URBAN PLANNING AND ENVIRONMENTAL PROJECTS
KIMBERLEY AND PORT ELIZABETH

INNOVATIVE TECHNOLOGY
Kimberley

REPORT
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Inregia

CONTENTS

Acknowledgment

During the month March 9 to April 9 1998, I progressed from knowing nearly nothing about Africa, and especially not South Africa, to a quite fair understanding of at least some part of the settlement system in Kimberley. However, this progress would have been absolutely impossible without the constant aid and support of the staff at the City Planning Office, especially my counterpart Les O'Connell, and of my co-workers at the Swedish advisory group.

I thank you all for the support and your constant patience to my questions and requests.

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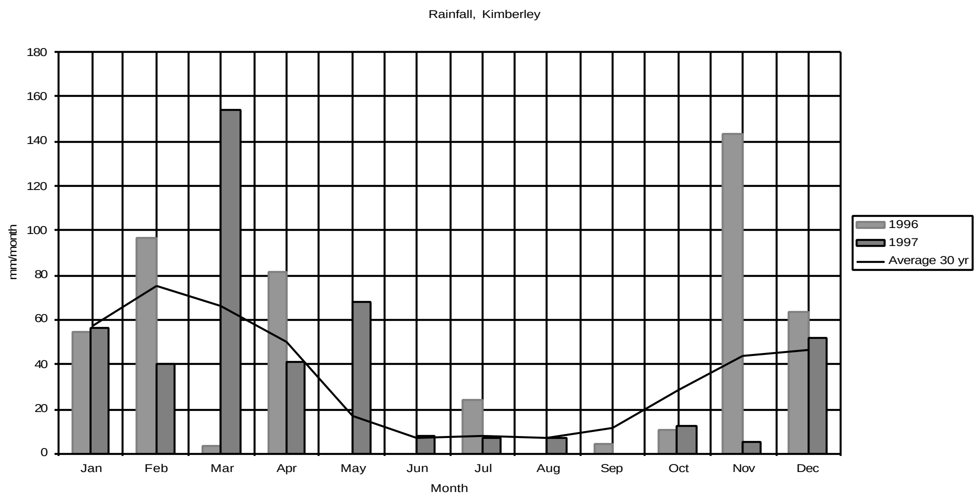
Introduction

Kimberley is situated in the steppe area in the Northern Cape province in South Africa. The area of the city is 9,040 ha, and the population is estimated to 214,000. However, there are uncertainties regarding the size of the population, since the population living in the low income areas, preferably in the northen parts of the town, is to a large extent not enumerated.

The cunsulting period was mainly used for an introduction to the characteristics of the area and a survey of the special problems on the site. The management problems seem in the first hand to be those of water, why a proposal to alleviate some of these problems was outlined.

Climate

Kimberley has an annual evapotranspiration of about 2,100 mm and an average rainfall of 419 mm. The evapotranspi-ration / rain-fall ratio (5.07) places Kimberley far into the arid climate area. The biome is a dry steppe.



Kimberley has summer rains with a rainfall peak often occur-ring during February. During the winter, a low precipitation combined with a relatively low temperature is normal..

The water budget of Kimberley

A rough estimate of the water use indicates that the average use is fairly high, higher than the normal Swedish water use of 173 litres*pers^{-1}*day^{-1}. The daily water use for the en-tire town is about 217 litres*pers^{-1}*day^{-1}, which is annual water use of more than 79 kl pers^{-1}*yr^{-1}. However, since the water coming to the sewage purification plants is only 115 l*pers^{-1}*day^{-1} (42 kl pers^{-1}*yr^{-1}), it seems as a large part of the water bought is used for irrigation or lost in another way, for example as leakage on the route to the waste water purification plant. This amount is substantial, about 7.5 million cubic metres per year (44% of the total use). See below.

	l per p*d	pop., m3/day	m3/p*yr	entire pop, m3/yr	% of total
From the Vaal river	**217**	46,375	79	16,926,795	100.00%
Garden irrigation or lost otherwise	**96**	20,582	35	7,512,500	44.38%
Black water	30	6,420	11	2,343,300	13.84%
Grey water	85	18,203	31	6,644,200	39.25%
Sewage treatment	115	24,623	42	8,987,500	53.10%

Local differences

It seems to be large differences between the water use of people living in different places in the town. A comparison between people living in Galeshewe (low income area) and Old Kimberley (high income area) shows a nearly 80% difference in water use per meter. The average number of people connected to a meter is higher in Galeshewe than in Old Kimberley, which aggravates the difference.

Therefore, an effort was made to differentiate the water budget between the areas of the town. This was made by the use of different data regarding the two watersheds in the town. In the south watershed, with the sewage water leading to the Baconsfield sewage plant, it lives about 43 000 persons, 20% of the population, predominantly high income. Here the daily water use is about 292 litres*pers^{-1}*day^{-1}, and about 40% of the water, 117 litres*pers^{-1}*day^{-1}, entering the area eventually comes to the sewage plant, which indicates that a large part of the water is used for irrigation. In the northern part of the town, almost the same amount of water per person, 115 litres*pers^{-1}*day^{-1}, comes to the sewage plant, but only 191 litres*pers^{-1}*day^{-1} are used. This indicates that about 100 litres*pers^{-1}*day^{-1} *more* is used for irrigation in South Kimberley than in the North. (See tables below.)

North Kimberley

to Homevale

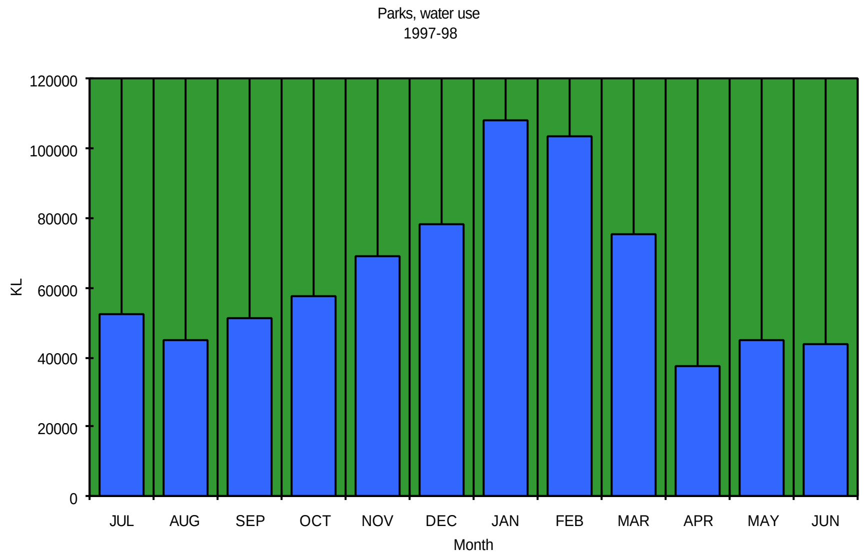
pop	80.00%	*171,200*			
	l per p*d	**m3/day**	**m3/p*yr**	**entire pop, m3/yr**	**% of total**
From the Vaal river	**191**	32,705	70	11,937,500	100.00%
Garden irrigation or lost otherwise	**76**	13,082	28	4,775,000	40.00%
Black water	30	5,136	11	1,874,640	15.70%
Grey water	85	14,487	31	5,287,860	44.30%
Sewage treatment	115	***19,623***	42	7,162,500	**60.00%**

South Kimberley

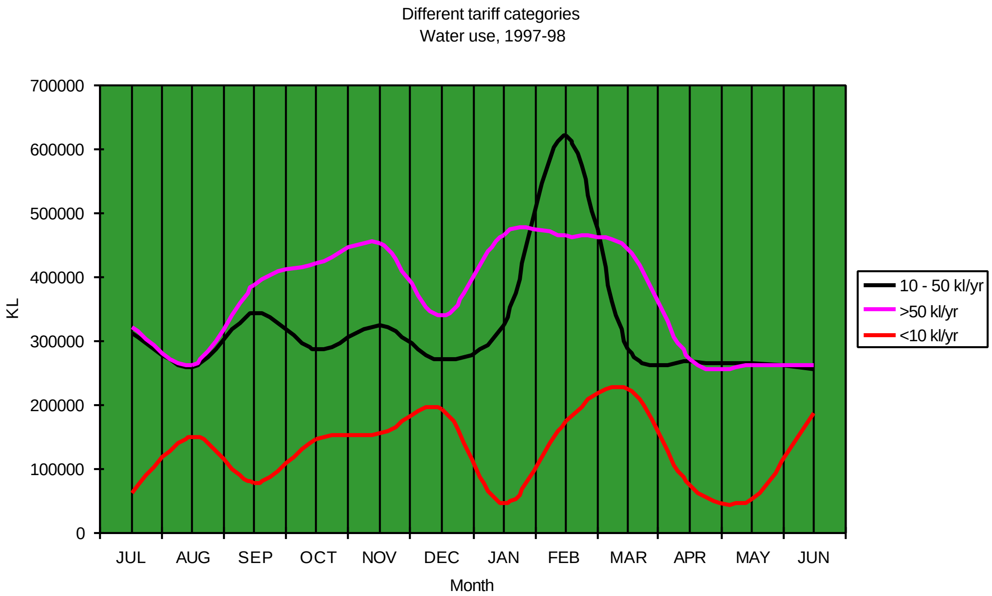
	to Baconsfield				
pop	20.00%	*42,800*			
	l per p*d	**m3/day**	**m3/p*yr**	**entire pop, m3/yr**	**% of total**
From the Vaal river	**292**	12,500	107	4,562,500	100.00%
Garden irrigation or lost otherwise	**175**	7,500	64	2,737,500	60.00%
Black water	30	1,284	11	468,660	10.27%
Grey water	87	3,716	32	1,356,340	29.73%
Sewage treatment	117	***5,000***	43	1,825,000	**40.00%**

Evidence

An interview with a family living in South Kimberley revealed a water use of 76 kl/month for five persons, i.e., about 500 litres*pers^{-1}*day^{-1}. The family consisted of three adults and two children below ten. However, one of the adults was hired as a gardener, and he was said to use large amounts of water for irrigation. This supports the hypothesis that the difference in water use between North and South Kimberley could be accounted for irrigation.



To further support this hypothesis, the water use pattern of parks that used municipal water was studied. This use showed a peak in January - February. This is in summer, when it is very hot, the evaporation is high and the need for lawn irrigation



is accordingly high.

After the study of water use pattern of parks, the water use in three different tariff groups was studied. The lowest tariff group showed a decrease in water use during the summer, supposedly because of an increased use of rain water during this period. In the highest tariff group, there was a constant and high use of water throughout the year, but the intermediate group showed a typical peak during the winter, when lawn irrigation is required. This pattern also supports the hypothesis that a large part of the water purified for drinking water is used for irrigation.

For irrigation purposes, however, purified drinking water is not very adequate because of its lack of nutrients and content of chlorine. A `less clean' water would be more appropriate in this case. This will be further discussed below.

Water route

The water route is typically linear, from the Vaal river, throughout the town and dispatched to irrigation and evaporation or directly to evaporation.

The mixed solution of grey (washing, dishing, shower etc.) and black (from toilet flush) water is transported in the waste water piping system to the plants in Baconsfield or Homevale. Also, the waste from the dry toilets is mixed into the waste water system. The plant in Homevale takes the majority of the sewage, about 20,000 kl per day of a total of about 25,000 kl. These figures are ambiguous because of failures in the measurement system.

The plants are of a two-step type, with mechanical and biological steps. There is no reduction of nitrogen or phosphorus from the effluent, which is let out into the Kamfersdam, where most of the water evaporates.

An increased salt content of the water in the Kamfersdam could be expected, which can be detrimental, as some of the water is recycled for irrigation in some of the central park areas.

The main route of the water is thus:

Vaal river ➪ use (as irrigation, greywater, toilet flush or drinking) ➪ mixing ➪ treatment ➪ evaporation.

Lack of information

An overview of the water use in Kimberley will however s how that a large part (35%) of the water is not used by the households:

Res. and flats	11,085,457	65.5%
Parks	1,230,796	7.3%
Charity & churhes	239,629	1.4%
Commercial	4,249,712	**25.1%**
Industry	121,200	0.7%
Total annual, KL	16,926,795	100.0%

Most of this `undefined' water is in a group called `Commercial'. However, this group is not only shops, it is also the public works, i.e., all municipal activities as schools, hospitals, minicipal buildings and the like but it is to a large extent the *military* water use. In the military bases of Kimberley, there are large water reservoirs filled by the municipal water, and misuse have been observed.

Problem analysis

Since Kimberley is situated in a very dry area, a good start seems therefore to discuss the way water is used, and if other ways of water use could be introduced.

The main management problems seems to be:

- A large part of the purified water is used for irrigation, often in a very inefficient way, as daytime and above ground irrigation.
- Irrigation is mainly directed towards `unproductive' use, e.g., lawns and ornamentals.
- The wastewater is polluted by black water, i.e., urine and faeces.
- Vegetable food is predominantly imported into the area.
- Rain water is not taken care of in the area, but is dispensed in a storm water system that eliminates the rain water as soon as possible.

As pointed out above, the ultimate destiny of the water entering the area is evaporation.

Shortage is met with increased import, however at high prices and uses of fossil energy, which makes the water management highly *vulnerable to increased energy prices*. The major part (26 Twh annually, 86%), of the energy input is used for the pumping of the water from the Vaal river to a cost of R 53,600,000. A sharp increase in energy prices of the type discussed by some authors (www://dieoff.org, www://hubbert-mines) could be detrimental to the system.

A main point is that the water is used ***either*** for irrigation ***or*** for washing since the *grey water* (i.e., the water used for dishing, washing, showering, bathing and the like) *is mixed with the black water* urine and faeces before it is leaving the building. Because of the high content of bacteria, viruses and the naturally abhorrent character of the faeces-urine mixture, the mixture of grey and black water has very low social acceptance for any form of re-use.

This means that the entire grey water volume (31 kl/p*yr (around 40% of what is annually taken from the Vaal river regarding the entire population)) is lost, although it could perfectly well be used for irrigation purposes.

Water saving potential

If new, water saving toilets, preferably source separating, were introduced, and the grey water was used for irrigation, this could lead to large savings in the water use. The grey water amount is about the same as today is used for irrigation, why it could be replaced without any loss of plant area.

Such a system would decrease the need for water with the amount today used for irrigation and toilet flush, which is 9.8 million kl per year or close to 60% of the current use.

Another possibility is that the grey water after some simple purification process could be re- used for grey water purposes, or as drinking water after some more extensive purification process.

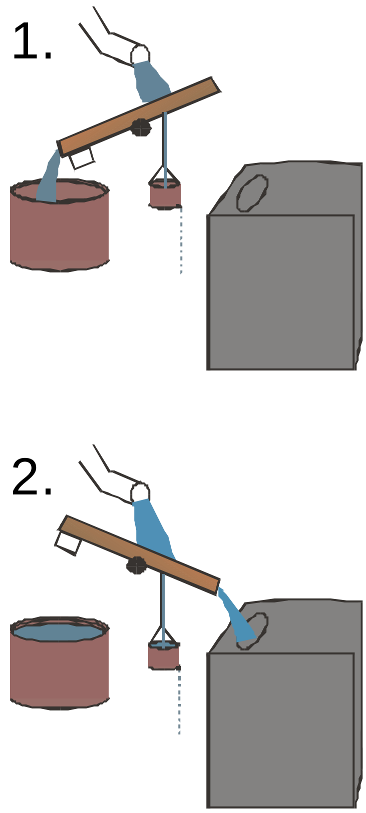
Storm water

The storm water is not used in the area. It is however evident that the methods for retention and use of storm water used in other dry parts of the world, e.g. Australia, also could be used here.

Tanks

Different types of tanks for storm water are a common feature of arid land settlements.

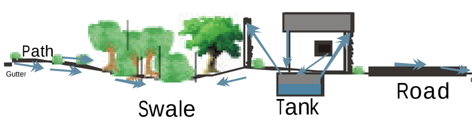
One problem regarding storm water retained from roofs is that the first water can be polluted from dust and other airborne pollutants that have settled on the roof. There exists, however, simple methods for the detention of the first impure water. In the figure to the right, a regulated part of the water coming from the roof is trickling down into the bucket that hangs under the levelled gutter. The first minutes, the water is detained and let out to a storage for impure water. When the bucket is full, the levelled gutter turns over and leads the water into the storage tank. There is a small hole in the bucket, so it can return to its original state after the rain when the bucket is empty.



A rainfall in the area will often measure to 20-30 mm, why the water falling on a house with a roof area of 50m^2 could collect 1,000 to 1,500 litres.

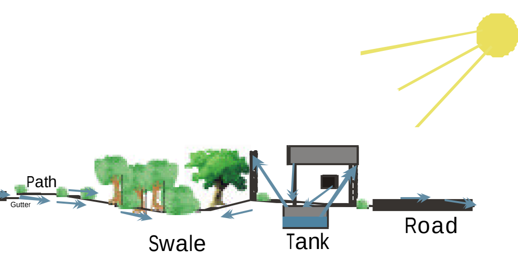
Swales

Another method used for storm water utilisation in dry areas is the use of *swales*, low depressions in the ground along the contour lines in a slope. The rainwater will not travel in the swales, but will be contained there until it sinks into the ground and replenish the ground water. Trees and shrubs in the



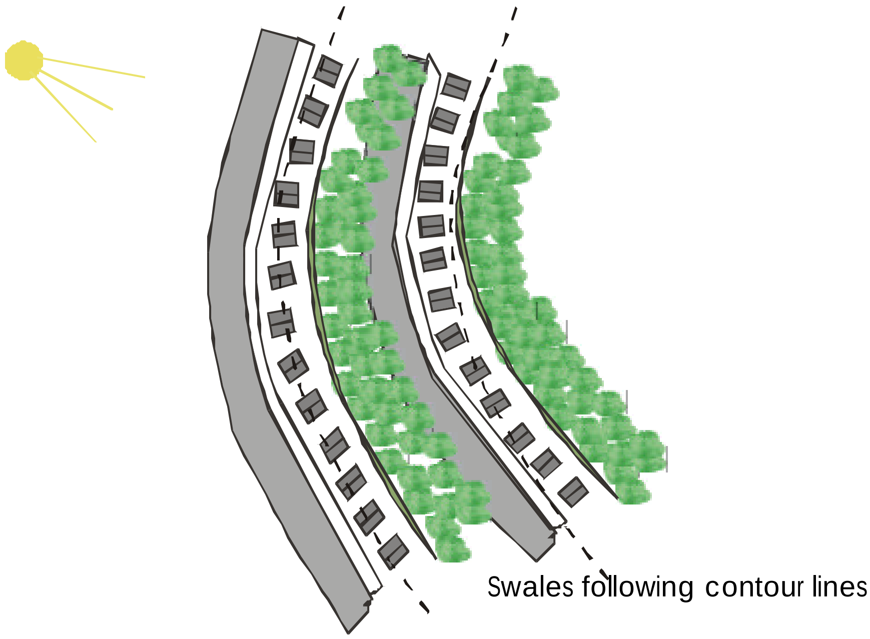
The principle of swales for storm water management

Storm water is collected in depressions between the houses. Vegetation uses the water for productive growth.



The principle of tanks for storm water management

Storm water is collected in tanks below the houses. Vegetation uses the storm water togheteher with grey water in Sanitas-walls for productive growth depression will increase the permeability of the soil and thrive from the increased access of water.

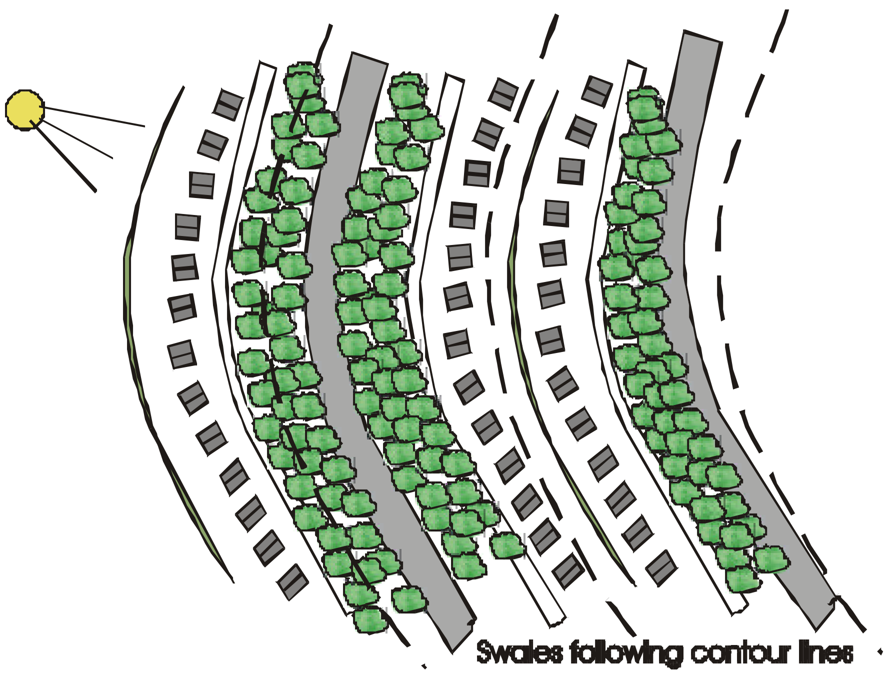


The vegetation in the swales could very well be of a productive type, e.g., fruit trees or berry bushes. The swales can also serve as refuges for wildlife.

In Kimberley, lanes of trees are often placed along roads. However, the trees are often in raised beds, why rain-water will not penetrate the soil under them. Furthermore, if the roads are also perpendicular to the contour lines, the water will not stay, but will become inaccessible to the trees.

The use of swales in urban planning

If the above shortcomings are avoided, an ample amount of uses for swales in urban planning opens. They can be used as demarcations between roads and footpaths, or between building blocks. Some ideas are depicted below.

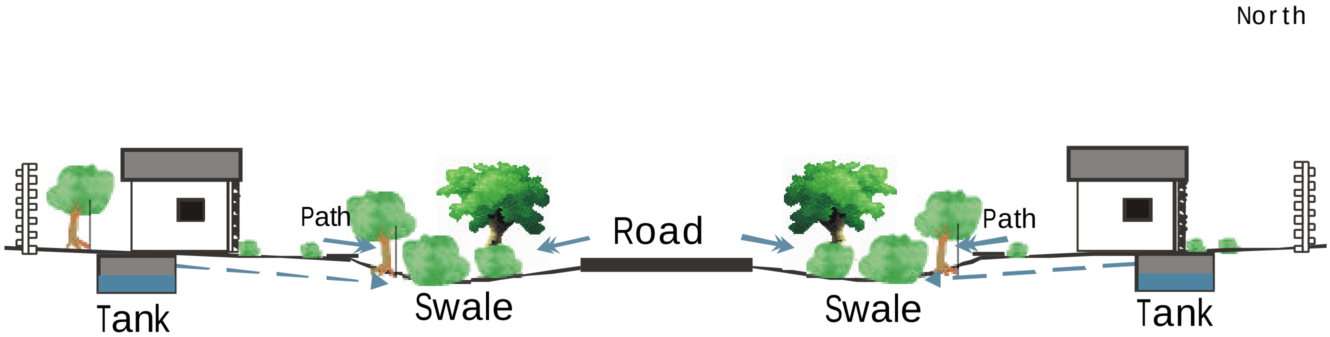


Different types of interceptions of swales and buildings will give different densities:

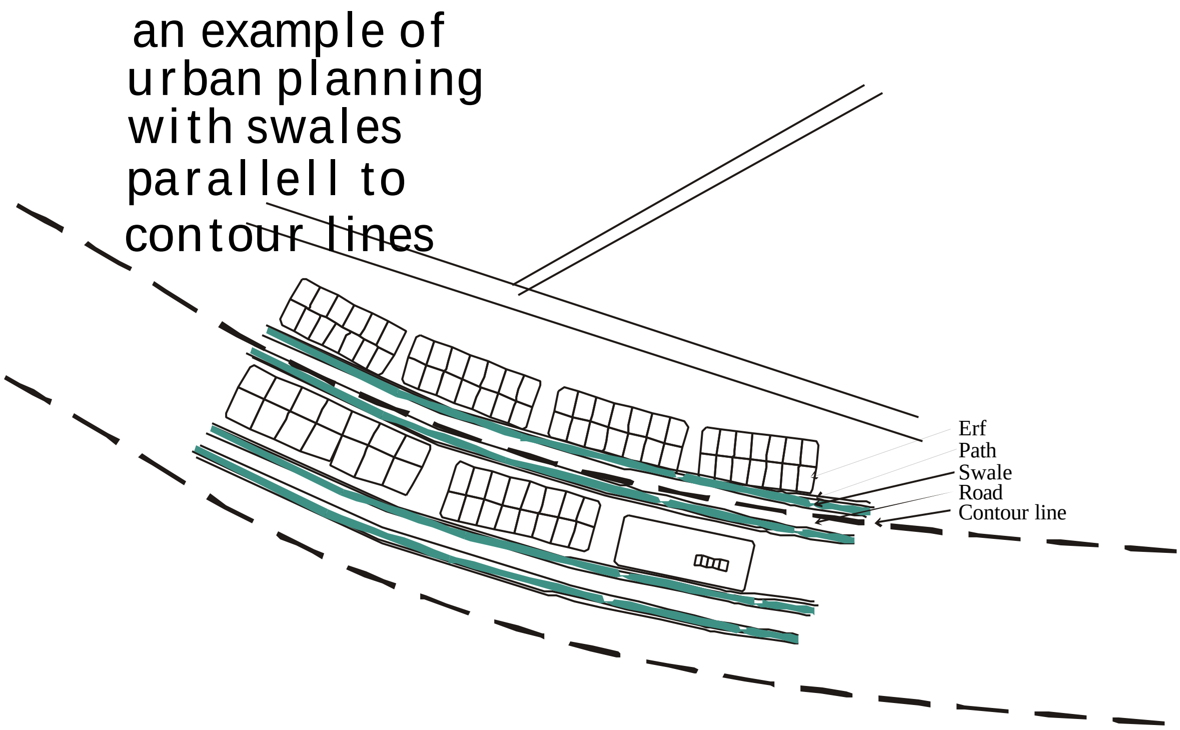
Either, rows of buildings could follow the roads. The swales lies in this case behind a Sanitas wall (see below) and the next road. This will create a shadowy and green impression of the built environment.

The buildings can also be placed `back-to-back' with lanes surrounding the roads on both sides. Preferably, paths for walking and biking will be placed between the swales and the houses. This arrangement could be chosen for roads with more intensive traffic, in order to diminish the traffic noise.

Below is a side-view of the last version above.



The swales can easily be included in urban planning. The example below could be a part of the planned Hull Street area.

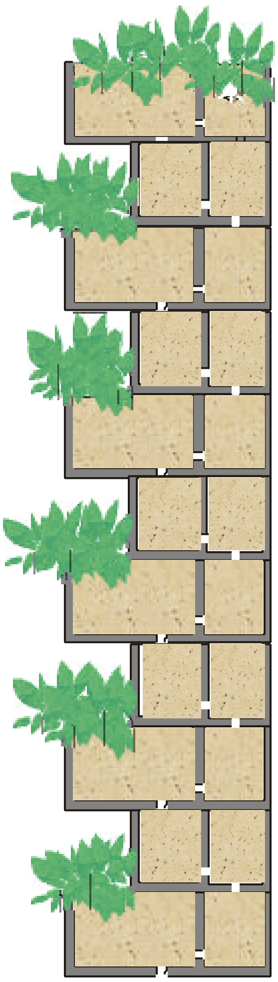


The Sanitas wall

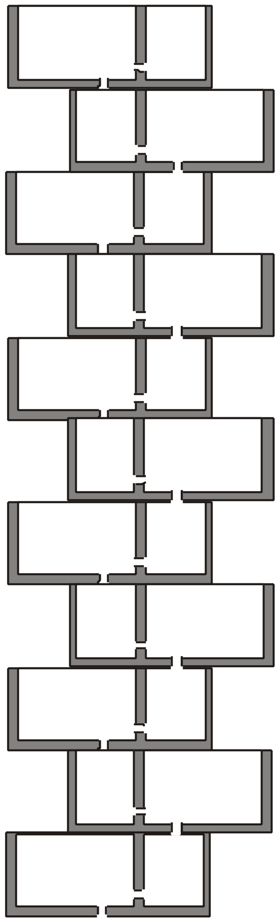
In the Sanitas farm, near Gaborone in Botswana, dr Gösta Nilsson has designed a type of concrete stones for a combination of construction and plant growing. The stones are two-compartmented. One compartment is filled with sand for the rigidity of the wall, the other with compost for growing plants. The wall is watered from above and works well both as a site for intensively growing plants and as a constructional element, to make walls of different types. (For further reading about this, see `The Productive Homestead - report of a study tour' by Uno Winblad, SIDA Feb 1992)

(Insert left: Single sided Sanitas wall. Insert right: Dual)

Stones of this type could be used for the combined intention of making use of and purifying grey water, plant growing, food producing and construction of low-cost homes or garden walls. The walls can be two-sided for solitary structures, or they can be single-sided for use as a constructive element in a building. If grey water is let into the top layer of a wall, it can percolate through it, furnishing the plants with water and nutrients. If not all the water is utilised by the plants, the remaining liquid would contain much less nutrients and micro-organisms than the grey water. It can thus be used as new grey water.



Single sided

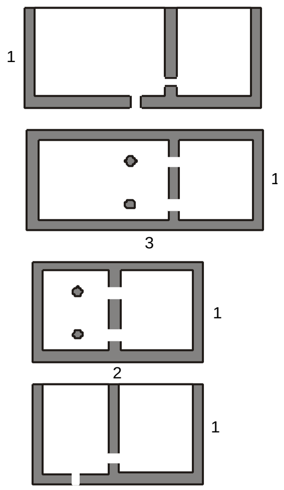


Dual

Space needed

Assuming the grey water production mentioned earlier of about 85 l/p*day, a single sided planted wall with a height of 3.15 m and a width of 13 m would be enough for the absorption of the grey water. A dual sided wall will consequently be 7.5 m in length.

Assumed in the calculation for this is a water demand of 6 l/m^2 per day for an intensively growing crop.

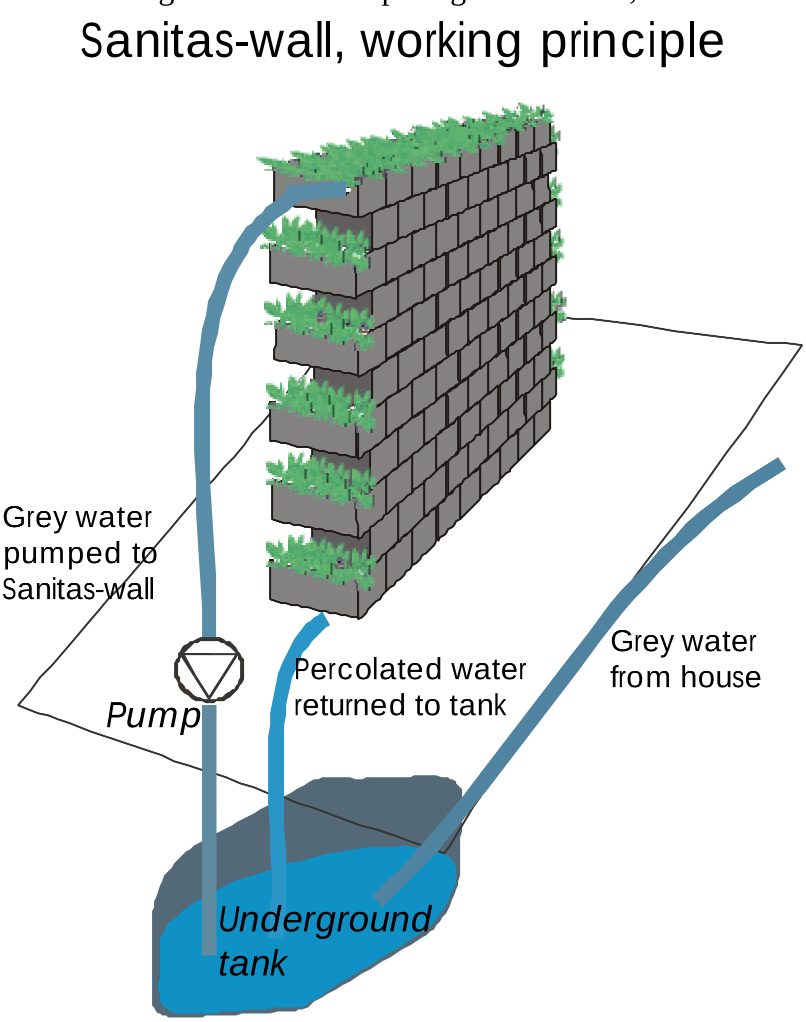


The stones used

To get an opinion of the cost for the wall, two differ ent concrete stone suppliers were asked. No answers are yet available for further calculations. The two stone types are depicted to the left. A maximum weight of 60 kg for the larger stone was delimited. In the calculations mentioned above, 22.5 cm is assumed to equal the measurement 1 in the figure. The corresponding inner measurement would then be 19 cm.. However, the size is much dependent of the weight and strength of the material .

Function

A section of the single sided wall, showing water path through the wall, and its working principle; The grey water from the house is collected in a (preferably underground) tank, pumped up into the top of the wall, where it is spread in underground gutter in the top layer. This gutter is levelled to ensure the smooth spread of water along the wall. After passage of the wall, the excess water will be collected and return to the tank or used inside the house.



To be able to use the grey water, a *source separating* toilet is needed, i.e., a toilet that doesn't mix urine and faeces, neither with each other nor with the grey water. Such toilets should not be confused with *composting* toilets, which compost faeces, organic household waste and urine together.

In the report *Ecological Alternatives in Sanitation*, (SIDA Publication on water resources No 9), a lot of different alternatives are discussed.

One of the most promising types in use in Sweden are the so called dry source separating toilets of the type that are produced by WM Ekologen AB and Separett AB. They only use 0.2 l water for urine flush. This type is also the cheapest.

New infrastructure

The introduction of source separating toilets implicates a new, but cheaper and easier maintained infrastructure. *Urine* should be collected and returned to the agriculture that provides the food to the population, *faeces* should be composted or incinerated to destroy pathogens, and the *grey water* could be taken care of locally, after its collection in tanks. These tanks could also be used to collect the rainwater from the roofs. Excess water from the tanks could be led out to swales nearby, and the percolated water from walls could be used for grey water uses. This would however need a double inlet of water to the houses, one for water of drinking water quality, another for other uses.

Problem solving strategies and methods

Long-tem strategies

Some long-tem strategies to increase the water efficiency may be:

1. Use the same water as many times as possible.
2. Prefer transpiration for evaporation.
3. Avoid irrigation and other water uses above ground.

The second two of these principles actually boil down to the first. In a situation where the ultimate fate of the water is to evaporate, a fair strategy could be to try to make as many uses of it as possible before it eventually leaves the area as moist in the air.

The introduction of source separating toilets opens the possibility to use the grey water for irrigation, as outlined above. The growing of vegetable plants could also be a possibility to reduce the food expenses as well as increasing the income.

Changes that could be done directly

Some changes that could be done directly, in the current building stock is:

4. Put bricks in the toilet tanks to diminish the flush volume.
5. Prohibit daylight irrigation.
6. Change the irrigation systems to underground watering.

When building new houses and rebuilding old:

7. At least: Put in triplicate piping systems to alleviate the future use of grey water separating systems.
8. Better: Use a source-separating waste water system.

In urban planning:

9. Place new roads parallel to the contour lines and surround them with swales
10. Avoid raised beds for lawns and plantations, instead, try to place planted areas *lower* than the surrounding impenetrable areas.