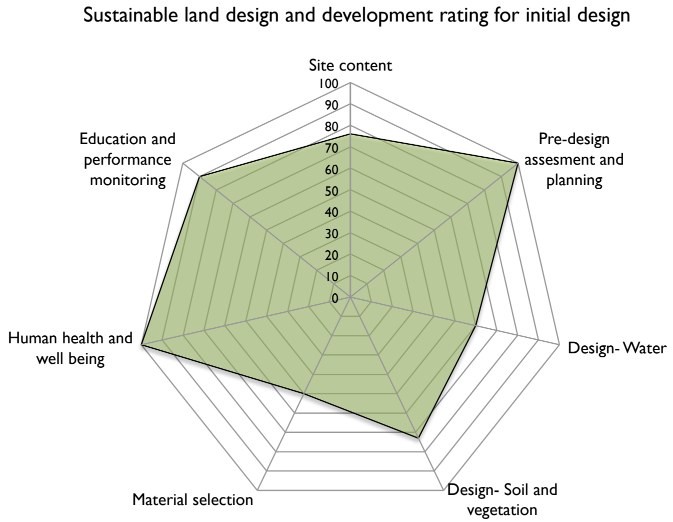


Figure 149. SITES sustainability rating (Author 2015).

Figure 145 indicates that the proposed design is overall sustainable. Material selection appears less sustainable due to the use of granite. Water is also less sustainable due to the fact that the site is not urban and does not require the same type of intensive storm water management systems.

The SITES rating is a good guideline for sustainability, but it is flawed. This thesis focused on sustainable corpse disposal and the impact it has on the environment, yet this part of the sustainability of the thesis is not accounted for in the SITES rating.