Appendix A

Greywater survey questionnaires

GREYWATER SURVEY QUESTIONNAIRE

Section 1: Bio-data

1. House Number: ____
2. Interviewee's Full Name: ____________________________________
3. Gender: ____
4. Age: ____
5. Religion: ☐ Ancestral beliefs ☐ Christianity ☐ Islam ☐ Other (specify): ____________
6. Occupation: ☐ None ☐ Formal ☐ Informal (no regular income)
7. Household Income per month (or estimate based on material belongings):
   ☐ None ☐ R1-R400 ☐ R401-R800 ☐ R801-R1600 ☐ R1601-R3200 ☐ > R3201
8. Education attained: ______________________________________
9. Relation to Head of Household: ______________________________
10. Number of people in household: _____________________________
11 Number of children, ages: __________________________________
12. Type of house: ☐ Traditional dwelling ☐ RDP House/ brick structure ☐ Informal dwelling
13. How long have you lived at the present site? ______________________

Section 2: Water Consumption Patterns

14. Distance from your house to water point:
   ☐ < 10m ☐ 10 - 50m ☐ 50 - 100m ☐ 100 - 200m ☐ 200 - 500m ☐ > 500m

14. Daily water use per household:

☐ < 20*l* ☐ 20*l* – 50*l* ☐ 50*l* – 100*l* ☐ 100*l* – 150*l* ☐ > 150*l*

15. Time taken fetching water per day:

☐ < 15 mins ☐ 15 – 30 mins ☐ 30 – 60 mins ☐ 1 – 2 hrs ☐ > 2hrs

16. The first time you draw fresh water in the day what is it used for? ________________

17. Type of containers used for storing clean water: ______________________________

18. Volume of water that can be kept in the house:

☐ < 20*l* ☐ 20*l* – 50*l* ☐ 50*l* – 100*l* ☐ > 100*l*

19. Other purposes for containers:

☐ Beer brewing ☐ Laundry ☐ Dish washing ☐ Cooking ☐ Other (specify): ________

20. What brands of the following products do you use?

Bath soaps: _________________________Washing powders: __________________

Dish washing liquids: ___________________ Shampoos: ______________________

Other detergents (specify): ____

21. How often do you wash your clothes?

☐ Daily ☐ Once a week ☐ Twice a week ☐ More (specify): _________

22. How often do you / members of the family take baths?

☐ Daily ☐ Twice daily ☐ Other (specify): __________________

23. What do you do with the dirty water after use?

☐ Throw away ☐ Water plants ☐ Reuse ☐ Other (specify): ____________

25. If you reuse the water give examples (e.g. using cooking water for dishes or bathing water for laundry): ____

Section 3: Grey water management

26. Do you think that greywater recycling would be useful in your community? Please give reasons for your answer: ____

____

27. Which are the most important services that you think would make life better?

☐ Electricity ☐ Houses ☐ Water ☐ Toilets ☐ Schools ☐ Refuse removal ☐ Other (specify): ________

28. Who do you think should provide these services? ______________________________
29. Do you think greywater is a major health problem in the community? Give examples:

____

30. What would you suggest as the best way of resolving the problem of greywater disposal? ____
31. Do you have any questions you would like to ask me?

Interviewer: ____________________________Date________________________________

Section 4: Existing greywater systems (as observed by interviewer)

32. Do any of the following occur at the water standpipes?

☐ Soak-away ☐ Concrete slab ☐ Gulley ☐ Kerb in-let ☐ Wash-trough

☐ Stormwater Channel ☐ Stormwater manholes ☐ Communal washing/ ablution facilities

☐ Greywater sand filters ☐ Grease traps

33. Are the existing greywater management systems working? If not, why not? Please give comments: ____

____

____

34. Please ensure that a photograph is taken at the interview site - supply a reference number and description here: ____

ASSESSMENT OF SETTLEMENT CHARACTERISTICS – QUESTIONNAIRE FOR LOCAL AUTHORITY

Question	Answer
Name of settlement, and Province	
Is this a rural, peri-urban or urban settlement?	
Approximate size of settlement (ha)	
Approximate no. of dwellings	
Approximate population	
Predominant type of dwelling (e.g. traditional, RDP, informal) or percentages of each	
How is water supplied to the houses? (e.g. taps in yard, communal standpipes, tanks, river etc)	
If Municipality supplies water, what is the average total amount supplied daily/monthly?	
What type of toilet facilities are there (e.g. flush, pit latrine, bucket etc)? On- or off-site?	
Average annual rainfall in the area (MAP)	
Depth to water table in wet season	
Distance to nearest surface water body	
Is the settlement situated within the 50 or 100year floodplain?	
Date	

Data sheet for sampling

Note: Sample code (eg. WC0101) and date of sampling must be indicated on sample bottle

Name of site				
Sample code		Province code	Site number	Sample number
Coordinates	Latitude			
	Longitude			
Date of sampling				
Name of person doing sampling				
Weather conditions		Rain ( ) Cloudy ( ) Clear ( ) Other specify ( )		
Sample source	Tap ( ) Borehole ( ) Well ( )	Kitchen ( ) Laundry ( ) Other specify ( )		
Sample history, i.e. how water has been used				
On-site observations	Odour	None ( ) Slight ( ) Strong ( ) Other specify ( )		
	Appearance	Clear ( ) Opaque ( ) Dark ( )		
	Colour			
Results of field tests	pH			
	Conductivity (mS/m)			
	Ammonia			
	E. coli			
	Phosphate			
Laboratory analyses required (please tick selected)	Total Kjeldahl Nitrogen			
	Turbidity			
	Nitrate/ Nitrite			
	Chemical Oxygen Demand			
	Total Phosphorous			
	Oil and Grease			
	Calcium			
	Magnesium			
	Sodium			
	Potassium			
	Boron			
	Sulphate			
	Chloride			
	Other (please specify)			

Province Codes:	
WC	Western Cape
EC	Eastern Cape
NC	Northern Cape
FS	Free State
KN	Kwazulu-Natal
NW	North West
MP	Mpumalanga
GP	Gauteng
NP	Northern Province/ Limpopo

Appendix B

Commercial greywater systems

Commercial greywater systems

Within the developed world there are numerous systems (some patented) which aim to dispose of greywater by treating it to acceptable standards and reusing it in some form of irrigation system. The systems described in this report are a selection chosen to describe some of the innovative means of treatment and disposal worldwide. It should be noted that most of these technical solutions presuppose that normal (full) water services are provided. In South Africa the use of greywater in certain areas warrants further consideration since this country is prone to water shortages, but some form of "on-site" treatment would be required to render this water safe for use. The cost implications, maintenance requirements and social acceptability of such systems would however have to be taken into account before deciding which treatment technology to adopt.

B1. BioSand

The BioSand system (Watertiger, 2006)) is a mineral-enhanced sand filter and is reported as being able to treat greywater to a level for use on gardens or for toilet flushing. It has a maximum consumption of 10kW of power and does not require tanker de-sludging. The system can be used alone or as final polishing for other processes such as reed beds or aerated systems. It is designed to treat rainwater, greywater and solids-separated toilet waste of up to 1,000*l*/d. Under most conditions it can produce high quality effluent with levels of BOD & SS <10mg/l.

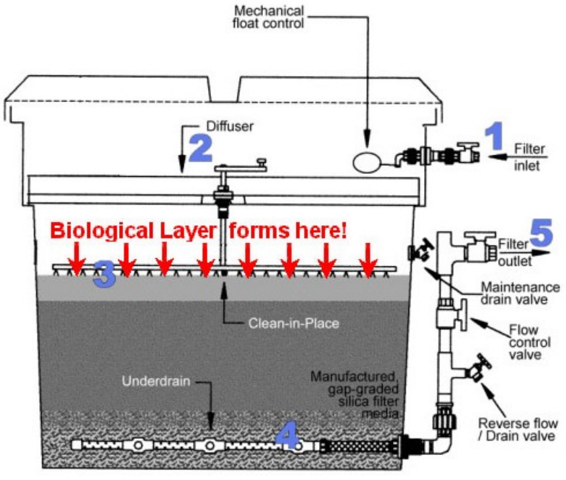

Figure B1.1:Cross-section through BioSand filter

Figure B1.2: Example of BioSand filter installation

Untreated water flows into the BioSand filter inlet and through the diffuser before flowing to the filter surface. The accumulation of organic matter, living and dead, forms a biolayer on the sand surface which develops with use, increasing filter effectiveness. Water then moves downward through the filter and is collected in the underdrain. Filtered water travels up through the standpipe to storage and/or disinfection.

B2. Greywater Drywell

This is a passive (gravity drainage) greywater disposal system for situations when greywater use may not be an option. It consists of a self-cleaning filter and settling tank with all the relevant plumbing fittings plus a drywell kit, which consists of vent and fabric wrap for direct disposal of household greywater. Drywells (The Natural Home, 2006a) are designed to provide alternative water management solutions which reduce the need for costly labour-intensive concrete and pipe-in-trench leaching systems. Top loading of effluent (greywater) ensures maximum surge capacity for the drywell. Irrigation of an orchard is often the typical use of greywater from a system such as this – the drywell acts as "emergency overflow" leaching pit and the majority of the water is delivered directly to the trees in the orchard. Figure B2.1 shows a typical greywater drywell filter / settling tank and Figure B2.2 is an example of the self-cleaning filter.

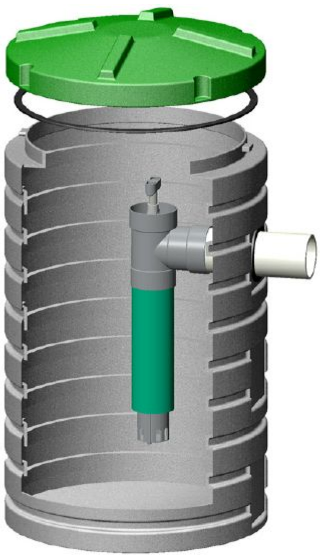

Figure B2.1: Greywater Drywell filter / settling tank

Figure B2.2: Self-cleaning filter for Greywater Drywell

The following instructions are given when purchasing this system and apply to greywater treatment in general:

- never store "treated" greywater in a large holding tank, cistern, lagoon or pond for future use.
- never allow greywater to drain on top of bare ground – the irrigation area needs to be below soil and/or mulch.
- never use unlabeled, unsealable or unvented containers for a filter basin – settling tanks need easy access.
- always vent the plumbing fixtures, filter basin, planter-bed, leach field and or leach pit to allow air into the system.
- always drain containers & planter-bed bases so as to allow oxygen to get into the soil.

B3. Alternating Intermittent Recirculating Reactor (AIRR)

The AIRR system (US EPA, 2006) consists of a septic/dosing tank, a biological reactor with both secondary and tertiary sections, a cover structure, a recirculating tank and a discharge tank or pipe. The septic tank needs to regularly pumped, and visual inspections need to be carried out on the pipes with routine maintenance on the cover structure. This system works for both single family residences as well as for entire communities; it is energy efficient, has low construction costs and is able to be upgraded. The AIRR system is classified as a recirculating sand gravel filter (biological activity is controlled on the surface area of media in combination with high oxygenation) and delivers treated effluent that is suitable for recycling and re-use in non-potable applications (may be discharged underground into drainfields, or into salt water, streams and rivers, or can be used to irrigate golf courses, parks, forests or farm land).

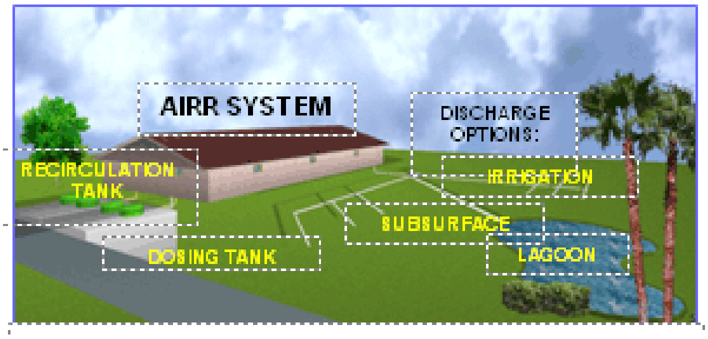

Figure B3.1: Schematic of AIRR system

Figure B3.2: AIRR facility

B4. AquaCycle 900

This system cleans water from baths and showers with claims of potential savings of up to 90,000*l* of water per annum for a family of four. It is easy to install, is odourless and maintenance is also kept to a minimum, with low energy requirements (about 0.6kWh per day). The Aquacycle system (Freewater UK, 2006) makes use of the patented SmartClean system and operates as follows:

- Prefiltration – larger particles like hair and textile fragments are collected. A special spray pump automatically flushes the filter and sediments are washed away into the main wastewater drain.
- Two-fold biological treatment – in the main and secondary recycling chambers the dirt particles are decomposed by bio-cultures. The water is pumped to the next station at three-hour intervals.
- Sediment disposal – the organic sediments, which are produced during the recycling process, are regularly sucked out from the chambers and diverted into the wastewater drain.

- UV-Sterilisation – on the way to the storage chamber the recycled water flows through a UV-light lamp, which disinfects it. The high quality of the water now conforms to the E.U. Directive for Recreational Water and can be utilised for a variety of non-potable uses around the home.

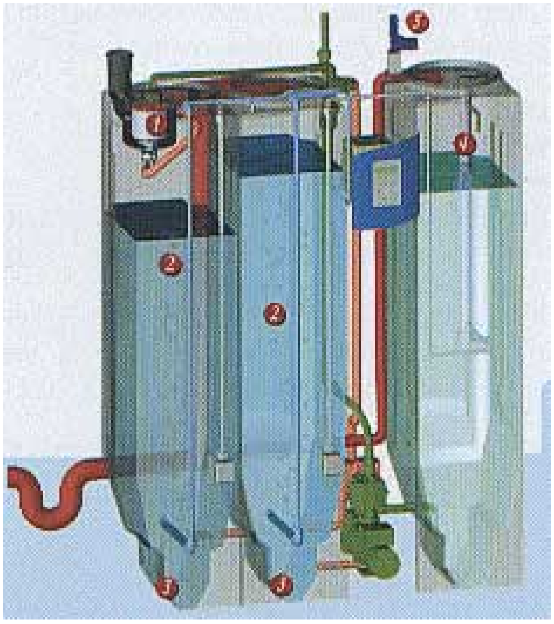

Figure B4.1: AquaCycle 900

B5. Clivus® LPF20

The Clivus® LPF20 (The Natural Home, 2006b) is a filtration system that retains hair, lint and large particles in greywater produced by showers, sinks, and washing machines. The purpose of this filtration is to protect the pump and greywater injection and distribution pipes from matting and clogging. Inside the Clivus LPF20 are two stretch filters supported by a grate over a dosing chamber and pump. Greywater is directed by a three-way valve to one filter at a time. As water flows into the filter, larger particulates are trapped inside while the greywater seeps through the membrane and collects in the dosing chamber below. The filter continues to stretch to allow water to exit as the particulate load becomes greater. When the filter is too full to stretch further, the valve is turned to allow flow into the second filter. Whilst the second filter is in use, the first is dried out and can be carefully replaced with a new one. Once the dosing chamber has filled to the pre-set level, the pump engages automatically and moves the accumulated filtered greywater into delivery pipes which direct it into associated planter beds for final cleansing by plants and soil organisms. Plant roots take up the nutrients and absorb much of the greywater. Activity of soil organisms further breaks down the organic material left in the greywater; and it is then ready to recharge groundwater without harm to the fresh water

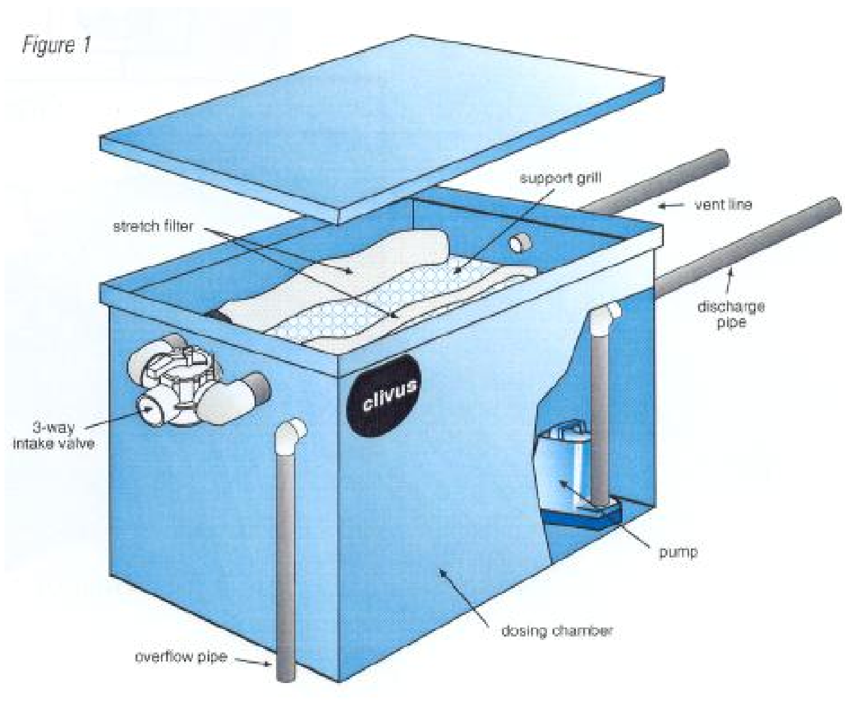

Figure B5.1: Clivus® LPF20 system

B6. Ecomax

The Ecomax system (Ecomax, 2006) consists of a sedimentation / septic tank connected to a “dual disposal field” via sealed pipes and a manual diverter valve for rotation of flow between fields. The greywater from the sedimentation tank flows into pervious geotextile-encased pipework which is laid beneath lawns or garden beds and is surrounded by specially prepared nutrient-removing modified soil. Bauxite residue is also used in the filter bed, which has good absorptive properties for some minerals and metals and also works as a good bacterial filter. Below ground disposal ensures that the greywater is already at root access without losses to evaporation, and also provides better protection of public health. A typical Ecomax cell for greywater removal from a three bedroomed home would be 9m long and 4.4m wide.

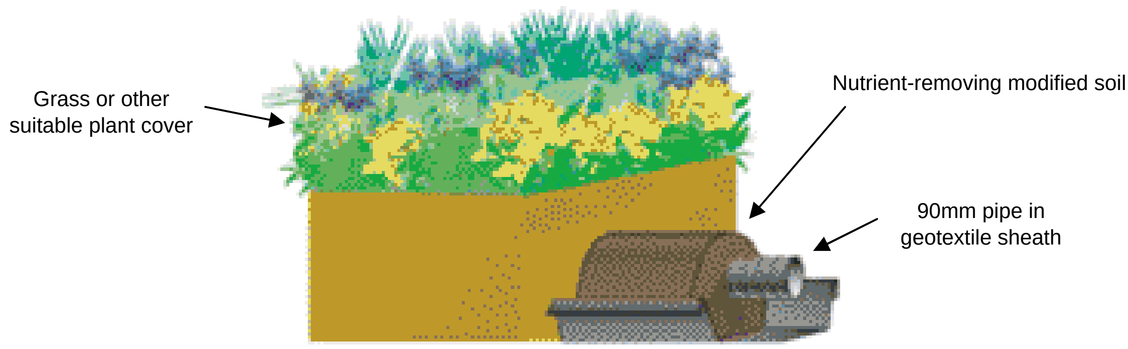

Figure B6.1: Oblique section through Ecomax system

B7. Hanson gravity chamber

Hanson Associates (Greywater treatment, 2006) have created a chamber which is capable of loading approximately 100*l*/m^2 per day, receiving all the greywater from a three-bedroom house. The system uses half of a 150mm diameter PVC pipe which is placed in a trench on mesh plastic netting to prevent the walls from sinking into the soil. No pre-filtration is used.

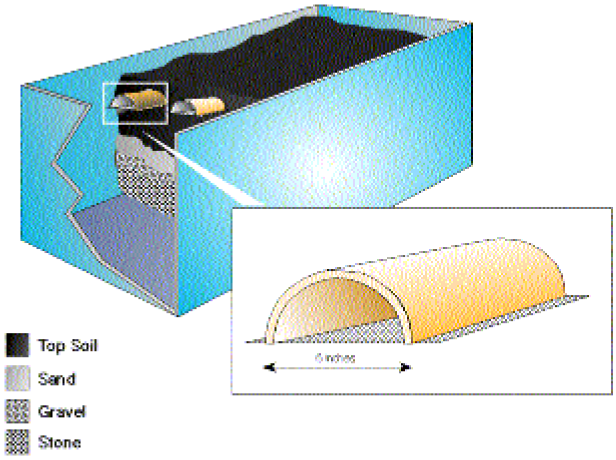

Figure B7.1: Gravity leaching chamber

B8. ReWater® distribution cone greywater system

This system (Rewater, 2006) captures, filters and reuses the shower, bath, wash-basin, and laundry water from domestic residences and disposes of it in the ReWater's patented underground drip system, which is reported to be at least 30% and up to 60% more efficient than sprinklers. The system consists of a tank, pump, auto on/off switch, automatic filter, backflow and switching valves and is generally connected to the most regularly-used showers and washing machine in the home as it has been found that about 95% of the reusable water comes from these few sources.

When the pump turns on during the irrigation cycle, water is sent to the top of the filter canister and forced down through the sand filter media where hair, lint, and other debris is trapped in tiny spaces between the sand particles. Water then travels out to a series of irrigation valves for use in the garden. To keep the filter clean, when the controller has accumulated a certain (programmable) amount of run time, it begins a self-cleaning cycle after that day's irrigation has been completed by using fresh water, and diverting the backwash to waste. The fresh water is rapidly forced up into the sand filter media, causing sand particles to rise and separate from each other, releasing the trapped debris. Lighter than the sand, the debris rises to the top and flows out to the waste line. When the process is over, the valves return to their irrigation position.

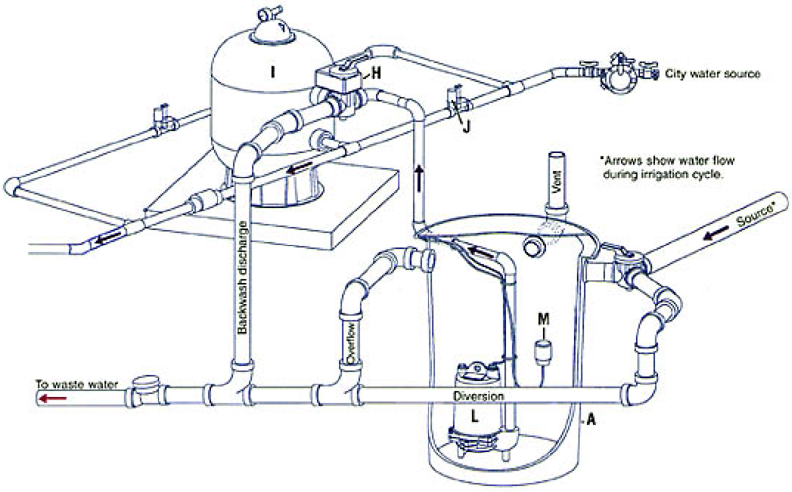

Figure B8.1: ReWater® filter system

B9. Greywater irrigated greenhouses

These greenhouses (Greywater treatment, 2006) are constructed in such a manner that the fertilized growing beds provide efficient greywater treatment. The beds are automatically irrigated using household greywater. One such greenhouse in New Hampshire (USA) uses a fish pool as the final treatment after the soil beds, which stays clear by means of a biological treatment technique involving a waterfall and bio-filter plates on the pool-bottom. These greenhouses have been reported as providing a family of 4 – 6 people with more than enough vegetables throughout the winter season.

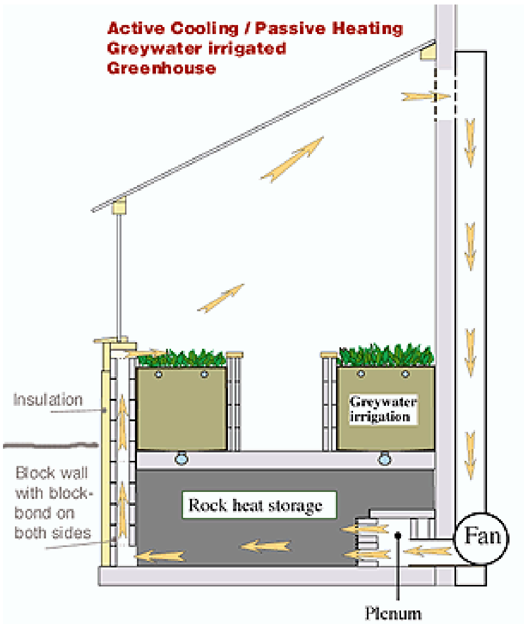

Figure B9.1 Greywater irrigated greenhouse

B10. Outdoor planters

These are masonry soil boxes which effectively serve to build up the site's soil profile (Greywater treatment, 2006). They also act as retarding mechanisms within sandy soils to slow down the greywater so that sufficient treatment can be accomplished. Within dense settlements it is suggested that two adjacent neighbours build a large mound on their properties which acts as a property divider. In so doing they would also be able to plant hedges or evergreens on the leaching area.

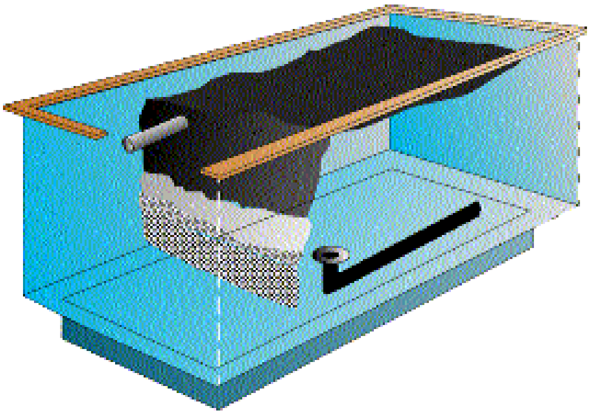

Figure B10.1: Schematic of greywater planter box

Figure B10.2: Greywater planter in British Columbia

Both aerobic and anaerobic pre-treatment of the greywater is possible before discharging it to the soil planters and can be used to improve the quality of the final effluent.

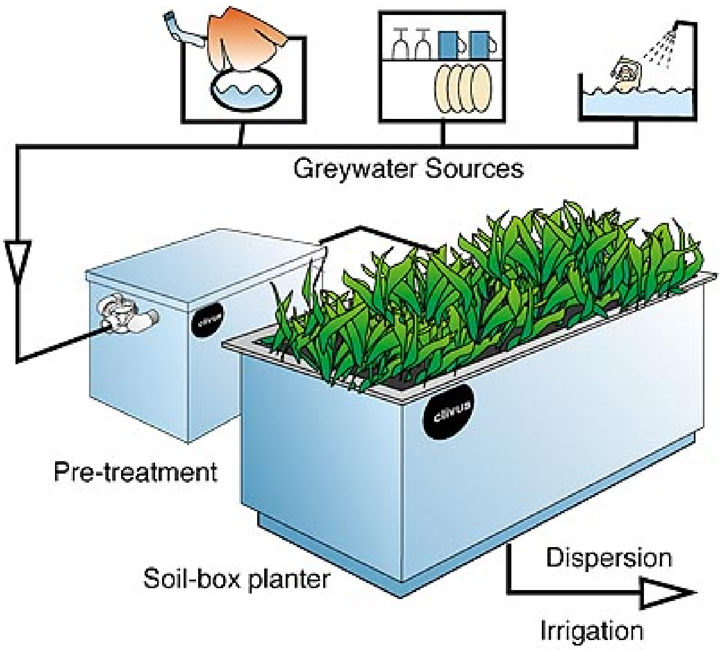

Figure B10.3: Treatment system with planter box

B10.1 Aerobic pre-treatment

A stretch filter treatment technique removes large particles and fibres so as to protect the sequential infiltration pipes from clogging. The stretch filter allows the rest of the organic matter to travel through to the next stage of processing. Directly after this primary filtration the greywater is transferred into a biologically active, aerobic soil-zone environment where both macro- and micro-organisms thrive. This filter system is suitable for public facilities where the principal source of greywater is hand-washing and showers without any food waste to speak of (food wastes may accumulate in the filter causing it to become anaerobic and resulting in odours). See Figure B10.4 for a typical Clivus fabric filter configuration:

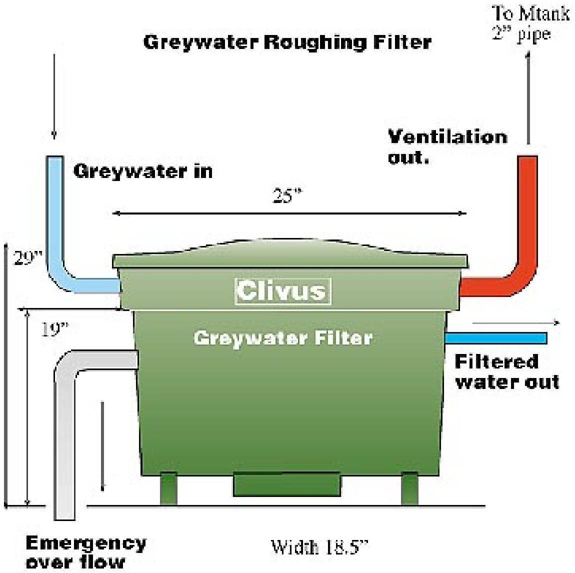

Figure B10.4: Aerobic pre-treatment with Clivus fabric filter

B10.2 Anaerobic to aerobic pre-treatment

This system usually consists of a three-stage septic tank that caters for sludge and grease separation, resulting in effluent that is anaerobic. Following the septic tank is a sand filter which serves to stimulate aerobic conditions, after which the greywater is routed to the planter bed. This results in purified water of "near potable-quality". This is reported to be one of the most effective, simple-to-maintain on-site treatment techniques and is recommended where there are significant quantities of food waste in the greywater to be treated.

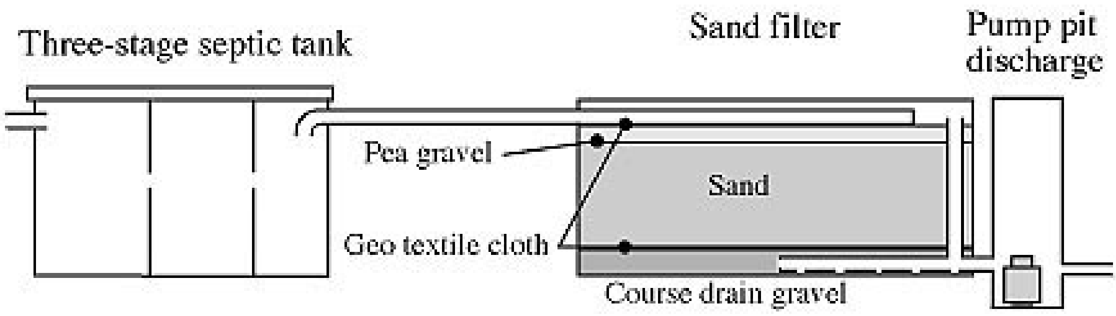

Figure B10.5: Anaerobic to aerobic pre-treatment system

B11. The Greywater Recycling System (GRS)

This is a greywater diversion device that is a gravity-fed primary treatment, distribution and irrigation system (Greywater recycling systems, 2006) which reuses greywater for watering gardens. The system does not store the greywater in any form and is used for immediate disposal of the greywater. The GRS can recycle up to 2000*l* of greywater per day using irrigation areas 70m^2 in size. Since it operates on a gravity system the irrigation beds need to be lower than the greywater source points. The system consists of distribution pipes and connectors, outlet housings, an aerobic grease filter and "H" nozzle components.

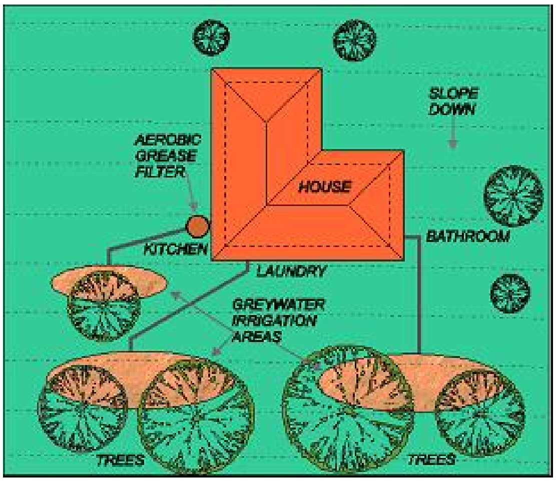

Figure B11.1: Schematic of Greywater Recycling System (GRS)

B12. Water Rhapsody

Similar to the GRS above, this is a pipe network where greywater from the bathroom and washing machine is filtered before entering a pump system (Water Rhapsody, 2006). The greywater is then pumped down a hosepipe from where it is sprinkled onto the garden. One of the features of this system is that there is no storage of the greywater as the pump switches on as soon as there is any flow into the tank.

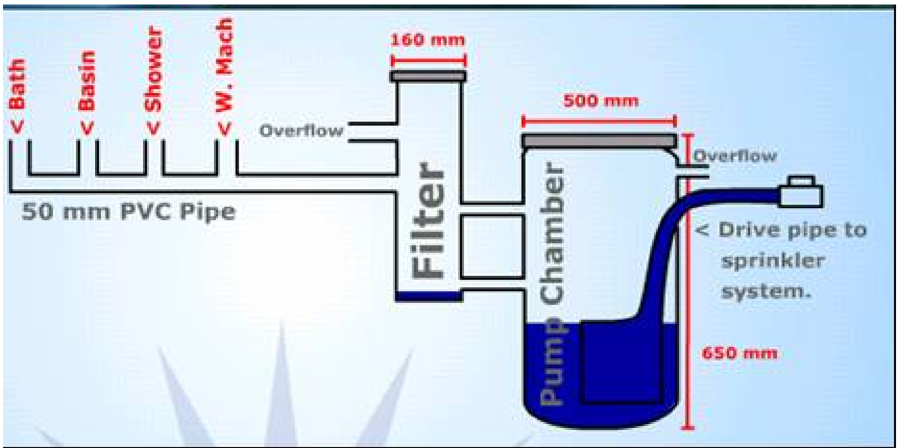

Figure B12.1: Water Rhapsody

B13. Garden Res-Q

Another system similar to Water Rhapsody and GRS, the Garden Res-Q unit (Garden ResQ, 2006) uses greywater from a home bathroom to irrigate a small to medium-sized garden. The unit is connected directly to the outside drain-pipes of an existing bath or shower where the greywater is filtered of hair and lint, and then a low-pressure pump is activated to pump the water through a normal 20mm garden hose as soon as the sump starts filling with the greywater. Once the shower has been turned off or the bath emptied, the pump automatically switches off and ceases the irrigation process until the next bath or shower. A return to sewer mechanism / overflow has been included in the design of the system, and a small percentage of greywater is automatically diverted to sewer during each session, thereby assisting with solid waste removal and keeping rubber seals wet and lubricated.

Figure B13.1: Garden Res-Q greywater system

B14. Tower gardens

The tower garden is a concept that was derived from a project occurring in Kenya (Crosby, 2004). Vegetables are grown in a column of soil surrounding a central stone-packed drain, in a bag usually constructed out of shade cloth. The type of shade cloth used to form the "skin" of this system is important. It was found that in South Africa, shade netting was ideal and could be used in conjunction with nylon string or fishing line to join up the ends to form the cylinder. Each day, greywater is poured on top of the stones so that the flow of water is controlled into the bag and vegetables are planted in holes cut in the sides of the bag.

The system is relatively easy to maintain with some basic irrigation skills. To account for the often-soapy greywater, pouring two buckets of clean water into the column each week clears the system. This system favours the growth of leafy vegetables such as spinach.

Figure B14.1: Example of a modified tower garden in use in Limpopo province

B15. Wattworks Greywater Treatment System

This system (Wattworks, 2006) uses greywater generated from the household to flush one or two toilets in the home. It stores water from the shower or bathroom in a holding tank which discharges excess water to sewer every 24 hours so as to not to cause any offensive smells.

Figure B15.1: Example of Wattworks installation

B16. Earthstar Greywater Systems

The Earthstar system (Realgoods, 2006) essentially consists of a 250*l* holding tank coupled to a greywater treatment system which is a simple sand filter with backwash cleaning. The irrigation cycle begins once the greywater reaches a certain level in the tank and a float switch activates a centrifugal pump. A simple 5-minute backwash cleaning process every 2 months is included in the design to keep the filter operating efficiently

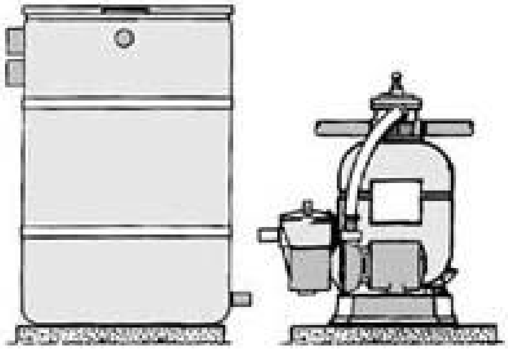

Figure B16.1: Simple schematic of Earthstar greywater system

B17. Casa Juliana Kitchen Greywater System

This system (Casa Juliana, 2006) has been designed to treat kitchen greywater and consists of a distribution hub from a 25*l* cement bucket and a 15mm PVC pipe which distributes the greywater to six small infiltration chambers. The kitchen greywater first passes through an interceptor which traps grease and fats before it is used for irrigation purposes.

Figure B17.1: Grease interceptor

Figure B17.2: Six pipes to distribute the greywater

Figure B17.3: Distribution hub

Figure B17.4: Detail of infiltration chamber at end of pipes

B18. Niimi Absorption Trench System

Greywater is led through a pipe to a collection tank where a distribution box feeds the absorption trenches (Rotaloo, 2006). The trenches are lined with 0.2mm thick heavy duty polyethylene and consist of inert mediums such as coarse gravel, shells, plastic etc. which are used for biological treatment of the greywater. The lengths of the trenches are designed on the volumes of water consumed by the household as well as the soil type in the area. These trench systems should not be used where the water table is less than 1.3m below surface level.

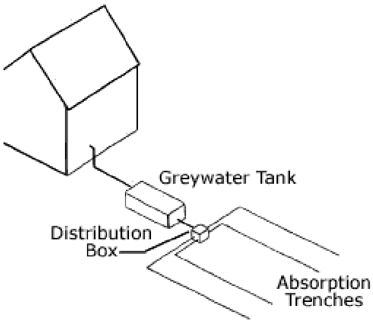

Figure B18.1: Typical layout of Niimi system

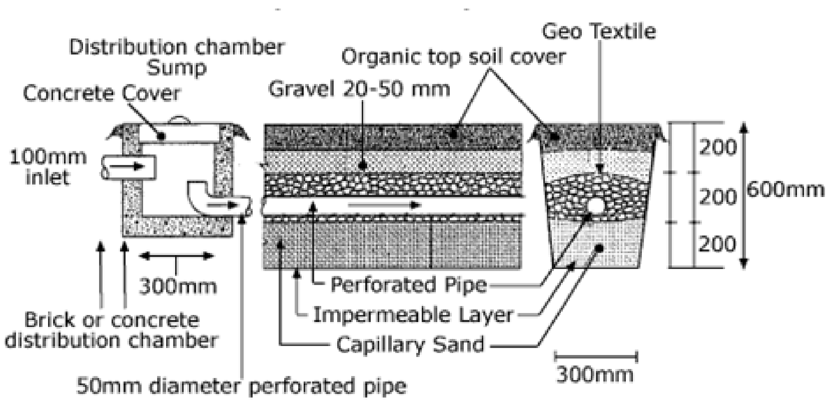

Figure B18.2: Section through Niimi absorption trench system

Appendix C

Health aspects of greywater use

Jo Barnes

Health aspects of greywater use

C1 Introduction

The urbanisation accompanying growing populations is increasing the demand for water supply in communities throughout the world, and the water resources for many cities are already proving inadequate. Accessing additional water sources is inherently costly and other water users (rural communities, industry and agriculture) may have competing water demands or water rights.

Water conservation, particularly through demand management, may delay the need for additional sources for a limited period. One approach that holds much promise in theory has been the reclamation of wastewater produced by communities themselves for non-potable uses such as landscaping, food and ornamental gardening, cooling, toilet flushing, etc.

Use of household greywater may be technically feasible, but a crucial consideration in decisions about implementation is risk. The use of domestic wastewater (greywater) to replace other water sources for irrigation is highly dependent on whether the health and environmental impacts entail risks that are acceptable or not. Contrary to common belief, greywater is not a 'safe' or harmless substance – it contains bacteria, viruses and other potential pathogens (organisms able to cause disease in humans or animals). Consequently, the potential reuse of greywater is as much a public health issue as it is a water conservation priority (Okun, 2000).

The species and total counts of the micro-organisms found in greywater vary widely according to *inter alia*, climatic conditions, season, available sanitation technology, sanitation habits of the people living in the communities and the disease incidences of the area (Palacios *et al*, 2001). This makes it difficult to categorise the microbiological quality of greywater from certain types of settlements.

C2 Summary of health-impact guidelines (Australia and USA)

In light of the lack of any code of practice for the use of greywater in South Africa, it is useful to summarise the main health-impact guidelines in the regulations used by two of the world leaders in greywater use, namely Australia (State of Victoria, 2003) and the United States of America (Water Conservation Alliance of Southern Arizona, 2003). These restrictions highlight the health risks discussed below:

- Water that has come into contact with a toilet, urinal or a toilet fixture such as a bidet should never be used as greywater.
- Water that has been used to wash nappies or other clothing soiled by faeces and/or urine should not be used as greywater.
- Water from the kitchen sink or used in the kitchen to wash dishes or food should not be used (it is too highly contaminated with grease, bacteria, blood and chemicals).

- Greywater should not be allowed to leave the boundaries of the property on which it is generated and should under no circumstances be allowed to enter the stormwater system. Therefore, it is imperative that provision be made for the safe disposal of excess greywater into the sewerage system during rain periods or when too much greywater is produced for the garden to absorb. This provision should be "fail-safe", in other words even if the greywater system malfunctions or blocks, the greywater should not under any circumstances contaminate freshwater lines.
- Greywater should never be allowed to pond or pool where mosquitoes and other insect vectors of disease can breed. Such pools will also very quickly develop a foul smell.
- Greywater should never be applied to edible crops – especially not to vegetables eaten raw or lightly cooked, such as in salads. It should also be avoided for root crops such as carrots, since the pathogens accumulate in the topsoil.
- Greywater should be withheld from areas where children play, such as lawns. Children are the highest risk group with respect to contracting infections from greywater.
- Water used to wash animals such as domestic pets should not be used as this has too high a concentration of organisms able to cause disease.
- Warm greywater should be stored in a holding tank to cool down and should be used within 24 hours; otherwise the bacterial load will rise too high for safety. This tank should be classified as a septic tank and all the regulations for septic tanks should apply to such a system.
- Do not use greywater if anybody living on the premises is suffering from diarrhoea, ear or skin infections.
- Keep children and pets away from areas that are irrigated with greywater and under no circumstances allow them to drink this water.
- Preferably use only 'low risk' greywater – e.g. warm-up water from the hot taps, rinse water, bath or shower water.
- Take careful note of the slope of the soil to be watered to avoid greywater run-off into water courses, swimming pools or dams.
- Evidence indicates that the microbes in greywater have higher survival rates in topsoil. Always use subsurface irrigation or irrigation under a heavy mulch cover. Never hose, spray or mist with greywater.
- People living on the premises where gardens are irrigated with greywater should be encouraged to wash their hands without fail before eating or drinking.

C3 Overall health impacts of poor water supply and sanitation

The health hazards of poor water supply and sanitation are manifold, but one of the major indicators used worldwide is the incidence of diarrhoea. According to the WHO Global Health Statistics (Harvard School of Public Health, 1996), an incidence rate of 77,344 cases of diarrhoea per 100,000 occurred worldwide in 1990, which caused 2.9 million deaths or a mortality rate of 56 per 100,000, mostly among children under the age of 5 years. These deaths represent approximately 15% of all child deaths under the age of 5 years in developing countries. A thorough review of water, sanitation and hygiene intervention studies found that the provision of water and sanitation services reduces diarrhoeal disease on average by between 25% and 33.3% (Esrey *et al*, 1991).

Attempts were made to try and obtain recent South African health clinic data on waterborne diseases or incidences of diarrhoea but it was only possible to get limited information at district level for typhoid and cholera cases (Section D10). While these numbers certainly give an indication of the impacts of poor water supply and sanitation on these communities (as evidenced by the typhoid outbreak in Delmas in 2005), the specific impacts from greywater disposal, particularly in densely-populated areas, could not be determined.

C4 Common contaminants in greywater

Greywater contaminants vary from house to house and depend amongst other factors on the number of persons living in the house, their lifestyles and their ages. Households with babies or small children produce greywater with higher faecal counts, as do households with pet animals (especially if the pets are bathed or washed on the premises). Households with inhabitants suffering from acute diseases such as gastroenteritis, eye or ear infections, or waterborne hepatitis (jaundice) can produce greywater with considerable loads of bacteria or viruses during the course of the illness. Households with persons living with a chronic infectious condition (e.g. HIV/AIDS, tuberculosis) may also produce greywater with increased infection risks over the long term as these individuals have severely compromised immune systems and are likely to have secondary infectious conditions.

Even greywater from which water from the kitchen sink has been excluded contains appreciable amounts of soaps and detergents, fabric softener, shampoo, hair conditioner, toothpaste, medicines, disinfectants, food particles, pesticides, dyes, cosmetics (make-up), lint and other fibres. Human waste products such as saliva, sweat, body oils, hair, blood, and some urine and faecal matter are additional sources of contamination.

Examples of pathogens (microbial organisms able to cause disease) that could typically be present in greywater are listed in Table C1. The diseases caused by such pathogens are mainly gastroenteritic diseases, skin infections and eye and ear infections. Among the viral pathogens, hepatitis viruses (causing jaundice) also feature prominently. In endemic areas, diseases such as cholera and schistosomiasis (bilharzia) can also pose a serious risk. In Table C2 some of the major waterborne pathogens are listed according to their significance to health. Health significance can be judged from their persistence in water, their resistance to disinfection by chlorine and the relative dose needed to cause infection. Some examples of organisms causing diseases other than gastrointestinal ones that are associated with casual contact with water appear in Table C3.

It must be borne in mind that once a communicable infection has taken hold in a few individuals from a contaminated water source, it can spread by means of person to person contact or as airborne or foodborne infection (depending on the pathogen). After the initial contact, water does not have to be the only vector. If greywater is used on a wide scale by thousands of homes, incidents of accidental ingestion and contamination will inevitably occur, especially if supervision of the adherence to safety precautions is not conscientiously carried out (Mitakakis *et al*, 2004). Thus the potential for waterborne diseases will inevitably rise under such circumstances and public health authorities should be aware of this. One of the points in a well-planned greywater policy should be a decision on what frequency of contamination incidents and/or water-related diseases constitute a sufficient level to sound the alarm for the re-assessment of the continued use of greywater in that community.

Table C1: Examples of pathogens associated with faecal contamination and poorly treated wastewater

Pathogen class	Examples	Disease
Bacteria	*Shigella* species	Baccillary dysentery
	Salmonella sp.	Salmonellosis (gastroenteritis)
	Salmonella typhi	Typhoid fever
	Enteropathogenic *E. coli*	Variety of gastroenteritic diseases
	Yersinia sp.	Yersiniosis (gastroenteritis)
	Campylobacter jejuni	Campylobacteriosis (gastroenteritis)
Viruses	Hepatitis A virus	Infectious hepatitis
	Norwalk viruses	Acute gastroenteritis
	Rotaviruses	Acute gastroenteritis
	Polioviruses	Poliomyelitis
	Coxsackie viruses	"Flu-like" symptoms
	Echoviruses	"Flu-like" symptoms
Protozoa	*Entamoeba histolytica*	Amoebiasis (amoebic dysentery)
	Giardia lamblia	Giardiasis (gastroenteritis)
	Cryptosporidium sp.	Cryptosporidiosis (gastroenteritis)
Helminths	*Ascaris* sp.	Ascariasis (roundworm)
	Taenia sp.	Taeniasis (tapeworm)
	Necator americanus	Ancylostomiasis (hookworm)
	Trichuris trichuria	Trichuriasis (whipworm)

Table C2: Orally transmitted waterborne pathogens and their significance in water extracted from WHO Guidelines for Drinking Water Quality, (1993)

Pathogen	Health significance	Persistence in water supplies[a]	Resistance to chlorine[b]	Relative infective dose[c]
Bacteria				
Campylobacter jejuni, *C. coli*	High	Moderate	Low	Moderate
Pathogenic *E. coli*	High	Moderate	Low	High
Salmonella typhi	High	Moderate	Low	High
Other *Salmonellae*	High	Long	Low	High
Shigella spp.	High	Short	Low	Moderate
Vibrio cholerae	High	Short	Low	High
Yersinia enterocolitica	High	Long	Low	High
Pseudomonas aeruginosa	Moderate	May multiply	Moderate	High (?)
Aeromonas spp.	Moderate	May multiply	Low	High (?)
Viruses				
Adenoviruses	High	?	Moderate	Low
Enteroviruses	High	Long	Moderate	Low
Hepatitis A	High	?	Moderate	Low
Enterically transmitted non-A, non-B hepatitis viruses, hepatitis E	High	?	?	Low
Norwalk virus	High	?	?	Low
Rotavirus	High	?	?	Moderate
Small round viruses	Moderate	?	?	Low (?)
Protozoa				
Entamoeba histolytica	High	Moderate	High	Low
Giardia intestinalis	High	Moderate	High	Low
Cryptosporidium parvum	High	Long	High	Low

[a]Period detected in water at 20ºC – Short: up to 7 days, Moderate: 7-30 days, Long: >30 days

[b]Water treated at conventional doses and contact times - moderate resistance means that organisms are not completely destroyed

[c]Dose required to cause infection in 50% of healthy adult volunteers. May be as little as 1 infective unit for some viruses.

Table C3: Examples of organisms causing non-gastrointestinal illnesses associated with recreational or casual contact with water

Health problem	Examples of Causes
Skin diseases	*Pseudomonas aeruginosa* Atypical mycobacteria *Staphylococcus epidermidis*
Respiratory diseases	Viruses, especially adenovirus Environmental mycobacteria, especially *Mycobacterium avium* complex (causing lung disease, particularly in immuno-compromised persons) *Klebsiella pneumoniae*
Ear infections	*Pseudomonas aeruginosa* *Staphylococcus aureus*
Liver or kidney diseases	*Leptospira* species Various hepatitis viruses
Eye infections	*Pseudomonas aeruginosa* *Acanthamoeba* species

C5 Risks to humans

A growing body of evidence indicates that the greatest risk of infection for enteric pathogens is borne by persons less than 19 years of age (Nwachuku & Gerba, 2004). Children are more likely to become ill from the consumption of contaminated water and from exposure via recreational activities. This may be because their immunological, neurological and digestive systems are still developing and/or because they are environmentally more exposed. Persons with compromised immune systems or those who suffer from other health conditions are also at increased risk. Old people, pregnant women, patients suffering from HIV/AIDS, tuberculosis, malnutrition and other chronic diseases also fall into this category. In South Africa this collection of people comprises a sizeable proportion of the population.

C6 Risks to edible crops

Using greywater to irrigate edible crops, especially vegetables and fruits eaten raw or after minimal processing, is unsafe. Greywater emanating from non-sewered areas (and particularly densely populated informal settlements) is not suitable for the irrigation of edible crops except in times of such severe food shortage where the risk of disease becomes less than the risk attached to compromised food supplies (a very rare occurrence). There is also a large body of evidence showing bacterial transmission from greywater or other wastewater to food crops and livestock kept for slaughter (Petterson & Ashbolt, 2001; Fasciolo *et al*, 2002; Sadovski *et al*, 1978).

Petterson & Ashbolt (2001) found that clumping of viruses on lettuce and carrots irrigated with wastewater occurs with subpopulations of viruses showing high persistence also occurring under these circumstances. These factors may cause the risks associated with such contamination to be under-estimated.

Fasciolo *et al* (2002) carried out experiments in Mendoza, Argentina to assess the sanitary acceptability of crops irrigated with treated wastewater. Garlic irrigated with wastewater only reached sanitary acceptability 90 days after harvest once the roots and soil were removed. Onions cleaned immediately after harvest reached sanitary acceptability 55 days after harvest and none of the irrigated crops were fit to consume raw at harvest. In some greywater advisory documents (some of those that are written from an engineering perspective) the user is only advised to withhold irrigation with greywater for one week before harvesting root crops (e.g. Marshall, 1997). This is not considered to be scientifically justifiable advice.

Sadovski *et al* (1978) investigated the levels of microbial contamination of vegetables irrigated with wastewater by the drip method. They could show that irrigation carried out under plastic sheeting or buried under the soil surface significantly reduced crop contamination. Unfortunately they also found that microbial contamination persisted in the irrigation pipes for at least 8 days and in the soil for at least 18 days.

Abdul-Raouf *et al* (1993) investigated the ability of *Escherichia coli* O157:H7 (a serious pathogen which causes disease with a high mortality rate) to survive or grow on raw salad vegetables. This was done to study the fate of such organisms should the crops become accidentally contaminated before harvest and consumption. It was found that populations of viable *E. coli* O157:H7 declined on raw salad vegetables stored at 5°C, but increased on vegetables stored at 12°C and 21°C (conditions such as would occur in ordinary shelf storage).

C7 Survival of pathogens in the environment

The ability of pathogenic organisms to survive in soil, in water and on surfaces has important implications for the production of safe food and for the health of humans and animals.

Maule (2000) investigated the survival of *E. coli* O157:H7 in various settings such as river water, different soil cores and stainless steel and plastic surfaces. Survival of the organisms was greatest in soil cores under rooted grass. Under these conditions a moderate decline occurred only after 130 days. The organism survived less readily in river water, where it fell to undetectable levels after 27 days. Air-dried deposits of the organism survived on stainless steel surfaces for periods in excess of 60 days. It was most stable at chill temperatures (4°C) and viability was only partially reduced at 18°C. The organism was also shown to survive for extended periods on plastic domestic food cutting boards at both chill and room temperatures. These data indicate the ability of some serious pathogens to persist in the environment beyond the expectations of some engineers and other advisors on greywater use projects!

Malkawi & Mohammad (2003) looked at the survival and accumulation of micro-organisms in soils with secondary treated wastewater as their source of pathogens. They irrigated soil samples with an amount of water equivalent to 100% of the Class A Pan evaporation reading, and some samples to 125% of the Class A Pan reading. The bacteriological analyses showed that the total coliform count was highest on the soil surfaces.

They stated that the results “strongly suggest the necessity to treat wastewater effluents to an extent to which no or very few residual bacterial contaminants will be detected”. In practice these results could be obtained with contaminated greywater as well and therefore the recommendation should be borne in mind by proponents of unrestricted application of greywater in home gardens.

C8 Note on outcome assessment in greywater reuse projects

One of the most frequently suggested ways of assessing the success of water and sanitation improvement schemes is to determine whether the prevalence of diarrhoea in the community has been reduced. Although instinctively persuasive, this is not a good outcome variable to use in such assessments in practice. After the initial contamination of water by waterborne pathogens, the environment very quickly becomes polluted by the movement of affected persons and animals, contamination carried around on the soles of feet and shoes, contaminated water wetting ever-increasing areas and the spread of person-to-person infection. An ever-widening circle of affected surfaces and people results, until the outbreak starts to wane, which can take some time.

In chronically polluted areas, there is a background level of endemic disease that takes a long time to dissipate; in keeping with the slow decreases in pathogen levels of pockets of affected surfaces, water pools, etc. The level of endemic diarrhoea in such a community (especially if it is an impoverished one) drops far more slowly than the outcome assessment that the intervention project usually allows for. If such levels are measured too soon after the intervention (within a few months or even sometimes a few years), no noticeable difference in diarrhoea prevalence will be recorded, leading to the erroneous conclusion that the intervention “did not work”. The study by Kirchhoff *et al* (1985) serves as an example. A study of chlorinating household raw water in clay pots in rural Brazil was carried out while using diarrhoea incidence as the outcome variable. Diarrhoea incidence was recorded in households where water was treated and where it was left untreated. Although the treated drinking water was significantly less contaminated by pathogens, they did not find a reduction in diarrhoea incidence between those using treated vs. untreated water during the study period. In other words the treatment was successful but it was not reflected in the way they wanted to measure the outcome. They concluded that an intervention such as the one in their study may affect disease rates only when other factors related to faecal-oral transmission are ameliorated *at the same time*. These realities need to be recognised by funding organisations and project leaders in their planning of health impacts of water-related projects and their assessment of the outcomes of such projects.

C9 Summary

Critics of overly restrictive policies for greywater reuse feel that rigid rules discourage home owners and especially the urban poor from utilising greywater as a resource. Unfortunately, making the use of greywater unrestricted (especially if there is no education about risks and no supervision) will increase the disease burden on those who can least afford it. According to the latest HIV survey by the Department of Health nearly 40% of women in South Africa between the ages of 25 and 29 years are HIV-positive. These women are in their peak childbearing years. They are also in the age and gender categories most likely to be involved in child care as well as cooking and cleaning, where most of the household greywater is generated. In impoverished areas they are also often involved in subsistence gardening, thereby coming into contact with polluted water (grey or otherwise). HIV infection damages the immune system and environmentally acquired infections can shorten the life expectancy of such persons. Greywater poses a much greater risk to those people than to the generally healthy, well-fed population of a First World country where much of our experience of greywater use originates.

In South Africa the advantages brought by extra food supplies generated using greywater in impoverished areas should be balanced against the risks of infection in vulnerable groups such as malnourished children and HIV positive persons. Achieving a balance in these special circumstances will be no easy task and the regulatory agencies should consult widely and debate wisely before they officially sanction the use of greywater. Key aspects of this would of necessity be the *education* that is crucial for the safe handling and use of greywater and the *supervision* of adherence to essential safety precautions (including personal hygiene practices).

There is an urgent need for research into the actual wastewater quality produced by low-income urban communities in South Africa and the health risks posed by such water. South Africa faces the conflicting demands of improving access to water for a large proportion of its inhabitants, while at the same time trying to improve the health of the population by reducing the risk of disease from dirty, polluted environments. This conflict needs to be very carefully weighed by the many stakeholders and affected public services before a decision on the widespread use of greywater in an unrestricted and unsupervised way is encouraged publicly. Okun (2000) stated that greywater use may be feasible, but "it imposes added public health risks that need to be accepted only as a last resort". It should be a subject for careful consideration of actual risks and wide consultation of affected persons before a decision is made on when that point of last resort is.

C10 Recent incidence of waterborne disease in South Africa

The following tables showing incidence of waterborne disease were sourced from the Epidemiology & Surveillance Directorate, National Dept. of Health (C = Cases, D = Deaths).

C10.1 Cholera

Province	2001		2002		2003		2004		2005		Total
	C	D	C	D	C	D	C	D	C	D	
Eastern Cape	0	0	2335	45	3141	38	740	4	0	0	6216
Gauteng	0	0	24	2	4	0	1	0	0	0	29
KwaZulu-Natal	1831	16	15339	71	579	0	6	0	0	0	17755
Mpumalanga	0	0	4	1	176	7	1773	29	0	0	1953
Limpopo	0	0	465	2	0	0	0	0	0	0	465
Western Cape	0	0	0	0	1	0	0	0	0	0	1
Total	1831	16	18167	121	3901	45	2520	33	0	0	26419

C10.2 Typhoid

Province	2001		2002		2003		2004		2005		Total
	C	D	C	D	C	D	C	D	C	D	
Eastern Cape	33	1	16	0	2	0	1	0	0	0	53
Gauteng	4	0	12	0	0	0	3	0	40	0	59
KwaZulu-Natal	22	0	10	0	5	0	33	0	28	0	98
Mpumalanga	0	0	24	0	1	0	0	0	590	0	615
Limpopo	179	11	110	5	89	1	21	8	33	0	432
Western Cape	12	0	0	0	4	0	2	0	0	0	18
Total	250	12	172	5	101	1	60	8	691	0	1275

C10.3 Typhoid Fever cases by district, 2000 – 2005:

1. Eastern Cape

Magisterial district code	District	No. of cases
3406	Libode	1
3408	Ngqeleni	6
3410	Port St. Johns	21
3412	Cofimvaba	1
3414	Tsomo	2
3415	Umtata	7
3416	Willowvale	7
3417	Cala	1
3418	Lady Frere	3
3703	Cathcart	2
3711	Victoria East	1
3713	Peddie	1
3801	East London	2
3803	Mdantsane	1
4301	Port Elizabeth	2
4402	Graaff Reinet	1
Total		59

2. Gauteng

Magisterial district code	District	No. of cases
7301	Germiston	2
7302	Alberton	4
7303	Boksburg	10
7304	Kempton Park	18
7305	Benoni	6
7401	Brakpan	2
7602	Cullinan	1
7801	Pretoria	1
7900	n/a	11
7901	Johannesburg	2
7902	Randburg	7
Total		62

3. Mpumalanga

Magisterial district code	District	No. of cases
6101	Highveld Ridge	2
6104	Delmas	590
6501	Nelspruit	1
6601	Nsikazi	1
6602	Barbeton	22
6603	Witrivier	1
6606	Nkomazi	4
6607	Eerstehoek	4
Total		625

4. KwaZulu-Natal

Magisterial district code	District	No. of cases
4701	Umbumbulu	1
4702	Umlazi	1
4802	Pinetown	3
4803	Inanda	2
4804	Chatsworth	15
5001	Mahlabatini	1
5101	Pietermaritzburg	23
5201	Camperdown	1
5202	Ixopo	6
5203	Umzintoti	1
5301	Port Shepstone	3
5401	Mount Currie	14
5601	Kliprivier	11
5603	Estcourt	1
5701	Newcastle	31
5703	Dannhauser	2
5705	Glencoe	2
5904	Eshowe	5
5905	Mtunzini	1
6001	Hlabisa	2
Total		126

5. Western Cape

Magisterial district code	District	No. of cases
0101	Cape	1
0102	Wynberg	1
0103	Simon's Town	1
0106	Mitchells Plain	5
0202	Kuilsrivier	7
0301	Caledon	2
0302	Hermanus	2
0304	Swellendam	2
0601	Worcester	1
0701	Malmesbury	3
Total		25

6. Limpopo

Magisterial district code	District	No. of cases
1010		7
1030		22
1040		58
2020		2
2030		4
2050		5
3020		153
3030		4
3040		74
3050		7
3060		4
4030		5
4040		94
4050		10
5020		1
6010		9
7405		4
7603		1
Total		464

Appendix D

Case studies

D1. Western Cape site surveys

The selection of sites in the Western Cape Province (WC) was a process that developed over time, culminating in a procedure for site selection that could be used for the remainder of the country. Similarly the survey methodology was also refined during the course of the WC study, including the survey questionnaire which was tested and finalised at the same time.

Eight sites were chosen for surveys in the Western Cape (Figure D1.1). Clanwilliam and Redhill were selected as the first sites to test the pilot questionnaire and familiarise the researchers with the problem of greywater management in non-sewered areas. Clanwilliam was chosen because the University of Cape Town (UCT) field station is located near the informal settlement of Khayelitsha, and it has been the focus of ongoing anthropology and archaeology research for a number of years. Redhill was selected based on the fact that it is an easily-accessible settlement relatively close to UCT.

Figure D1.1: Locality map of Western Cape province showing selected sites for surveys

In order to select further sites for the WC province, settlements were visited along a transect from Saldanha Bay and Vredenburg on the west coast of the WC, through to Kleinmond on the south coast. Field observations were taken at six sites along this transect with particular attention being given to the proximity of these sites to sensitive environments such as wetlands, rivers or natural vegetation. From this it was determined that Fairyland in Paarl and the informal settlement in Kleinmond were two sites where the potential health and environmental impacts of greywater could be high. Two further second round sites, one on the Cape Peninsula and one on the Cape Flats were also selected for sampling and surveys because of their potential impacts on wetlands (Masiphumelele) and on groundwater (Sweet Home Farm).

The two final sites chosen (Khayelitsha RR and Lingelethu, Malmesbury) were identified through the use of Census 2001 data, and after discussions with the relevant local authorities. Khayelitsha RR was chosen as an example of a dense settlement and Lingelethu as an example of an informal settlement with limited services on the edge of an RDP development.

D1.1 Khayelitsha, Clanwilliam

D1.1.1 Background

Clanwilliam was one of the earliest colonial settlements in South Africa and thus has a very long history of continuous habitation. The climate is typical of the Cape – winters that are cold and wet, and hot, dry summers (with temperatures reaching 40°C at times). The main economic activities are agriculture and tourism with the rooibos tea industry being the most important. Vineyards and citrus farms also provide seasonal employment to hundreds of unskilled workers, many of whom reside in Khayelitsha. Given the seasonal nature of agricultural work, the farm workers suffer periods of unemployment and poverty which compels them to seek work elsewhere. Population figures are thus heavily influenced by the season and there seems to be a general growth in the numbers of low-income Xhosa, Sotho and Tswana speaking migrant workers into the predominantly Afrikaans-speaking town (mainly coloured and white population).

As with the rest of the country, the system of social stratification and access to resources, including water, reflects the old hierarchies. The new arrivals to the town are also the ones most likely to have insufficient access to services. In August 2004 there was some conflict between Sotho speakers and Xhosa speakers in the migrant farm-labour community, which resulted in shacks being destroyed. This conflict highlighted the competition for work and other resources, including water. The increase in the population has been mainly due to migration, predominantly among the economically active age groups 15 – 34 and 34 – 65, with many of these in the low-income groups earning R2,400 or less per annum. The challenges of poverty have put tremendous pressures on the Cederberg Municipality’s resources as the numbers of disabled people and those living with HIV/AIDS have also increased.

Minimal water, sanitation and refuse collection services have been supplied to Khayelitsha and although the water supply is fairly reliable, sanitation and refuse collection services are less efficient. Four flush toilets have been made available in the settlement, but there is no drainage system for the greywater and the communal flush toilets do not function efficiently. Most residents have thus resorted to using the surrounding bush as their toilet. Greywater thrown out of buckets and basins is just left to flow down the slope into make-shift furrows, adding to the runoff from the standpipes. It then either evaporates in the sun or forms stagnant puddles, which cause odours and contribute to unsanitary living conditions in the settlement.

Prospects for the Khayelitsha community appear to lie with future access to RDP housing, but the informal settlements have grown at a much faster pace than the stock of RDP houses. It would seem therefore that although official planning focuses on providing waterborne sanitation, electricity and other basic services to as many people as possible, as per government policy, there may well be a need to develop alternative methods of providing water and sanitation to (upgraded) informal settlements which will incorporate a methodology for the strategic management of greywater.

D1.1.2 Description of research

Groups of social anthropology students spent a day interviewing men and women in different households who were willing to answer questions on water use and greywater management. There was no structured sampling and the main aim was to get as many diverse viewpoints as possible. An average household water consumption of 65*l* per day (*l*/d) was estimated based on the replies to questions on water consumption.

Figure D1.2: Greywater stream, Clanwilliam

Figure D1.3: Litter at Clanwilliam

D1.1.3 Social findings

There do not seem to be any significant water use practices that are influenced by cultural or religious beliefs. Socio-economic circumstances however show that income influences the amount of water used, types of detergents, frequency of laundry and amount of greywater generated. The low incomes, high unemployment levels and seasonal character of the work make the Khayelitsha, Clanwilliam community different from informal settlements in and around the city of Cape Town. The overall impact of the community on the environment is limited given the relatively small amounts of water used, greywater produced and dry climate that prevents buildup of stagnant water.

D1.1.4 Water quality

No water quality data was captured during this early survey.

D1.1.5 Concluding remarks

This was the first field trip undertaken and was therefore exploratory in nature, providing an opportunity for the research team to finalise the methodology, and pilot the survey questionnaire for further site visits.

D1.2 Redhill

D1.2.1 Background

The Redhill informal community in Simonstown dates back to the 1980s when people employed at the Kogelfontein road works and at the Cape of Good Hope Nature Reserve (Silvermine) set up a squatter settlement after failing to find accommodation in Simonstown. Plans to resettle them at Masiphumelele (Noordhoek) were rejected on the grounds that it was too far from their workplace. The original settlement was on Cape Farm 1404 – this was privately owned by a Mr. Kopfer who was compensated for the use of his land by the Provincial Administration of the Western Cape (PAWC). In 1995 there were 122 structures at Redhill – in the last ten years this figure has increased to over 200 structures, spread over three distinct camps.

The Redhill settlement is built on a slope surrounded by rocky National Park land covered in fynbos. The Redhill Road, a paved route between Simonstown and the small town of Scarborough, marks the upper boundary of the camp. Tall eucalyptus and Chilean pine trees shelter the settlement and provide firewood. Several steep rocky areas have prevented the construction of homes in certain vicinities and have created wooded natural patches dividing the settlement into camps. The lower camp consists of only a handful of houses and is significantly quieter than the rest of Redhill. The middle camp is the most populous area of the settlement with residents that are mostly Xhosa-speaking and come from the former Ciskei and Transkei regions of South Africa. The upper camp has about 25 houses and residents here are Afrikaans-speaking and are mostly "coloured."

Redhill is relatively small and not as densely populated as most other informal settlements. It has what appears to be an effective political and administrative regime that prevents new settlers from putting up more shacks. Plans exist for the future development of formal township housing in Simonstown but this will in all likelihood exclude the unemployed and so although the Redhill informal settlement may not be allowed to expand, it nevertheless might continue to exist for much longer than planned in order to accommodate those who will not be able to afford formal housing.

Redhill has sandy, relatively infertile soils and receives large amounts of rainfall. These factors together appear to have an impact on Redhill water use and wastewater management practices. Present services in the settlement comprise pit latrines and communal tapstands from 5 water tanks, which are connected to a constant supply. Some of these services were initially financed by PAWC while RDP funding was later acquired by Simonstown to extend and improve the services (basic refuse removal services are also provided but are not very efficient). The residents of the settlement pay a flat rate to the municipality for water supply and refuse removal. The City of Cape Town (CoCT) has recently installed 10 urine diversion (UD) toilets at Redhill as part of a pilot study to test the efficiency of the new sanitation technology; however this will not impact on greywater management in the settlement as there is still no means of greywater disposal.

There has been little change in Redhill since it was established more than twenty years ago. Most important is the fact that the community has not been allowed to grow significantly. Damage to the environment, including water related pollution therefore appears very low if not insignificant due to the relatively low population density.

D1.2.2 Description of research

Building on the pilot study conducted in Clanwilliam, the Redhill survey was more focused in its combining of social and environmental aspects of water use and greywater disposal. Samples of the greywater were taken and the women who were in charge of the laundry and kitchen duties were asked direct questions about the detergents and other chemicals that they used as well as details about how they used and re-used the water before discarding it as waste. From this it was ascertained that households used on average about 75*l*/d.

Figure D1.4: Tapstand at Redhill

Figure D1.5: Clothes washing at Redhill

D1.2.3 Social findings

For all its well organized political lobbying, Redhill is a much-divided community, which is more likely to respond to household, rather than community-level interventions. Redhill residents share little and have shown no communal spirit in tackling problems like leaking water pipes for example.

When asked what they would like to see change in their lives both the Clanwilliam and Redhill residents prioritized ‘proper houses’ which have electricity and waterborne sanitation. These concerns are seen as the most pressing needs in resident’s lives. The functioning and malfunctioning of water supply is a daily frustration, however in both settlements the municipalities provide clean water on a daily basis. In the long run, greywater recycling may be essential for managing the drought-prone region's water supply and alleviate the mild concerns over wastewater on the ground, but this is not the main worry of the people in these settlements.

D1.2.4 Water quality

Tests were conducted (on two separate sampling trips) on greywater generated from laundry washing for the purpose of establishing water quality and in an attempt to define the nature of greywater. Results showed a wide range of values with respect to Chemical Oxygen Demand (COD), Total Phosphorous (P), Sodium (Na), Total Kjeldahl Nitrogen (TKN), and Oil and Grease. Of concern were the high levels of these constituents that have the potential to impact on aquatic systems and downstream users should this water infiltrate into groundwater or flow into other water bodies. In addition, the level of faecal coliforms (greater than 1800 counts/100ml) is further cause for concern. High levels of faecal contamination are often associated with the washing of children's nappies but in this case, no nappies were observed in any of the containers where laundry water was sampled.

Table D1.1: Redhill water quality indicators (15 June 2004)

Water quality indicator	Tapstand	Sample number					
		1A	3	4A	4B	5A	5B
COD (mg/l)	16.1	226	1161	2128	2041	1646	1613
Total Kjeldahl Nitrogen (mg/l)	<1.0	7.1	18.4	27.5	28.2	22.1	18.1
Total Phosphorous as P (mg/l)	<0.1	5.3	30	25	32	27	40
Oil and Grease (mg/l)	<1	38	138	80	190	188	230
Sodium as Na (mg/l)	80	114	416	700	880	700	700
E.Coli (per 100ml)	-	-	-	-	>1800	-	>1800

Table D1.2: Redhill water quality indicators (13 August 2004)

Water quality indicator	Sample number			
	1A	2A	3A	4A
COD (mg/l)	121	2834	113	32.4
Total Kjeldahl Nitrogen (mg/l)	26.4	100	33.5	14.8
Total Phosphorous as P (mg/l)	5.1	14.7	8.3	5.9
Oil and Grease (mg/l)	<1	684	16	20
Sodium as Na (mg/l)	169	170	184	96
E.Coli (per 100ml)	>1800	>1800	>1800	>1800

D1.2.5 Concluding remarks

Redhill appears to be a very stable small community closely supervised by the municipal authorities and unlikely to grow. Its water management practices are wasteful and there does not appear to be any system for managing wastewater other than by letting it sink into the ground or evaporate. It can only be speculated what the long-term health and environmental consequences will be, but the current situation seems to be tolerable.

D1.3 Fairyland

D1.3.1 Background

Fairyland informal settlement is located in a peri-urban area adjacent to the town of Paarl and is administered by the Drakenstein municipality. The site is relatively small with 172 structures and an approximate population of 500 people (van Wyk, 2004). The site was supposed to be upgraded to an RDP status in 2005. Fairyland has been used as a temporary settlement for those awaiting RDP houses; however two residents interviewed during field visits claimed that they had lived in Fairyland for at least 5 years.

Water supply and sanitation services at the site are inadequate. Although communal toilets were installed by the municipality, all appeared to be dysfunctional. They were dirty, blocked and had reached the stage where residents were choosing to use the fields nearby as their toilets instead. As a temporary measure the Municipality intends increasing the number of toilets to 1 for every 4 households in the near future and will ensure that each household has their own lock and key to a designated toilet (van Wyk, 2004). Communal washbasins were also provided but these were vandalized and in a poor state. Most washing took place at a communal tapstand or in front of the houses after water had been collected from a tapstand nearby. Communal tapstands were surrounded by concrete bases with brick walls, which drained excess water to kerbside gutters aligning a grid-iron road system between the shacks.

D1.3.2 Description of research

Three people were interviewed at Fairyland. There was no systematic approach to the selection of the interviewees. People who were found doing washing at the time were engaged in an interview and asked to answer questions about their generation and use of greywater. The selected water quality indicators (COD, TKN, Tot P, Oil and Grease, Na and pH), piloted during the Redhill study, were used in all four of the second round case studies. Each sample was sent to an independent laboratory for tests.

Figure D1.6: Stormwater channel at Fairyland

D1.3.3 Social findings

It is estimated that household water use in Fairyland is approximately 75*l*/d. Informal discussions with at least 4 residents revealed that they were unhappy with the state of the toilets and were concerned that their children were often sick from living in these conditions. At least two mothers complained that their children frequently played in dirty water that accumulated along the kerbsides which had become blocked with litter.

D1.3.4 Water quality

In contrast to the above statement, the site appears relatively well-managed with respect to greywater. Despite the fact that fine gravel surface soils predominate, there was little evidence of any standing greywater on surfaces either between huts or near tapstands.

Three samples of washing water and a sample of clean water from a tapstand was taken. These samples were taken to the laboratory for independent testing. The results are shown in Table D1.3.

Table D1.3: Fairyland water quality indicators (16 September 2004)

Water quality indicator	Tapstand	Laundry A	Laundry B	Laundry C
COD (mg/l)	8.0	4577	843	1526
Total Kjeldahl Nitrogen (mg/l)	<1	58.9	93	27
Total Phosphorous as P (mg/l)	<1	159	93	27
Oil and Grease (mg/l)	4	34	8	48
Sodium as Na (mg/l)	4.6	980	106	296
E.Coli (per 100ml)	0	0	>1800	>1800

In all cases, "Omo" washing powder was used for laundry. Of concern was the large volume of water that was flowing freely along the kerbside drainage channels. This water was channeled to a collection point intended for further treatment at the sewage works in Paarl. Observations on the 20 September 2004 showed that the grate at the collection point was blocked with litter allowing water to bypass the catchpit and enter an open stormwater canal feeding into the Berg River, which has a sensitive ecological system. Apart from possible direct impacts on aquatic systems and habitats, effluent from informal settlements and other activities could also contribute to eutrophication problems in the river.

Samples taken from the catchpit at Fairyland indicate relatively high levels of COD and Na, despite the dilution effects of large volumes of water flowing at this point. Samples taken in the stormwater drain eight metres prior to entry into the Berg River show high levels of COD, Na and E.Coli. While other sources of water are likely to contribute to the quality of water flowing into the Berg River, field observations revealed that the flowing water was generated from activities at Fairyland. Water quality indicators measured from samples taken at the catchpit in Fairyland and in the stormwater drain are shown in Table D1.4.

Table D1.4: Water quality at the catchpit at Fairyland and in the stormwater channel close to the Berg River (16 September 2004)

Water quality indicator	Typical laundry water sample	Sample from catchpit	Stormwater channel next to sewage works
COD (mg/l)	1526	843	56.2
Total Kjeldahl Nitrogen (mg/l)	27	93	20.8
Total Phosphorous as P (mg/l)	80.5	24.5	3.5
Oil and Grease (mg/l)	48	8	2
Sodium as Na (mg/l)	296	106	141
E.Coli (per 100ml)	>1800	>1800	>1800

D1.3.5 Concluding remarks

It is not possible to provide conclusive evidence of pollution from such a small sample other than to state the obvious. Eriksson *et al* (2002) report that most of the COD in greywater derives from household chemicals like dishwashing and laundry detergent, and similarly, detergents are likely to be the primary source of P and Na in this wastewater. The high concentrations of both P and Na in the greywater samples from Fairyland are a direct result of the large volumes of soap powder that are used. The obvious and most urgent, environmental concern is the spillage of sewage and greywater into the stormwater network, which ultimately finds its way into the Berg River.

D1.4 Kleinmond

D1.4.1 Background

The settlement is located on the periphery of the town of Kleinmond which is located along the southern Cape coast approximately 100km from central Cape Town. The site is in the transition zone of the Kogelberg Biosphere Reserve situated on the slopes of Voorberg Mountains and is within 1km of the Palmiet River estuary. There are approximately 346 structures on the site accommodating 1,600 people (van der Berg, 2004).

Services to the site include communal taps, washbasins and toilets, linked to a reticulation system. These services appeared to be functional but were in a poor condition (sewers were overflowing) and they were also situated some distance from the dwellings. This resulted in people collecting their water and taking it back to their homes for the purposes of washing and doing laundry, instead of using the communal facilities. Greywater is then discarded onto the ground in front of the dwellings after washing. In terms of the brief of this project, sites like these are effectively excluded from the scope of the study, however the situation warrants further research since the settlement is situated in a relatively sensitive area and is likely to generate reasonable volumes of greywater despite being sewered.

D1.4.2 Description of research

The site was visited on two occasions, firstly to assess the applicability of the settlement with respect to the generation of greywater, and secondly to collect water samples and conduct interviews.

Samples and interviews were conducted on 20 September 2004. Three people were interviewed to establish the amount of water that each household was using and the manner in which greywater was being disposed. Three water samples were collected from laundry water, while a fourth sample was taken from a communal tapstand.

Figure D1.7: Communal toilets and washing facility at Kleinmond

D1.4.3 Social findings

Interviews were held to determine the volumes of water consumed per household and their use of greywater. It was established that approximately 105*l*/d of water is used per household. All interviewees claimed that they tossed their greywater onto the ground outside their homes.

D1.4.4 Water quality

Two samples of washing water and a sample from a tapstand were collected for further tests.

Table D1.5: Kleinmond water quality indicators (20 September 2004)

Water quality indicator	Tapstand	Laundry A	Laundry B
COD (mg/l)	4.0	3854	3172
Total Kjeldahl Nitrogen (mg/l)	<1	63.4	156
Total Phosphorous as P (mg/l)	<1	180	112
Oil and Grease (mg/l)	2	12	46
Sodium as Na (mg/l)	29.6	960	780
E.Coli (per 100ml)	0	0	0

As mentioned previously, the high COD appears to be linked to the large concentrations of soap powder used in the washing of laundry. In all three cases the interviewees used “Sunlight” soap powder for their laundry.

D1.4.5 Concluding remarks

The greywater samples from Kleinmond were heavily polluted and are of particular concern given the site’s proximity to environmentally sensitive areas. This site also demonstrates that while an area may be technically sewered, communal sanitation facilities do not necessarily provide an effective means of greywater disposal.

D1.5 Sweet Home Farm

D1.5.1 Background

The site is located in Philippi on the Cape Flats and has approximately 1,800 structures. The population growth rate is negative with the number of structures having decreased from 2,200 to 1,800 during the period 2003 to 2004. The decrease is attributed to the fact that people have been relocated to other areas due to flooding. The civic committee of Sweet Home Farm tries to prevent people from settling in the area as the settlement is low-lying and subject to flood inundation.

Observations from the first field visit (15 August 2004) showed many shacks were badly flooded following rains of up to 80mm in the first week of August. Floodwaters subsided slowly due to the high water table and saturated soils. Field kits were used to test the water for Tot P and Ammonia (NH_3). In the case of the former, >5 mg/l was measured and in the latter, >3 mg/l was measured. No other tests were conducted.

Water is provided to the settlement via 37 standpipes dispersed across the area. Communal toilets have been installed. All have locks to doors and are shared by 5 households. The toilets appear to be relatively well maintained and have been designed to operate as pour flush systems. This system reduces water demand in areas where there is limited supply, and also limits the volumes of sewage to the treatment works. The site is due to be upgraded in the future with the numbers of toilets increasing from 240 container toilets to 450 waterborne toilet systems. The number of standpipes will also be increased as well as the number of greywater collection containers (Gerber, 2004).

D1.5.2 Description of research

The site was visited on two occasions; the first time to assess the applicability of the settlement with respect to the generation and disposal of greywater, and the second time to collect water samples and conduct interviews.

Samples and interviews were conducted on 16 September 2004. Three people were interviewed to establish the amount of water that each household generates and the manner in which greywater was being disposed. Three water samples were collected from laundry water while a fourth sample was taken from a communal tapstand.

Figure D1.8: Shacks at Sweet Home Farm

Figure D1.9: Flooding at Sweet Home

D1.5.3 Social findings

Most of the residents experienced severe flooding during the first week in August. The team was taken to a number of houses that were flooded and samples were taken for P and NH_3 analysis.

Interviews during the second visit revealed that households used an estimated 70*l*/d. The system of establishing communal toilets in which 5 households were given 'ownership' and responsibility appeared to be working well.

D1.5.4 Water quality

Three samples of household clothes-washing water and one of a nearby tapstand were collected for analysis and are presented in Table D1.6.

Table D1.6: Sweet Home Farm water quality indicators (16 September 2004)

Water quality indicator	Tapstand	Laundry A	Laundry B	Laundry C
COD (mg/l)	8.0	3709	11289	10483
Total Kjeldahl Nitrogen (mg/l)	<1	50.8	279	186
Total Phosphorous as P (mg/l)	<1	144	210	77.5
Oil and Grease (mg/l)	<1	56	160	706
Sodium as Na (mg/l)	14	910	1700	770
E.Coli (per 100ml)	0	0	NS	NS

D1.5.5 Concluding remarks

Conditions at Sweet Home Farm during flooding underscore the need for greywater management. Although limited water sampling tests were undertaken, the levels of P and NH_3 in the flooded homes are indicative of a potentially serious problem. The slow infiltration of floodwaters combined with heavily polluted greywater, has the potential to place residents' health at great risk.

D1.6 Masiphumelele

D1.6.1 Background

This informal settlement is situated in Noordhoek in the Fish Hoek / Sun Valley area of the Cape Peninsula. Whilst the majority of houses in this settlement have been converted to RDP status, the periphery of the settlement continues to attract a shack-dwelling population. There are approximately 387 structures that have been erected adjacent to the Noordhoek wetland. It is estimated that 1,935 people live in these structures (Faure, 2004).

Attempts have been made by the Municipality to service the informal dwellings with tapstands and communal toilets. It was observed that women conducting their washing at tapstands discard their greywater either onto the soils or into the open stormwater drains alongside. Greywater and other polluted water is carried via these canals directly into the wetland.

D1.6.2 Description of research

The site was visited on two occasions. The first visit was used to assess the generation of greywater and the proximity of the settlement to the Noordhoek wetland. Water samples were collected and interviews were conducted during the second visit.

Samples and interviews were conducted on 16 September 2004. Three people were interviewed to establish the amount of water that each household was using and the manner in which greywater was being disposed. Three water samples were collected from clothes-washing water while a fourth sample was taken from a communal tapstand.

Figure D1.10: Stormwater channel to wetland, Masiphumelele

D1.6.3 Social findings

Following interviews, it was estimated that the amount of water used by households was about 100*l*/d.

D1.6.4 Water quality

The close proximity of tapstands to stormwater canals, which ultimately feed the Noordhoek wetland, is a cause for concern. The wetland has no visible surface water as it is filled with *Phragmites Australis*, a common reed known to thrive in nutrient rich soils and in conditions where the water body is less than 1.5m depth. The high levels of COD, P and N, amongst others, contribute to the deterioration of these wetlands.

Table D1.7: Masiphumelele water quality indicators (20 September 2004)

Water quality indicator	Tapstand	Laundry A	Laundry B	Laundry C
COD (mg/l)	16.0	1935	11451	10161
Total Kjeldahl Nitrogen (mg/l)	<1	31.2	210	150
Total Phosphorous as P (mg/l)	<1	2.3	168	125
Oil and Grease (mg/l)	4	126	278	322
Sodium as Na (mg/l)	13.6	244	1210	948
E.Coli (per 100ml)	0	>1800	>1800	>1800

D1.6.5 Concluding remarks

A large number of people are living in close proximity to the wetland and contributing to the impacts thereon by depositing greywater and other sewage along the stormwater canals and directly into the wetland. The high levels of nutrients measured from laundry activities and the immediate release of this water into the stormwater canals is a major cause for concern.

D1.7 Khayelitsha RR

D1.7.1 Background

The township of Khayelitsha (‘new home’) contains the largest informal settlements within the Cape Metropolitan Area (CMA). The township covers an area of approximately 41km^2 and was initially intended to accommodate about 250,000 people (Minor *et al*, 2004). Population estimates vary widely from 350,000 to 900,000. There are virtually no elderly people in Khayelitsha – approximately 30% of residents are of school going age and the remaining 70% are of working age (Statistics South Africa, 2001).

Only 30% of the housing stock is regarded as formal (Minor *et al*, 2004). The majority of the residential areas are poorly serviced and lack adequate access to water and sanitation facilities.

There are few formal employment opportunities in Khayelitsha. Only 4% of residents work in the area, mostly in jobs provided by the municipality. According to Census 2001, 46.6% of households have an annual income of R9,600 or less, while 25% of all households have no formal income (Statistics South Africa, 2001).

D1.7.2 Description of research

The research was conducted on the 11th and 13th December 2004 at a relatively new section of "invaded" land called Khayelitsha RR, with an estimated population of 800 people. The interviews and sample collection process started at a central location on Lansdowne Rd near the fire station. From there the group of researchers spread out into the interior of the densely-settled area across the railway line. The settlement is so densely built-up that there are no roads or even paths between the shacks in most sections. Fire engines and other service vehicles would not be able to get through in an emergency but a postman on a bicycle is able to deliver mail to the numbered shacks. These addresses were used to identify the households where interviews were obtained, although there were a few structures that had not been allocated numbers.

D1.7.3 Social findings

Khayelitsha RR is a typical urban informal settlement occupied by low-income workers and migrants seeking work and a better life in the city. Household incomes ranged from no income to over R2,000 per month but a large number of people reported pensions and child support grants as their main source of income. Gifts from relatives were also mentioned as survival strategies.

Although the socio-economic profile of Khayelitsha is only slightly different to that of the other settlements, the size of the township as a whole, and its population density, makes the disposal of wastewater and solid waste difficult. The totally inadequate sanitation facilities in the RR section for example have resulted in many people using the remaining open land on and around the railway line as a toilet. Water standpipes are provided on the outside edges of the settlement only, and household water consumption seems to depend on the proximity of the shack to the tap. An average household water use of 55*l*/d was estimated.

Figure D1.11: Tapstand at Khayelitsha RR

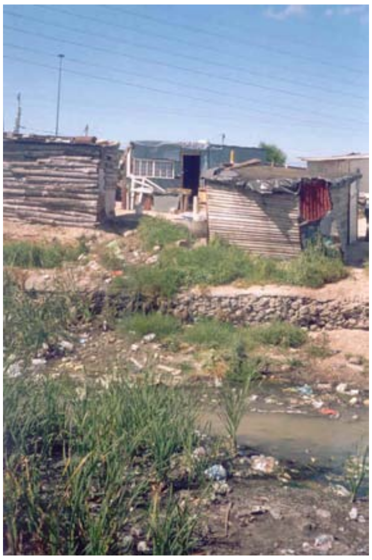

Figure D1.12: Stormwater channel

Much of the greywater was either thrown into the nearby stormwater canal or kerbside drains. Although most people were aware that it was wrong to dump wastewater into the canal, they nevertheless did so. A lot of the waste thus ends up in this canal as well as the downstream detention pond both of which overflow with polluted water and various solid matter. At the time of the visit a private firm sub-contracted by the Council was trying to clear the stream of plastic and other refuse but unless this clean-up exercise is regularly conducted it will not have much of a positive impact on the environment.

D1.7.4 Water quality

Water samples taken from sites in Khayelitsha were tested for COD, Tot P, DO, NH_3, pH and E.Coli with most of the tests being conducted in the field. As recorded at other sites described in the report, the COD levels were high and were again shown to be higher in the case of dishwashing water than for laundry. Residents living close to open stormwater drains were observed tossing water into the drain thereby contributing to the contamination. Samples from the drain show high levels of P and NH_3, and the COD level is also extremely high. Of interest too is the relatively high pH of the water, which ranges from 9.4 to 10.2.

Table D1.8: Khayelitsha RR water quality indicators (13 December 2004)

Water quality indicator	Laundry K1	Laundry K2	Laundry K3	Laundry K4	Dishes K5	Stormwater drain
COD (mg/l)	-	-	143	3586	7012	23904
Total Phosphorous as P (mg/l)	9	16	16	2.4	16	7
Dissolved Oxygen (mg/l)	3.6	3.6	3.6	3.7	3.8	3.5
Ammonia N as NH_3 (mg/l)	1.9	3	16	2.7	>3	>3
pH	10.2	9.9	10.4	9.4	9.8	10.2
E.Coli (per 100ml)	>1800	>1800	>300	>1800	0	>1800

D1.7.5 Concluding remarks

The link, if any, between the types of detergents and other cleaning materials used by consumers and the nature of the greywater produced has not yet been determined. This will require further investigation once the chemical content of the various branded washing materials that the residents referred to has been further investigated. For virtually all the survey areas, water consumption is limited to basic needs such as drinking, cooking, washing and bathing. There were a few very isolated examples of vegetable and flower growing, and where the water supply permitted, attempts by the children to splash about under a tap to keep cool. Other children even used ponds full of polluted water to play in. Some of the municipal authorities responsible for health mentioned the need for education to teach people how to care for their environment but only by raising the standard of communal facilities beyond their current low levels will such education campaigns become meaningful. There is little that individual households can do to clean up their environment, and the authorities need to be more directly involved.

D1.8 Lingelethu, Malmesbury

D1.8.1 Background

The town of Malmesbury is over 250 years old. It is now one of the main agro-industrial centres in the Western Cape and is home to over 27,000 people. Its main economic activity is agriculture of which grain production and processing are especially valuable. Vineyards and tourism are also well established.

D1.8.2 Description of research

Malmesbury was one of the sites in the WC that was selected after examining the Census 2001 data and noting the relatively high potential for greywater generation in a non-sewered environment. As with other sites, water supply was made the most important criterion for further investigation of the Census data. After correlating with income levels and dwelling type and also race (population group), Malmesbury was identified as having a sufficient concentration of households with no sanitation (4,179) to warrant a survey.

As it turned out, the recent (since Census 2001) provision of RDP housing in the area has reduced the number of households without sanitation in Malmesbury. After consultation with the Housing Department at the Swartland Municipal offices therefore, the informal settlement of Lingelethu was identified as the most suitable site for the survey as it was still unserviced. This is about to change however – the project team was informed that plans for the provision of RDP housing to the residents of Lingelethu were advanced and that everyone in Malmesbury would have access to waterborne sanitation within a year's time.

Although the majority of the population in Malmesbury are "coloured", Lingelethu is made up of the more recent arrivals who are Xhosa and Sotho speakers. In this sense at least, the sample is not representative but it was a suitable study site otherwise, and it was decided to proceed with the survey.

Figure D1.13: Water supply at Lingelethu

Figure D1.14: Washing at Lingelethu

Interviews were conducted on 15th December 2004 by four main researchers and four research assistants with the local councilor acting as guide and mediator. The research assistants administered the questionnaire to the women who were doing their laundry or doing other domestic work. Samples of the greywater were collected and, using the finalised questionnaire, direct questions targeting socio-economic information and water use patterns were asked.

D1.8.3 Social findings

Water consumption, and therefore greywater production in Lingelethu was much less than was recorded for the informal settlements in the CoCT. In fact all rural or small town informal settlement households surveyed in the province consumed less than 70*l*/d of water. This was due to a combination of factors including reliability of water supply, storage capacity of household as well as distance from tapstands.

The municipality provides plastic bags for solid waste disposal, water from communal tapstands and waterborne sanitation at communal toilets. The latter, however, were not functioning at the time of the visit and residents of Lingelethu used the neighbouring farmlands and open spaces to relieve themselves. This had created conflict with a neighbouring farmer who had dug a deep trench to separate the informal settlement from his land. Clearly when council planners build communal toilets they should also plan for continuous management including cleaning and repairs, otherwise they quickly become useless. The use of newspaper in place of toilet tissue for example is understandable for low-income populations but it leads to blockages and effectively renders standard toilets unusable unless there is proper maintenance. The same argument applies for greywater management devices, such as soak-aways – if these are not maintained and cleaned regularly by responsible personnel, they will not be effective.

D1.8.4 Water quality

Four samples of household clothes-washing water and one of the water from the hose-pipe at the communal toilet block were collected for analysis. The results are presented in Table D1.9.

Table D1.9: Lingelethu water quality indicators (15 December 2004)

Water quality indicator	Laundry L1	Laundry L2	Laundry L3	Laundry L4	Tapstand L5
COD (mg/l)	4014	11223	4096	5407	<8
Total Phosphorous as P (mg/l)	8	16.6+	6.3	16.3	0
Ammonia N as NH_3 (mg/l)	2.88	>3.6	>3.6	2.28	0
pH	9.2	9.8	9.5	8.7	7.2
E.Coli (per 100ml)	0	0	>1800	0	0

D1.8.5 Concluding remarks

According to the Housing Department officials in the Malmesbury municipality, the informal settlement has been earmarked for upgrading, which will include the provision of waterborne sanitation. The town's farms and industries will however continue to attract migrant workers and there will thus in all likelihood continue to be some informal, unserviced housing in the area. The lessons that can be drawn from this example of greywater management are limited because of the small population involved but can be summed up as follows:

- There is an adequate supply of water in the settlement and no need for the use of greywater for irrigation – it is therefore not considered as a resource for recycling but rather waste for discarding. It may help to green the yard around the shack and to keep the dust down, but the growing of vegetables or even flowers and shrubs with greywater for irrigation was not considered an option by those residents interviewed;
- As for most other services, it appears that most people in informal settlements look to the local government to provide adequate water and wastewater management systems.

D1.9 Western Cape findings

The following maps show some of the overall findings from the case studies in the WC province, particularly in respect of the types of settlements surveyed, and selected water quality data:

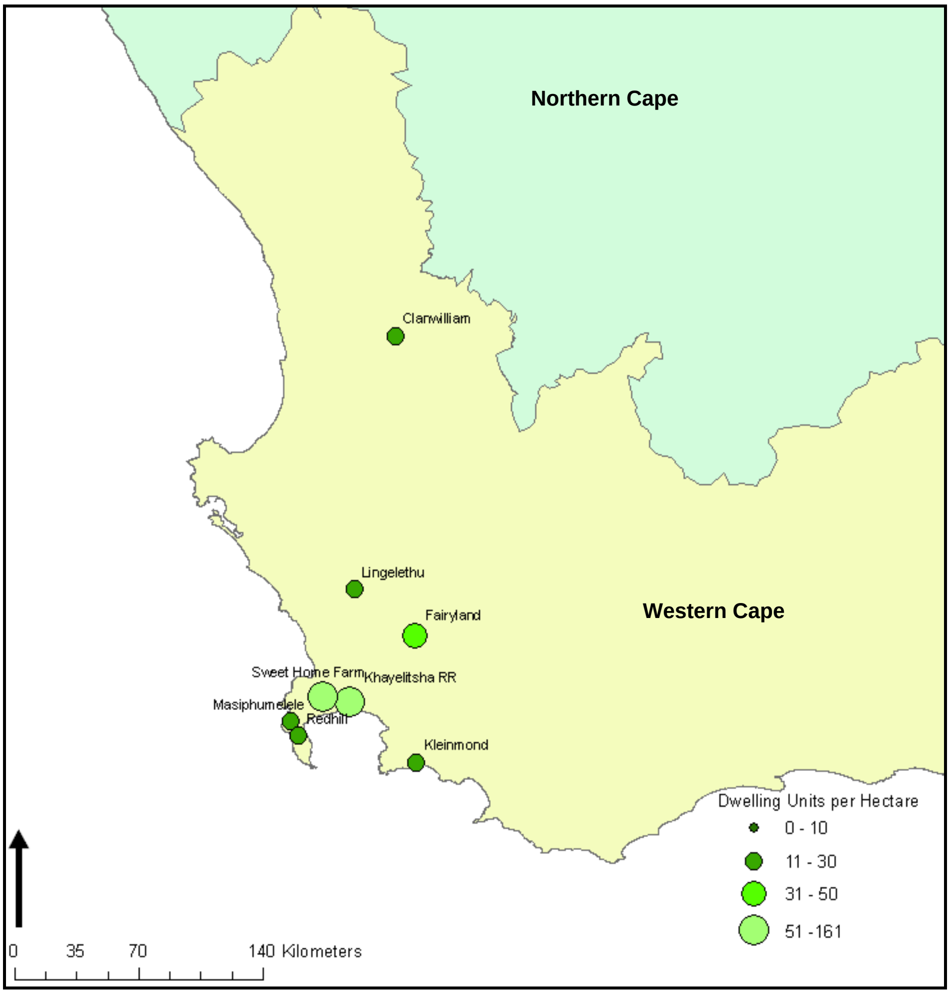

Figure D1.15: Settlement density figures for Western Cape sites

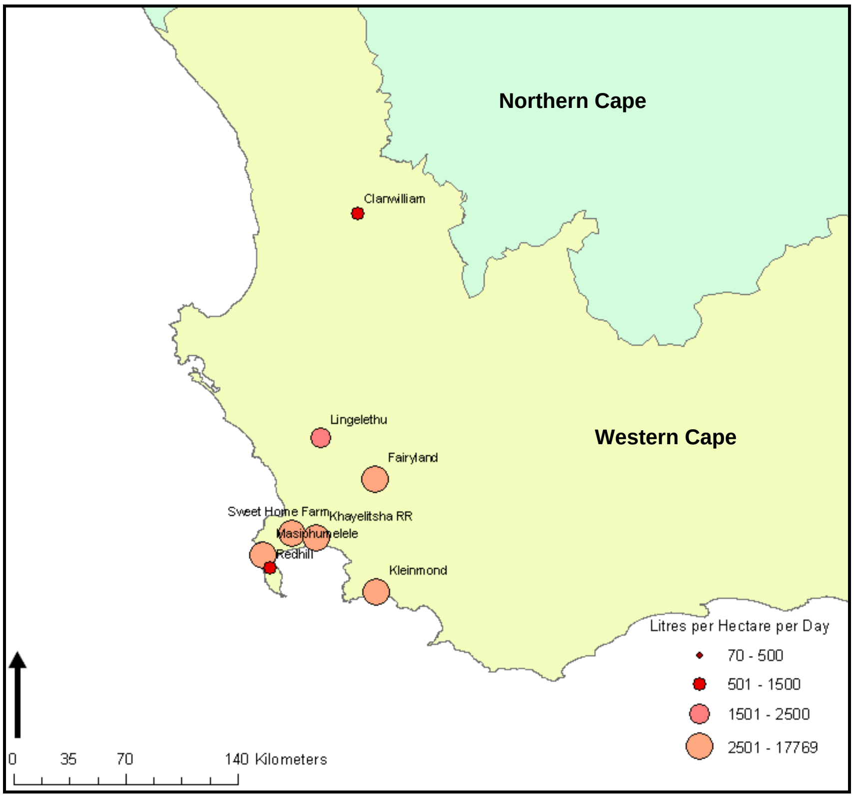

Figure D1.16: Greywater generation figures for Western Cape sites

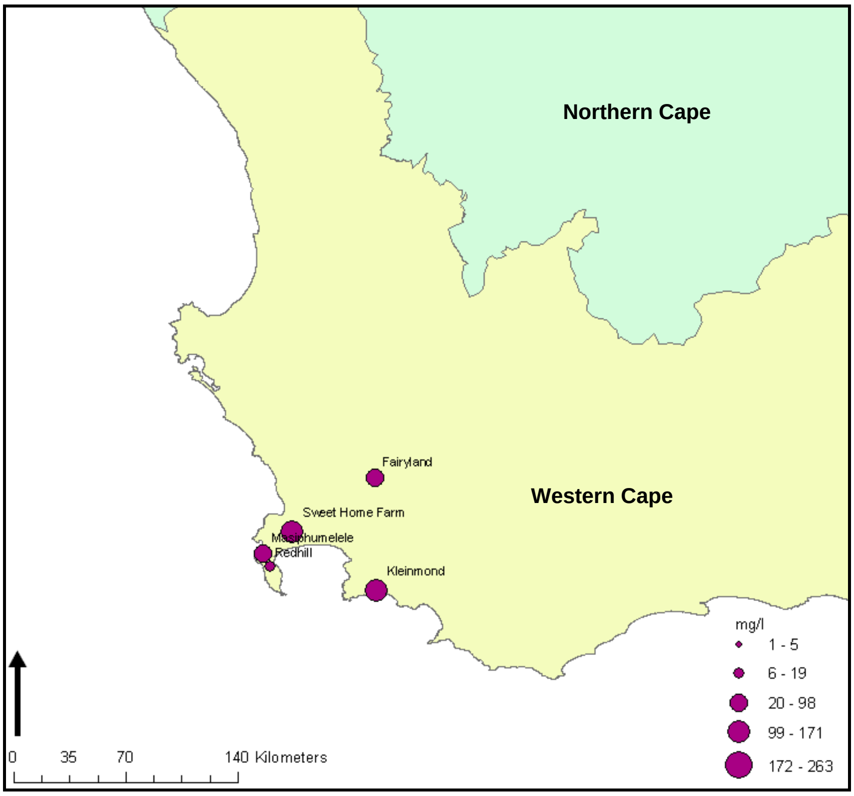

Figure D1.17: Total Phosphorous figures for Western Cape sites

D2. Eastern Cape site surveys

The majority of South Africa's population resides in the better-watered eastern regions of the country, including the Eastern Cape province (EC) which is endowed with many springs and rivers. Although parts of the province are rich in water and frequently flooded in the rainy season, the Eastern Cape also experiences periodic droughts. In April 2005 when the site surveys were conducted, the countryside was still lush after good rains. Figure D2.1 shows the locations of the selected sites for surveys in the province.

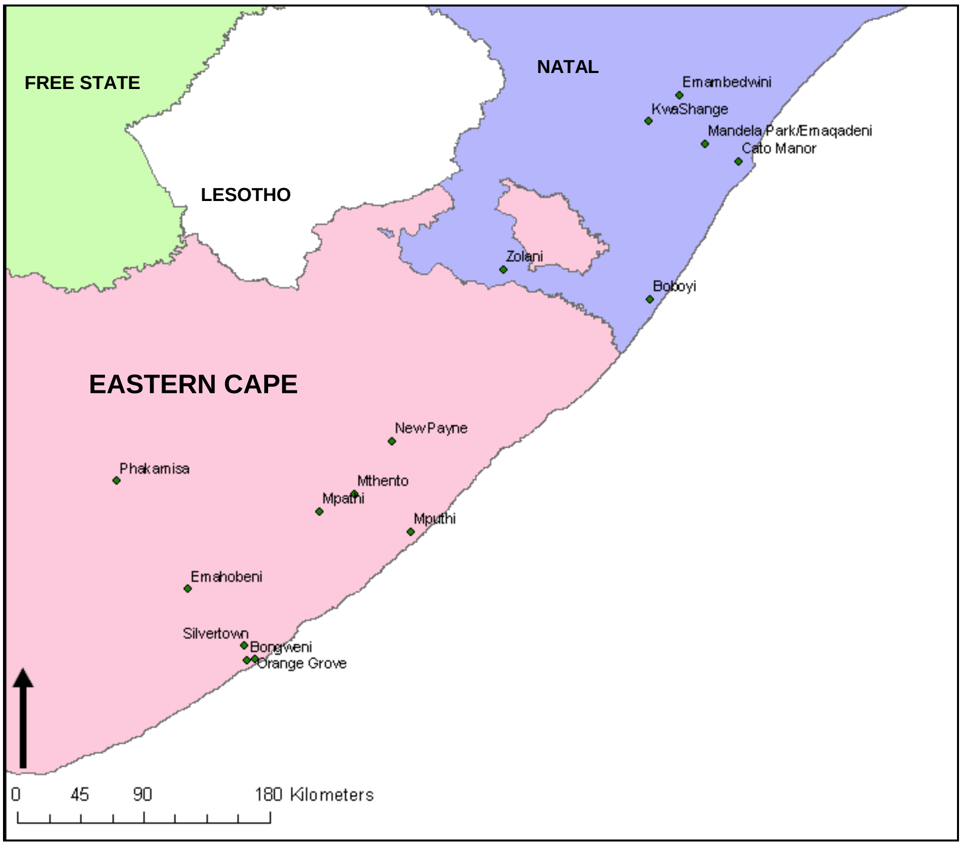

Figure D2.1: Map of Eastern Cape province showing selected sites for surveys

Whereas the major cities in the Nelson Mandela Metropolitan area (e.g. Port Elizabeth) and Buffalo City Municipal District (East London) provide their industrial / commercial properties and households with adequate supplies of high quality water, the rural areas of the EC are not well-serviced and are home to some of the poorest people in the country. When the Reconstruction and Development Programme (RDP) started in 1994, the EC had the largest backlog in the provision of basic services. The former inhabitants of the Ciskei and Transkei homelands in particular lacked, and many still lack, access to potable water and basic sanitation, and the RDP thus allocated a large percentage of its water service delivery funding to the EC.

The 1998 Poverty and Inequality Report stated that in rural areas, more than 80% of households had no access to piped water or waterborne sanitation (May, 1998). Although millions of people have since been provided with these services, the investment in water and sanitation may well be nullified by the lack of employment opportunities in the province, which has in turn resulted in the Eastern Cape becoming a net exporter of migrants to other provinces. The complex and sometimes unpredictable population dynamics involving seasonal, trans-provincial and trans-state migration also often result in previously well-serviced areas becoming overwhelmed by rapid population increases.

On-site surveys were conducted in nine different settlements in the Amatole and Oliver Tambo districts of the Eastern Cape.

D2.1 Silvertown

D2.1.1 Background

The area around Buffalo City, like much of the eastern part of South Africa, has undulating hills and rolling terrain. Due to the nature of the topography, many wetland systems are found in this area.

Rainfall occurs throughout the year, but predominantly in the spring to early summer months, namely August to November. Annual rainfall averages approximately 960mm in the East London area. During the month of March when the fieldwork was undertaken, the grass was green and the maize ready for harvesting

Silvertown is an informal spill-over of Mdantsane Township which is considered to be one of the larger townships in South Africa. Mdantsane as a whole is reported to accommodate 175,790 people (45,384 households) within a complex of urban and peri-urban components. Buffalo City surveys however indicate an actual population that is close to 350,000 people, or 25 to 30% of the city’s population. The township is located 20km from the East London CBD, situated along the N2 highway between East London and King William’s town. Over a quarter of the population is under the age of 15 years, reflecting a high level of dependency. In addition, HIV/AIDS, high unemployment and major security problems mean that Mdantsane faces many social challenges.

Silvertown has some old brick buildings and more new shacks. It may have been a farm at some point in the past. Like most other informal settlements it is home to many job-seekers from the rural areas who reside there in order to be closer to factories and construction sites. Plots have been demarcated and parceled out by local leaders and the occupants anticipate that their shacks will hopefully develop into fully serviced RDP-type formal housing in the near future. Although provided with water and close to main roads used by local taxis and delivery vans, Silvertown lacks most other services, including electricity. The lack of street lights in what is an extremely crime-prone area is of major concern to the residents.

D2.1.2 Description of research

The research consisted of interviews with both men and women in their homes and at the water points.

Figure D2.2: Surveys at Silvertown

D2.1.3 Social findings

In the sample of six households surveyed, the average number of people per household was just over three. The amounts of water used did not seem to depend on distance from the tap as much as on the reliability of supply. Most households were easily within 10m of a tapstand but it was reported that there are long queues in the mornings. The on-site surveys took place during the middle of the day however, and there were no queues observed at the taps. Greywater was simply tossed into the long grass around the houses and no signs of water-logging or runoff except at the tapstands, was observed.

D2.1.4 Water quality

One sample each of washwater and tapwater were tested in the field for selected variables, as shown Table D2.1. The tests showed that the water from the tapstand was of acceptable chemical quality but that the greywater had high levels of P and NH_3.

Table D2.1: Silvertown water quality indicators (2005)

Water quality indicator	Tapstand	Laundry
Conductivity (mS/m)	43.6	188.6
Ammonia N in NH_3 (mg/l)	0	3+
Total Phosphorous as P (mg/l)	0	5+
pH	8.6	8

D2.1.5 Concluding remarks

The Silvertown community has adequate access to water. It does not have a visible greywater drainage problem as most of it seeps away into long grass or evaporates, thus preventing the build-up of water. The problem of mosquitoes and skin rashes (perceived as a consequence of insect bites) were cited but it would be difficult to isolate greywater as the main cause.

D2.2 Bongweni, Fort Grey

D2.2.1 Background

The site is situated approximately 100km west of East London (Buffalo City). It is a rural area with a low population density of approximately 4 to 5du/ha. The built structures are mainly traditional huts. Water is obtained from two large 5,000*l* tanks in close proximity to the village. These tanks are filled each week by the local municipality, although residents reported that they frequently ran out of water. People from other villages also used this supply. Greywater does not appear to pose any problems because of the low population.

D2.2.2 Description of research

Four interviews were conducted with women; all of whom were involved in washing laundry at the time of the visit. Water samples were taken from the communal water tank and from a container of laundry (rinse water).

Figure D2.3: Water containers at Bongweni

D2.2.3 Social findings

The settlement of Fort Grey is semi-rural. The informal structures were similar to any found in urban squatter settlements but they were sparsely settled, surrounded by long grass, and the owners grew maize and kept livestock. There were no standpipes in the area but clean water was delivered by tanker and kept in drums at the entrance to the settlement. Unemployment and poverty were found to be high and the household size of over six was higher than previously visited urban settlements.

D2.2.4 Water quality

One sample each of washwater and tapwater were tested in the field for selected variables, as shown in Table D2.2. There appears to be no problem with greywater being tossed on the ground or used for limited irrigation around the homes. Houses are situated on a relatively flat area. Greywater was used to water grass patches a few metres away from the homes and runoff appeared minimal. No rivers are in the near vicinity of this settlement.

Table D2.2: Bongweni, Fort Grey water quality indicators (2005)

Water quality indicator	Tapstand	Wash Sample
pH	7.2	7.8
Total phosphorous as P (mg/l)	0.0	3.5
Conductivity (mS/m)	520	916
Ammonia (mg/l)	0.1	3.0

D2.2.5 Concluding remarks

Mosquitoes were the main water-related problem reported in Fort Grey but this could have been attributed to the fact that there had been a lot of rain and there were large pools of water around, suggesting a high water table or impervious rock. Pigs were also seen wallowing in the pools and this clearly provided breeding grounds for mosquitoes.

D2.3 Orange Grove

D2.3.1 Background

Orange Grove was suggested as a potential survey site by the planners in the Buffalo City Municipal offices. It is a rapidly expanding settlement located near the airport and close to a planned export promotion zone. The jobs that attracted people to the city have however not yet materialised for many. The site is densely settled and in appearance resembles many other South African informal settlements.

D2.3.2 Description of research

The three research assistants interviewed the men and women who had come to the communal standpipe to fetch water and do their washing. The preferred water containers were 25*l* plastic jerry cans and 20*l* plastic buckets. Women were generally observed carried these containers on their heads while the men were seen ferrying several containers at a time in wheel barrows.

Figure D2.4: Collecting water at Orange Grove

D2.3.3 Social findings

Residents expressed bitterness about the conditions in the settlement. Tapstands were difficult to access and were surrounded by muddy puddles. A lot of activity was observed around these tap stands. Pigs were also found around this muddy water. There were no concrete sills, pathways or means to drain the area. A further problem was the fact that the settlement was situated on a reasonably steep slope and this created added hardships in transporting water containers.

D2.3.4 Water quality

One sample each of washwater and tapwater were tested in the field for selected variables, as shown in Table D2.3.

Table D2.3: Orange Grove water quality indicators (2005)

Water quality indicator	Tapstand	Wash Sample
pH	6.9	7.6
Total Phosphorous as P (mg/l)	0.5	5+
Conductivity (mS/m)	495	764
Ammonia (mg/l)	1.1	2.2

D2.3.5 Concluding remarks

Areas around communal tapstands were very muddy and difficult to access and there were clearly insufficient communal tapstands available.

D2.4 Phakamisa Park

D2.4.1 Background

This site is situated 16km north-west of Queenstown. It is a rural area and is characterized by large plots with a settlement density estimated at about 8du/ha. The team visited the site on a Saturday morning and found many young children in the area. Housing structures were found to be a mixture of traditional and formal homes. There were also many old, run-down shack dwellings. Communal toilet facilities were provided in blocks (with two toilets each) but were clearly inadequate and most were dysfunctional; either broken or blocked. Some residents had built their own pit latrines in their yards. The settlement is relatively flat with spacious yards surrounding the houses.

D2.4.2 Description of research

Five interviews were conducted and two water samples were taken from containers of laundry.

D2.4.3 Social findings

Although generally poor, some of the people had initiated improvements to their houses such as the digging of private latrines, but the general feeling was that the local authorities should provide water and sanitation services to each household.

D2.4.4 Water quality

Two samples of washwater were tested in the field for selected variables, as shown in Table D2.4.

Table D2.4: Phakamisa Park water quality indicators (2005)

Water quality indicator	Wash sample 1	Wash sample 2
pH	8.4	9.3
Total Phosphorous as P (mg/l)	2.3	1.5
Conductivity (mS/m)	681	346
Ammonia (mg/l)	3+	1.5

D2.4.5 Concluding remarks

One interviewee was adamant that soap damages vegetable crops and she therefore avoids using greywater. In general, the interviewees were unhappy about conditions at the site. They complained that while the amount of tapwater made available was sufficient, there were too few communal standpipes and that the toilets were inadequate.

D2.5 New Payne

D2.5.1 Background

The area between Kei River and Umtata is characterised by undulating terrain with valley thicket occurring within the steep river valleys and grasslands on top of the ridges. Rainfall occurs predominantly in the summer months, typically from October to March. Annual rainfall averages approximately 650mm in the Umtata area with the wettest month of the year February, and the driest June. The grass was still long and green in this area during the survey period and the maize was still at the pollination stage.

D2.5.2 Description of research

Three interviews were conducted with one woman (18 years old), a teenage boy (15 years old) and an older man (35 years old). One sample of laundry water was taken.

D2.5.3 Social findings

Unemployment appears to be the most critical concern at New Payne although the settlement's proximity to Umtata means some people do have paid employment and there is some money in circulation locally. Most of the houses were made of bricks and were of a reasonable standard. The houses were quite well-spaced and some households had maize gardens on fenced plots. Many households had rain tanks on their properties for the storage of water which could be used to augment the potable water supply.

D2.5.4 Water quality

One sample each of washwater and tapwater were tested in the field for selected variables, as shown in Table D2.5.

Table D2.5: New Payne water quality indicators (2005)

Water quality indicator	Tapstand	Wash sample
pH	8.2	7.7
Total Phosphorous as P (mg/l)	0.0	4.5
Conductivity (mS/m)	82	1128
Ammonia (mg/l)	0.0	2.6

D2.5.5 Concluding remarks

The concept of rain harvesting was noteworthy; however, judging from a remark from one of the residents, it appears that people use hoses attached to the communal tapstands to top-up their rainwater containers, which are generally used merely as storage facilities.

D2.6 Mputhi

D2.6.1 Background

This is a rural area situated on very steep slopes overlooking the Idutywa River. The river is used for washing and bathing. Water is dammed up along the side of the river where it is collected for drinking purposes. Women were observed washing laundry further upstream and goats were seen sharing the same water source. The river appeared to be polluted.

The population density was estimated at 5 to 10du/ha. Houses were brick-built structures clustered on the crest of the hill overlooking the river.

D2.6.2 Description of research

Two interviews were conducted. A water sample was taken at the watering hole on the Idutywa River, a sample of laundry water and a sample of wastewater that had ponded in a shallow depression alongside the river.

Figure D2.5: Watering hole at Idutywa River

D2.6.3 Social findings

The young men herding livestock and tending the maize gardens in the residential area were the only signs of a rural economy. Most people appear to be dependent on wages, pensions or other grants as sources of money.

D2.6.4 Water quality

One sample each of water from the river, laundry water and wastewater were tested in the field for selected variables, as shown in Table D2.6.

Table D2.6: Mputhi water quality indicators (2005)

Water quality indicator	Water from river	Wash sample	Waste water sample
Ph	8.4	8.2	9.6
Total Phosphorous as P (mg/l)	1.0	1.0	1.5
Conductivity (mS/m)	384	372	1194
Ammonia, NH_3 (mg/l)	0.2	2.0	0.2

D2.6.5 Concluding remarks

The results of the analyses of the river water suggest that the river is polluted, with evidence of abnormally high P and NH_3 levels. This same water is being used for drinking purposes without any form of filtration or treatment and is thus cause for concern.

D2.7 Mthento

D2.7.1 Background

Situated 20km south of Umtata, this is a rural settlement with a sparse population density (3du/ha). There are no standpipes servicing the inhabitants. Water is collected from nearby gullies but at the time of the visit these were dry. The area is undulating with loamy soils. Greywater is unlikely to pose a problem in this area and could potentially provide an alternative source of irrigation water.

D2.7.2 Description of research

Two interviews were conducted with older women.

D2.7.3 Social findings

The economically active population appeared to be absent as a consequence of labour migration. The team only observed older women and young children in the settlement.

D2.7.4 Water quality

No water samples were taken.

D2.7.5 Concluding remarks

The priorities expressed by the two interviewees were those of toilets, water supply, and drainage systems during the summer rainfall period.

D2.8 Mpathi

D2.8.1 Background

Mpathi village is a few kilometers out of Idutywa and was selected as an example of a rural settlement with minimum services. The local population of this area is predominantly of the Xhosa-speaking Fingo ethnic group whose main farming activities include small-scale cultivation of maize and the raising of cattle, sheep and goats. The undulating country is sparsely settled and the population density for Mbashe Municipal District is estimated at 7du/ha. Idutywa, approximately 33km north of Butterworth, is the site of an old military post located in the valley of the Mputhi River, a tributary of the Mbashe River.

D2.8.2 Description of research

The research in Mpathi consisted of interviews with villagers both in their homes and at the spring where the young men were watering their livestock and the young women were doing the laundry and collecting water for domestic use. As the lowest point in the valley was the site of the spring, the stream and the channel for the run-off from the houses and grazing areas, it was expected that the levels of pollution in the spring water would be high. Indeed one woman complained bitterly about a previous outbreak of cholera and demanded that the authorities should provide potable water to the village.

D2.8.3 Social findings

Unlike the typical rural homesteads of scattered “rondavels”, Mpathi is laid out like a formal township. Although poorly serviced, the houses, livestock and stands of maize suggested that the people were not as poor as some that had been seen elsewhere in the province. Despite the apparent advantages of this however, the settlement was still lacking in basic services.

D2.8.4 Water quality

No water samples were taken.

D2.8.5 Concluding remarks

Interviewees were strongly of the view that greywater should be discarded and not used for irrigation. They claimed it caused diseases and was unhealthy. One interviewee wanted flushing toilet systems to remove the “dirty water”. The model of proper water supply and wastewater management that people have in mind appears to be that of the urban fully serviced house.

D2.9 Emahobeni

D2.9.1 Background

This settlement is situated 4km from Stutterheim. Houses were generally shacks, interspersed with some mud houses and a few RDP houses that have been built alongside the settlement. The settlement is best classified as a peri-urban area of low density (10du/ha). This is a well-established settlement in terms of age. Communal tapstands were supplied to the settlement, but interviewees claimed that the number of taps were inadequate. The soils are loamy with evidence of red oxides in clay. The topography is relatively steep.

D2.9.2 Description of research

Three interviews were conducted and three water samples taken (two of laundry water, one tapstand).

Figure D2.6: Flooded tapstand at Emahobeni

D2.9.3 Social findings

The RDP houses in Emahobeni are quite sparsely laid out. The communal taps and toilets were not well maintained and long grass was observed growing all around the pathways. The water taps had no soakaways and there were stagnant pools formed around them. The communal toilets had been so misused and filled with newspapers and other solid waste that they were no longer functional, which meant that people had resorted to digging their own pit latrines, using the bush or using the better facilities at the local bottle store. Yet again, the advantage of locating taps and toilets within individual yards, with the responsibility for their upkeep being given to an individual household, was demonstrated.

D2.9.4 Water quality

Two samples of washwater and one of tapwater were tested in the field for selected variables, as shown in Table D2.7.

Table D2.7: Emahobeni water quality indicators (2005)

Water quality indicator	Tapstand	Wash sample 1	Wash sample 2
pH	8.2	7.6	8.1
Total phosphorous as P (mg/l)	0.0	1.2	4.5
Conductivity (mS/m)	84	314	448
Ammonia (mg/l)	0.0	3+	2.6

D2.9.5 Concluding remarks

In all areas the DWAF-defined “adequate access to water” of 25*l*/c.d within 200m of private or communal tapstands / standpipes was provided for most people. The delivery of potable water has clearly been a priority of government. In rural settlements, however, women walked relatively long distances to water points, and the water was also likely to be of a poorer quality (e.g. from springs or open drums replenished by tankers). Mosquitoes and poor drainage were cited by two interviewees as problems. One interviewee suggested that simple drains should be constructed at the water points, and that this was a matter that should be addressed by the community committee.

In both the peri-urban and rural areas visited in the Eastern Cape Province, the amount of greywater generated appeared to be manageable, mainly owing to the fact that they were mostly sparsely settled areas where the runoff did not form stagnant pools or streams of effluent. This suggests that the current method of greywater management can probably remain unchanged in many places. If on the other hand greywater is perceived as an unutilised resource in a water-short country, then improved technologies for greywater recycling are worth promoting. In urban dense settlements, the residents and the local authorities appear to be convinced that the only option is to convey all wastewater into the sewerage system.

D3. KwaZulu-Natal site surveys

The KwaZulu-Natal site surveys took place at the end of June 2005 and included rural and urban settlements in the areas around Kokstad, Port Shepstone, Lower Tugela, Pietermaritzburg, Stanger and Durban, that were chosen based on their proximity to watercourses and thus the potential environmental impacts that could result from greywater disposal. Figure D3.1 is a map of the province showing the positions of sites visited.

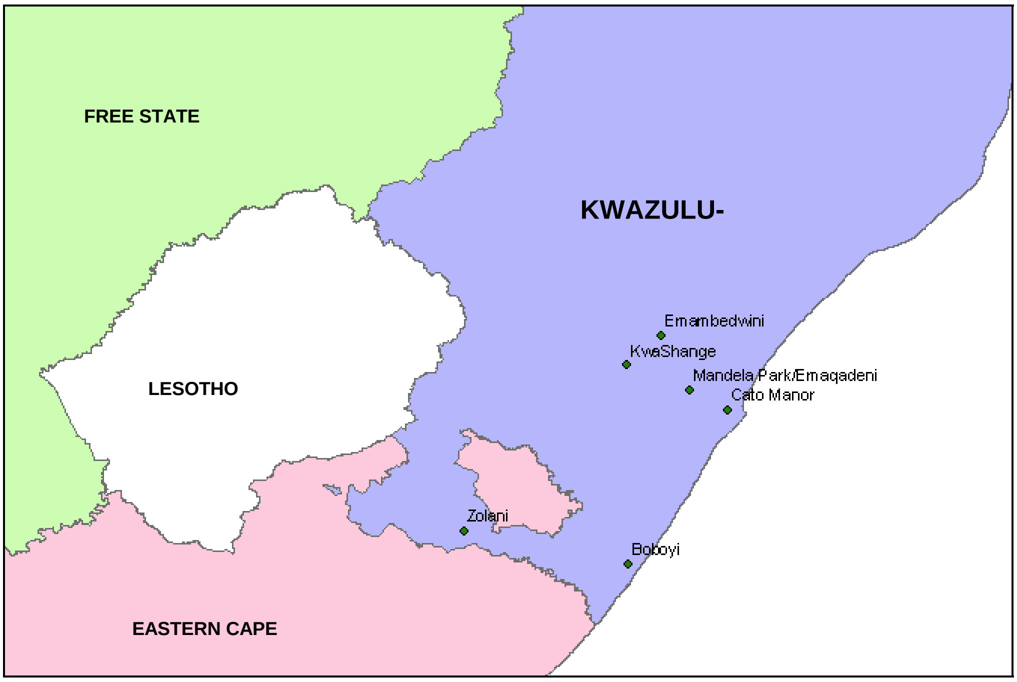

Figure D3.1: Map of KwaZulu-Natal province showing selected sites for surveys

D3.1 Zolani, Kokstad

D3.1.1 Background

The settlement is situated approximately 2.5km from the CBD of Kokstad and 1.2km from the outskirts of the formal town. It is located on a floodplain formed by the meandering of the Mzintlava River, formerly a part of the Bhongweni farm. The area is gently concave with a moderately steep slope within 70m of the river banks (see Figure D3.2) forming a gradient of 1:7. The highest point of the settlement is approximately 25m above the river bed. From the perspective of this study, the site provides an example where run-off of greywater could enter the river and also where residents use the stream for washing and bathing.

The area receives approximately 800mm rainfall per annum. Soils are dark, reddish and loamy, severely impacted by the movement of people and vehicles. Evidence of some gullying along the river banks suggests that run-off could be severe during rain storms.

D3.1.2 Description of research

The site selection was informed by Census 2001 which recorded that the settlement of 'Horseshoe', also known as Zolani, had 1,134 black households without sanitation and water supply. The area was also recommended by an official of the Engineering Division of the Kokstad Municipality. In this study, the settlement is referred to as Zolani, Kokstad.

D3.1.3 Social findings

The researchers estimated the population at Zolani to be between 2,500 and 3,000. There is a high density of people living in an area of approximately 50ha. Since Census 2001, some progress has been made by the municipality to implement services. Standpipes, with concrete slabs surrounding these tapstands and stormwater channels, have subsequently been established in the settlement. The construction of RDP housing began in 2005. Pit latrines were mostly to be found in the yards of individual households but there were other communal latrines situated in the settlement. Many residents complained however that they were not permitted to use these pit latrines and they were therefore forced to use the bushes or the river.

Unemployment appears to one of the most important concerns. Residents reported very low levels of income (less than R400 per month appeared to be the norm) while three of the people interviewed reported living off social grants. The majority of the interviewees claimed that water, housing and toilets were highest on their list of priorities required to meet their immediate needs. Residents did not wish to reuse greywater, claiming that greywater was dirty and could cause disease. One interviewee claimed that the tapstand was close to his residence and there was therefore no need to conserve water by reusing it.

Figure D3.2: Shacks situated on moderate slopes on banks of Mzintlava River

Figure D3.3: Children washing clothes in Mzintlava River

Washing at tapstands is forbidden by the municipality. Apparently spot checks are conducted and if people are caught by officials doing their laundry, clothing items are confiscated. Interviewees were not certain why this policy was necessary. It is possible that it has been put in place to prevent queues forming at tapstands and thereby improve general access to water. The researchers found a number of women washing laundry a few metres from tapstands in close proximity to unlined stormwater drains (culverts), and greywater was being disposed into these culverts.

There was very little evidence of any attempt to grow vegetables or plants in the yards. In part, this could be explained by the fact that residents felt unsettled and insecure now that the process of constructing RDP housing had began. This insecurity caused them to question the wisdom of investing time and effort into the growing of vegetables or plants in an area likely to be used for formal housing in the near future.

D3.1.4 Water quality

Six samples of washwater, river water and tapwater were tested in the field for the selected variables (Table D3.1).

Table D3.1: Kokstad water quality indicators (2005)

Water quality indicator	Tapstand	Laundry: 1st wash using Sunlight powder	Laundry: 1st rinse. Slight odour	Laundry: 1st wash from Sunlight powder	Dish water using Sunlight	Mzintlava River
Total Phosphorous as P (mg/l)	0	3.5	0.7	4.2	5+	0
pH	7.8	7.9	9.4	8.3	9.8	8.3
Conductivity (mS/m)	0.1	87	33	116	559	15.4
Ammonia N as NH_3 (mg/l)	0	3.5	3+	1.7	0.2	0.9
Dissolved Oxygen (mg/l)	0.9	1.2	1.2	2.4	0.1	1.4

D3.1.5 Concluding remarks

Although the settlement was undergoing considerable changes with the construction of RDP housing in a section of the site, Zolani nevertheless presented a good example of a situation in which residents no longer rely on water from the nearby stream. Tapstands in the near vicinity of their houses meant they no longer needed to reuse dirty water. All interviewees expressed a preference for tossing dirty water onto the ground, as they were mistrustful of reusing it, citing that it could cause disease.

D3.2 Boboyi, Port Shepstone

D3.2.1 Background

The steep hilly topography of Boboyi consists of conglomerates, greywacke and shales formed during the Cambrian Period about 570 million years ago. Surface soils have subsequently been modified considerably through urban and agricultural activity, resulting in loams and clays with relatively poor soil infiltration, especially on flat or gentle slopes. The site was chosen because of its proximity to a network of rivers discharging into the Mzimkulu River, a large perennial river with its outflow immediately north of Port Shepstone. The settlement lies approximately 7.5km west of Port Shepstone CBD.

Prior to agricultural activity and urban encroachment, the vegetation is likely to have consisted of coastal forests and thornveld. Remnants of this vegetation can be observed in the steep valleys near the crest of hills. Boboyi is described as a built-up area on SA Topographic map 3030CB Port Shepstone; however the hilly terrain has ensured a sparsely-developed area especially on slopes of 1:3 or steeper.

Homesteads in Boboyi were generally old brick structures, well-maintained, and situated on reasonably large stands of 800m^2 or more. Most residents used their gardens to grow vegetables and plants. Water is available either in the yard or from nearby tapstands.

D3.2.2 Description of research

The site was chosen because of its physical and topographical characteristics – a hilly topography in close proximity to a number of small rivers draining into the Mzimkulu River.

Potential interviewees were selected because they were present in their yards or around the homesteads and in most cases interviewees were washing laundry at the time. Water samples were taken from containers in which laundry was being washed. One sample contained nappies that had been left to soak for over 5 hours (Sample no. KN0205). Samples were also taken from two tapstands and from nearby rivers.

Figure D3.4: Topography of Boboyi

Figure D3.5: Sampling river below the settlement

D3.2.3 Social findings

It is difficult to estimate the population of Boboyi. The settlement has low density housing and is estimated to have less than 5du/ha.

Boboyi is a peri-urban area. In general, interviewees find work and income from employment in nearby Port Shepstone. Growing food in the area surrounding their houses merely supplements the household food supply and no households appeared to be subsisting entirely from the produce.

On average, the interviewees were found to have lived in the area for 5 years or more. It is expected therefore that people have formed habits to deal with greywater and opinions about the use of greywater. Households collect up to 150*l* of water per day with the average being closer to 100*l*. The daily chore of collecting water on average took about 15 minutes. Daily storage amounts to approximately 100*l* per household. Most households were well organized with buckets and barrels in which to store water.

In general the interviewees preferred to use washing powder for laundry rather than the green "Sunlight" soap bar. They claimed that the powder was a little more expensive but was more effective. Unlike other settlements visited in this study, there were a fair amount of other cleaning agents used for cleaning floors and basins – "Chibochi", "Dettol" and "Handy Andy" were identified.

There was overwhelming agreement that greywater tossed onto the ground attracted flies and mosquitoes. As a result, some residents said that they poured the water onto a defined spot in the yard. In one case, the residents chose a spot to the side of the house to avoid wastewater running off into the neighbour's yard down the slope. Interestingly, some residents were happy for the water to run downhill into the rivers. They claimed that they no longer needed the river as a water source. Another resident suggested that greywater should be piped directly to the river!

D3.2.4 Water quality

Five samples of washwater, river water and tapwater were tested in the field for the selected variables (Table D3.2).

Table D3.2: Boboyi water quality indicators (2005)

Water quality indicator	Laundry KN0205	Laundry KN0208	Laundry KN0204	Tapstand KN0203	River KN0206
DO (mg/l)	0	0.4	1.4	0.7	0.5
Conductivity (mS/m)	167.8	132	83.2	19.2	48.9
Total Phosphorous as P (mg/l)	2.5	2.8	3.2	0	1.4
Ammonia N as NH_3 (mg/l)	3	3	3	0	0
pH	9.3	9.2	9.9	9	7.6

D3.2.5 Concluding remarks

Despite the proximity of the houses to nearby rivers (average distance ranges between 20 and 70m) and steep slopes, the water quality in the rivers appeared to be relatively good, based on the sample (KN0206) results. This is surprising since many of the interviewees claimed that they were happy to use the rivers to dispose of their wastewater. Owing to the fact that interviewees had resided for a relatively long period at Boboyi, it was disappointing to find that residents had not found creative solutions to deal with greywater. The dominant perception was that greywater is dirty, creates a health risk and needs to be thrown as far away as possible.

D3.3 KwaShange, Pietermaritzburg

D3.3.1 Background

KwaShange is situated 20km south west of Pietermaritzburg CBD. It is a low-density rural settlement with traditional, brick-built structures in a peri-urban area. The settlement is a small village with less than 3du/ha. Most houses are traditional and are situated within 100m – 500m of a water body. KwaShange lies on a ridge approximately 250m from the Nembes River. This river feeds the Msunduze River, which then enters the Henley Dam approximately 2km downstream. Streams were flowing at the time of the visit. A sample was taken from one of these rivers close to the settlement. A further sample was taken from the stream at the bottom of the valley. The geology of the area consists of shales, mudstone and shallow soils typical of the KZN midlands.

D3.3.2 Description of research

The site was chosen because of its physical and topographical characteristics – it is located in a small catchment with headwaters fed by numerous streams in close proximity to the homesteads.

The researchers visited the site on a Sunday morning and anticipated that it would be easy to find people to interview. A total of 14 interviews were conducted at various homesteads. Interviewees were found in the near vicinity of there homesteads and yards. Washing and general cleaning activities were observed in only a few households. Water samples were taken from a variety of containers, some with laundry at the first stages of washing; some with rinse water; and one sample from stored greywater.

D3.3.3 Social findings

Houses in this area were mainly found to be brick structures. In most cases houses had 3 to 4 rooms, with other family units adjoining or alongside the main house. Most of the interviewees received water either from a tap in the house or from a tapstand close to their homes.

Figure D3.6: Overlooking the Msunduze River

Figure D3.7: Laundry washing in a yard with a water tap in garden

Homesteads all have pit latrines. It was reported that inhabitants did use river water for drinking purposes, but they had been warned by a Councillor that it was unsafe to do so. Rivers lower down the valley were used for washing clothes or large washing loads.

From the interviews conducted it appeared that people enjoy living in this area and have stable social relations with their neighbours. The average income per household falls into the range of R801 – R1,600; at least 6 of the interviewees said that their household income was partly sustained by pensioners contributing to the household expenses.

D3.3.4 Water quality

Six samples of washwater, river water and tapwater were tested in the field for the selected variables and samples were also collected for analysis in a laboratory (Table D3.3).

Table D3.3: KwaShange water quality indicators (2005)

Water quality indicator	Laundry KN0301	Rinse water KN0302	River KN0303	Laundry KN0305	Dishes KN0304	Stored water KN0308
Total Phosphorous as P (mg/l)	6.2	5.8	5.2	406	12.3	11.2
Total Kjeldahl N	33.1	37.3	<0.10	152	105	108
pH	9.6	9.2	7.6	9.4	9.7	7.4
Conductivity (mS/m)	57.1	27.8	13.2	58	72.3	78.9
Ammonia N as NH_3 (mg/l)	<0.15	10.3	<0.15	44.7	<0.15	7.4
Dissolved Oxygen (mg/l)	0	0	0.3	0.1	0.6	0
Oil & Grease	332	584	<1	1528	2416	224
Boron (as B)	<0.10	-	-	-	-	<0.10

D3.3.5 Concluding remarks

Since water is easily available to most people living in this settlement, there was an obvious reluctance to use greywater because it was perceived to be dirty. Most interviewees claimed that they tossed dirty water away and were reluctant to try and reuse it. Greywater is however sometimes used for washing floors, to dampen and control dust in the yards, for making bricks, and feeding cattle.

D3.4 Emambedwini, Wartburg

D3.4.1 Background

Emambedwini is situated approximately 12km east of Wartburg. It is a rural area with relatively low-density brick and traditional homesteads forming a ribbon development alongside the many tributaries that flow into the Mkabela and Mqeku Rivers. The settlement density is estimated at approximately 4du/ha. Most houses are within 100m to 500m of some form of surface water. Streams were flowing at the time of the visit, but appeared to be polluted towards the bottom of the valley with cattle either feeding or walking through areas where surface flow was temporarily contained. The geology of the area consists of shale, mudstone and shallow soils typical of the KZN midlands.

D3.4.2 Description of research

Once again the site was chosen because of its physical and topographical characteristics, with homesteads that are located along the hills and in valleys adjacent to watercourses. Pit latrines were found at each homestead where interviews took place. Most homes had a water source in the home and/or yard.

The researchers visited the site on a Monday morning. A total of 14 interviews were conducted at various homesteads. Most interviewees were found washing laundry and other items at the time of the visit. Water samples were taken from the river and a spring (used for drinking purposes), and from containers, some with laundry and others with kitchen utensils.

Figure D3.8: Dispersed settlement overlooking the Mkabela River Valley

Figure D3.9: Small dam polluted by sediment and dirty water

D3.4.3 Social findings

Homesteads in this area were mostly brick structures with some traditional buildings. In most cases houses had 3 to 4 rooms, with other family units adjoining or alongside the main house. Water was obtained from a tap in the house or from a tapstand within 200 to 500m of their homes. Some interviewees claimed they drew water from nearby streams. Vegetables and maize were being grown in the yards or fields attached to the properties.

Interviewees reported low levels of income (average range R401-R800) and education, with most people only having been educated to senior primary school level.

D3.4.4 Water quality

Five samples of washwater, river water and tapwater were tested in the field for the selected variables and samples were also collected for analysis in a laboratory (Table D3.4).

Table D3.4: Wartburg water quality indicators (2005)

Water quality indicator	River KN401	Laundry soaking KN405	Kitchen KN406	Laundry KN407	Spring used for drinking KN409
Total Phosphorous as P (mg/l)	5.2	769	12.5	8.5	5.7
Total Kjeldahl N	<0.10	40	43.9	79	12.1
pH	8.9	10.3	9.3	10.2	6.2
Conductivity (mS/m)	11.5	1260	264	177	28.8
Ammonia N as NH_3 (mg/l)	<0.15	4.4	<0.15	20.8	0.22
Dissolved Oxygen (mg/l)	0.9	0.5	0.6	0.6	0
Oil & Grease	<1	3640	736	1056	48

D3.4.5 Concluding remarks

All interviewees were reluctant to use greywater as it was perceived to be dirty, to cause diseases and to encourage mosquitoes and flies. The poor state of rivers and roads were the main problems facing the people in this settlement. Rivers are used for washing large items such as blankets, carpets and mats and there appears to be little respect for the resultant pollution of the river or for the impacts on neighbours further downstream.

Of interest are the results for water sample KN405 (soaking laundry) in Table D3.4; they not only indicate high levels of P, but also unusually high levels of Oil and Grease. This is likely to have occurred from the practice (observed on various occasions) of leaving the detergent bar in the basin of soaking laundry for prolonged periods, thereby resulting in larger quantities of chemicals in the laundry solution. In addition to this, many residents reported using a tar-based household disinfectant ("Madubula") around their shacks as a sanitizer and as an insect repellant, which could also explain the elevated Oil & Grease levels measured ("Madubula" is a creosotic material rich in phenolic and cresylic compounds).

D3.5 Mandela Park & Emaqadeni, Botha's Hill

D3.5.1 Background

Emaqadeni is an old peri-urban settlement situated 3km west of Botha's Hill, Durban. It has a low population density estimated at 5du/ha. Properties surrounding the homesteads are large, ranging between 800 and 1,500m^2. Most homes had taps either in the house or in the yard.

Mandela Park was chosen because of its close proximity to the Valley Trust, a well known NGO operating in the area that provides educational and medical services. It was assumed that the Valley Trust would have had some input into the redevelopment of the RDP-type settlement and may have intervened in the implementation of the dry sanitation systems and urine diversion toilets that had recently been installed. No water samples were taken at this settlement.

D3.5.2 Description of research

Ten interviews were conducted at Emaqadeni. It was noticeable that there were not too many people around at the time when the interviews were being conducted and the researchers did not easily find potential interviewees.

Figure D3.10: Mandela Park: controlled water supply

Figure D3.11: Mandela Park: Urine diversion toilets

D3.5.3 Social findings

Emaqadeni: those people that reported on incomes indicated a higher than usual household income (above R1,600). At least two homes were headed by young children.

Mandela Park: Registration for housing in the area began in 1994. In 2004 Jali Construction company began building RDP houses. The drum / tank system of dispensing water to every home was installed in May 2005. The plan is to have 200*l* drums filled daily at a specific time. The water is considered safe, but the problem of an unlocked lid to the container is now seen as a risk factor. Residents feared that the water could be contaminated by their neighbours. The drums also get very hot in the summer. All greywater is thrown into a channel where it seeps away. One of the interviewees had no knowledge of the Valley Trust even though the boundary of the Trust was within 150m of the interviewee's home. It was also claimed that the new dry sanitation systems did not work.

D3.5.4 Water quality

Six samples of washwater, river water and tapwater were tested in the field for the selected variables and samples were also collected for analysis in a laboratory (Table D3.5).

Table D3.5: Emaqadeni, Botha's Hill water quality indicators (2005)

Water quality indicator	Bath water KN501	River KZN503	Laundry: KN505	Tapstand KN506	Ponded water KN507	Stored water KN508
Total Phosphorous as P (mg/l)	2.8	0.90	511	1.1	21.6	0.70
Total Kjeldahl N	26.3	1.7	5.0	0.70	11.3	1.0
pH	9.2	8.4	9.2	7.4	9.1	7.8
Conductivity (mS/m)	32.8	45.2	82.3	21.3	91.3	93.5
Ammonia N as NH_3 (mg/l)	10.5	<0.15	5.3	<0.15	8.7	1.2
Dissolved Oxygen (mg/l)	1.2	0.2	0.4	0	0	0.1
Oil & Grease	312	4	152	<1	216	<1

D3.5.5 Concluding remarks

There was nothing surprising about the water quality found at this site. Once again greywater was treated as dirty water that should not be touched.

D3.6 Cato Manor, Durban

D3.6.1 Background

This site is severely degraded and represents some of the worst conditions seen at any of the settlements visited in this study. The site lies 8km west of the Durban CBD lying at approximately 150m above mean sea level. Gently sloping hills of shale and sandstone drain water from a small catchment towards Durban Bay. The site was chosen because of its close proximity to centre of Durban CBD. Run off from Cato Manor flows into the Mkhumbane River, drains into the Umbilo Canal and ultimately into the Durban harbour.

Figure D3.12: An informal dwelling at Cato Manor

Figure D3.13: Polluted stream east of Cato Manor

The settlement is a dense, informal establishment. Water is collected from communal tapstands. In general residents have to queue for over 20 minutes to get water. At the time of the field work, RDP houses were being erected close to the settlement.

D3.6.2 Description of research

A total of 20 interviews were conducted. Interviewees were selected because they were cleaning items in close proximity to their homes. Water samples were taken from rivers on either side of the ridge straddling the houses. Samples were also taken of a ‘first wash’ laundry container.

D3.6.3 Social findings

The Cato Manor population is poor with low levels of education ranging from Std 2 to Matric, with the average being Std 5 (Grade 7). Most interviewees were unemployed or held very informal jobs.

D3.6.4 Water quality

Six samples of washwater, river water and tapwater were tested in the field for the selected variables and samples were also collected for analysis in a laboratory (Table D3.6).

Table D3.6: Cato Manor water quality indicators (2005)

Water quality indicator	Polluted River KN601	Ponded KN603	Laundry KN604	River KN605	River KN606	Tapstand KN607
Total Phosphorous as P (mg/l)	37.2	20.4	14.4	6.9	24.6	0
Total Kjeldahl N (mg/l)	189	55	488	42	53.2	-
pH	9.2	8.2	8.8	7.9	7.8	7.4
Conductivity (mS/m)	45.4	52.8	54.3	54.3	84.3	12.7
Ammonia N as NH_3 (mg/l)	61.6	33.3	7.6	19.5	25.3	0
Dissolved Oxygen (mg/l)	0.3	0	0.6	0	0	0.2
Oil & Grease (mg/l)	3348	36	108	<1	84	-

D3.6.5 Concluding remarks

High levels of phosphorous were found in the river east of Cato Manor (37mg/l) with associated high levels of Oil and Grease (3348mg/l), and nitrogen (189mg/l). The rivers surrounding this settlement generally appeared to be in a very poor condition.

D3.7 Eastern Cape and KwaZulu-Natal findings

The following maps give an indication of the types of settlements that were visited in both the Eastern Cape and KwaZulu-Natal as well as an overview of the water quality results obtained:

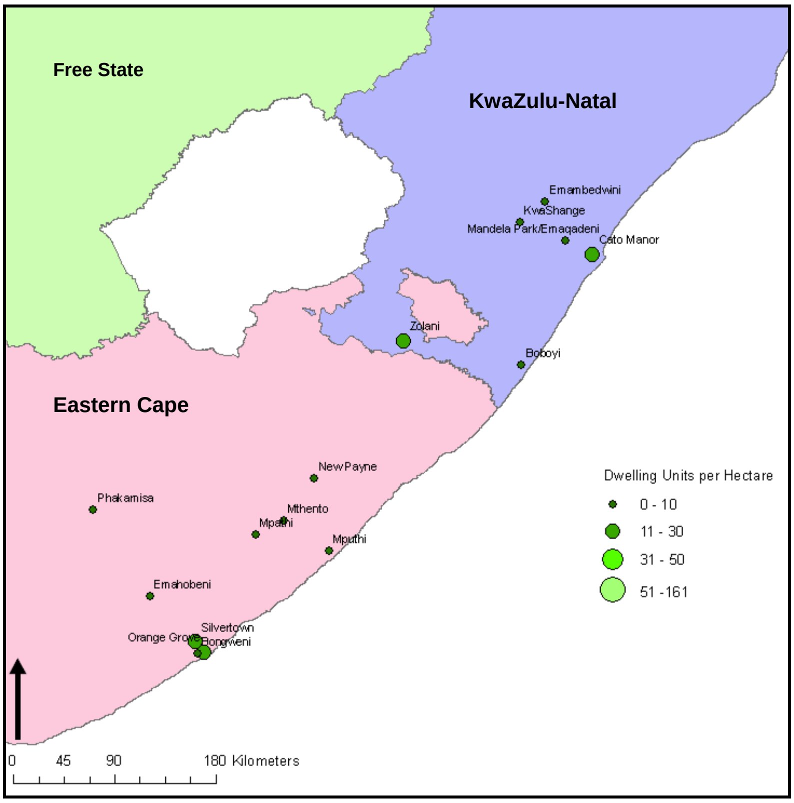

Figure D3.14: Settlement density figures for Eastern Cape and KZN sites

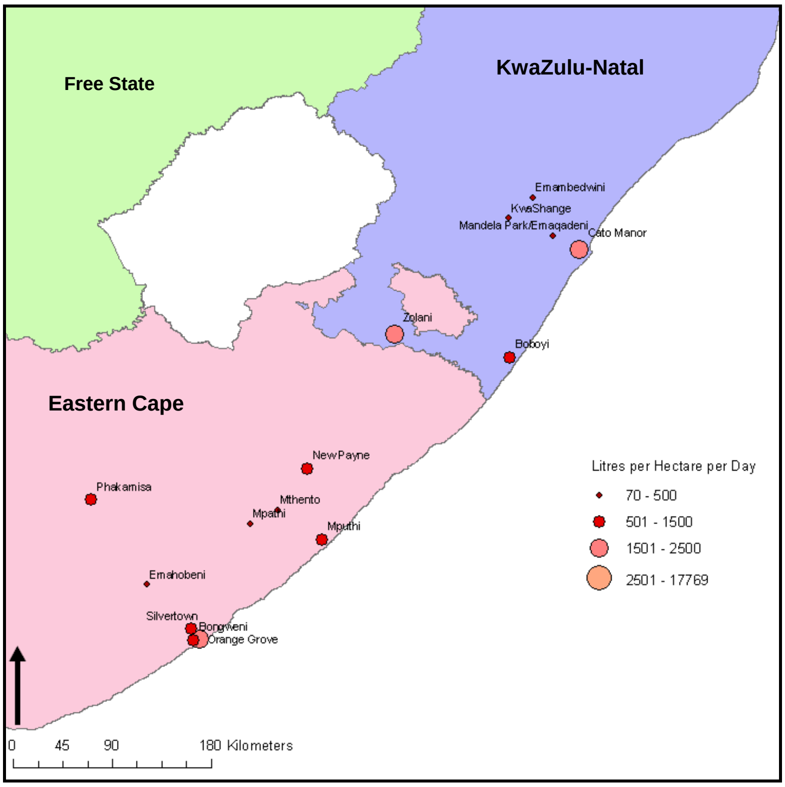

Figure D3.15: Greywater generation figures for Eastern Cape and KZN sites

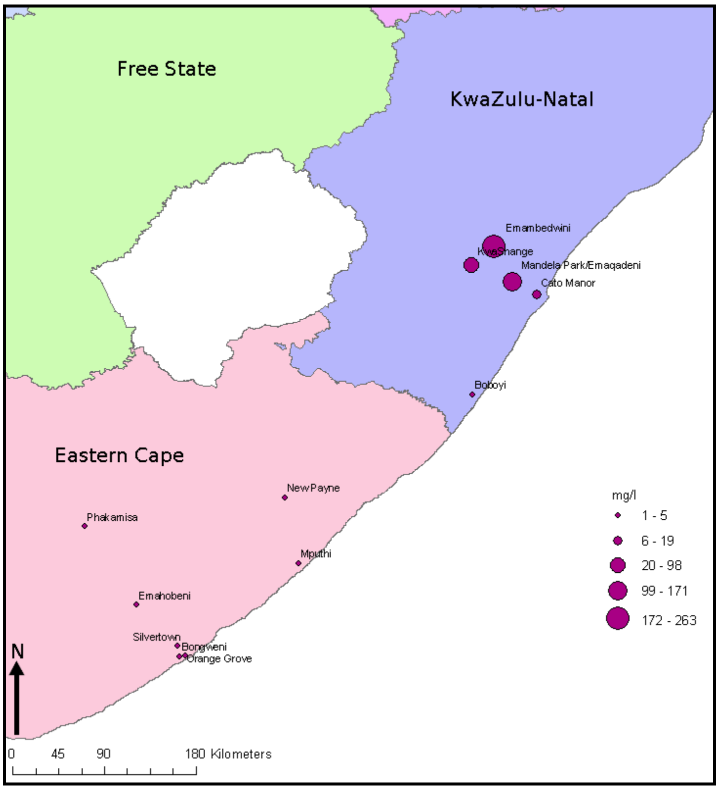

Figure D3.16: Total Phosphorous figures for Eastern Cape and KZN sites

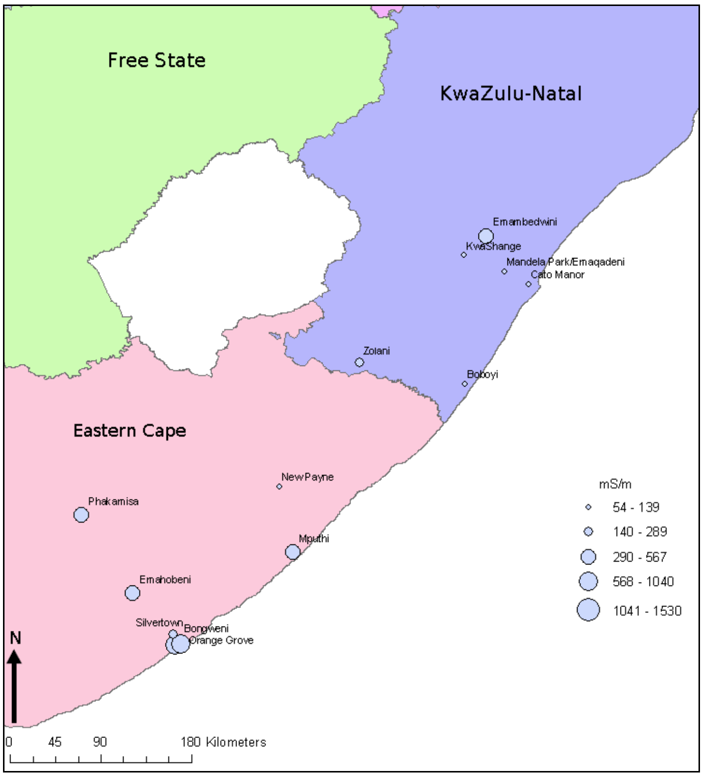

Figure D3.17: Electrical conductivity figures for Eastern Cape and KZN sites

D4. Limpopo site surveys

The Limpopo province was visited during January 2005 during the same period that the surveys were conducted in Mpumalanga. Most of the settlements visited (about 80%) were rural with the remainder being townships and communal authority areas. The surveys focused on the areas around Groblersdal (Leeufontein), Sekhukune (Jane Furse), Polokwane and Potgietersrus (Mahwelereng) as shown in Figure D4.1. It was found that water supply is often from underground sources and is generally well managed although people spend quite a lot of their time fetching water.

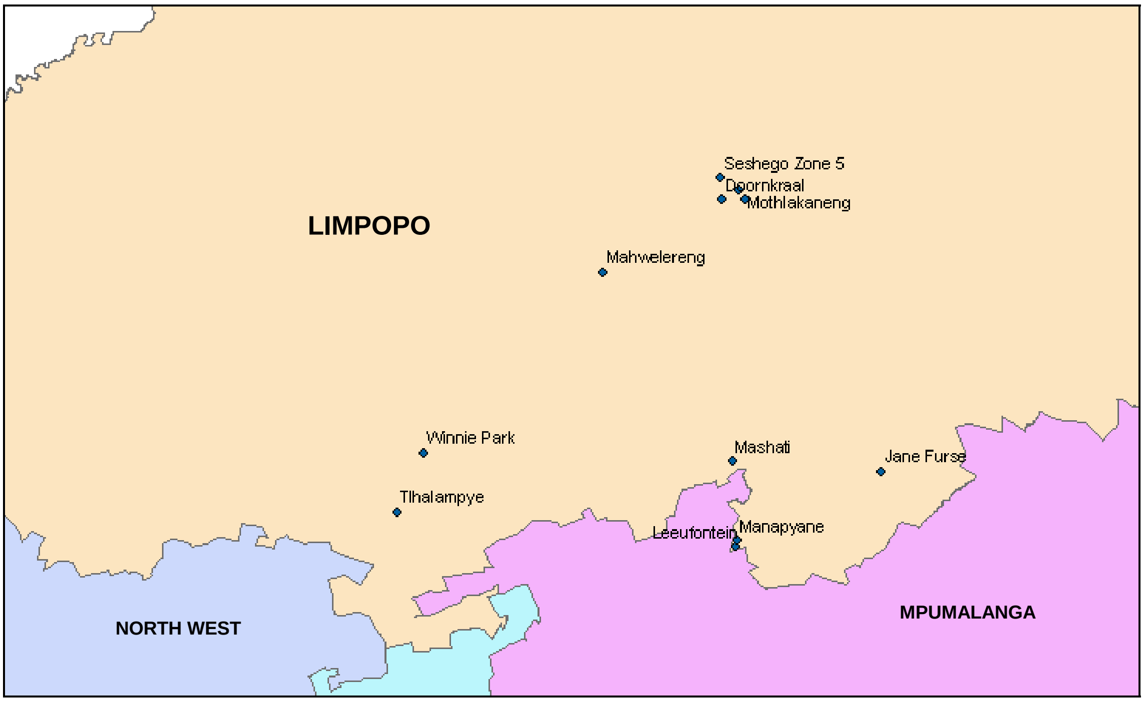

Figure D4.1: Map of Limpopo province showing selected sites for surveys

D4.1 Leeufontein / Manapyane, Groblersdal

D4.1.1 Background

According to Census 2001, Groblersdal and the settlements in its near vicinity had over 3,000 households which were non-sewered. However, this did not appear to be the case during the 2005 survey. The researchers were eventually guided by commuters, who were waiting at taxi ranks near the city centre, to two small settlements 12km north east of Groblersdal. Leeufontein is a recent housing project with RDP-type housing, while Manapyane is a small village approximately 1km from Leeufontein. Figure D4.2 shows the new housing development at Leeufontein with reasonably spacious yards. In the hot, dry climate of this region, most residents had planted trees and shrubs in their yards to create shaded areas, but greywater was not being used to water these plants. Both settlements used pit latrines and accessed their water from nearby communal tapstands.

D4.1.2 Description of research

A similar approach was adopted to previous surveys: interviewees were selected because they were involved in washing laundry or dish-washing in their homes or yards at time of the visit. Four interviews were conducted: two at Leeufontein and two at Manapyane.

Figure D4.2:New housing development at Leeufontein

Figure D4.3: Children around the tapstand

D4.1.3 Social findings

The average household in Manapyane is nearly double the size of that in Leeufontein. The settlement density at Leeufontein is approximately 5du/ha, while at Manapyane it is closer to 3du/ha. The number of people per household at Leeufontein is 4 compared to 8 at Manapyane. At Manapyane the yards were being used to grow some vegetables, fruit trees and shade trees. Interviewees were however reluctant to use greywater on their crops.

D4.1.4 Water quality

One sample each of washwater and tapwater from Leeufontein, and one sample of washwater from Manapyane were tested in the field for selected variables, as shown in Table D4.1.

Table D4.1: Leeufontein & Manapyane water quality indicators (2005)

Water quality indicator	Laundry L1	Laundry M1	Tapstand: Leeufontein
Conductivity mS/m	770	112	73.6
Ammonia N in NH3 (mg/l)	Too dirty	3	0
Total Phosphorous as P (mg/l)	Too dirty	5	0
pH	10.9	9.3	8.7
E. Coli (per 100ml)	-	-	-

D4.1.5 Concluding remarks

Residents are conscious of water scarcity and the difficulty of having to fetch water from some distance, especially at Manapyane, however they were still reluctant to use greywater.

D4.2 Jane Furse, Sekhukhune

D4.2.1 Background

The decision to visit Jane Furse was guided by Census 2001 data, which suggested that over 3,500 households in and around the town were without any form of sanitation. On arrival however, it was difficult to identify these areas. Most areas had had some development and non-sewered areas were difficult to find. Unfortunately, the research team arrived late in the day and municipal officials were not available for consultation. As an alternative, the researchers visited two large, well-established homes near the centre of the town. These homes were supplied with pit latrines. Water supply was available in the yards and reticulated to these houses.

D4.2.2 Description of research

The researchers relied on by-standers to help identify non-sewered areas in the town. Only one water sample was taken and two interviews were conducted.

D4.2.3 Social findings

The two selected interviewees represented a high socio-economic sector within the town and are clearly in the minority. The homes were well-established places with well-managed gardens, indicative of households with a reasonable income.

D4.2.4 Water quality

One sample of dishwater was tested in the field for selected variables, as shown in Table D4.2.

Table D4.2: Jane Furse water quality indicators (2005)

Water quality indicator	Dishwater sample
pH	10.3
Total Phosphorous as P (mg/l)	1.6
Conductivity (mS/m)	389
Ammonia (mg/l)	2.9

D4.2.5 Concluding remarks

The two residents interviewed were aware of water shortages and scarcity and were already using greywater on their plants and grass, but they felt that it had to be managed properly. One interviewee suggested that people should be supplied with large containers for greywater, which could be emptied by the municipality each week.

D4.3 Doornkraal, Polokwane

D4.3.1 Background

Doornkraal is a relatively new housing development situated 10km west of Polokwane. It is an area with limited infrastructure located on an old farm, and as such it forms an isolated settlement. Houses are constructed of corrugated iron on plots of approximately 100m^2. It is estimated that the total population is 500, with an average density of 15du/ha. It is a non-sewered area and there are no communal taps with water being obtained from a well-point. Most residents reported that they needed to walk more than 500m to access this water. This resulted in residents doing their washing at the well point. The potential for greywater to enter the groundwater at this point is very high as can be seen from the results of the water sample tested at this site.

D4.3.2 Description of research

The researchers were guided to the site by a police officer from Polokwane who appeared to be knowledgeable about settlements surrounding the city. Four interviews were held, while water samples were taken of greywater generated from washing, and one sample taken of the underground water supply.

Figure D4.4: Doornkraal dwelling

Figure D4.5: An unprotected well point

D4.3.3 Social findings

Doornkraal is a relatively recent settlement, which was not captured in the 2001 Census. Interviewees reported on their daily struggle of fetching and carrying water from the well point. For most this meant a walk of over 500m, consuming at least two hours of time each day. Given the scarcity of fresh water, the interviewees showed great reluctance to reuse the water and suggested that any water left in containers became contaminated with all kinds of human waste.

D4.3.4 Water quality

One sample each of washwater and underground water were tested in the field for selected variables, as shown in Table D4.3.

Table D4.3: Doornkraal water quality indicators (2005)

Water quality indicator	Laundry D1	Underground water source D2
Conductivity (mS/m)	489	105.5
Total Phosphorous as P (mg/l)	5+	2.5
Ammonia N as NH_3 (mg/l)	3+	2
pH	9.7	7.7

The high levels of P and NH_3 in the underground water supply is a cause for concern. It is possible that this water is being contaminated by washing water that is tossed onto the ground near to the well point pipeline.

D4.3.5 Concluding remarks

The difficulty of accessing water influences the quality of greywater. Greywater is treated with extreme caution resulting from the high concentration of chemicals and that residents showed no interest in trying to use this water for other purposes.

D4.4 Mothlakaneng, Polokwane

D4.4.1 Background

Mothlakeneng is situated 18km west of Polokwane. It is a high-density area with limited infrastructure. Houses consist of a mixture of corrugated iron shacks on small plots no more than 40m^2 while others are brick-built structures on larger plots of 80m^2. It is estimated that the total population is 1,500 with an average density of 25du/ha. It is a non-sewered area serviced with a limited number of communal taps. There was no protection around these taps and consequently the area surrounding the taps was sodden and muddy.

Figure D4.6: Collecting water from a communal tapstand

The soil type is clay, rich in iron and other minerals. Residents were observed cleaning their shoes in laundry water because of dust and dirt.

D4.4.2 Description of research

Four interviews were conducted, while water samples were taken of dishwashing, laundry and tap water.

D4.4.3 Social findings

Nothing significant to report.

D4.4.4 Water quality

One sample each of dishwater and laundry water, as well as one sample of tapwater was tested in the field for selected variables, as shown in Table D4.4. Traces of P and NH_3 suggest that the tapwater could be contaminated.

Table D4.4: Mothlakaneng water quality indicators (2005)

Water quality indicator	Tapwater M1	Dishwashing M2	Laundry M3
Conductivity mS/m	99.3	189.3	202
Total Phosphorous as P (mg/l)	3	5+	5+
Ammonia N as NH_3 (mg/l)	0.6	3+	1.8
pH	7.8	8.9	9.9

D4.4.5 Concluding remarks

The amount of effort required to collect water influences the water quality after use and also the perception of the users. Interviewees were very reluctant to use greywater. The levels of P and NH_3 are a cause for concern and should be investigated further.

D4.5 Seshego Zone 5, Polokwane

D4.5.1 Background

Seshego is a well-established informal settlement situated 15km south-west of Polokwane. The infrastructure is limited but there appears to be good management of the settlement judging by the open spaces between the rows of housing, trees found in open spaces and the well-managed informal roads between the houses. Houses are constructed of corrugated iron on plots of approximately $80m^2$. It is estimated that the total population is no more than 350 with an average settlement density of 10du/ha. It is a non-sewered area and water is supplied at communal taps. Most residents reported that they fetched water from between 200 and 500m from their homes.

The site lies on sandy to clay soils on a gentle gradient within 500 to 800m of a river. Observations of the stream (about 2m wide) revealed that it was gently flowing, clear water, but pools of algae had collected in areas of low flow. It is unlikely however that greywater tossed on the ground at the settlement would have any impact on this stream.

D4.5.2 Description of research

Three interviews were conducted. Three water samples were taken: two of laundry and one from a communal tap.

D4.5.3 Social findings

Nothing to report.

D4.5.4 Water quality

Two samples of washwater and one of tapwater were tested in the field for selected variables, as shown in Table D4.5.

Table D4.5: Seshego Zone 5 water quality indicators (2005)

Water quality indicator	Tapwater S1	Laundry S2	Laundry S3
Conductivity mS/m	105.5	143	123.5
Total Phosphorous as P (mg/l)	1.5	5+	1.8
Ammonia N as NH_3 (mg/l)	0	3	0
pH	8.5	8.4	8.4

D4.5.5 Concluding remarks

A similar pattern in water quality was detected here relative to the other settlements that were visited surrounding Polokwane. The drinking water had high levels of P and higher than expected levels of Electrical Conductivity (indicating high Total Dissolved Salts). Interviewees were unanimous in treating greywater with caution, although two respondents were using this water on ornamental plants.

D4.6 New Pietersburg, Polokwane

D4.6.1 Background

New Pietersburg is an informal settlement on the periphery of Polokwane, approximately 4km west of the centre of town (close to the industrial sector) and has very limited services other than communal water supply points.

The settlement is relatively densely populated with plenty of makeshift shelters towards the outskirts. It is estimated that 800 to 1,000 people inhabit the settlement with a settlement density of over 18du/ha.

The settlement lies on gentle gradient leading down to the river which is approximately 800m from the nearest house. The soils are sandy-clay. It is unlikely that greywater would have any direct impact on the river.

D4.6.2 Description of research

The researchers visited the site late on a Sunday afternoon. Some washing was taking place but most inhabitants were either watching a local soccer match being played on a green belt between the settlement and the river, or were fetching water. The researchers interviewed three people doing washing at the time. A greywater sample was taken from a laundry container and high levels of P and Electrical Conductivity were noted. It was interesting to note that tapwater samples taken from three separate tapstands also revealed similar high values for P and EC, indicating some form of pollution of the water source.

Figure D4.7: A well-manicured garden in a degraded squatter settlement

D4.6.3 Social findings

Residents were not happy with the conditions in the settlement. One interviewee complained of the unsanitary conditions and general dirt that characterized the settlement. They felt that it was unsafe and their health was at risk. All interviewees felt that greywater should be thrown away because it was unsafe. One inhabitant had a very neat garden and used greywater on occasion on her plants (Figure B4.7). Also of interest was the residents' desire to learn more about greywater as illustrated by comments such as, "Give us more education", or "Teach us how to handle it".

D4.6.4 Water quality

Three samples of tapwater and one of laundry water were tested in the field for selected variables, as shown in Table D4.6.

Table D4.6: New Pietersburg water quality indicators (2005)

Water quality indicator	Tapwater NP1	Tapwater NP2	Tapwater NP3	Laundry NP4
Conductivity mS/m	102.5	110.8	110	153
Total Phosphorous as P (mg/l)	3.8	3.8	3.8	5+
Ammonia N as NH_3 (mg/l)	0	0	0	3+
pH	7.9	7.8	7.8	8.9

D4.6.5 Concluding remarks

It is difficult to properly assess the quality of the greywater owing to the fact that there are high levels of both Phosphorous and Electrical Conductivity in the water supply. The water supply to this settlement in particular, requires further testing and investigation.

D4.7 Mahwelereng, Potgietersrus

D4.7.1 Background

The Potgietersrus area was selected because Census 2001 data indicated that over 3,000 inhabitants in the municipal district were without sewerage facilities. The researchers were unable to establish how much work had been done in the interim to address the situation; nevertheless it proved relatively easy to find areas which were non-sewered. Mahwelereng is situated less than 4km from the centre of town. It is a well established formal settlement on the periphery of Potgietersrus.

D4.7.2 Description of research

The researchers collected information in the usual manner. Four interviews were conducted and three water samples were taken: two from laundry washing and one from a tapstand.

Figure D4.8: Disposing of greywater down a pit latrine

D4.7.3 Social findings

The community appeared to be well organized. Interviewees indicated that community structures were in place and there was a sense of community interest and pride in the area. Homes and yards were neat and orderly. In general, people had settled here for lengthy periods and in the case of 3 interviewees, for over 8 years. All these respondents were conscious of water scarcity and the need to save water. Some used greywater on ornamental plants and even on vegetables. People were observed disposing of excessively dirty greywater down the pit latrines and also using the cleaner greywater to clean the toilet seat.

D4.7.4 Water quality

One sample of tapwater and two samples of washwater were tested in the field for selected variables, as shown in Table D4.7.

Table D4.7: Mahwelereng water quality indicators (2005)

Water quality indicator	Tap water MH3	Laundry MH1	Laundry MH2
Conductivity mS/m	65.9	89.9	124
Total Phosphorous as P (mg/l)	0.5	5+	5+
Ammonia N as NH_3 (mg/l)	0	0.5	2.5
pH	7.8	9	9.3

D4.7.5 Concluding remarks

Nothing unusual was noted at this site other than the effort on the part of the individuals to use greywater where possible to their best advantage. In one case, it was being used to grow vegetables but only if the water was sufficiently diluted. The researchers were impressed with the experience of the interviewees with respect to the use of greywater.

D4.8 Mashati, Potgietersrus

D4.8.1 Background

The village of Mashati is best described as a peri-urban area although it is situated approximately 18km from the town of Potgietersrus. Houses are placed on large plots of 800m^2 or more in a typical grid-iron pattern. The streets between the houses are wide and give a sense of space. There are mature trees throughout the settlement and the river, situated about 1km to the north of the centre of the settlement, also adds to the tranquility of this place. Some of the interviewees had lived in Mashati for over 30 years. Many were involved in tending their plots of maize, vegetables and plants. The soil was found to be loamy clay and rich in oxides, judging by its red colour.

D4.8.2 Description of research

Four interviews were conducted. Two water samples were taken and analysed in the field and also one sample from a borehole in the yard of one of the interviewees.

Figure D4.9: A traditional house in the background with maize in the foreground

D4.8.3 Social findings

The social circumstances are more typical of a rural area in which households are headed by an elderly person, usually a grandmother, and in which the immediate children are working elsewhere while the grandchildren are being looked after by the elders. Food is produced from the available land in the yards.

The population of Mashati is estimated at 350 people, while density is low at about 3du/ha. There is ample space to dispose of greywater or to use it for other purposes.

D4.8.4 Water quality

Two samples of laundry water and one sample of the borehole water that was being used for drinking purposes were tested in the field for selected variables, as shown in Table D4.8.

Table D4.8: Mashati water quality indicators (2005)

Water quality indicator	Borehole MT1	Laundry MT2	Laundry MT3
Conductivity mS/m	104.6	248	330
Total Phosphorous as P (mg/l)	0.3	5+	2
Ammonia N as NH_3 (mg/l)	0	3+	1
pH	7.7	10.6	10.3

D4.8.5 Concluding remarks

The interviewees indicated that they were not in favour of using greywater for irrigation purposes. They have found that it kills their crops (maize was identified as one crop that wilts and dies with soapy water).

D4.9 Winnie Park, Nylstroom

D4.9.1 Background

Winnie Park is a settlement that was developed over the last 2 years as a site-and-service plan. It is situated 12km south west of Nylstroom. The inhabitants have been supplied with housing materials and most houses are simple in their construction, mostly decked with corrugated iron. Yards are fenced off. The soil is sandy with very little vegetation (trees) offering much shade or protection from the sun. Each house has a pit latrine and a communal tap within 200m of the dwelling. Concrete slabs have been placed around these taps and the run-off is observed to be significant. The area is generally flat with no waterbodies in the nearby vicinity.

D4.9.2 Description of research

The researchers arrived late in the day to seek interviews, but still managed to find a number of people busy washing and cleaning in their yards at about 16h00. Four people were interviewed. A sample of laundry washing water was tested as well as sample from a tapstand.

Figure D4.10: An example of care taken in keeping yards tidy

D4.9.3 Social findings

There is little to report on this aspect of the visit other than it was noted that the inhabitants took pride in their homes as is evident in Figure B4.10. In general, yards were well-kept and a number of residents were seen sweeping the yards. Residents had also made an effort to grow plants in their yards. In two cases, the interviewees reported that they had dug holes in their yards to dispose of their greywater.

D4.9.4 Water quality

One sample each of washwater and tapwater were tested in the field for selected variables, as shown in Table D4.9.

Table D4.9: Winnie Park water quality indicators (2005)

Water quality indicator	Tap stand WP2	Laundry WP1
Conductivity mS/m	42	234
Total Phosphorous as P (mg/l)	0	5+
Ammonia N as NH_3 (mg/l)	0	3+
pH	8.3	10.1

The water quality from the one communal tap that was sampled appears to be of excellent quality.

D4.9.5 Concluding remarks

The availability of communal tapstands placed strategically around the settlement has meant that people spend less than 30 minutes per day collecting water. This availability also means that people are putting clean water on their gardens and do not see much point in using dirty water on their plants. Nevertheless, the interviewees were well aware of the value of water and did feel that conservation was important.

D4.10 Tlhalampye, Bela Bela

D4.10.1 Background

The site is situated 8km north east of Bela Bela. It is an adjunct to the much older former township of Warmbaths. It is an informal settlement with site-and-service infrastructure providing pit latrines and communal water taps. The layout of the settlement was found to be poor, with shacks scattered about rather than following the usual grid pattern. The scarcity of taps provided work for some in that water was being transported to homes by donkey cart. The surface soils are sandy and flat. There were no visible waterbodies in the nearby vicinity.

Figure D4.11: Transport of water on donkey cart

Figure D4.12: Well-managed yard where greywater is used to water the garden

D4.10.2 Description of research

The researchers arrived in the early morning with the intention of interviewing people doing their first washing chores of the day. Water samples were taken from dishwater and from laundry washing. Four people were interviewed using the standard structured questionnaire.

D4.10.3 Social findings

The population of this section of the township, called Tlhalampye is approximately 300, with a settlement density of about 4du/ha. The sandy soil meant that people were not troubled by greywater and were able to toss it on the ground without attracting flies or mosquitoes because it infiltrated quickly.

Most people appeared to be unemployed and in at least one case, the interviewees were living in very severe and squalid conditions (overcrowded and dirty). By contrast, one of the interviewees presented a neat yard with well-established flowers and shrubs and claimed to regularly water the plants with greywater.

D4.10.4 Water quality

One sample each of tapwater, dishwater and laundry water were tested in the field for selected variables, as shown in Table D4.10.

Table D4.10: Tlhalampye water quality indicators (2005)

Water quality indicator	Tapstand T1	Laundry T2	Dishwater T3
Conductivity mS/m	56	845	770
Total Phosphorous as P (mg/l)	0	5+	3.5
Ammonia N as NH_3 (mg/l)	0	3+	2.2
pH	7.8	10.7	7.9

D4.10.5 Concluding remarks

The water supply appears to be of a high quality. Greywater does not appear to be a problem given the space available to dispose of it and the sandy soil conditions.

D5. Mpumalanga site surveys

The Mpumalanga site surveys were undertaken together with the visits to Limpopo province during January 2005 and included two semi-rural settlements in the areas around Witbank (Masakane) and Middelburg (Doornkop). Figure D5.1 is a map of the province showing the positions of sites visited.

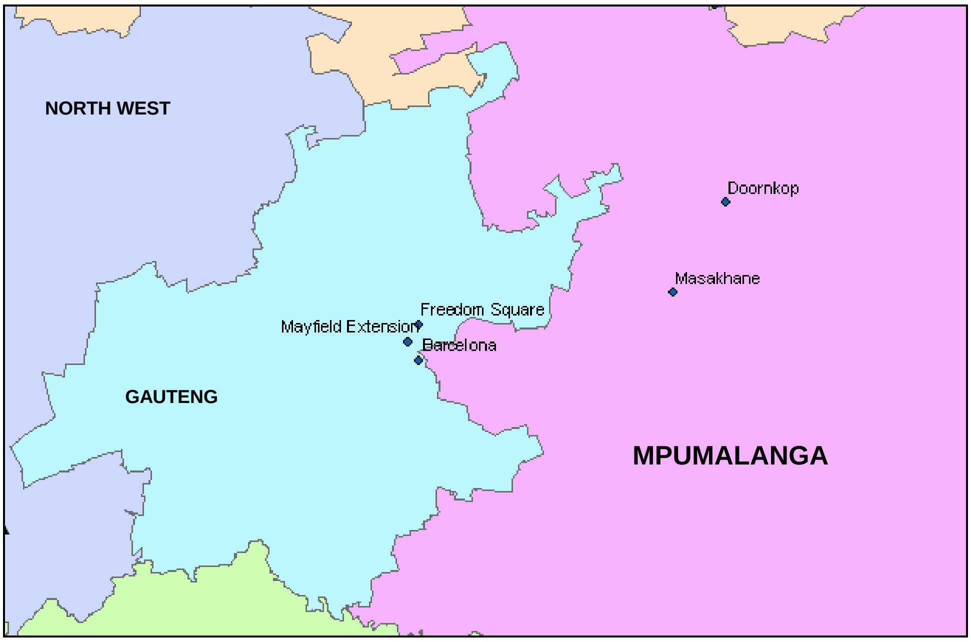

Figure D5.1: Map of Mpumalanga province showing selected sites for surveys

D5.1 Masakhane, Witbank

D5.1.1 Background

The researchers were directed to Masakhane after discussions with municipal officials at Witbank (Water Services Division). The research team was informed that this was the only site in the near vicinity of Witbank that did not have waterborne sanitation. Masakhane is a peri-urban settlement situated 8km west of Witbank. Most houses are shacks built from corrugated iron and wood, but there are also brick structures. Designs varied a great deal. There was very little evidence of attempts to grow produce from gardens. Properties were generally 400 to 500m^2 with the actual house taking up about 50% of this area. Thus, there was ample space that could be used to grow produce. It is estimated that the settlement density was 15du/ha.

D5.1.2 Description of research

Initially the rainy weather conditions made it difficult to find people with whom to conduct interviews. Eight interviews were eventually conducted. Water sampling and testing was confined to field test assessments only.

Figure D5.2: Drawing water from an unprotected spring

Figure D5.3: Greywater stored to feed pigs

D5.1.3 Social findings

Interviews indicated that household income was in the order of R401-R800 per month. Water is not supplied to homes. Most people fetch their water from an unprotected well point or from a local spaza shop whose owner pumps water from a borehole into a 5000*l* tank for everybody's use without any charge.

On average, residents reported spending between 1 and 2 hours fetching and carrying water every day. There was no desire to reuse water other than in one case where water was stored to feed to pigs.

D5.1.4 Water quality

Five samples of dishwater, laundry water and stored greywater were tested in the field for selected variables, as shown in Table D5.1. No samples were tested of the tapwater in Masakhane.

Table D5.1: Masakhane water quality indicators (2005)

Water quality indicator	Laundry M1	Laundry M2	Dish washing, M6	Stored greywater used to feed pigs, M4	Dishes M5
Conductivity mS/m	176.3	153.7	143.6	1346	310
Total Phosphorous as P (mg/l)	5+	4	5+	Too discoloured	4
Ammonia N as NH_3 (mg/l)	3	2	3+	Too discoloured	3+
pH	9.8	9.9	6.5	7.5	3.3

D5.1.5 Concluding remarks

Seven out of eight interviewees were in favour of water being re-used and recycled, but only after it was properly managed. Some suggested that storage containers are required to manage the situation properly. This preparedness to recycle was unusually high compared to other sites. The shortage of water and difficulty of access may however influence this preparedness.

D5.2 Doornkop, Middelburg

D5.2.1 Background

The researchers initially visited the Middleburg town municipality, but were unable to arrange an interview with the manager from Water Services. Later, a meeting was held with the Town Clerk who is enthusiastic about the municipality's role in peri-urban renewal programmes, which are promoting densification and improvements in service provision. Unfortunately these plans have yet to reach fruition and the researchers were unable to visit any sites under construction. The researchers were also informed that there were no non-sewered areas on the periphery of Middelburg. It was advised that the nearest site to Middelburg was Doornkop. This was verified the next morning during site visits to two informal settlements to the south of the city. These settlements were all sewered.

Doornkop is situated 18km north of Middelburg. It is a rural settlement that falls under a tribal authority. Homesteads are larger brick structures on plots of approximately 800 to 1,200m^2 and the settlement density is estimated at approximately 6du/ha. In many cases, produce is grown on the property and includes vegetables, maize and fruit trees. Communal land adjacent to the settlement is used for grazing cattle. Water is obtained from an underground supply. It is pumped into two large 5,000*l* tanks. On average people spent between 15 to 30 minutes per day fetching water over a 50 to 100m distance. Four water samples were taken and tested in the field.

Figure D5.4: Large open areas in properties with communal land in background

Figure D5.5: Interview held with residents among the fruit trees

D5.2.2 Description of research

As explained earlier the researchers were advised to visit Doornkop by the Town Clerk of Middelburg Municipality. Once again, interviewees were selected because they were washing laundry at the time of the visit. Four interviews were held.

D5.2.3 Social findings

The interviewees appeared to have made this rural settlement a lifestyle choice. Most interviewees did not have work other than finding various means of subsisting under these circumstances. Education levels were relatively high. No-one offered an estimate of household income. Residents appeared largely content with their situation despite the efforts required to fetch water daily.

D5.2.4 Water quality

Four samples of tapwater and washwater were tested in the field for selected variables, as shown in Table D5.2.

Table D5.2: Doornkop water quality indicators (2005)

Water quality indicator	Tapstand	Laundry D1	Laundry D2	Laundry D3
Conductivity mS/m		53	94.5	229
Total Phosphorous as P (mg/l)		5+	5+	5+
Ammonia N as NH_3 (mg/l)		3+	2.8	3+
pH	8.8	9.3	9.7	9.8

D5.2.5 Concluding remarks

Interviewees were conscious of water shortages and scarcity. They indicated a willingness to conserve water. However, the overwhelming impression was that greywater was dirty, even toxic, and could not be used.

D6. Gauteng site surveys

The Gauteng site surveys took place at the beginning of July 2005 and were focused on the East Rand area, as shown in Figure D6.1.

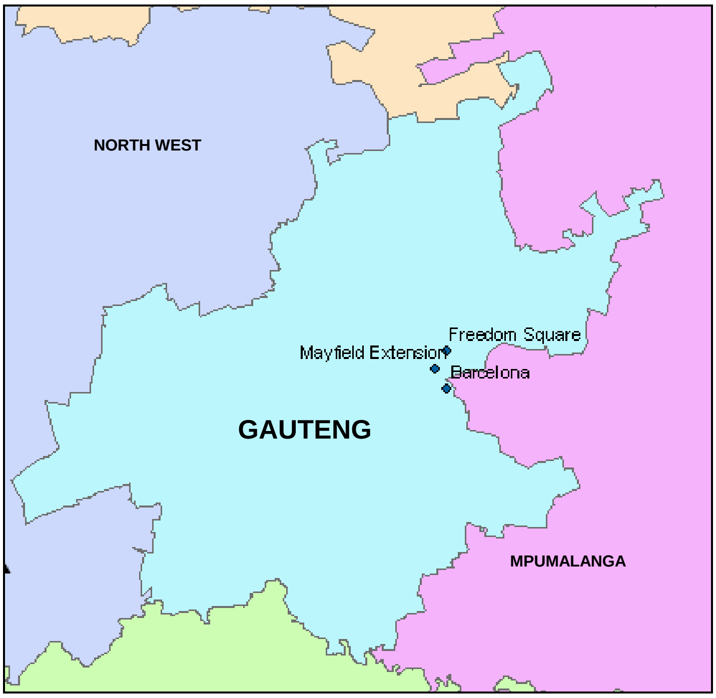

Figure D6.1: Map of Gauteng province showing selected sites for surveys

Gauteng province is the most urbanized of the provinces in South Africa, and the East Rand area i.e. Ekurhuleni Metropolitan Municipal Council (EMMC) in which the surveys were conducted, is a major mining and industrial area. Although the whole of the EMMC area was once grassland through which a few rivers flowed, today the various urban and industrial developments have so transformed the landscape that most of it can no longer be described as natural (according to land use patterns recorded in 2000, only 43 percent of the land in EMMC is still natural). The non-sewered areas visited were all informal settlements whose inhabitants either work or seek work in the nearby industrial centres of Benoni and Boksburg.

Mining has had the greatest impact on the environment, including the water quality in and the flow patterns of rivers and streams in this area. The most important surface water systems in the part of the East Rand that was surveyed are the Blesbokspruit and Grootvlei rivers. These rivers flow through the Benoni / Daveyton area south through Springs and the outskirts of Nigel to the Vaal River. The Blesbokspruit is particularly important for its RAMSAR site status, as is the Marievale Nature Reserve. Both of them are threatened by discharges of excess minewater from Grootvlei and other mining areas, as well as agricultural inflows from the smallholdings and sewage effluent from Daveyton and informal surrounds.

Freedom Square informal settlement is situated in the catchment area of the Kaalspruit / Olifantspruit, which flows north into Midrand joining a tributary from the Clayville industrial area. There are many other informal settlements apart from Freedom Square in this area, some of which are situated along river banks and they are all seen as causes of high microbial contamination in the rivers. However, as already noted for Daveyton, the water pollution from the squatter settlements is part of a larger urban problem. Other contributors to this pollution include mining and other industries, municipal sewage reticulation and sewage treatment works as well as agricultural runoff (Dept of Environmental Affairs & Tourism, 2003).

There are many in-stream dams located on the watercourses and tributaries which were mainly created for agricultural or mine water storage. Indeed, the towns of Benoni, Boksburg and Springs are all famous for their dams, golf courses and boat clubs that use the water. There are also a number of endoreic pans (collecting water but having no primary outflow, for example Bullfrog Pan) in the EMMC, pans which occur within more urbanised areas, e.g. Homestead Lake and Rynfield Dam and those that were dammed for mining purposes, e.g. Leeuwpan, Jan Smuts, and Rolfes Pan in Jetpark.

Although many of the wetland habitats in the EMMC have been degraded and some lost altogether, they represent one of the most important ecosystems in the area due to their substantial hydrological, biological or ecological role in the natural functioning of the catchments in the Metro. Many of the watercourses and pans form part of these wetlands, most notably is the man-made Blesbokspruit wetland system, which is one of the larger wetland systems in the highveld and part of which (near to Springs) is the designated RAMSAR site (1996).

D6.1 Mayfield Extension

D6.1.1 Background

Mayfield Extension informal settlement is laid out on a grid pattern approximating what could be considered the normal RDP township pattern, with most of the houses consisting of informal dwellings constructed with metal sheets. It is less densely settled than some informal settlements with about 254 dwellings (approximate population of 1,016 people) on about 8ha of land (i.e. 32du/ha), and is situated near Daveyton on the East Rand. Mayfield gives the impression of potentially developing into a permanent settlement once it has been upgraded as there are neatly laid-out stands with ample space within and between the yards for the location of the experimental dry sanitation toilets that are currently being piloted in the area. Not all parts of the settlement have these toilets however, so most people are still using unventilated plain pit latrines and there are communal standpipes for water supply.

Annual rainfall in the area amounts to approximately 600mm and the settlement is situated within the 50-year flood plain of the nearest river, which is about 200m from the closest shack. The depth to the water table was reported as about 1.2m during the wet season.

D6.1.2 Description of research

Between Friday 2 July 2005 and Monday 4 July 2005 a team consisting of a key researcher and two student research assistants worked on the East Rand (Gauteng) conducting research on greywater management in the area. It was decided to focus on settlements where on-going trials were being conducted on three different models of dry sanitation toilets. Some time was spent during the first day at the Benoni offices of the Ekurhuleni Metropolitan Municipal Council (EMMC) and discussions were held with members of their Water Department. Interviews were then conducted in the Mayfield Extension informal settlement; a reporter from the WRC's Water Wheel accompanied the team to take pictures of the fieldwork and file a report for the magazine

Preliminary assessments of settlement characteristics were made possible by way of faxed questionnaires that were sent to municipal officials before the visit and these were discussed with staff members at the Boksburg offices of the EMMC on 2 July 2005.

Figure D6.2: Garden in Mayfield Extension

D6.1.3 Social findings

There was evidence of some gardening in Mayfield with attempts to maintain tiny patches of green lawns, flower and vegetable gardens, fruit trees and hedges with varying degrees of success. At the time of the visit the region was in the middle of the dry winter season and much of the vegetation was dead, but around some of the houses gardens seemed to be relatively well maintained. Greywater was used more for keeping down the dust than for irrigation but where it had been used to irrigate gardens; grey detergent residues were visible on the surface suggesting a build up of salts and oils. The amount of greywater generated by most Mayfield households was relatively low – lower than it would have been had the water supply been more reliable. Rivers of run-off were therefore not observed in this area due to the lower population density and the dry taps in many parts of the settlement. Adding to the problem of controlling dust in the settlement, the residents also complained about the lack of a proper drainage system and reported that during the summer rains the water table rises and floods the pit latrines. It appears that the area has large areas of dolomite, which causes the problems with drainage.

Although people were aware of the concept of recycling, the use of greywater was a totally new concept and the responses to the questions about its usability were hesitant. More information will be required before their perceptions can be taken as a serious measure of their opinions. Indeed the researchers were asked several times if they thought the water was usable. In the event that the use of greywater around the household was to be promoted by the local authorities, they would need to provide detailed information on the safest ways of using greywater. At present there are trial and error use patterns evident but by and large greywater is not considered to be a major resource.

D6.1.4 Water quality

One sample each of tapwater and washwater were collected for analysis in a laboratory (Table D6.1).

Table D6.1: Mayfield Extension water quality indicators (2 July 2005)

Water quality indicator	First wash GP0101	Tap water GP0102
Total Phosphorous as P (mg/l)	240	<0.10
Total Kjeldahl N	43	<1.0
pH	9.8	8.2
Conductivity (mS/m)	653	272
Ammonia N as NH_3 (mg/l)	21.8	<0.15
Dissolved Oxygen (mg/l)	0.6	0.3
Oil & Grease	1484	36

D6.2 Freedom Square

D6.2.1 Background

Freedom Square informal settlement is a very densely populated urban settlement near Tembisa on the East Rand with about 1,050 dwellings (approximate population of 4200 people) on about 6.5ha of land. This settlement appears chaotic compared to Mayfield Extension, and completely unplanned with dwellings so closely built next to one another that the new experimental toilets had to be built on the periphery of the settlement owing to the lack of space between the houses. According to one of the consultants employed on the dry sanitation project, Freedom Square with 162du/ha (and not Mayfield with only 32) is considered to be typical of the informal settlements in the EMMC area. It is very likely however that this whole settlement will be relocated at some point in the future, even though the current site is convenient for working people wishing to stay near their employment centres. The high-tension electricity pylons that pass over the houses are enough of a health hazard to warrant relocation, but in any case the people’s sense of insecurity is reflected in the lack of order in building. Security and crime issues were cited by many as the most important issues that they would like the local authority / government to address, e.g. the new toilets located on the edge of the settlement were considered out of bounds after dark because thieves and rapists lay in ambush there.

Annual rainfall in the area amounts to approximately 500mm and the settlement is situated about 800m from the nearest surface water body. The depth to the water table was reported as about 1.5m during the wet season.

D6.2.2 Description of research

Freedom Square was highly recommended by the EMMC officials as a settlement where interesting things were happening with regard to service delivery and where the community was integrally involved in the selection, testing and possibly modification of the three models of waterless toilets being piloted by the Council. Freedom Square is also considered to be a typical Gauteng informal settlement in terms of the density of the population and general lack of facilities.

As with the other sites visited, water samples were collected and interviews were conducted of (mainly) women who were doing their laundry at the communal tap, and others who expressed interest. The local committee leader was also interviewed and he provided an overview of the political processes around sanitation as well as certain environmental issues in the settlement.

Figure D6.3: Greywater disposal down stormwater manhole

Figure D6.4: Stormwater drain at Freedom Square

D6.2.3 Social findings

Owing to the high density of houses in Freedom Square, there were no noted attempts at gardening. However, as usually happens when a large number of people are disposing of their wastewater on the ground, streams of water have formed, which in this case could end up in other people's shacks. It was agreed amongst the residents therefore that all greywater should be carried from the homes and deposited in the stream that takes runoff from the standpipes to the stormwater drain near the main road. Many women did their washing at the standpipes and thus dumped their laundry water into the overflow from the taps. Smaller amounts of greywater from the kitchens were probably just thrown onto the sand near the houses but some children were also observed carrying buckets of greywater to the stormwater drain as agreed. In one case it was noted that a woman whose house was situated near a stormwater manhole was using the manhole to dispose of large amounts of laundry water. Some plastic bags and other solid waste also ended up in the manhole owing to the fact that the main refuse dump was on the outskirts of the settlement, near the toilets.

D6.3 Barcelona

D6.3.1 Background

Radical elements belonging to the ANC and PAC are said to have been behind the 1993 land invasions that resulted in the creation of Barcelona, a squatter camp near Daveyton. Plots were apparently sold to people and promises made regarding the delivery of services after the elections. PAC officials were also associated with squatter settlements in other parts of the EMMC area which they justified ideologically as repossession of lost ancestral lands. A newspaper report suggested that "…an ANC self-defence unit member was selling stands for R45, while (a PAC activist was) selling stands for R80. The funds were not being handed over to any organisation, and both enriched themselves in the process." (Donaldson, A., 2001). Be that as it may, the informal settlement of Barcelona (probably named after the Barcelona Olympics of 1992) is seen as a spill-over of Daveyton township. As the backyard shacks became overcrowded and new migrants arrived continuously from the rural areas, Daveyton township was extended in several directions. The Etwatwa extension has formal housing but the great majority of the "surplus" population ended up in the squatter settlements.

Barcelona is situated on a large plain which turns into a swamp in the wet season. It is, like Mayfield Extension, also laid out on a grid pattern reflecting both an orderly distribution of plots (i.e. local organization either by the rogue politicians or by grassroots campaigns) and anticipation of legalization and the provision by local government of RDP houses. However, Barcelona unlike Mayfield does not have the old eucalyptus trees that the mining companies planted in order to draw down the water table and still has the natural vegetation of local grassland. As the settlement grows, even the low lying areas that people have avoided thus far when putting up their houses may be invaded thereby affecting both surface and underground water.

According to the Ekurhuleni State of the Environment Report (Department of Environmental Affairs and Tourism, 2003), the squatter settlements around Daveyton township require special attention as they may be contributing to the deterioration of wetlands on the Blesbokspruit which is a tributary of the Vaal. It was reported that generally however, it is the mining, manufacturing and commercial industries that are the main reason for the mushrooming of formal and informal residential settlements in this area are collectively to blame for:

- Elimination/transformation and fragmentation of natural habitats to create urban landscapes.
- The fact that the Rocky Highveld and Moist Cool Highveld grasslands have been fragmented by the conversion of natural habitats into man-made structures.

- The filling in of pans in the EMM for urban development, and the isolation of wetlands and surface waterbodies. These pressures have all lead to losses of ecosystem function and biodiversity. Fences and walls on the edges or across pans also prevent natural migration of adult and juvenile Giant Bullfrog species between foraging areas and suitable breeding sites.
- Poor services in impoverished settlements which have lead to sewage pollution (no proper sanitation), litter and solid waste pollution (no / poor waste collection services) and deteriorating water quality in surface water bodies. The informal settlements in the Daveyton area are therefore contributing to the deterioration of the RAMSAR site on the Blesbokspruit.

D6.3.2 Description of research

Barcelona differs from the other two sites in not having the dry sanitation testing project and also by being located on a previously undeveloped, thus natural landscape. Interviews were conducted with men and women found using water for laundry, to water their gardens or fetching water at the standpipes. The opinions of those who were just sitting outside their houses were also sought. As with the other sites samples of the greywater were also collected.

Figure D6.5: Vegetables growing in Barcelona

D6.3.3 Social findings

It is very difficult to plot the movements of residents of informal settlements, especially as that was not the aim of this project. It was noticeable however that some of the owners of houses also had residential addresses elsewhere in the Johannesburg area, either to be near schools or work. It would seem therefore that some of the people that invest in a stand may not necessarily be homeless. It also means that the population fluctuates though probably not enough to register major differences in water use patterns.

As in Mayfield, there were visible signs of attempts to keep small patches of lawn (which were mainly brown on account of the dry winter conditions) as well as hedges, flower and vegetable gardens and the odd peach tree. Clearly the township model of maintaining one's yard is well known but it is too difficult to fully attain when using communal water points and when water supplies are irregular. Thus, although there are always a few determined households that invest time and effort in creating a garden and improving their landscape, most wait for proper housing before making the effort. The more secure the claim on the land and the more stable the household the greater the likelihood of gardening. Bachelor shacks in other words are neglected whereas family ones tend to have better kept surroundings. The use of greywater to irrigate lawns or flowers is not considered normal behaviour. Not only is the water dirty, it is argued, but the people in formal housing do not use it. Tossing it out onto the dusty ground is therefore considered the normal use for greywater.

D6.4 Concluding remarks from Gauteng surveys

Most of the people interviewed were hearing about greywater for the first time but were vaguely familiar with the concept of recycling as an environmental intervention. The research assistants even had some difficulty translating the greywater recycling concept although residents seemed to be aware of the concept of water reuse as illustrated by the practice of putting a bucket of water to multiple uses before discarding it as dirty. In Mayfield, the people said the water table is shallow and when it rains even the pit latrines become waterlogged. Clearly then, tossing greywater on the ground will only add to the pools of stagnant water. Barcelona was also situated in an area of flooding, especially the low-lying outskirts of the settlement. Freedom Square on the other hand was at the end of a main road and all its runoff ended in the stormwater drains. In all these sites therefore, greywater was neither a resource nor a major inconvenience at the time of the research. More important issues for the residents were the reliability of the water supply, toilet facilities, and especially in Freedom Square, the lack of security, particularly at night.

Various problems were encountered with the communal facilities and particularly the experimental toilets. In the EMMC as in most other councils, planners and consultants assume that every informal settlement constitutes a community. First and foremost a community is not a given but is constructed around a common interest or goal. When people from different parts of the country simply congregate in a particular area in the hope of finding employment this does not generally constitute enough of a sense of community for them to be mobilized into campaigning for the provision of water and sanitation services and for a healthy environment for them to live in.

It has been observed that water standpipes and communal toilets are sometimes vandalized for no apparent reason. In contrast to this, people in other areas have taken the initiative to repair broken pipes and taps themselves, dig drainage ditches and dump their greywater and solid-waste in dedicated disposal areas. In general however, the majority of South Africans associate post-apartheid urban life with RDP houses as the minimum standard. Each homeowner therefore expects to have his/her own water supply point and toilet, and so preliminary evaluations of the EMMC dry sanitation pilot reported that:

- “In most cases it was found that members of households where the toilet was installed were the ONLY users (emphasis added) of systems…”

- "…we found in Mayfield that instead of four households sharing a toilet as planned, this was not easily implemented because each plot was usually fenced off and some had razor wire all round. So if the owners of the house are away then the toilet was also out of bounds." For whatever reasons some neighbours could be involved in a dispute and "stop talking to each other" during which time they would, of course, not be in a position to share access to the toilet.

The EMMC consultants also confirmed the project team's observations that when there was no clearly-defined responsibility for the cleaning and maintenance of the communal facilities everyone tended to stop cleaning them with the result that they either became unusable or the private property of whoever took the initiative to clean and lock up the toilets. Thus, for toilets more than for water points, privacy, decency and a sense of propriety demand that each house has its own facility unless a much greater level of discussion than currently occurs between developers and residents is implemented prior to the introduction of communal services.

After preliminary contacts were made with EMMC officials, the non-sewered areas selected satisfied the demographic requirements and also provided an opportunity to observe the ongoing experiment (testing) of dry sanitation systems and how these would affect the way people use their water and manage their wastewater.

The following maps show the results obtained during the site surveys in Limpopo, Mpumalanga and Gauteng:

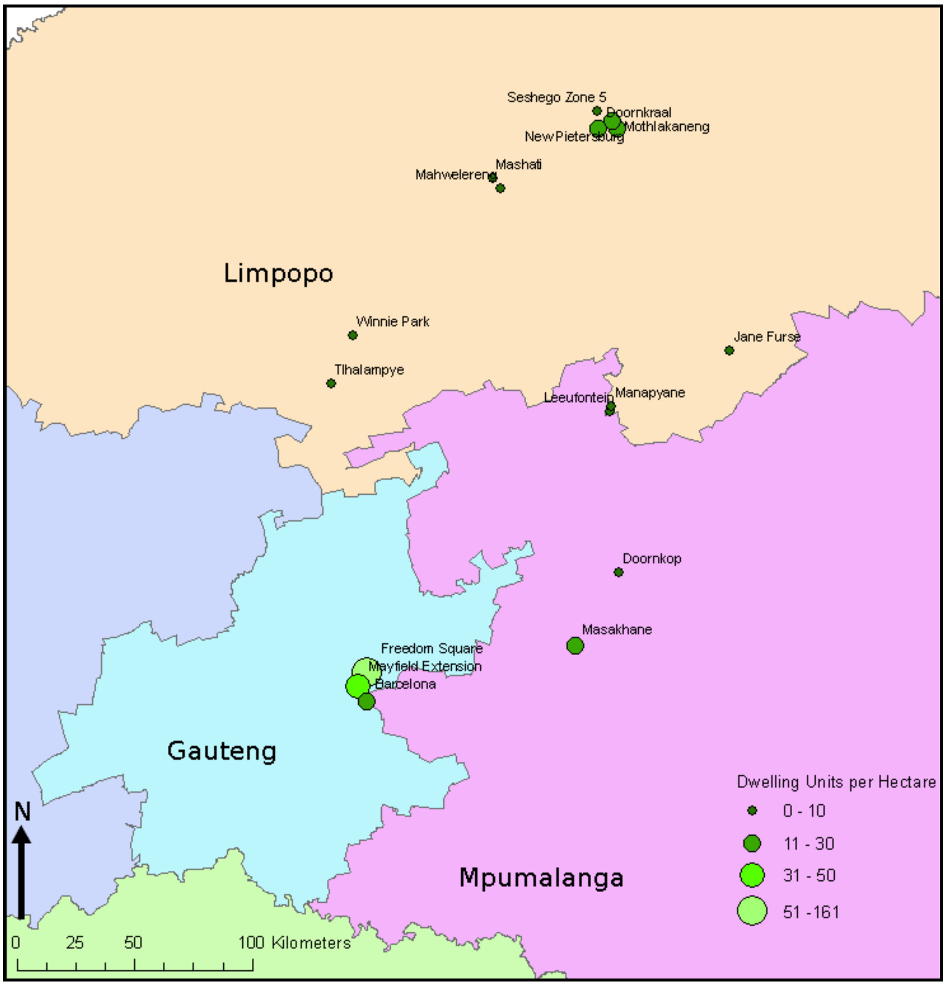

Figure D6.6: Settlement density figures for Limpopo, Mpumalanga and Gauteng

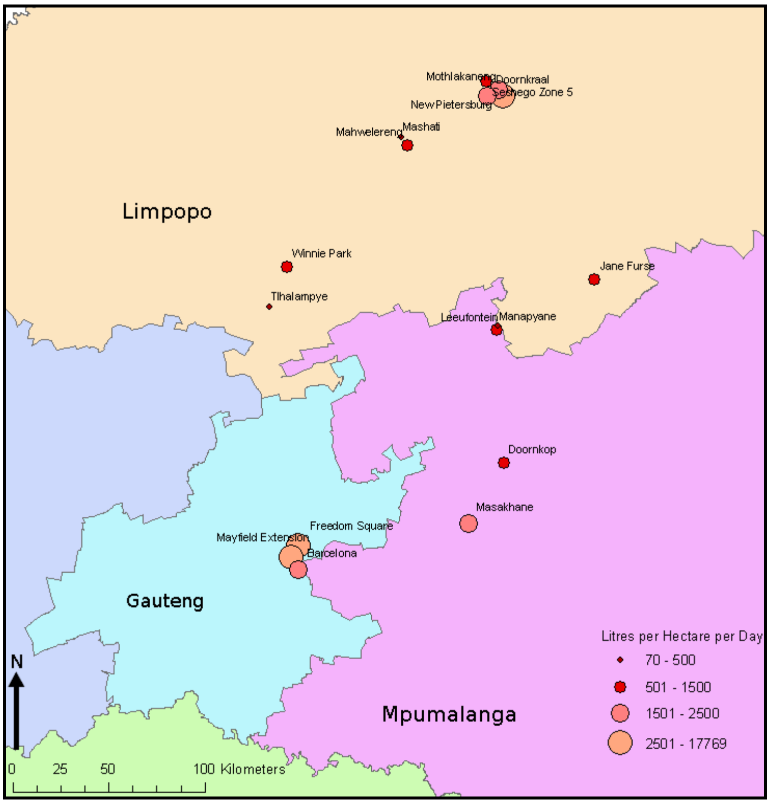

Figure D6.7: Greywater generation figures for Limpopo, Mpumalanga and Gauteng

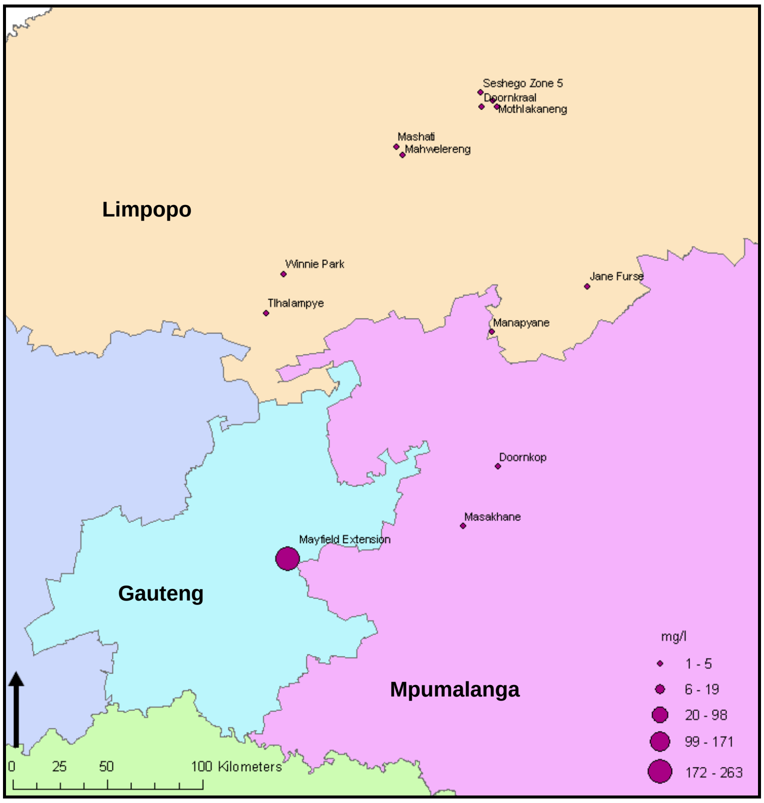

Figure D6.8: Total Phosphorous figures for Limpopo, Mpumalanga and Gauteng

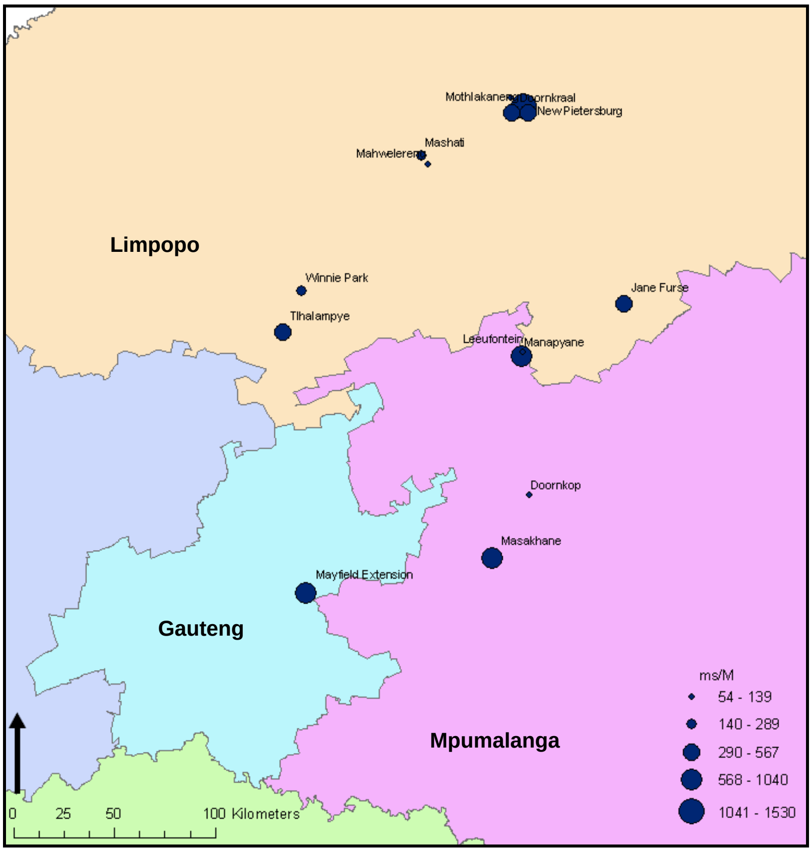

Figure D6.9: Electrical Conductivity figures for Limpopo, Mpumalanga and Gauteng