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Sustainable Water and Waste Management in Remote Desert Environments

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SUSTAINABLE WATER AND WASTE MANAGEMENT IN REMOTE DESERT ENVIRONMENTS

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Submitted to: Desert Research Foundation of Namibia and The Gobabeb Research and Training Centre
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ABSTRACT

Water and waste management are increasingly difficult challenges in today's world, especially in remote areas like the Namib Desert where the Gobabeb Research and Training Centre and Topnaar people reside. Our project recommended ways to improve sustainability of water and waste systems at the Centre by introducing biodegradable detergents and better recycling, and to improve sanitation in the Topnaar settlements through better solid waste management. Our recommendations helped the Centre and the Topnaar achieve sustainability in a sensitive desert environment.

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AUTHORSHIP

All group members contributed towards the final version of this report. Each section was written by one group member and then given to the rest of the group for major edits and revisions. This process of revisions made it impossible to attribute any section to one individual group member. Below are the main focuses of each group member:

- Marissa Goerke - Presentation preparation and creating the GRTC Water Map.
- Brendan Henrich – Editing the report for tone, diction, and writing style.
- Natalie McMillan - Editing the movie and collection of trickle filter data.
- Kelsey Wall - Analyzing water data and working with the Topnaar staff.

Finally, all sections of the final report were read aloud for final group review and approval.

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DEFINITIONS AND ABBREVIATIONS

Waste water – used water in general.

Greywater – used water from domestic uses like washing dishes, laundry, and showers. Greywater can be filtered and recycled and used again for other purposes like gardening.

Black water – used water containing human waste.

Trickle filter – a filter using a fixed bed of material like sand to filter water.

Dry Toilets – toilets that can be implemented in rural settlements in arid areas. This sanitation method takes advantage of the dry climate to dry out human waste. There are several different designs of dry toilets; the ones in place in the Topnaar Settlement are Otji Toilets.

Solid waste – domestic refuse, though the types of garbage generated may vary between sites and cultural domains.

Recycling – reuse or repurposing of any material or object that could be considered waste

Topnaar People – The Topnaar People are a sub-group to the Nama people. They are historically a group of hunter gatherers but they no longer can hunt because they reside in a national park. The Topnaar are settled in the Kuiseb basin about 100 km away from Walvis Bay.

GRTC – The Gobabeb Research and Training Centre

DRFN – Desert Research Foundation of Namibia

EXECUTIVE SUMMARY

Inadequate sanitation, waste, and water management causes the majority of deaths worldwide (Prüss-Üstun, 2008). Clean water and living spaces are essential to good human health, but many places in rural Namibia do not have access to such important necessities. Geographic location, environment, government involvement, and lack of funding all play a role in the condition of water and waste management systems in isolated areas. The focus of our project is on water and waste management at the Gobabeb Research and Training Centre (GRTC) and the nearby Topnaar settlement, both of which are remotely located in the Namib Desert.

The GRTC, a mecca for desert researchers, has made great strides to maximize the effects of its research while minimizing its effects on the environment. However, improvements to the water and waste management systems will support their most important long-term goal: sustainability in a sensitive desert environment. The GRTC bores water from the Kuiseb River bed, but since many water meters at the Centre are missing or broken, knowledge of how much water is used is unknown. The GRTC recycles waste water through a trickle filter, but bacteria killing detergents have been limiting the effectiveness of the filter. Despite separating recyclables from garbage at the Centre, all waste, regardless of its recyclability, is recombined and brought to the landfill in Walvis Bay. Our project sought to find solutions to these problems.

As the GRTC seeks to improve sustainability, the Topnaar settlement seeks to improve their sanitation practices. In the Topnaar settlement, beyond the existence of water pumps, storage tanks, and some dry toilets, waste and sanitation practices are unknown. Our project aimed to improve water and sanitation management in this settlement, improving the quality of life for the Topnaar.

The project goal was to make recommendations to improve water and waste management at the GRTC and in the nearby Topnaar settlement. Our project focused on improving the water metering system, determining appropriate biodegradable detergents, and improving the solid waste cycle at the GRTC.

FINDINGS

Water use at the GRTC

Finding 1: There is limited knowledge of the water system at the GRTC. Staff members are unaware of the location and working status of various elements of the water system, such as water meters, pipes, and shut offs.

Finding 2: Several water meters are broken or missing from the Centre's buildings.

Finding 3: There is a lack of consistent and accurate water meter readings, which leads to gaps in the water use records.

Detergents at the GRTC

Finding 1: Detergents, ranging from cleaning products to soaps used for bathing, are not biodegradable.

Finding 2: There is no education on the detergents' negative effects on the trickle filter. Most people are unaware of the problems non-biodegradable soaps are causing.

Solid waste at the GRTC

Finding 1: Plastics are the most common type of garbage.

Finding 2: Recyclables are separated, but later recombined with all garbage and then brought to the Walvis Bay landfill.

Waste and Sanitation Practices at the Salt River Topnaar Village

Finding 1: The water from the Salt River storage tank is safe to drink, but contamination from unclean drinking vessels and personal storage containers may compromise the safety of the water.

Finding 2: Garbage is either left in a mining test hole or discarded on the ground, away from homes and near the Kuiseb River bed.

Finding 3: There are no dry toilets at the Salt River Topnaar settlement, but residents are interested in having them.

RECOMMENDATIONS

Our recommendations for *water management* at the GRTC are to:

- **Install water meters at all buildings without them, fix water meters that are broken, and label all water meters for easy identification.** Our map of the water system outlines where the missing and broken meters are located.
- **Regularly and accurately record the water meter readings in *The Water Management Database,* a spreadsheet we created to facilitate record keeping and analysis.** Our findings show that water meter readings are recorded by hand using charts with varying layouts. Our spreadsheet simplifies the process: all data is stored in one place, in the same format, and is easily analyzed.
- **After completing the above two recommendations, create an educational display showing water use statistics**. Our findings show that there is a lack of understanding of the water system at the GRTC, and with an educational display, we believe that increased awareness will lead to more responsible water use.

Our recommendations for *waste water management* at the GRTC are to:

- **Use the biodegradable detergents from Cernol Chemicals and monitor the effects on the trickle filter.** Walter Holch, the Centre's technical advisor, should be present, as he can best discern any changes at the trickle filter.
- **Do further research on providing biodegradable detergents (or soaps) to all visitors though dispensers in showers and at the sinks.** We found that residents are willing to use a standardized, biodegradable soap, but finding an appropriate product requires more research.

Our recommendations for *solid waste management* at the GRTC are to:

- **Reorganize recyclable categories to match those of Rent-A-Drum: plastic, cans, paper, and glass, and then use Rent-A-Drum's recycling service**. We have created new signs that can be placed above the bins. Residents already correctly separate recyclables from garbage, so we believe

that this recommendation will be easy to implement and greatly improve the Centre's contribution to sustainability.

- **Separate compost into trickle filter sludge and food found in the organic waste bins.** The organic compost should be used in the garden. As far as the compost of human waste from the trickle filter, further research must be done into its potential safe reuse.

Our recommendations to *improve conservation education* at the GRTC are to:

- **Show our orientation video to all visitors to the Centre upon their arrival**. The video welcomes viewers to the GRTC and increases awareness of the water and electrical systems and sustainability practices.
- **Explain to the cleaning staff why certain soaps and cleaning practices are discouraged.** Better communication between the cleaning staff and the managers would lead to more sustainable cleaning practices.

Our recommendations to *improve water and sanitation management* in the Topnaar settlements are to:

- **Build a fence around the hole serving as the garbage collection site in the Salt River Topnaar settlement, and then research a longer-term solution to solid waste management;**
- **Improve the relationship between the GRTC and the nearby Topnaar settlements**, in ways such as a GRTC sponsored garbage clean-up day;
- Do further research on educating the Topnaar on repair and maintenance of their solar powered water system;
- Do further research on education on the importance of clean drinking vessels and storage containers;
- Do further research on improving human waste management.

Our recommendations lay out important steps for improving the sustainability of the GRTC and the quality of life of the Topnaar. We present these recommendations to the Desert Research Foundation of Namibia and the GRTC hoping that continued work on these topics will improve water and waste management in the lower Kuiseb River basin.

1. INTRODUCTION

Lack of effective clean water, waste water, and solid waste management systems is detrimental to people's health, as unmanaged water and waste systems can carry deadly diseases. Unfortunately, access to sanitation facilities is a widespread problem: an estimated 55% of people in rural areas worldwide lack access to such facilities (CIA, 2012). Figure 1 illustrates the percentage of people with access to sanitation facilities by country. Inadequate access leads to almost four million deaths every year from sanitation, water, or poor hygiene related diseases, with the vast majority occurring in developing countries (Prüss-Üstün, 2008). For example, in Africa most solid waste disposal sites are simple, open air dump sites, such as the one seen in Figure 2, which are unsanitary and pose major health and ecological concerns as diseases or pollutants can enter groundwater supplies (Koen, 2005). The situation is even more critical in rural Namibia, where 83% of the population does not have access to sanitation facilities and 75% does not have access to clean water. This poor access underlies over half of the deaths in children under 5 years old (Xoagub, 2012; CIA, 2012; Smith, 2011).

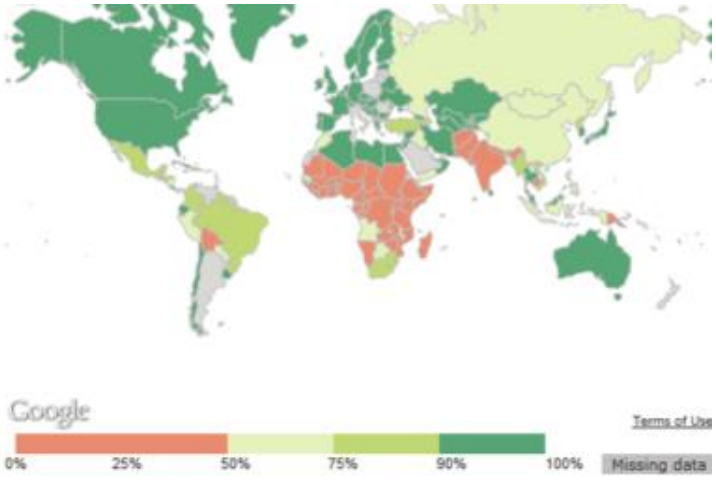

Figure 1: Access to Improved Sanitation Facilities (Data Resources and Estimates. 2011).

Water and waste management should be dealt with properly; however, this is not the case at the Gobabeb Research and Training Centre (GRTC) and in the Topnaar settlements in the Namib Desert (DRFN, 2007). This is at least in part due to the remote location and limited resources in the lower Kuiseb River Basin, which runs through the Namib Desert. Although water and waste management practices at

the GRTC are adequate, there is significant room for improvement in, for example, their solid waste collection and waste water recycling systems. In the Topnaar settlements, there are dry toilets available in some villages, but there are no solid waste management systems.

Figure 2: Open Air Dump Site

Water, waste water, and waste can all be managed in a responsible way, but the means are determined by the nature of the waste and the available resources. In developing countries, unclean delivery systems and storage containers can contaminate drinking water, which can be cleaned to drinking quality through filtration or chlorination (Lantagne et al., 2006). Waste water can be recycled, for purposes other than drinking, through trickle filters, activated sludge systems, or sand filtering (Ghunmi et al., 2011). To effectively manage waste in isolated areas with limited resources, various composting, recycling, and solid waste collection programs have been developed (Koen, 2005). Human waste is often managed with septic tank systems, dry toilets, or honey buckets in remote areas, as alternatives to a municipal sewer system (EPA, 1999). At the GRTC and nearby Topnaar settlements, various methods have already been implemented to address waste and sanitation problems. The GRTC currently has a trickle filter to process their waste water, a transportation plan to dispose of their solid waste, and a septic system to manage human waste. The Topnaar settlements have government provided storage tanks and pumps to safely store and dispense water, and some settlements have dry toilets to manage their human waste, though the toilets are reportedly unused.

Improvements to water and waste management have been implemented at the GRTC and Topnaar settlements, but there are problems and unaddressed issues with the current solutions. At the GRTC, detergents have been reducing the

effectiveness of the Centre's trickle filter, and a study into the types of detergents used and which detergents would be better for the trickle filter has not been completed. The types and amounts of solid waste generated at the GRTC and the amount of water used have also not been recorded or monitored adequately. In addition, education about the various systems at the Centre, such as the water or electrical systems, and proper sustainability practices is lacking, which exacerbate these systems' inefficiencies. In the Topnaar settlements, beyond the existence of water pumps, storage tanks, and some dry toilets, waste and sanitation practices are unknown.

The goal of this project was to develop a series of recommendations to improve the waste, clean water, and waste water management primarily at the GRTC and peripherally in a nearby Topnaar settlement. To assist our sponsors, the Desert Research Foundation of Namibia and the GRTC, we developed separate research objectives for each location. For clean water, we determined the quantity of water used at the GRTC to make recommendations on how to better record the information and thus help the GRTC better manage its water. For waste water, we determined which detergents would be best to use at the GRTC and recommended replacement detergents based on compatibility with the trickle filter and cost. We determined the types and quantities of waste by performing a waste audit. With this information, we made recommendations for a more sustainable waste cycle through recycling. To promote education of the various systems and sustainability at the GRTC, we created an orientation video to demonstrate appropriate practices to long-term researchers and visitors alike. For the Topnaar settlements, we observed current waste and sanitation practices and made recommendations to promote healthier living conditions. The solutions for the management of clean water, waste water, human waste, and solid waste that this project identified are crucial to improving the sustainability of the GRTC and the future quality of life in the Topnaar settlements.

2. BACKGROUND

Managing water and waste are increasingly challenging problems in the world today. In this chapter we will examine how clean water and different forms of waste are managed throughout the world. We will also describe the general conditions of water and waste management at The Gobabeb Research and Training Centre and in the nearby Topnaar settlements, both located in the Namib Desert in Namibia.

2.1 WATER AND WASTE

Clean water and sanitary living spaces are essential to human life (United Nations, 2005). Satisfying these physiological needs forms the base of Maslow's Hierarchy and must be addressed for any population to function and grow (McLeod, 2011). The methods developed for the delivery of clean water and proper waste management have been essential to the growth of civilizations (Gadgil, 1998). Without a clean environment and clean water, diseases can spread and threaten human life.

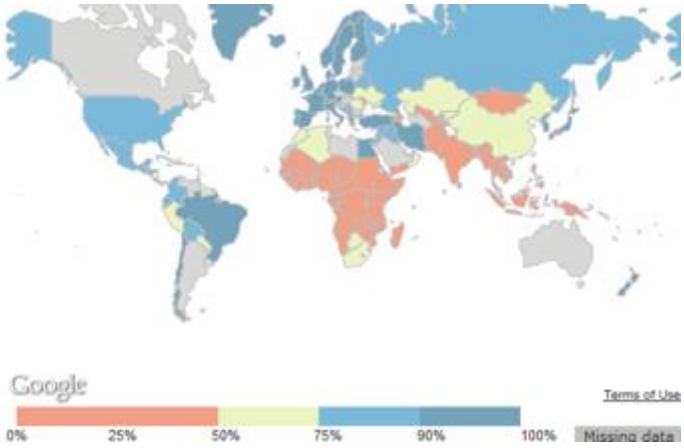

Figure 3:Percent of Population with Piped Water Supply (Joint Monitoring Programme, 2010).

Both the delivery of clean water and the removal of waste water from homes are essential to promote healthy living conditions (Gadgil, 1998). Everyone needs access to clean water, but throughout the world different challenges are faced in accessibility and availability of clean water. Waste water should be transported away from homes in a sanitary manner, but not everyone has the luxury of modern infrastructure, as demonstrated in Figure 3. Waste water can also be reused by

adopting various forms of filtering to clean it, which is especially important for countries with scarce supplies of water.

2.1.1 Clean Water

An average person needs about 2.5 liters of potable water a day to survive, so the availability and condition of water is essential to life (Gadgil, 1998). Clean water, or potable water, is defined as water safe to drink. Clean water must have acceptable quality in terms of its physical, chemical, and bacteriological characteristics. In populated, developed areas, clean water is delivered to homes through public water lines. This water is generally taken from reservoirs and filtered and often treated with chlorine. Besides water lines, people can also access potable water through wells (either personal or public) or by collecting rainwater. These two alternative methods are more applicable to developing countries and less densely populated areas.

Despite being essential to life, potable water is not available to everyone. As of 2010, only 54% of the world had access to piped public drinking lines and only 28% of less populated, rural areas had access to piped water (Gadgil, 1998). Due to poor access, about half the population in the developing world is suffering from one of the six main diseases attributed to lack of clean water: dysentery, Ascaris, Dracunculiasis, Hookworm, Schistosomiasis, and Trachoma. These diseases are caused by waterborne viruses, bacteria, worms, or other parasites, which can be found in unclean or untreated water. Occurrences of these diseases are especially high in rural areas of Africa, for example, where only 25% of the population has access to clean water (Joint Monitoring Programme, 2010).

Due to the severity of water-borne diseases, there has been extensive research into practical household water treatment and safe storage in developing countries. The most common methods for treating water are chlorination, filtration, and solar disinfection (Lantagne et al., 2006). Of these methods, chlorination and solar disinfection are the most cost effective, easiest to implement, and practical on a small scale. Chlorination involves treating drinking water with a small amount of

chlorine that kills most bacteria and viruses. The only cost associated with chlorination treatment is the price of the chlorine solution: no tools are required. However, chlorination is not always effective against some organic and inorganic contaminants, and it does affect the taste of the water. Another method of water treatment is solar disinfection, which involves placing water filled plastic bottles on a sunny roof or rack for several hours. The sun's ultraviolet rays destroy bacteria and viruses found in the water. This inexpensive method can be a boon to poor, rural settlements, such as the Topnaar of the Namib Desert, as this process only requires plastic bottles. This technique, however, is not effective in cleaning visibly dirty water.

2.1.2 WASTE WATER

Waste water comes in two forms: greywater and black water. Greywater is used domestic water, including used water from sinks, showers, and laundry, but not from toilets (Ghunmi et al., 2011; Mourad et al., 2011a). Greywater amounts to 60-75% of the total waste water produced worldwide; the other 25-40% is black water, which is used water from toilets. Black water requires extensive, often expensive, treatment to be able to be reused, and as such, greywater is generally the only form of waste water reused. There are some notable exceptions to this practice, such as the Olympic Park in London, which recycles black water for reuse in toilets and in gardening, and in Windhoek, Namibia, where black water is treated and put back into rivers (Fulcher, 2012; Lahnsteiner, 2005). Waste water is a resource that can be used to address water shortages everywhere: from non-arid first world countries to arid developing countries alike. In both areas, waste water reuse has become more widespread due to overuse of the available fresh water resources (Arnell, 2006; Ghunmi et al, 2011b).

Wastewater reuse is part of the solution to the worldwide problem of clean water overuse. However in its raw form, waste water is unusable and must be treated. Irrigation with untreated waste water can introduce unwanted pathogens or surfactants (environmentally harmful chemicals present in detergents) into the

environment (Mourad et al., 2011; Gross, 2008). Pollutants in waste water caused by detergents are difficult to remove and chemically stress the water (WHO, 2006a). These pollutants could eventually enter the groundwater where they would become part of the ecological system. There are, however, alternative detergents, generally referred to as "green", that do not contain these pollutants (Schagen, 2012). Raw waste water also contains solids in suspension, which clog dispersal systems (Ghunmi et al., 2011b). To reuse wastewater, filtration is clearly necessary, but the level of waste water treatment is dependent on the means and resources of the people who want to reuse it. The types of systems used can vary from expensive industrial water filters, to less expensive trickle filters.

In developed nations, waste water will go through any number of preliminary, primary, secondary, or tertiary treatment stages depending on its final purpose (Water UK, 2006). The amount of filtration required depends on the country's waste water reuse standards (WHO, 2006b).

The first stage is preliminary treatment, which consists of removing solids from the water, such as waste, grit, oil, or grease (Water UK, 2006). Next is primary treatment, where waste water flows into settlement tanks and the heavy organic material contained in the waste water sinks to the bottom and is removed. In some instances, a nutrient removal process is also implemented where iron or aluminum salts are added to reduce excessive plant growth. This process is commonly used when biodegradable detergents are found in the waste water.

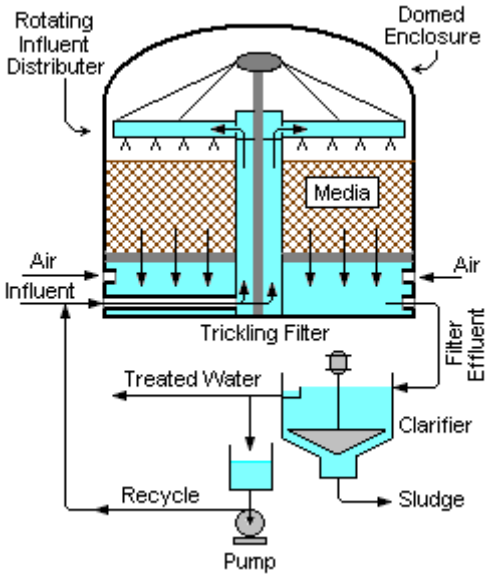

Figure 4: Trickle Filter

The remaining liquid portion of the waste water is then subjected to a secondary, biological treatment stage. Possible types of secondary treatment are biological filtration, activated sludge systems, or hybrid systems (Water UK, 2006; Sutherland 2007). Biological filtration is most

commonly seen in trickle filters, seen in Figure 4. Trickle filters remove organic pollutants from water by passing waste water over a medium, which, over time, becomes covered with a biological film, referred to as sludge. The sludge contains bacteria that degrade the organic waste in the water. However, chemicals in non-biodegradable detergents kill these essential bacteria, and without them, there is a buildup of sludge and the trickle filter is less effective. When appropriate detergents are used, however, trickle filters are easy to setup and maintain and are excellent for small to medium sized communities where larger, land intensive treatment systems are not applicable and power is scarce (EPA, 2000).

The final step in filtering water is tertiary treatment, where water is passed through sand filters, ponds, or wetlands to further clean the water. This step is only done where high quality water output is required, such as in places where plant life is particularly sensitive (Water UK, 2006; Sutherland, 2007).

Beyond tertiary treatment, water disinfection by ultraviolet light or filtering through fine membranes can enhance water to bathing quality (Ghunmi et al., 2011a). Due to the treatment of water with bacteria during the recycling process, recycled water must go through intensive steps to go on to become potable drinking water.

Even in developed countries, all four steps in water filtration are not always used (Ghunmi et al., 2011a). However, developed countries have the means to utilize all of the steps and can afford expensive treatment options, whereas developing countries have more limited resources. Despite this, waste water reuse is most important in developing countries with limited supplies of water.

It has been estimated that within the next 50 years, more than 40% of the world's population will live in countries with water scarcity (WHO, 2006a). Waste water reuse is thus a vital means of water conservation, especially in arid climates such as in Namibia. However, there are potential concerns when recycling water in arid climates, as identified by a study conducted in Israel (Gross et al., 2008). The concerns included: 1) water leaching from treatment systems could contaminate water supplies such as rivers or aquifers; and 2) poorly treated water can lead to

surfactant buildup in arid soils, which leads to water repellent soil that would inhibit much needed aquifer replenishment through rainfall. However, the study also found that due to the inherent properties of sand, some natural filtration would occur, which would enhance the effluent quality beyond its treated state.

2.2 Waste Management

Waste must be properly treated to maintain a clean environment (Municipal Solid Waste, 2013). Waste comes in three main forms: solid waste (garbage), human waste, and waste water. People throughout the world have different methods to deal with these types of waste.

2.2.1 Solid Waste

In developed countries, solid waste is collected through publicly or privately organized pickups and delivered to landfills (US EPA, 2012). Solid waste can also be recycled, reducing the amount of pollutants entering the earth through landfills. Common recycled materials are paper, glass, metals, and organic waste. However, solid waste is not always disposed of properly, both in developed and less developed countries. If solid waste is not disposed of properly, it can have adverse ecological effects on wildlife and the environment, and pollutants such as pesticides, heavy metals, oils, or non-degradable chemical compounds can enter groundwater supplies or can be accidently consumed by humans or animals alike.

To determine the types of solid waste generated in a community, a waste audit can be performed. Waste audits are studies that identify where waste is coming from, what types of waste there are, and where it ends up (Municipal Solid Waste, 2013).

A previous WPI research group performed a waste audit in Costa Rica to determine what types of solid waste were being produced (Ouellette et al., 2011). Through waste audits, surveys, interviews, and on-site assessments, they were able to determine firsthand the nature of the waste generated by this community. They also spoke with community leaders and learned about their perspectives on what was considered garbage and what they saw as their problems with waste

management. The result of this project was the recommendation that the communities develop a composting, recycling, and municipal solid waste collection program. The team created a handbook for community leaders that broke down what types of solid waste should be recycled, composted, or collected, with the benefits and disadvantages of each process. Both the waste audit, which determined the nature, extent and perception of the problem, and the education process, which provided a relevant and useful solution to the community, can be applied to any form of waste management problems in rural communities.

2.2.2 HUMAN WASTE

Human waste is ideally collected through a sewer system, where both the solid and liquid (black water) forms of human waste are disposed of in a sanitary way. However, not everyone, even in developed countries, is connected to such a sewer system. These people must seek alternative methods of disposing of human waste, such as septic tank systems, honey buckets, or dry toilets. Septic Systems contain a septic tank, which holds and slowly separates solid and liquid waste, and after various methods of filtration, the clean liquid waste is released into the earth (EPA, 1999). The solid portion slowly builds up in the septic tank and must be removed when full. Honey buckets are buckets used for collecting human waste, which is by far the least sanitary of the methods of removing human waste discussed in this section. Dry toilets [Figure 5] are particularly useful for isolated populations. They work by separating the liquid waste from the solid waste and then drying out the solid waste as quickly as possible. A drying catalyst, such as ash, is generally found in dry toilets to accelerate the drying of the human waste. Once dry, the waste can be added to a compost. This waste management system requires little maintenance,

Figure 5: Dry Toilets

no power, no transport of waste, and produces fertilizer for farming if properly composted.

2.3 FACTORS AFFECTING WASTE MANAGEMENT IN NAMIBIA

Namibia, a developing country in the south-western section of Africa, has a highly arid climate and very low population density (IIASA, 2013). Rainfall is scarce in most areas, totaling only about 150mm per year on average. Most of the rainfall occurs between January and April and the region typically experiences its driest time between September and December.

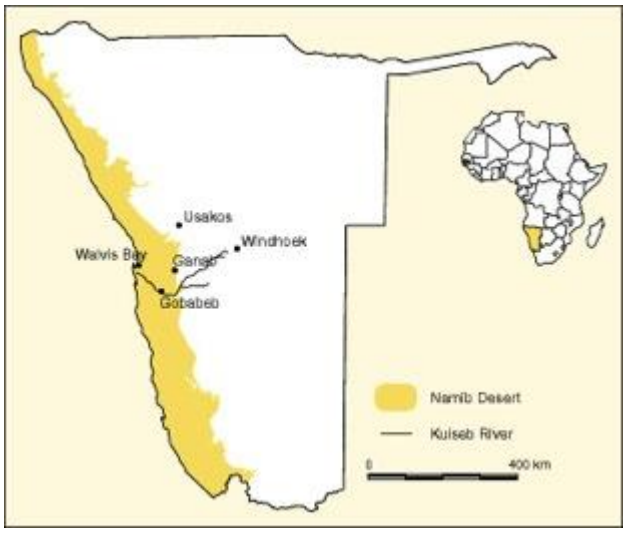

Figure 6: Namibia Map, showing Namib Desert and GRTC (Henschel et al, 2007)

Namibia is divided into thirteen administrative regions, with the focus of our project in the Erongo Region. The Erongo Region is located in the western central part of Namibia. The Namib Desert [Figure 6] covers the majority of the region, and there are only four ephemeral rivers that run through the region: the Swakop, Omaruru, Ugab, and Kuiseb (SAIEA, 2011). Approximately 110,000 people live in the Erongo Region with only 20% living in rural communities (Haukongo, 2001). The region has a very low population density, which is largely concentrated in the coastal towns of Swakopmund, Walvis Bay, and Henties Bay and the interior town of Arandis, while the rest of the population lives scattered throughout rural areas (NamWater, 2009). In the rural areas, there is little infrastructure to manage waste, meaning that the people must create their own means of disposal. The region's hot and dry climate contributes to high evaporation rates, which cause problems for water management. The conservation of water is essential in all parts of Namibia, especially in desert regions, and the recycling of greywater through filtration could be a boon to the people in retaining their already scarce water supplies.

The Topnaar settlements in the Namib Desert and the GRTC, the focuses of our project, are both located in the Erongo Region.

2.4 Water & Waste Management at the GRTC

Located in the middle of the Namib Desert, the GRTC [Figure 7] faces unique challenges in water and waste management as all systems need to be self-contained. The GRTC bores its own water, recycles its waste water, and manages its solid waste. However, with long-term sustainability in mind, these systems are not ideal.

Figure 8: GRTC in the Namib Desert

The GRTC has several different systems to manage its potable water supply. Water is pumped from a borehole across the Kuiseb River into the GRTC's iconic water tower, seen in Figure 8. The water is treated with chlorine provided by NamWater once a month. The water from the tower is then dispersed to the different buildings at the Centre and to a swimming pool. Each building at the Centre is equipped with a water meter, but it is unknown if they are all functioning correctly, and there is no known record of regular water meter readings. There are no limitations or strategies for management of water use at the Centre besides low flow showerheads and toilets, as well as some informational signs about restricting water use posted in many buildings at the Centre. Unfortunately, as the water lines at the Centre were not designed for a low flow system, any further reduction in the water flowing out of the buildings would cause clogging in the waste water pipes.

Figure 7: GRTC Water Tower

The GRTC has septic tanks as well as a trickle filter that process waste water.

Figure 10: Main Station Trickle Filter & Septic System

The GRTC would like to use the recycled water for the garden, but the trickle filter reportedly does not produce an effluent of a high enough quality, so the recycled waste water is sent into the Kuiseb River bed. The trickle filter performed well until residents began using non-biodegradable detergents, which killed both the anaerobic bacteria in the septic tanks and the aerobic bacteria in the trickle filter, seen in Figure 9 and 10. The bacteria break down organic waste within the system; so without them the waste water is not effectively cleaned. Due to these damaging detergents, the naturally occurring sludge became denser and harder to remove, which eventually lead to buildups that reduced the capacity of the tank. The Centre switched to a different type of biodegradable detergent after the sludge incident, but the trickle filter then suffered from a fungal bloom, causing blockages in the trickle filter and decreased performance. There are plans to add a polishing stage to the current system to increase the quality of the effluent, but it has yet to be implemented. The system and additional plans can be viewed in Appendix B.

Figure 9: Filtering of Water through the Trickle Filter

The Centre has three septic systems, one at the main Centre, Kuiseb Camp, and Tsabibis. The main Centre septic tank system collects waste water from several buildings and treats it in an anaerobic three-chamber septic system. Sludge from this septic system remains within the three chambers, and the output water is pumped up to the trickle filter. The Kuiseb Camp septic system, serving the accommodations at the Centre, also pumps its effluent to the trickle filter. The effluent from the last system at Tsabibis staff quarters drains directly into the Kuiseb River bed without filtering, but there are plans to update this system to include a trickle filter, as seen in Appendix C.

The GRTC separates recyclables from garbage but recombines everything to be delivered to a landfill in Walvis Bay, partially because Namibia lacks a strong recycling infrastructure. There are some companies attempting to bring recycling to Namibia, such as Rent-A-Drum, but this nascent effort has yet to be adopted across the country (Rent-A-Drum Recycling, 2011). The GRTC disposes of all its biodegradable waste in its composting container for use in the garden. However, residents at the Centre occasionally dispose of waste in the wrong bin, reducing the effectiveness of the separation and the compost.

2.5 Water & Waste Management in the Topnaar Settlements

The Topnaar people inhabit the western central Namib Desert near the ephemeral Kuiseb River, about 100 km from Walvis Bay. They reside in sixteen small villages, an example of which can be seen in Figure 11, ranging from one to several families each. Water is provided by the government to some villages using solar-powered submersible pumps and 5000-liter storage tanks from which water is distributed gravitationally (Mary Seely, personal communication, 1/28/13). Villages that depend on a piped water supply from NamWater sometimes cannot pay the water bills and are cut off. In regards to human waste, some of the sixteen Topnaar settlements have dry toilets to properly contain human waste. However, the dry toilets are reportedly not used, and according to Mary Seely, it is because the community members see no benefit in using them. Solid waste management in the Topnaar settlements is also a problem, as garbage is piled up relatively near to their homes and often not disposed of in a safe and sanitary way.

Figure 11: The "Salt River" Topnaar Settlement

There have been several past efforts in these communities to improve waste management. Last year, Mary Seely submitted a proposal to the United Nations for aid to improve sanitation in these villages, but unfortunately it did not receive

funding. Additionally, there was a meeting in 2009 between the GRTC and the Topnaar communities wherein requests to aid the settlements were discussed, but no actions had been taken as of May 2013.

2.6 SUMMARY

Proper water and waste management are essential to both human health and the success of civilizations. Around the world, people face different challenges in the delivery of clean water and removal of waste from their communities. The GRTC and the Topnaar settlements have made important strides in water and waste management, considering their location and available resources, but there is still room for improvement. In the next section, we detail the methods we took to make our recommendations to improve these systems.

3. METHODOLOGY

The goal of our project was to provide The Gobabeb Research and Training Centre (GTRC), in collaboration with the Desert Research Foundation of Namibia, recommendations to improve the water and waste management at the GRTC and in a nearby Topnaar settlement. We divided the management systems into water, solid waste, human waste, and waste water. At the GRTC we identified problems with the water, waste water, and solid waste management systems and how they could be improved. In the Topnaar settlement, we determined the current sanitation practices and ways that the village waste management could be improved. In this chapter we explain the methods that we used to accomplish our research objectives.

3.1 WATER, WASTE WATER, AND SOLID WASTE MANAGEMENT AT THE GRTC

Our primary focus at the GRTC was to determine the quality and performance of the water, waste water, and waste management systems in order to identify sustainable improvements to these systems. To improve the water system at the Centre, we created a diagram of the water and waste water system, performed daily water meter readings, conducted informal interviews on water use, performed water quality testing on the drinking water, and analyzed the previous five year's weekly water meter readings. To improve the waste water management system at the GRTC, we performed direct observations of the current waste water system, conducted informal interviews about waste water practices, performed water quality testing on the effluent being produced by the trickle filter, performed a twelve-hour reading of the trickle filter flow rate, and analyzed the turbidity of the output of the trickle filter. For solid waste management practices at the GRTC, we followed a similar methodology: we created a diagram of the solid waste management system, carried out direct observations at the waste collection areas, conducted informal interviews about waste disposal practices, and performed a waste audit. We spent two weeks at the GTRC at the end of March and another week there in the second half of April to complete our field research.

3.1.1 WATER MANAGEMENT

Originally, there were no usable plans of the layout of the water and waste water network at the GRTC. To give the new director of the GRTC, Dr. Gillian Maggs-Kölling, and her staff information on water and waste water management, treatment, and reuse, we created a diagram of the layout of these networks. To create the diagram, we first met with Andre Boeker, an intern researcher, and Noah Fribley, a training coordinator, at the GRTC. They took us on a tour of the buildings connected to the water and waste water system. We then went on a tour with Sameül //Gowaseb, a general worker at the GRTC, who explained the technical side of the system. Next, we obtained a map of the GRTC from Noah Fribley, where we drew in the locations of the pipe lines, manholes, septic tanks, and the trickle filter. Additionally, we indicated locations of the water meters and their operational status. Finally, we took our annotated map and transformed it into a graphic representation of the water and waste water system using Photoshop. The diagram helped us to understand the system and it could be used to educate current and future staff at the Centre.

We also obtained the records of water meter readings that the Centre had been collecting for the past five years and analyzed it using Excel. We examined this data to determine where the most water is used and if an educational tool could be developed to show the residents of the Centre how much water is used on a monthly basis. Additionally, to understand how the meters worked and to verify the current reading system the Centre has in place, during our second trip to the GRTC, we made full system readings on Monday, Wednesday, and Friday. This helped us to understand the flaws in their current system as well as where improvements could be made. We also conducted readings, and obtained flow rates, every hour between 8:00 and 20:00 on Tuesday, April 16th, at the main water tower. We recorded all of this information into the tables seen in Appendix D. Analyzing this data showed us what times in the day the Centre uses the most water.

Finally, we conducted interviews to gather information on employees' opinions of the water quality, the amount of water they typically use, and the

current educational initiatives that exist on water conservation. A detailed outline of the questions we asked the GRTC staff can be found in Appendix E. During our interviews, many of the staff mentioned that they were concerned with the quality of the drinking water, so we performed basic water quality testing with a water testing kit provided by Walter Holch. We tested the water for hardness, pH, ammonia, ammonium, nitrate, nitrite, and phosphate levels following the included instruction manual (Appendix F). The results from this water quality test were recorded in the data chart found in Appendix G.

3.1.2 Waste Water Management System

To make recommendations for sustainable waste water management at the GRTC, we first needed to gather information, through observations and interviews, about the staff's and residents' normal usage of detergents. We spent a day helping the cleaning staff and asked them about the types and purpose of their cleaning detergents. We also walked through the interns' housing, labs, kitchens, and other relevant buildings at various times during the day to observe detergent use. We took pictures of detergents we found, noted their locations, and recorded the information on the observation forms (see Appendix H). However, it is important to note that we did not trespass or disturb people, as we made our observations during teatime when no one would be at their residence. Since we were not able to see what people used for their personal detergents, we continued to look into personal detergent use.

To further our research, we performed informal interviews with the residents. The interviews aimed to gather information on employees' knowledge of the trickle filter, what kinds of detergents they use, if their detergents are biodegradable, and if not, if they would be willing to use a biodegradable replacement. A detailed outline of the questions for the GRTC staff and residents can be found in Appendix E, the same outline that contains the water questions.

We directly observed the trickle filter's cleaning process to determine if there were any avoidable problems or inefficiencies during maintenance. Through sight,

smell, and water quality testing, we determined the quality of the effluent being produced. Like in the previous water quality test, we tested for pH levels, nitrite, nitrate, ammonium, and phosphate of the effluent. Additionally, we saw how the resultant sludge from the septic system was removed from the tank and moved to the compost bin. The observations and testing revealed the effectiveness of the filter and how the resultant sludge was managed.

We also conducted daily flow rate monitoring of the trickle filter to see how the cleaning process affects the flow through the filter. For one week every morning at 9:00, we measured the output flow rate by timing how long an arbitrary volume of effluent takes to drain. We then divided the volume of collected effluent by the time it took. This data is presented in the chart in Appendix I.

We also obtained trickle filter flow rates, every hour between 8:00 and 20:00 on Tuesday, April 16th. We recorded all of this information into the tables seen in Appendix D. Analyzing this data showed us what times in the day the trickle filter is treating the most water.

We also observed the turbidity of the effluent each day by placing it in a white bucket and taking pictures. We collected and compared these pictures in the data table shown in Appendix J.

Lastly, in order to make our recommendations to improve the trickle filter's performance, we looked into what biodegradable detergents are available in Namibia. We found the company Cernol Chemicals, went to their Windhoek office, and talked with a representative on appropriate detergents for the Centre. We also looked for and recorded available biodegradable detergents in grocery stores in Walvis Bay.

3.1.3 Solid Waste Management

To improve the waste cycle at the GRTC, we began by discussing the current solid waste management practices with Noah Fribley, who guided us through the facilities. We then explored waste disposal areas to learn about the solid waste flow through the Centre and we discovered that the GRTC staff collects all of the Centre's

garbage every Monday and Friday. We also saw how the staff handled the waste by determining if the garbage remained separated in various recyclable and non-recyclable categories. With this information, we compiled our findings in a waste flow diagram.

After we observed the main waste disposal sites, we took pictures of the collection sites at Old House, the intern living quarters, and our clay houses to gain a better understanding of the quantity and types of waste produced. The Centre's staff and residents sort their garbage into the following categories:

- Organic Waste (Labeled as Bio)
- Metal
- Paper and Plastic
- Glass
- Other

During our first week at the GRTC, we took pictures of these bins on Friday morning right before the garbage was collected. During the second week, we did the same on Sunday and Wednesday. When we returned for our third week at the Centre, we took pictures of the garbage on Sunday and Friday. The data is presented in the chart found in Appendix K.

We also investigated the Kuiseb River bed near the GRTC and the surrounding area to record any solid waste contamination that we found. Contaminated areas were photographed for future reference for the GRTC. The photos helped to document any safety hazards created by the waste buildup at the Centre.

As we walked around the GRTC making direct observations on solid waste management, we also conducted informal interviews with staff, interns, and any visitors we came across. The questions addressed the typical waste they disposed of and possible ways to improve waste management at the Centre. A complete outline of the questions can be found in Appendix E.

Lastly, to make our recommendations to improve solid waste management at the Centre, we researched recycling programs in Namibia. We found the company

Rent-A-Drum, and we visited their office in Windhoek to talk about various options for the GRTC.

3.2 Water and Waste Management in the Salt River Topnaar Settlement

Our objective in the Topnaar settlement was to determine the residents' current water and sanitation practices. Our research methods were designed to help us identify ways to improve the current practices surrounding clean water, solid waste, and human waste. To determine the sanitation status of the village, we spent a day observing the villagers' lives, the conditions in the village, and informally interviewing some villagers. We also performed water quality testing of the village's water supply. Our research methods for the Topnaar settlements reflected the limited resources, unknown sanitation practices, and limited literacy rate of the Topnaar population in this settlement. We traveled to the village with Sebedeus Swartbooi, a Community Intern at GRTC, who was originally from one of the Topnaar settlements. He was able to translate for us when we visited the village.

3.2.1 Building Trust

We first tried to build a rapport with the people living in Salt River Village to establish trust and open lines of communication. To do this, our team brought small games and candies. However, the Topnaar's trust of GRTC researchers had already been marred by prior experiences: we learned that we were not the first people to work in the village and that often times, nothing had come out of the research done in the settlement. We worked closely with Sebedeus to explain our purpose to the villagers and to find out what had gone wrong with the previous work.

3.2.2 Sanitation Practices

For water management, we observed the Topnaar's clean water practices and the condition of the village's water system. We used a water quality testing kit

to test the water in the storage tanks at the Topnaar settlement: we tested for hardness, pH, ammonia, ammonium, nitrate, nitrite, and phosphate levels. The details of the methods we used for each of the tests can be found in Appendix F, which are the same tests we used to test the water at the Centre.

To understand human waste management, we discussed the practices of the Salt River Village residents with Sebedeus and observed the different methods of human waste management the residents have implemented.

Lastly, we identified what solid waste was being produced in the village. We observed their garbage and where they disposed of it. While walking through the village and performing our direct observations, we had informal conversations with villagers to gain a better understanding of what they considered garbage and what their current waste management system was. These questions can be found in Appendix L.

3.3 SUMMARY

To make meaningful recommendations to improve the sustainability of the GRTC and the sanitation practices in the Salt River Topnaar Village, our group conducted interviews, performed observations, tested water quality, monitored flow rate and effluent of waste water, and performed a waste audit. Using these methods, we were able to gain a deeper understanding of the current management practices at both the GTRC and the Salt River Village. In the next chapter, we will present and analyze our research findings.

4. Results and Analysis

In this chapter we will present and analyze the results of our research at the Gobabeb Research and Training Centre (GRTC) and the Salt River Village. At the GRTC, we focused on four areas of research: water management, waste water management, solid waste management and conservation education. We have also included our findings on the water and waste management at the Salt River Topnaar village.

4.1 Water Management at the GRTC

This section covers our results regarding water management at the GRTC. These findings are based on data we collected from the water system tour of the GRTC, daily and hourly water meter readings, analysis of the past five years of weekly water meter readings, water quality testing of their drinking water, informal interviews about water practices, and direct observations.

4.1.1. Finding 1: Limited Knowledge of the Water System

Upon arriving at the Centre, we learned that there is limited knowledge among GRTC staff and residents about the water system. To best display our findings, we developed a detailed map of the Centre's water system, shown in Appendix M.

We found broken meters at Old House, Clay House three, and Luxury Hill five and missing meters at the Tsabibis staff quarters, the Kuiseb Camp, Villas, Clay House kitchens, Main Station, and Bungalows. Beyond broken and missing meters, we also noted broken and exposed pipes, pipe shut offs, water sources, and cockroach infestations. Pre-existing meters are also unlabeled, which contributes to flaws in accurate data collection. Additional information on the water system from our system tour can be seen in Appendix N.

4.1.2 Finding 2: Lack of Consistent and Comprehensive Water Meter Readings

The missing and broken water meters are a large contributing factor to the lack of consistent and comprehensive water meter readings. Upon analyzing the data from 2009 through 2012 (Appendix O), we discovered that 85% of the Centre's water usage is unmetered, as shown in the pie chart in Figure 12. Additionally, by combining the percentages of the metered guest buildings, we were able to determine that guests use about 10% of the Centre's water. To validate this data we analyzed the data from just the year 2012 in a similar manner, which can be viewed in Appendix P. It is important to note that these percentages and graphic representations were produced after removing all outliers caused by errors in data collection. Since the data is cumulative, outliers are defined as sharp peaks or dips. Examples of unacceptable meter reading outlier data, and their possible causes, are noted in Appendix Q.

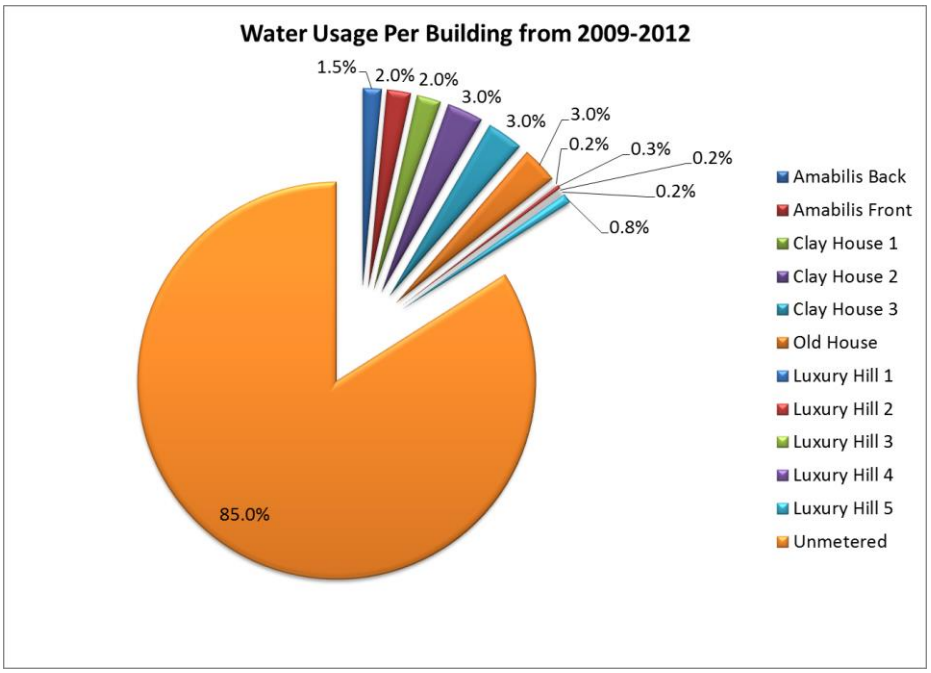

Figure 12: Water Usage Per Building from 2009-2012

We also discovered that, even with a consistent data sheet, there were still discrepancies in data collection. The discrepancies included differing numbers of significant digits and orders of magnitude. When we took meter readings for a week, we determined the correct way to read the meters, which can be seen in Table 1. Table 1 shows the number of meters cubed of water that has moved through that meter since it was installed.

Table 1: Daily Water Meter Readings

Date	Amabilis		Clay House			Luxury Hill Solar Geysers					Old House	Main Water Meter
	Front	Back	1	2	3	1	2	3	4	5		
15/4	920	572	730	796	Broken	83					Broken	393905
17/4	921	573	730	796	Broken	83	120.747	101.0784	83.8041	319	Broken	394078
19/4	921	573	730	796	Broken	83	120.747	101.1718	83.8946	319	Broken	3941679

The week of meter readings in Table 1 also shows that the functional meters do not change much daily. The blue cells mark which meters are filled with water, which, if they are not broken yet, soon will be. Additionally, the red cells indicate broken meters. No water was used in Clay Houses 1 and 2 because there were no residents in those buildings. Water was used to clean Amabilis during our meter reading time period, which is reflected by the small increase of two cubic meters. Amabilis would have used significantly more water if there was a large group using that building's facilities during our readings. Buildings like Villas, Kuiseb Camp, and Tsabibis, are not included because they do not have water meters.

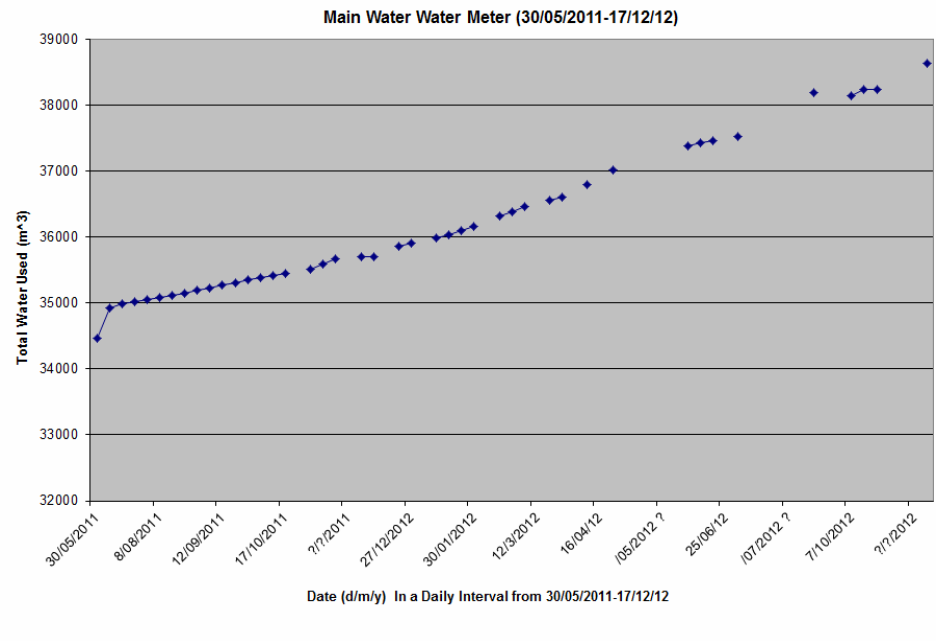

Figure 13: Main Tank Water Readings

We also found that water meters are not recorded consistently. For example, we graphed the total amount of water used by the Centre between May 30th, 2011 and December 17th, 2012, as seen in Figure 13. This chart reflects the total cumulative amount of water used. The dates marked with a "?" represents data that did not have a proper dates recorded for that data entry. The gaps in the graph demonstrate that there were no meter readings for several consecutive weeks during 2011 and 2012.

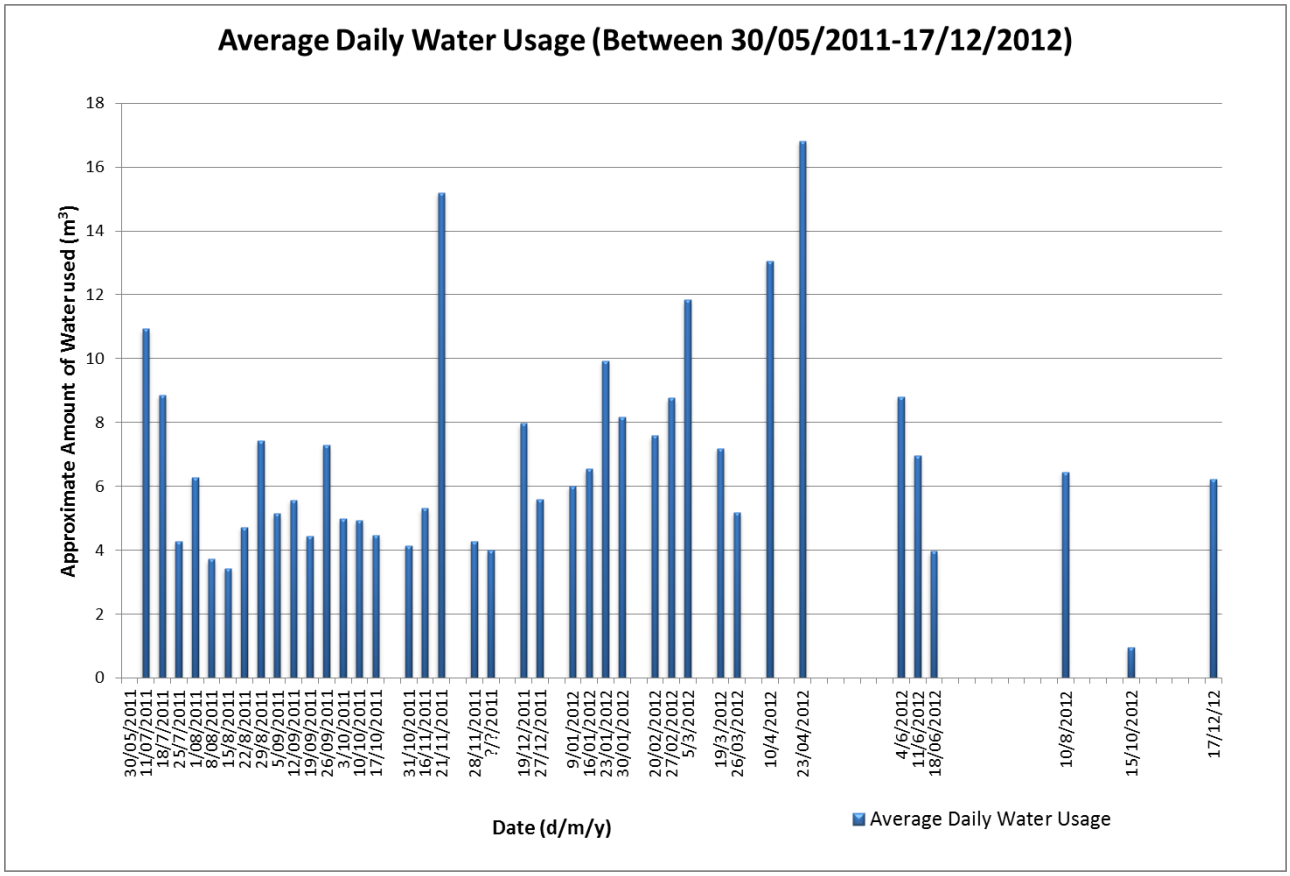

Figure 14: Average Daily Water Usage

Despite all of the analysis we were able to do, the inconsistent and inaccurate data prevented us from creating a graphic on how much water the Centre uses on a monthly basis and how much each building uses per year. However, we were able to calculate the average daily water usage between the meter readings (Figure 14). We did this by finding the amount of water used between each meter reading and dividing by the amount of days between readings. The average daily water usage over this period was 7.1 m^3. We were also able to determine through hourly water meter readings seen in Appendix R, that the Centre uses the most water at 10:00, 14:00, and 18:00.

4.2 Waste Water Management at the GRTC

This section covers our results on waste water management, particularly in regards to detergent use at the GRTC. These findings were determined through conversations, observations, and working alongside with the cleaning staff at the GRTC.

4.2.1 Finding 1: Types and Quantities of General Cleaning Detergents Used at the GRTC

Much of the information we discovered about cleaning practices at the Centre was contradictory. For example, the administration said the main Centre floors were cleaned once a month, but the floor was cleaned twice during our three-week stay. Also, some of the cleaning staff follow different cleaning procedures. Most of the cleaning staff limits detergent use by only using two or three dabs of detergent per cleaning surface, as seen in Figure 15. However, we found that one staff member used approximately 4 ounces of cleaning detergent for cleaning all of the offices in the main Centre. In all cases, after the detergent has been applied to a cloth, it is placed in a five litre bucket of water and the water is used to clean all of the office floors in the main Centre.

Figure 15: A Dab of Cleaning Solution

Some staff use a floor polish remover called Floor Strip in combination with the cleaning detergents Handy Andy and Mop & Shine, which is concerning because Floor Strip contains caustic chemicals. The frequency of cleaning varies: the majority of cleaning staff said they use floor polish once a month, but another said they only use it once every four months.

Figure 16: Dumping out Dirty Water

Another finding was that the staff are aware that excessive detergent use is bad for the trickle filter, but they do not understand why. They do not always pour soapy water down the drain, but may dispose of it outside, as seen in Figure 16, meaning

that most of the cleaning detergents reaching the trickle filter are the ones used to clean showers, toilets, sinks and any personal detergents. More detailed information on exact cleaning practices at the Centre can be found in Appendix S. The staff also mentioned that it would be helpful to have any new changes at the Centre discussed as a group, with Sebedeus or Josef present to explain anything they did not understand.

We also determined the quantities of detergents used at the Centre. Based on the information supplied to us by the management and from our observations, the cleaning staff approximately uses the amounts of cleaning detergents listed in Table 2 over the course of four months. While going through the detergent closet, we also found a 5-litre container of Swachem Namibia Bactiwash, a detergent containing bactericides, which could potentially be very harmful for the trickle filter.

Table 2: Non-Biodegradable Detergents Found In Old House

Type	Amount	Price
Ammonia	25 Liters	N$285.30
Floor polish	25 Liters	N$634.70
Floor Polish Remover	5 Liters	N$245.90
Dishwashing Liquid	5 Liters	N$77.60
Mop and Shine	25 Liters	N$303.50
Fabric softener	25 Liters	N$61.50

In an effort to introduce biodegradable detergents at the Centre, we researched biodegradable alternatives and looked into several companies and stores. First, we determined the available detergents at the grocery store Pick n' Pay in Walvis Bay, which is noted in Appendix T. There were no biodegradable shampoos or body washes available, but we did find one type of biodegradable laundry detergent, Bio-Classic, and dish soap, Bio-Crystal. However, we learned from meeting with a representative of Cernol Chemicals that detergents labeled as biodegradable may only be partially biodegradable or contain bactericides, which could be detrimental to the trickle filter. Therefore, it was essential for us to obtain product data sheets for any options for biodegradable detergents at the Centre. We also looked at acquiring detergents from Cernol Chemicals by consulting with a

representative to determine what kinds of detergents would work well with the Centre's waste water treatment system. Information detailing the detergents of which we acquired samples, including product data sheets, comparative pricing, and contact information for Cernol Chemicals, can be found in Appendix U.

4.2.2 Finding 2: Personal Detergents are Not Biodegradable

From observing the personal detergents used in the Centre's kitchens, laundry room, living quarters, and bathrooms, we learned that most detergents were not biodegradable. Figures 17 and 18 show all of the detergents seen in Old House, all eighteen of which were non-biodegradable.

Figure 17: Personal Detergents

Figure 18: More Personal Detergents

We supplemented our observations with interviews with the long term residents of the GRTC. We found that fifteen out of seventeen residents do not use biodegradable detergents, as shown in Figure 19. The full conversation summaries are in Appendix V and a spreadsheet organizing the answers to the interview questions is in Appendix W.

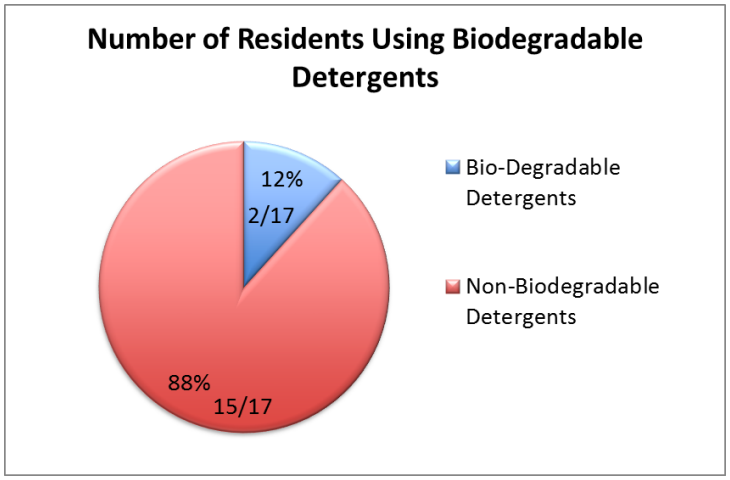

Figure 19: Number of Residents Using Biodegradable Detergents

The graph shows that the majority of the interns and researchers use personal detergents that are not biodegradable.

4.2.3 Finding 3: Residents are Unaware of Detergents' Effect on the Trickle Filter

Through interviews, our team discovered that most residents at the GTRC were not educated on the effects detergents could have on the waste water system and trickle filter. Figure 20 illustrates the level of education on the issue. The one person we counted as "aware" stated that he knew it was an issue but used non-biodegradable soaps and shampoos anyway.

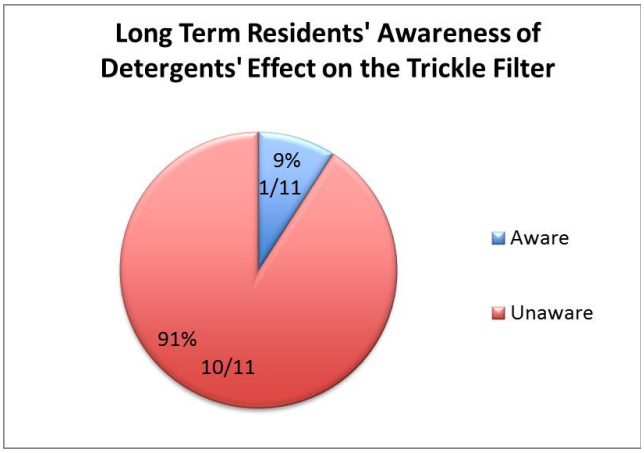

Figure 20: Long Term Residents' Awareness of Detergents' Effect on the Trickle Filter

In these same interviews, we also learned that there would be an interest in using a GRTC supplied biodegradable detergent. Figure 21 shows the residents' interest in using a Centre provided soap, shampoo, and dishwashing detergent. Of the residents interviewed, only one said he would not use it nor did he consider it a feasible idea. Six thought the idea was good, but were unsure if it would be successful. One had the concern that there was no infrastructure in place to manage the purchase of these detergents. The other five thought that long term residents, themselves included, might not want to use biodegradable shampoos because they were unsure of the effects it would have on their hair. However, they supported the idea for short term visitors. The other five respondents thought the idea was good and could be easily implemented.

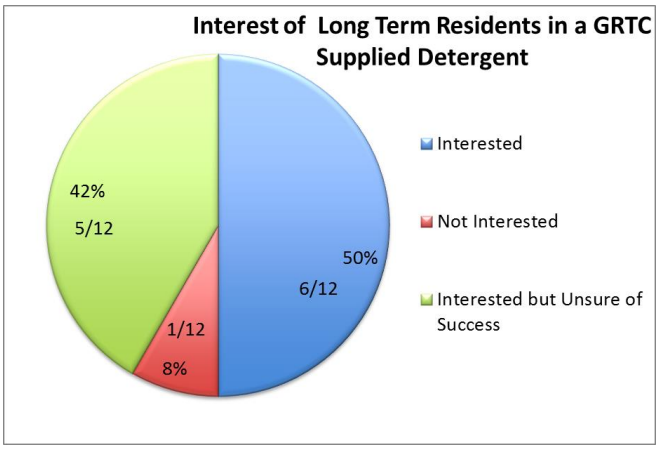

Figure 21: Interest of Long Term Residents in a GRTC Provided Biodegradable Detergent

4.2.4 Finding 4: Water Tower and Trickle Filter Flow Rate

Using the hourly main water meter readings, seen in Appendix R, we graphed the flow rate of the water leaving the tower over a twelve hour span, as seen in Figure 22.

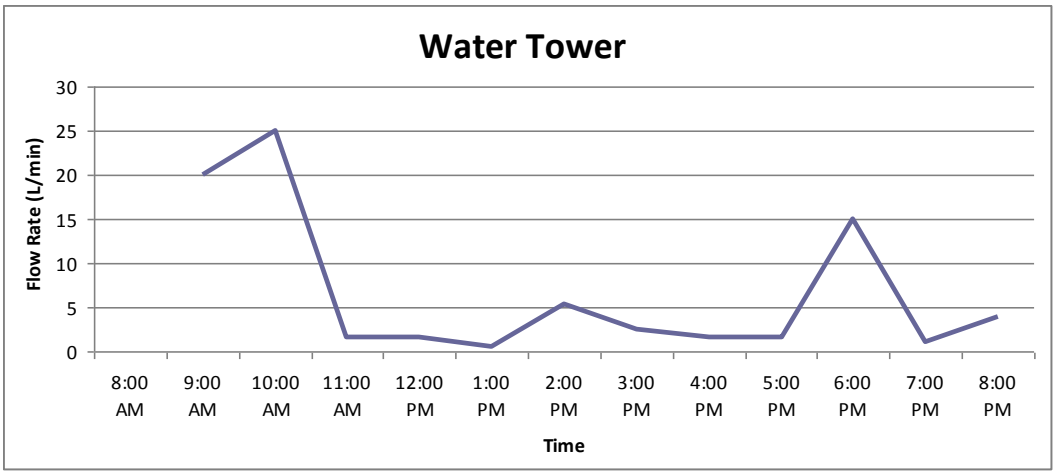

Figure 22: Water Tower Hourly Flow Rate

The graph shows that the peak water usage times are at 10:00, 14:00, and 18:00, suggesting that most water is being used around the morning tea time, lunch, and at dinner time. We also analyzed the flow rate out of the trickle filter over the same twelve-hour span, as seen in Figure 23.

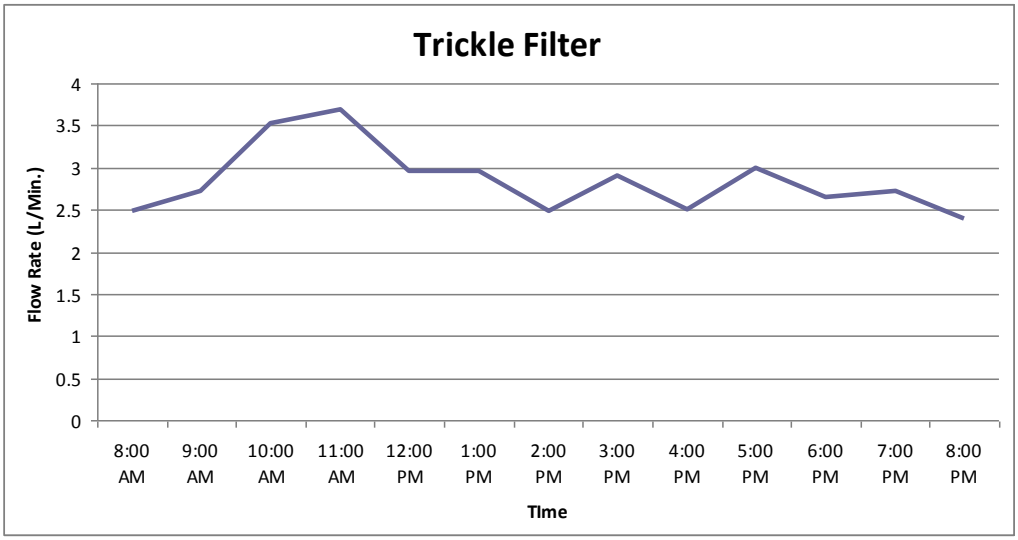

Figure 23: Trickle Filter Hourly Flow Rate

Figure 23 shows a main peak in the flow rate at 11:00. Based on this, we believe it takes about an hour or two for water to move through the system. We charted the daily flow rate data so that we could compare it with the system's reported capacity of 2.5 m^3 per day, as seen in Figure 24. On Monday and Thursday the flow rate was well within the system's capacity, and on Tuesday and Wednesday was just above

capacity. However, on Friday the flow rate of the trickle filter far surpassed the designed capacity of the system. This indicates that the waste water produced by the Centre may sometimes be too high for the capacity of the system. Additional daily and hourly flow rate data can be viewed in Appendix X.

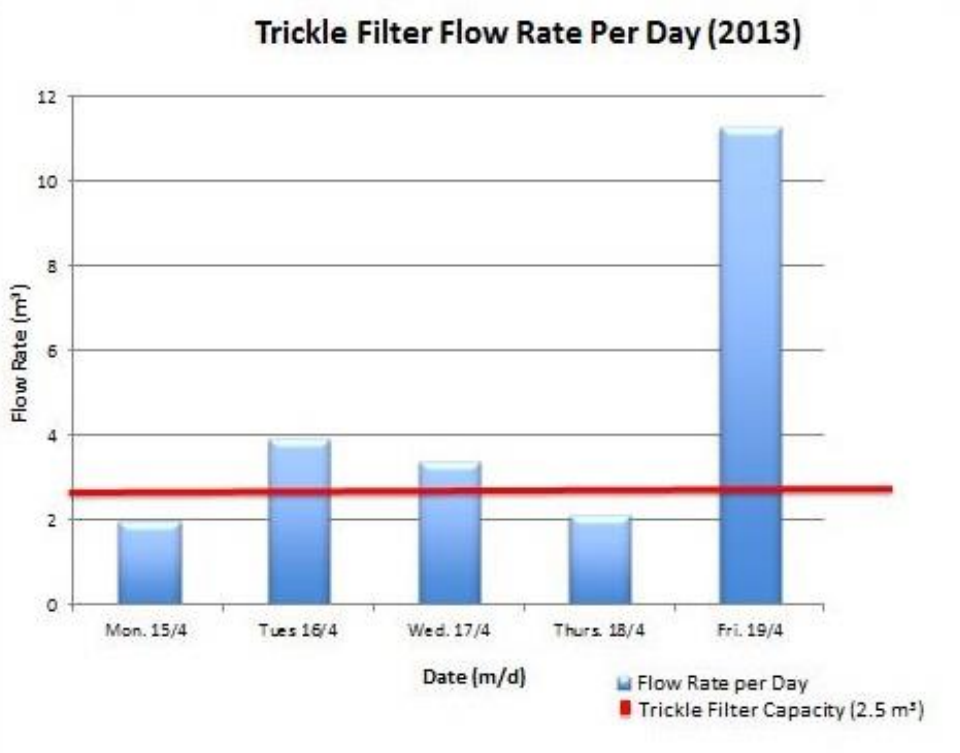

Figure 24: Trickle Filter Flow Rate Per Day

4.2.5 Finding 5: Trickle Filter Effluent Turbidity and Quality

We first analyzed the turbidity, or the amount of dissolved solids in the water, of the trickle filter's output. Our findings from the four day turbidity monitoring can be seen in Table 3.

Table 3: Four Day Turbidity Monitoring

Day	Tuesday	Wednesday	Thursday	Friday
Photograph				

The color of the effluent was similar on the first three of the four days, with an increase of turbidity on the final day of monitoring. The change corresponds to the return of a large group of staff and interns who were away at the beginning of the week, but had returned to the Centre later on Thursday, after our 9:00 readings. The results indicate that an influx of visitors to the Centre has a direct effect on the system's capability to break down solids suggesting that turbidity testing should only be done when there is a consistent number of people at the Centre.

We found that the chemical composition of the trickle filter effluent is of very poor quality when compared to safe water. High levels of ammonium, ammonia, and phosphate indicate that there is organic waste left in the effluent and that the trickle filter is not performing adequately. The ammonium, ammonia, and phosphate levels are off our charts and well into toxic levels as shown in Table 4.

Table 4: Effluent Water Quality Testing

Test	**Value**	**Implications of Test Values**
pH	8.5	Basic, but safe
Ammonium (NH_4/NH_3)	>10 mg/L	Toxic levels
Phosphate (PO_4)	7.8 mg/L	High level - Potential cause of increased algae
Nitrite (NO_2-N)	1 mg/L	Dangerous level
Nitrite (NO_2)	3.3 mg/L	Dangerous level
Nitrate (NO_3)	5 mg/L	Acceptable

The effluent quality tests were preliminary and gave us a rough indication of the quality. The tests should be followed up with professional equipment to get a more comprehensive analysis.

4.3 Solid Waste Management at the GRTC

In this section we discuss our findings regarding solid waste management. The results are based on information we collected from interviews with residents at the Centre and from our three-week waste audit.

4.3.1 Finding 1: The Majority of Solid Waste Generated is Plastics

We determined the quantities and types of solid waste generated at the Centre by conducting a waste audit at the Clay House 3 kitchens and at Old House. A full chart of the waste audit can be found in Appendix Y. In analyzing the waste audit, we found that paper and plastic amounted to almost 44% of the total documented waste, as seen in Figure 25. Specifically, we noted that the majority of the waste was plastics from food packaging. This was consistent with what residents believed they disposed of most, which can be seen in the spreadsheet compilation of the residents' interviews in Appendix W. We also noted that there was little paper waste. The waste audit also demonstrated that people at the GTRC consistently sort their garbage correctly, with only two misplaced bottles and one misplaced can over a three-week period.

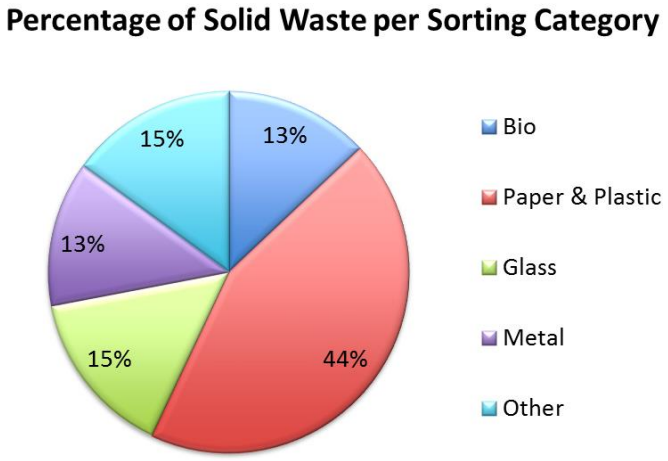

Figure 25: Percentage of Solid Waste per Sorting Category

The data from the waste audit was not a complete representation of all of the waste generated at the Centre, but it is a sufficient sample size for determining the percentages of the different types of solid waste at the GRTC. The weekly garbage totals for the Clay House 3 kitchens and Old House are shown in the Figure 26.

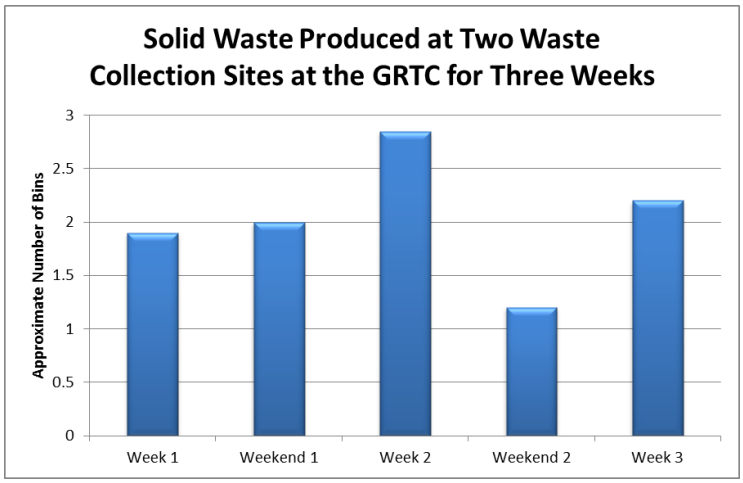

Figure 26: Solid Waste Production at Clay House 3 Kitchen and Old House

This shows that these two waste collection sites produce about two bins (40 gallons each) worth of solid waste in a typical week.

The GRTC generally produces ten bags of garbage between Monday to Friday, as shown in Figure 27 indicating that the two buildings audited comprise approximately one fifth of the total solid waste produced at the Centre.

Figure 27: Typical Amount of Solid Waste Produced During the Work Week

4.3.2 Finding 2: Lack of Recycling at the GRTC

The GRTC practices waste separation at five different waste disposal sites around the Centre, an example of which is shown in Figure 28. Bins and signs will sometimes become mismatched. For example, the metal bin is under the bio sign, and the other waste bin is underneath the glass sign, while the glass bin is missing.

Although waste is sorted correctly at the Centre, it does not remain separated. The solid waste is combined on site, as seen by the piling of the weekly garbage in Figure 27, and transported by interns to the Walvis Bay landfill site on trips to town. We also documented the separation, and eventual recombining of waste in a solid waste flow chart of the Centre, seen in Figure 29.

Figure 28: Waste Collection Site

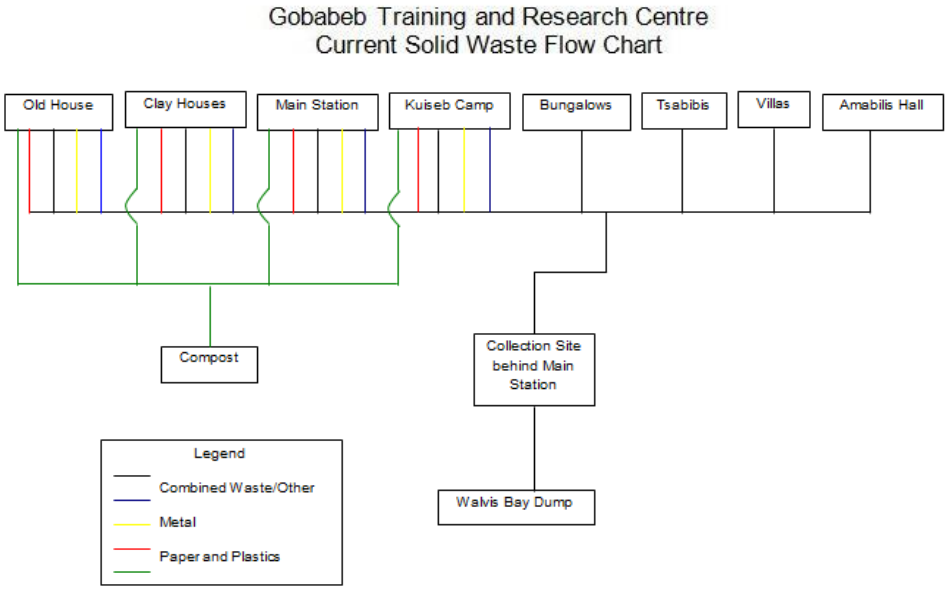

Figure 29: Solid Waste Flow Chart

The 'Bio' or organic waste is also dumped at Walvis Bay even though there is a compost bin at the GRTC. From observations and conversations we learned that the compost bin is not taken care of and dry human waste is added to this bin on a weekly basis. We also found that there is some confusion about which kinds of organic waste can be composted because the signs above the garbagecans, as shown in Figure 30, are somewhat ambiguous, as they do not describe what should or should not be placed in the bins.

Figure 30: Solid Waste Separation Labels

4.3.3 Finding 3: Waste Contamination at the Tsabibis Staff Quarters

When we explored the Centre and its surrounding areas, we found very little waste contamination. However, we did observe waste around the Tsabibis Staff Quarters including paper, plastic, glass, and multiple broken cars. Even more concerning was the discovery of two dead baby donkeys, pictured in Figure 31. While the solid waste found at Tsabibis poses a threat to the environment and the health of the staff residing there, the dead animals pose more serious problems because of the possibility of pathogens. Our full observations can be viewed in Appendix Z.

Figure 31: Dead Donkeys

4.4 Lack of Education and Orientation at the GRTC

Through interviews (Appendix U), we found that the lack of awareness about sustainability, particularly in regards to the waste and water systems, stems from the lack of an adequate orientation. Figure 32, created from the interview answers in Appendix

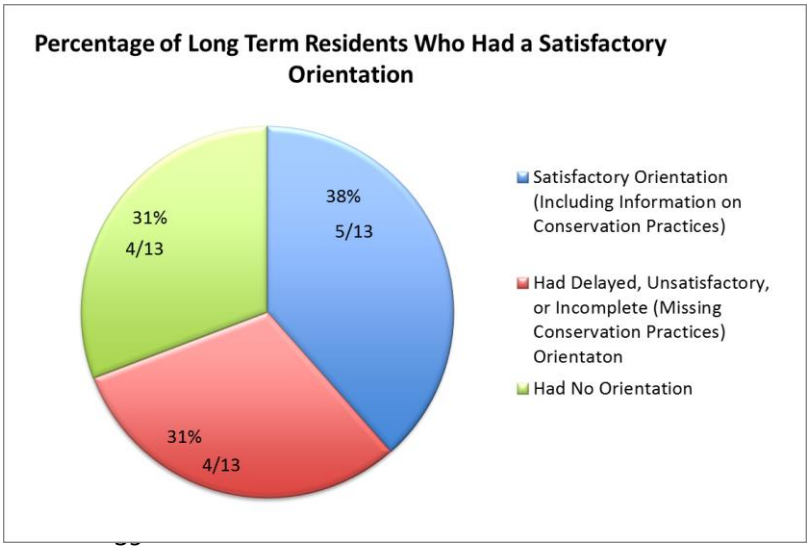

Figure 32: Long Term Residents Who Had a Satisfactory Orientation

W, demonstrates the percentage of long term residents who received satisfactory orientations. Our criteria for a satisfactory orientation is one that occurred immediately on arrival, effectively oriented the new resident, and provided important information on conservation practices and system management at the GRTC. Following these criteria, only about 38% of the long term residents received a satisfactory orientation, 31% received unsatisfactory orientations, and about 31% did not receive any orientation at all.

4.5 Water, Waste, and Sanitation Practices at the Salt River Topnaar Village

In this section we discuss findings on the waste and sanitation management in the Topnaar village of Salt River, based on our observations during a day trip. The observations compliment conversations we had with Sebedeus, our translator and our main liaison to the Topnaar people. Since we had only a short amount of time in this village, we were only able to obtain a limited range of findings, our complete visit summary can be seen in Appendix AA.

4.5.1 Finding 1: Poor Water Management System

We found that the water in Salt River's main tank is of very good drinking quality, as shown in Table 5.

Table 5: Salt River Village Water Quality Testing

Test	**Value**	**Safe Drinking Water**
pH	9	7
Ammonium (NH_4/NH_3)	0 mg/L	<0.003 mg/L
Phosphate (PO_4)	1 mg/L	1.5 mg/L
Nitrite (NO_2-N)	<0.1 mg/L	<0.1 mg/L
Nitrite (NO_2)	<0.3 mg/L	<.3 mg/L
Nitrate (NO_3)	0 mg/L	0 mg/L

The effluent quality tests were preliminary and gave us a rough indication of the quality. The tests should be followed up with professional equipment to get a more comprehensive analysis.

However, once the water leaves the tank it is likely that it will become contaminated. The small above ground plastic pipes that supply water to each of the houses are prone to damage and show signs of makeshift repairs, as seen in the left image in Figure 33. Once the water is piped to each house, the residents collect the water in small open reservoirs that are often dirty. One of these reservoirs is shown in the right image in Figure 33, as well as a drinking cup of questionable cleanliness.

Figure 33: Left: Makeshift Repairs to a Pipe Right: Unclean Collection Containers

We also observed that the main tank pump is often left on when the tank is already full, causing the tank to overflow. During our visit to Salt River we witnessed the tank being left to overflow for twenty minutes, as shown in Figure 34.

Figure 34: Overflowing water tank

In this Topnaar settlement, solar powered pumps are used to pump water to the main tank. However, when they need maintenance or repairs, no one in the village knows how to fix them. When the system was originally installed, several elders were taught how to maintain and fix the solar panels, but unfortunately, over time these people either passed away

or moved away. Now, when the system breaks, the villagers need to go to neighboring settlements for water, sometimes for extended periods of time, as the government is very slow to provide help with repairs.

4.5.2 Finding 2: No Solid Waste Management

We observed no safe solid waste management practices at the Topnaar village. The areas around the houses were very clean, but just out of sight of the houses were numerous open air dump sites. One of these piles can be seen in Figure 35, which mainly consisted of discarded car parts and bottles.

Figure 35: Trash near Topnaar Village

The majority of the solid waste we found around the Topnaar Village was consolidated to an area just to the edge of the Kuiseb River bed. The area contained the accumulation of years of solid waste and mainly consisted of cans, bottles, and animal bones and hides, as shown in Figure 36. The waste disposal area also serves as a playground for the children of Salt River, which demonstrates that the residents are not fully aware of the hazardous nature of the waste. The close proximity of the waste site to the Kuiseb River also suggests that the residents are unaware of the risk of contaminating the downstream portion of the river.

Figure 36: Village Dump Site

However, the village did have one sparsely used waste collection site: an unmarked abandoned mining test pit. Such a collection site is far from ideal, as the deep pit is a danger to small children and livestock. Through conversations with village residents we learned that the villagers do not like the mining test pit and are dumping solid waste inside of it in an attempt to fill it in, as shown below in Figure 37.

Figure 37: Abandoned Mining Pit

4.5.3 Finding 3: Unsafe Human Waste Sanitation Practices in the Village

Though some of the Topnaar settlements have government provided dry toilets, we found none at the Salt River village, meaning that most residents relieve themselves in the Kuiseb River bed. This can be inconvenient and difficult for the elder members of the community, especially at night or during the heat of the day. Due to these inconveniences, there is an interest in bringing toilets to the village. In fact, one villager had already begun constructing a makeshift flush toilet, as seen in Figure 38.

Figure 38: Makeshift Flush Toilet

4.6 Summary

We learned that the Centre's broken or missing water meters do not provide them with sufficient information to determine the Centre's average water use. We also learned that the majority of detergents affecting the trickle filter are from residents' personal use and that most of these detergents are not biodegradable. We also found that the Centre's recycling program is inefficient and could be greatly improved. Lastly, we found that there is a lack of sanitation practices in the Salt

River Topnaar village. We used these results and findings to develop meaningful recommendations to provide to our sponsor, the GRTC. We present these recommendations in the next chapter.

5. Conclusions and Recommendations

Based on the results of our research we have developed a series of recommendations for our sponsors, the Gobabeb Research and Training Centre (GRTC) and the Desert Research Foundation of Namibia, to implement at the GRTC and the nearby Topnaar settlements. The purpose of our recommendations is the improvement of the sustainability of the GRTC and the quality of life of the Topnaar villagers.

5.1 The Gobabeb Research and Training Centre

Our recommendations for the GRTC are divided into the following categories: water, waste water, and solid waste management and finally education related to achieving sustainable management of these commodities.

5.1.1 Water Management

We recommend that the GRTC install water meters at all buildings without them, fix those water meters that are broken, and label all water meters for easy identification. Our map of the water system outlines where the missing and broken meters are located. Our findings show that there is an inadequate amount of data on water use, partly due to the lack of functional water meters. We were able to determine how much water the Centre uses by looking at the outgoing water meter on the main tower, but with the majority of the water meters defunct, we were unable to determine where this water is used. Ensuring that each building has a functional water meter will allow for thorough data collection, which can support future efforts to improve water management.

We recommend that the GRTC regularly and accurately record the water meter readings in *The Water Management Database,* a spreadsheet we created to facilitate record keeping and analysis. Our findings show that water meter readings are recorded by hand into charts with various layouts. Our spreadsheet simplifies this process: all data is stored in one place, in the same

format, and automatically able to be analyzed. With this new method of record keeping, it becomes simple to distill the information. For example, for creating an educational info-graphic or poster on water usage at the Centre, an explanation of the tool can be seen in Appendix AB.

We recommend that the GRTC, after completing the above two recommendations, create an educational display showing various water use statistics. We recommend that this display contains information such as total water use at the Centre and water usage per building. The display should also be updated to include the most recent month's statistics. We envision a poster mirroring the graphs generated by our spreadsheet, and as months pass, bars will be drawn to update the water usage graph, and pie charts breaking down water usage by building can be pasted on the poster. Our findings show that there is a lack of understanding of the water system at the GRTC, and with the educational display, we believe that increased awareness will lead to increased responsibility in water use at the Centre.

5.1.2 Waste Water Management

We recommend that the GRTC use the biodegradable detergents we acquired from Cernol Chemicals and monitor the trickle filter's reaction to these detergents' use. We left two cleaning products with the director of the GRTC: Elite and Geldet, which should be used in place of the cleaning products currently used. Elite can be used for general cleaning and Geldet for more soiled areas, such as bathrooms. We recommend that this testing begins when Walter Holch, the Centre's technical advisor, is at the Centre, as he can best discern any changes at the trickle filter. A more detailed description of these detergents and their prices can be found in Appendix U. If these detergents seem appropriate for the Centre after testing, the administration can arrange for purchasing them in bulk in Walvis Bay or Windhoek.

We recommend that the GRTC does further research into providing biodegradable detergents (or soaps) to all visitors though dispensers in showers and at sinks. We found that residents of the Centre would not be opposed

to using a standardized, biodegradable soap, but finding an appropriate product requires more research. Soaps sold at stores such as Pick-n-Pay unfortunately are not required to disclose their ingredients or level of biodegradability. To acquire this information, one must call the company and obtain a product's data sheet. Alternatively, one can go to a chemical supplier, such as Cernol Chemicals, and talk with a representative about the needs of the Centre. Cernol Chemicals did not have an appropriate detergent for hands or for use in the shower at the time we contacted them.

5.1.3 Solid Waste Management

We recommend that the GRTC reorganize their recyclable categories to correspond with Rent-A-Drum's: plastic, cans, paper, and glass. Currently, the Centre combines plastics and paper into one category. To use Rent-A-Drum's recycling service, these will need to be sorted into separate bins, leaving the Centre with four bins for recyclables (plastic, paper, cans, and glass), one for organic material, and a non-recyclable bin. Additional information on Rent-a-Drum and what exactly can go in each bin can be found in Appendix AC. We recommend that the Centre use the new signs provided in Appendix AD to help sort their waste into Rent-a-Drum's required categories.

We recommend that the GRTC use Rent-A-Drum's recycling service to improve recycling at the Centre. Despite separating recyclables from garbage at the Centre, our observations show that all waste, regardless of its recyclability, is currently recombined and brought to the landfill in Walvis Bay. We have purchased four bulk, reusable Rent-A-Drum bags that can be filled with a single type of recyclable each and brought to the collection Centre in Swakopmund to be recycled. Though our waste audit, we found that the Centre's residents already correctly separate their recyclables from garbage, so we believe that this recommendation will be easy to implement and greatly improve the Centre's contribution to sustainability.

We recommend that the GRTC separate their compost into two individual composts: one composed of trickle filter sludge, and the other from food found in the organic waste bins. We found that residents are reluctant to use the garden because compost from the trickle filter, which contains human waste, is used to fertilize the plants. We propose that the Centre only uses the organic waste from the bio bins in the compost for the garden to both repurpose otherwise discarded waste and to foster use of the garden. For this compost, we recommend to use a container with a top, such as the unused plastic containers that are near the water tower, to increase compost production. We also recommend the Centre use the sign created in Appendix AE to promote proper composting practices. As far as the compost of human waste from the trickle filter, further research must be done into what residents at the Centre are comfortable with.

5.1.4 Conservation Education at the GRTC

We recommend that the GRTC show our orientation video to all visitors of the Centre upon arrival. This video aims to welcome the viewers to the GRTC and to increase awareness of the water and electrical systems at the Centre and various sustainability practices, the script for which can be found in Appendix AF. We found that not everyone receives an adequate orientation when they arrive at the Centre. It is important for visitors and long-term researchers alike to be aware of topics discussed in this orientation video so they can maximize their experience and research, but minimize their impact on the environment.

We recommend that the GRTC explain to their cleaning staff why certain soaps and cleaning practices are discouraged. From our interviews with the cleaning staff, we learned that they are told certain cleaning methods are appropriate and others are not, but they have never been given any reasons as to why. Upon explaining to them the nature of the trickle filter and biodegradable detergents, they said that they would be more cautious in their use of inappropriate detergents and would be willing to use biodegradable replacements. We believe that a stronger line of communication between the cleaning staff and the managers at the

Centre would lead to better cleaning practices: this could be accomplished by having some members of the cleaning staff in attendance at the staff meetings.

5.2 The Topnaar Settlements

Since our time at the GRTC was very limited and our focus was on addressing problems at the GRTC, we had little time to conduct research in the nearby Topnaar settlements. As such, most of our recommendations are to conduct further research in these settlements, which potentially could be the beginning of a new project. Our recommendations for the Topnaar settlements, based on our visit to only one settlement, are divided into the following categories: water, human waste, and solid waste management and improving relations between the GRTC and the settlements.

5.2.1 Water Management

We recommend that further research be conducted at the Topnaar settlements in improving water management, specifically looking at the following: 1) Educating the Topnaar on repair and maintenance of the solar powered water system; and 2) Education on the importance of clean drinking vessels and storage containers.

5.2.2 Human Waste Management

We recommend that further research be conducted at the Topnaar settlements in improving human waste management. We found that there is a clear desire to improve human waste management in the settlement we visited, but exactly how and with what goal in mind has not been determined.

5.2.3 Solid Waste Management

We recommend that a fence is built around the hole currently serving as the garbage collection site in the Salt River Topnaar settlement, and that research into finding a longer-term solution to solid waste management, such as a collection system, be conducted. The large mining test hole that is a repository for the Topnaar's garbage is a danger to everyone, especially children and livestock, and a fence around the perimeter would prevent someone from falling in. The hole, however, is only a short-term solution to solid waste collection.

When the hole fills up, another one will have to be made. A longer-term solution includes a collection system managed by the GRTC that could collect garbage from all nearby Topnaar settlements.

5.2.4 Relationship Building between the GRTC and Topnaar Settlements

We recommend that steps be taken to improve the relationship between the GRTC and the nearby Topnaar settlements, in ways such as:

- GRTC sponsored clean-up day; where members of the Centre, along with the Topnaar villagers, clean up the garbage that has collected in the riverbed near various Topnaar settlements (a full explanation of what we recommend for this clean-up day can be found in Appendix AG).
- More attention from the GRTC to Sebedeus Swartbooi's Topnaar Cultural Walk. We found that people would be interested in taking this tour to learn about the Topnaar. The tour would benefit both parties: the GRTC would have a new attraction for visitors to the Centre, and the Topnaar could earn some income through tourism and selling such products as crafts or !nara seeds.

5.3 Conclusion

The GRTC, a mecca for desert researchers, has made great strides to maximize the effects of its research while minimizing its effects on the environment. Our recommendations seek to aid the Centre in its most important long-term goal: sustainability in a sensitive desert environment. Our recommendations for the Topnaar Settlements aim to improve, or guide research to improve, the water and sanitation management in the settlements, thus improving the quality of life for the Topnaar. We present these recommendations to the Desert Research Foundation of Namibia and the Gobabeb Research and Training Centre in the hope that continued work on these topics will improve water and waste management in the lower Kuiseb River basin.

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APPENDIX A: SPONSOR DESCRIPTION

The Desert Research Foundation of Namibia (2013) focuses on projects in the areas of land, water, and energy. These projects all aim to improve the three core missions of the DRFN: enhance decision making, manage the natural environment, and foster sustainable livelihoods. The DRFN team envisions "a Namibia in which people manage the environment for sustainable livelihoods"(Paragraph 1). The purpose of their projects and involvement, as stated on their website, is to "enhance decision making for sustainable development" (Paragraph 2). The DRFN (2012) contributes to sustainable growth by research, policy, raising awareness of the general population, monitoring, evaluation, training, environmental education, and consulting projects. The organization's goal is to help develop a better understanding of arid areas and how to improve managing water, land, and energy in these areas so that the standard of living of the local populations may be raised.

The DRFN (2007) is a non-profit and non-governmental organization. The organization is mainly supported by the fundraising efforts of Friends of Gobabeb and from research grants. International scientists, students, and researchers frequently come to Gobabeb Research and Training Centre to study. The GRTC was founded by entomologist Dr. Charles Koch at the site of an abandoned Topnaar community called !Nomabeb (GRTC, 2013). Together with the support of the South African Transvaal Museum, Dr. Koch founded the Namib Desert Research Station, which was later known as the GRTC.

The staff at the DRFN (2013) is subdivided into three groups that represent the main desks of the organization: the water, land, and energy desks. These desks are presided over by the director of the DRFN, Viviane Kinyaga, and are supplemented with the support staff and associates for increased effectiveness. The support staff is composed of employees who work with the library and research, administration and finance, and interns for general assistance. Additional support

comes from five associates, who work outside of the main desks, to provide support, implementation, and strategic planning for the projects. The Water Desk staff is the most pertinent to our project, which is composed of one project coordinator, Carole Roberts, three researchers, Clarence Mazambani, Fransiska Gamises, and Kenneth Ganeb, and one research assistant, Christerline Ndeleki. The support staff is comprised of the knowledge management support officer, Ronald Kanguti, the chief accountant, Stefan Nel, and Annemarie Brandt, senior accountant.

The GRTC (2013) staff organization is similar to the DRFN's organization. There is an administration and management branch, a research branch, a training branch, and Centre service branch. The organization also has a board members, patrons, and associates. The organizational structure of the employees for both the DFRN and GRTC can be found in the attached in Figure A1 and A2, respectively.

The DRFN (2013) is partnered with the Namibia Nature Foundation in an alliance called the Namibian Institute of Sustainable Development. This alliance is still developing, but outlines for its development are in place. The institute serves as an umbrella mechanism for coordination and collaboration between the two organizations. The alliance works to promote sustainable development such as economic growth, improved livelihoods, and environmental productivity and resilience.

The DRFN has strong relationships with several partner organizations, such as the Polytechnic of Namibia. At the GRTC, the DRFN has been hosting students since 1989 for both classes and internships. The DRFN is a partner with the Southern African Development Community (2013), whose goal is environmental sustainability through education, networking, and training. SADC operates in member countries. In southern Africa, the DRFN also partners with the Environmental Long Term Observatories of Southern Africa, which is a think-tank forum for the National Environmental Observation Networks (EON) (SAEON, 2013). The EON follows the principles of observation, information, and education, which

fall in line with the ideals of the DRFN. The DRFN's staff conducts studies in the area of desertification, which is the main interest of Desertnet (2013), a German network for research. They are a worldwide organization with a presence in the Namib Desert, which uses cutting edge science and research to combat desertification. The DRFN also has relationships with various communities throughout the country, including the Topnaar community, which is a target population of our project, and Grundorn South and Nico Noord, two communities that were the area of focus in previous water desk project (GRTC, 2013). The DRFN plays an important role in these communities in terms of sustainability and development.

The DRFN (2007) provides economic, political, and social support through their strong presence in Namibia and their extensive collection of information. Their library will provide us with information about the area and the solutions that communities have already tried. On their website there is a database that contains over 4,000 documents from their two libraries in Windhoek and at the GRTC, and other databases including: The Summer Desertification Program, Envioteach, and DEA Research Discussion Papers. Along with this information, the DRFN also publishes an annual report about the status of their existing projects and the goals of the organization over the past ten years, all of which are available online. Overall, there is a wide variety of resources that the DRFN provides interested researchers.

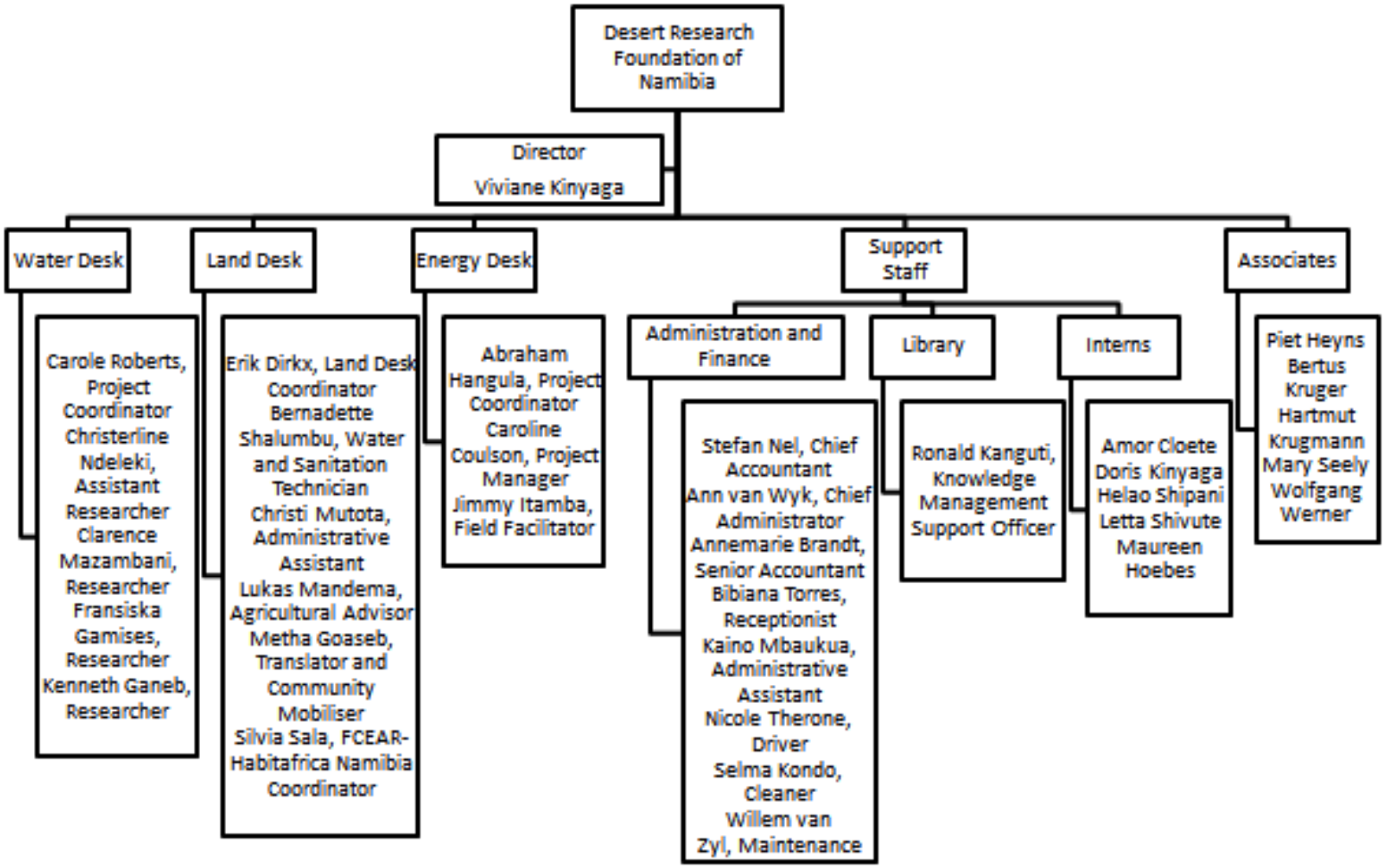


Figure 39: DRFN Staff Organization Structure Adapted from DRFN, 2013

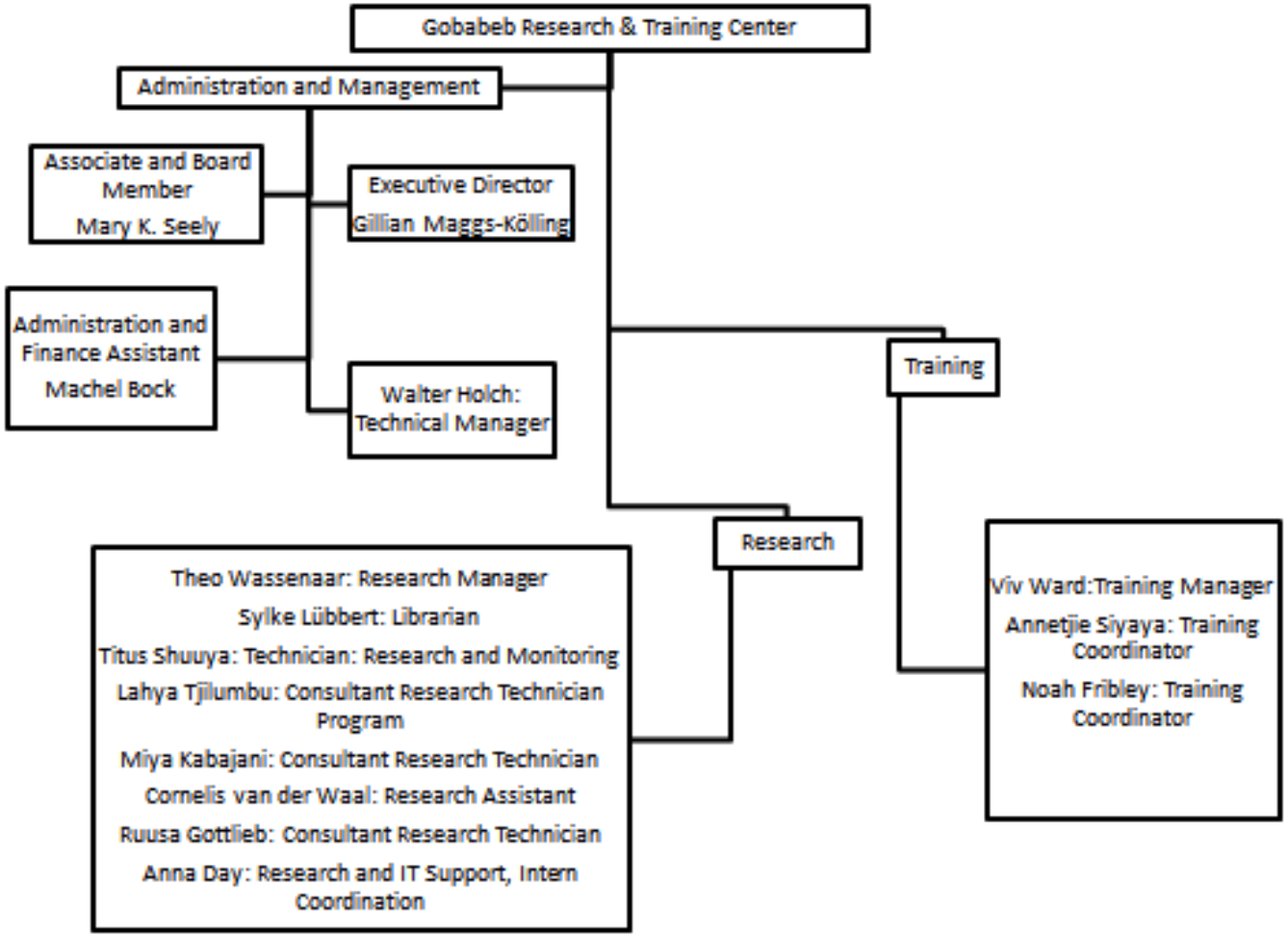
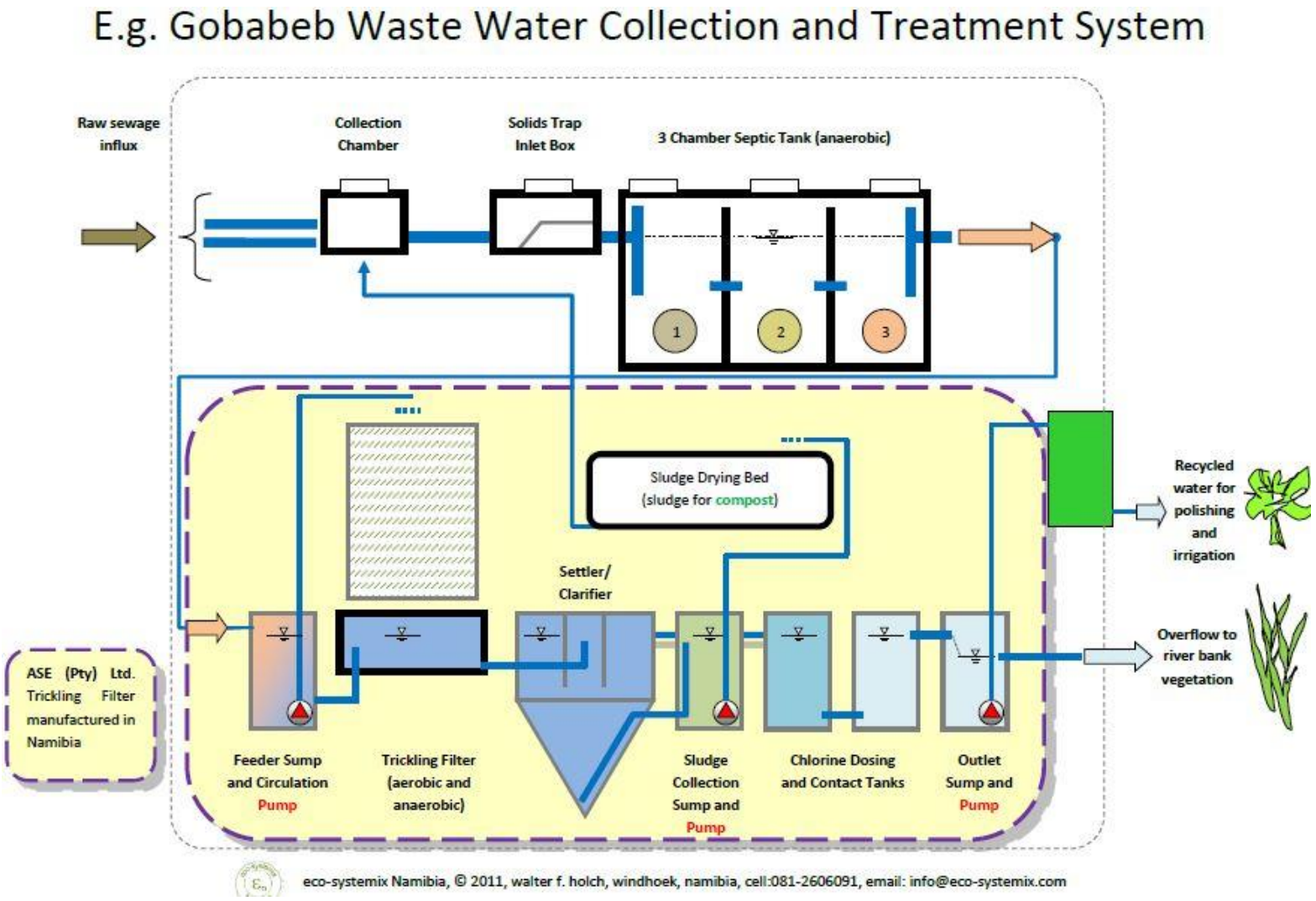


Figure 40: : Gobabeb Research Centre Staff Organization Structure Adapted from GRTC, 2013

APPENDIX B: WASTE WATER TREATMENT AT THE MAIN STATION



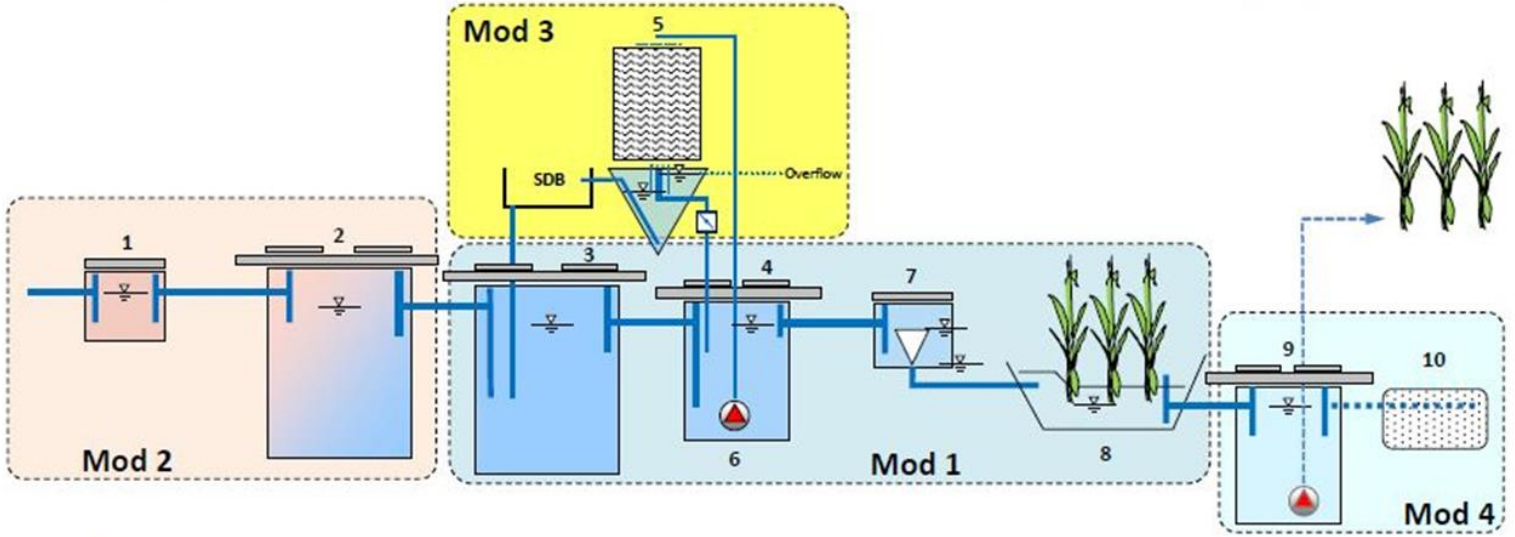
Above: A schematic of the current waste water treatment system at the main station of the GRTC. Currently, there is no polishing stage after the Outlet Sump and Pump.

Above: A picture of the last phase of the septic tank at the main station. Far left: Settler/Clarifier, Middle Bottom: Sludge Collection Sump and Pump, Middle Top: Chlorine Dosing and Contact Tank 1, Right Top: Chlorine Dosing and Contact Tank 2, Right Bottom: Outlet Sump and Pump

Note: The Collection Chamber precedes the Solids Trap Inlet Box. It can be found on the left-hand side of the main station waste water treatment building. The three chambers of the septic tank wrap are found as follows: 1 is directly above the Inlet Box, 2 is in the top left corner of the waste water complex, and the third chamber is directly to the left of chamber 2.

APPENDIX C: PLANS FOR UPDATING THE WASTE WATER TREATMENT AT THE TSABIBIS STAFF QUARTERS

Cascaded/gravity fed waste water collection and treatment system 500L-2500L per day (**recycle&reuse all**)



1	solids/fat trap	solids remain in liquids until removed, no drying up and difficult removal, consolidated sludge seals path to unit '2'; **solids removal** every 1-2 months
2	primary settling tank	standard HD-PE-2500-5000L tank, anaerobic digestion, **anaerobic sludge**, sludge removal once per year, ideal for long-term composting and tree **planting**
3	secondary settling tank	standard HD-PE-2500-5000L tank, receives sepage from SDB, dried sludge removal every 2 weeks, sludge is ideal for rapid/thermophylic composting for **vegetable production**
4	circulation tank	standard HD-PE-1000-2500L tank, receives **settled influent** from tank '3' and **rapid-oxygenated water** from unit '5', discharges into unit '7' flush chamber
5	trickling filter, sludge hopper, clarifier (high loading rate, power=!)	**rapid oxygenation**; above ground level, gravity feeding the system, ca 2-3m^3 packing volume, ca 80m^3 surface/m^3, induding sludge hopper (clarifier type), self-desludging, rest water level guarantees enough humidity to prevent drying out of sludge and bacterial film if system has to cope some time without power, easy maintainable with suction lance to **sludge drying bed (SDB)**, only sepage water is recirculated back to settling tank "3"; an overflow indicates cleaning the suction lance; flow regulated through ball valve
6	circulation pump	either 220VAC or 12VDC waste water pump, 1-4 m^3/h **as long as power is available** (no electronic controls involved, only one float switch)
7	flush chamber	'toilet cistern type', **intermittent flushing**, volume ca. 50-200L, **self-regulating** (no electronic controls involved), self-flushing, **self-cleaning**, may need rubber ring replacement every two years
8	constructed wetland	the **'lungs of the system'**, receive intermittent flushes to do the breathing and **avoid filter clogging**, **self-regulating**, **high buffer capacity**, vertical or horizontal flow type, weld mesh inlays for **phosphate removal**; plants for **nitrate removal**; substrate: 19/13/4-8/2mm; planting: vertical=*phragmites australis*, horizontal=*typha latifolia*
9	collection tank	standard PE-2500L tank, **IF treated water to be used THEN** PV pump or 220VAC pump to site (no electronic controls involved, only one float switch), water quality checks every three months (NTU, pH, NO_3/NO_2, PO_4, TDS, DO) COD/BOD/TOC tests every 6 months, Cl_2 contact tank after wetland ("8")
10	French drain	caters for overflow of collection tank (soakaway, groundwater recharge)
---	Notes:	all tanks have ferro-cement hard covers, two manholes, are ventilated; the system works with power=rapid oxygenation/nitrification, the effluent can be reused for irrigation; the system also works without power for some time, the treated waste water is then pushed out to unit '10'; the flush chamber works like an oversized toilet cistern and is self-flushing once filled to the upper level; the wetland works best if it receives intermittent flushes so that it can breathe; tanks 2-4 resemble a three chamber septic tank similar to the one at Gobabeb station; a separate sludge drying bed [SDB] to be installed anywhere near the system. $\Delta H=\sum h_i \sim$ 1m;

APPENDIX D: CHARTS FOR DAILY WATER METER READINGS AND HOURLY METER AND FLOW RATE READINGS

Date	Amabilis		Clay House			Luxury Hill Solar Geysers					Old House	Main Water Meter
	Front	Back	1	2	3	1	2	3	4	5		
Monday												
Wednesday												
Friday												

Time	**Main Water Tower**	
12 Hour Water Meter Reading	**H2O used (L)**	**Tower Flow Rate**

APPENDIX E: GUIDELINES FOR OPEN-ENDED INTERVIEWS AT THE GTRC

GENERAL

- How long are you staying at Gobabeb?
- What are your main projects at the Centre?
- Was there an orientation for interns when you first arrived?

WATER

- What are your thoughts on water quality at the Centre?
- Do you drink untreated tap water?
- Do you boil the water before drinking?
- Do you filter the water before drinking?
- How often do you shower? Use the Sink? Flush the toilets? (Daily)
- Are there any limitations on how much water you can use?
- Is there any form of education or orientation relating to water for people who come to stay at the Centre?
- How do you feel water conservation at the Centre could be improved?
- Are there any unnecessary water usages? What are they?
- Do you think they could use the trickle filter water to wash the cars?
- Are there any limits on the types of detergents you can use? Examples: shampoos, soaps, conditioners, toothpastes, etc.
- What do you think of the Centre providing biodegradable detergents? Example soap dispensers in the showers?
- Since the interns have to buy supplies for a month at a time, do you think the Centre should buy biodegradable detergents in bulk and provide them for the interns? Would this make it easier for you to buy supplies?
- Would you be willing to use shampoo if it was in a dispenser in the shower?
- Would timers in the shower make people more conscious of their water usage?

SOLID WASTE

- Where do you throw away your garbage?
- What types of garbage do you throw away?

- Do you recycle/reuse anything that could be considered waste? What do you recycle?
- Can you use the donkey manure for fertilizer in the garden? Do you?
- Would you like to change your methods of throwing away garbage? If yes, why and how?
- How do you feel garbage management and recycling at the Centre could be improved?

APPENDIX F: WATER QUALITY TESTING METHODS – SERA AQUA-TEST

pH-Test

The pH Value tells how acidic or alkaline the water is. The pH scale ranges from 0-14. The Lower the pH value, the more acidic the water is – the higher the pH value, the more alkaline it is. Neutral water has a pH value of 7.0.

Directions for use:

1. The vials must be cleaned thoroughly before and after each test . Shake the liquid reagent before using. Close reagent bottle immediately after using.
2. Rinse the vial several times with the water to be checked; fill to the 5 ml mark and dry the exterior.
3. Add 4 drops of the reagent and shake lightly. Under natural daylight, place the vial on the white area of the color chart and compare the colors from a position above. Avoid direct sunlight.

Ammonium/Ammonia – Test

If the bacterial activity in the Aquarium or garden pong has been disturbed, it can no longer decompose toxic ammonia (converted from relatively harmless ammonium), which is the result of protein breakdown. Elevated pH levels play a strong role in this conversion.

Directions for use:

1. The vial must be cleaned thoroughly before and after each test. Shake the liquid reagents before using. Close reagent bottles immediately after using and do not exchange caps.
2. Rinse the vial several times with the water to be checked; fill to the 10 ml-mark for freshwater, or the 5 ml-mark for saltwater. Dry the exterior.
3. Add 6 drops of reagent 1; close vial with the cover and shake.
4. Remove cover; add 6 drops reagent 2; close the vial with the cover again and shake.
5. Remove cover; add 6 drops reagent 3; close the vial with the cover again and shake. Then remove the cover.
6. Wait 5 minutes. Under natural daylight, set the vial on the white area of the chart and compare the colors from a position above. Avoid direct sunlight. For freshwater read the values in line a), for saltwater use line b).

7. Determine the level of toxic ammonia from the chart below according to the measured value.

Measured Value (mg/L)	pH 7.0	7.5	8.0	8.5	9.0
0.5	0.003	0.009	0.03	0.08	0.18
1.0	0.006	0.02	0.05	0.15	0.36
2.0	0.01	0.03	0.11	0.30	0.72
5.0	0.03	0.09	0.27	0.75	1.80
10.0	0.06	0.17	0.53	1.51	3.60
Etc.	Actual ammonia level in mg/l				

Harmless
Harmful with long-term exposure
Acutely toxic

Phosphate –Test

Phosphate values up to 1.0 mg/l can be found in natural, unpolluted waters. Often concededly higher levels are found in Aquariums and garden ponds. This is caused by the overstocking of fish, phosphate-rich foods, and plant fertilizers containing phosphate. In combination with a high nitrate level, a high phosphate level can lead t excess algae growth. To avoid this, we recommend testing regularly for phosphate levels in your aquarium or garden pond. High Phosphate levels can lead (in freshwater above 0.1 mg/l) can be lowered by conducting regular water changes (approximately 10-30% weekly) and/or by adding fast growing plants (in freshwater) or ornamental algae (in saltwater), also, in freshwater aquariums using sera phosvec.

Directions for use:

1. The vial must be cleaned thoroughly before and after each test. Shake the liquid reagents before using. Close reagent bottles immediately after using and do not exchange caps.
2. Rinse the vial several times with the water to be checked; fill to the 10 ml-mark. Dry the exterior.
3. Add 6 drops reagent 1; whirl lightly.

4. Add 6 drops reagent 2; whirl lightly.
5. Add one heaping measurement spoonful (included with the set) reagent 3; close vial with the cover and whirl lightly. Open the vial.
6. Wait 5 minutes. Under natural daylight, set the vial on the white area of the chart and compare the colors from a position above using the “10ml + 0 ml” values. Avoid direct sunlight.
7. If the color is dark blue, the water sample contains 2.0 mg/l or more phosphate. Repeat the measurement with a diluted sample as described in the following steps.
8. Thoroughly rinse the vial with water t be checked and fill it to the 5-ml mark. Top up the sample to 10 ml with sera aqua-dest. Repeat Steps 3-5.
9. Wait 5 minutes. Compare the color to the chart once again, this time using the “5 ml +5 ml” values.
10. If the color is still a dark blue, the measured value is 4.0 mg/l or higher. In this case, continue testing at the “2 ml + 8 ml” level using the corresponding line in the color chart for evaluation. Phosphate levels up to 10.0 mg/l can be determined.

Nitrite – Test

Nitrite is formed in the Aquairum and in the garden pond as an intermediate in the breakdown process of fish excrements. High nitrite levels endanger fish. Nitrite is converted to nitrate by the bacteria in a biologically functioning filter – for example, in a filter activated with sera nitrivec (freshwater) and sera KOI BIOCLEAR (garden pond), or sera ammovec (fresh-salt water). We recommend that the combined use of sera aqutan (in the aquarium) or sera KOI PROTECT (in the garden pond), plus sera nitrivec (freshwater) or sera ammovec (fresh-salt water) according to the directions for use, with every water change.

Directions for use:

1. The vial must be cleaned thoroughly before and after each test. Shake the liquid reagents before using. Close reagent bottles immediately after using and do not exchange caps.
2. Rinse the vial several times with the water to be checked; fill to the 5 ml-mark. Dry the exterior.
3. Add 5 drops each of reagent 1 and reagent 2.
4. Close the vial with the cover and shake lightly. Remove the cover.
5. Wait 3 to 5 minutes. Under natural daylight, set the vial on the white area of the color chart and compare the colors from a position above. Avoid direct sunlight.

Water Quality Results:

NO_2-N	NO_2	Effect and Corrective Action
5.0 mg/l	16.5 mg/l	Highly toxic. Conduct water change
1.0 mg/l	3.3 mg/l	Dangerous level. Conduct partial water change
0.5 mg/l	1.6 mg/l	Harmful level. Conduct partial water change
0.3 mg/l	0.9 mg/l	Tolerable level. No action required
<0.1 mg/l	<0.3 mg/l	Good level. No action required

Nitrate – Test

Fish, plants and invertebrates (saltwater) suffer, while algae thrive, when the nitrate level is above 50 mg/l. Regularly checking the nitrate level in you aquarium or garden pond can help you prevent elevated nitrate levels. To lower and maintain the nitrate level, install a sera bio-denitor in an aquarium, add fast growing plants (in freshwater) or ornamental algae (in slatwater0, and/or conduct more frequent partial water changes – providing you tap water is low in nitrate.

Directions for use:

1. The vial must be cleaned thoroughly before and after each test. Shake the liquid reagents before using. Close reagent bottles immediately after using and do not exchange caps.
2. Rinse the vial several times with the water to be checked; fill to the 20 ml-mark. Dry the exterior.
3. Add 6 drops reagent 1 and one level measuring spoon (included with the set) of reagent 2; close the vial with the cover and shake vigorously for 15 seconds.
4. Open the vial and add 6 drops reagent 3; close the vial again and shake. Remove the cover.
5. Wait 5 minutes. Under natural daylight, set the vial on the white area of the color chart and compare the colors from a position above using the “20 ml + 0 ml” values. Avoid direct sunlight
6. If the color is dark red, the water sample contains 40 mg/l or more nitrate. Repeat the measurement with a diluted sample as described in the following steps.
7. Thoroughly rinse the vial with water t be checked and fill it to the 10-ml mark. Top up the sample to 20 ml with sera aqua-dest. Repeat Steps 3-4.
8. Wait 5 minutes. Compare the color to the chart once again, this time using the “10 ml + 10 ml” values.

9. If the color is still a dark red, the measured value is 80 mg/l. In this case, continue testing at the “5 ml + 15 ml” and, if necessary, the “2 ml + 8 ml” values, using the corresponding lines in the color chart for evaluation. Nitrate levels up to 400 mg/l can be determined by using this method.

APPENDIX G: WATER QUALITY TESTING DATA CHART

Test	**Value**	**Implications of Test Values**
pH		
Ammonium (NH_4/NH_3)		
Phosphate (PO_4)		
Nitrite (NO_2-N)		
Nitrite (NO_2)		
Nitrate (NO_3)		

APPENDIX H: DETERGENT OBSERVATIONAL CHART

Location	Photograph

Additional Notes:

APPENDIX I: TRICKLE FILTER FLOW RATE DATA SHEET

Trickle Filter:

Date	Time	Volume (L)	Time (Sec.)	Time (Min.)	Flow Rate (L/min)

APPENDIX J: TRICKLE FILTER EFFLUENT MONITORING DATA SHEET

Day	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Photograph				

APPENDIX K: GTRC WASTE AUDIT CHART

Types	Bio	Paper and Plastic	Glass	Metal	Other Waste
Date 1					
Notes:					
Date 2					
Notes:					
Date 3					
Notes:					
Date 4					
Notes:					
Date 5					
Notes:					
Date 6					
Notes:					
Date 7					
Notes:					

* Each date has a picture of each of the bins for that day as well as notes about the amount and anything that does not belong in the bin.

APPENDIX L: GUIDELINES FOR OPEN-ENDED INTERVIEWS AT THE TOPNAAR SETTLEMENTS

WATER

- Where do you collect your water?
- How and where do you store your water?
- How often do you collect water?
- How much water do you use in a day?
    - How often do you fill up your water buckets?
    - For how many people?
    - And animals?
- What is your main use of water?
- Do you think your water is clean in the village?
- How and where do you dispose of your dirty or used water?

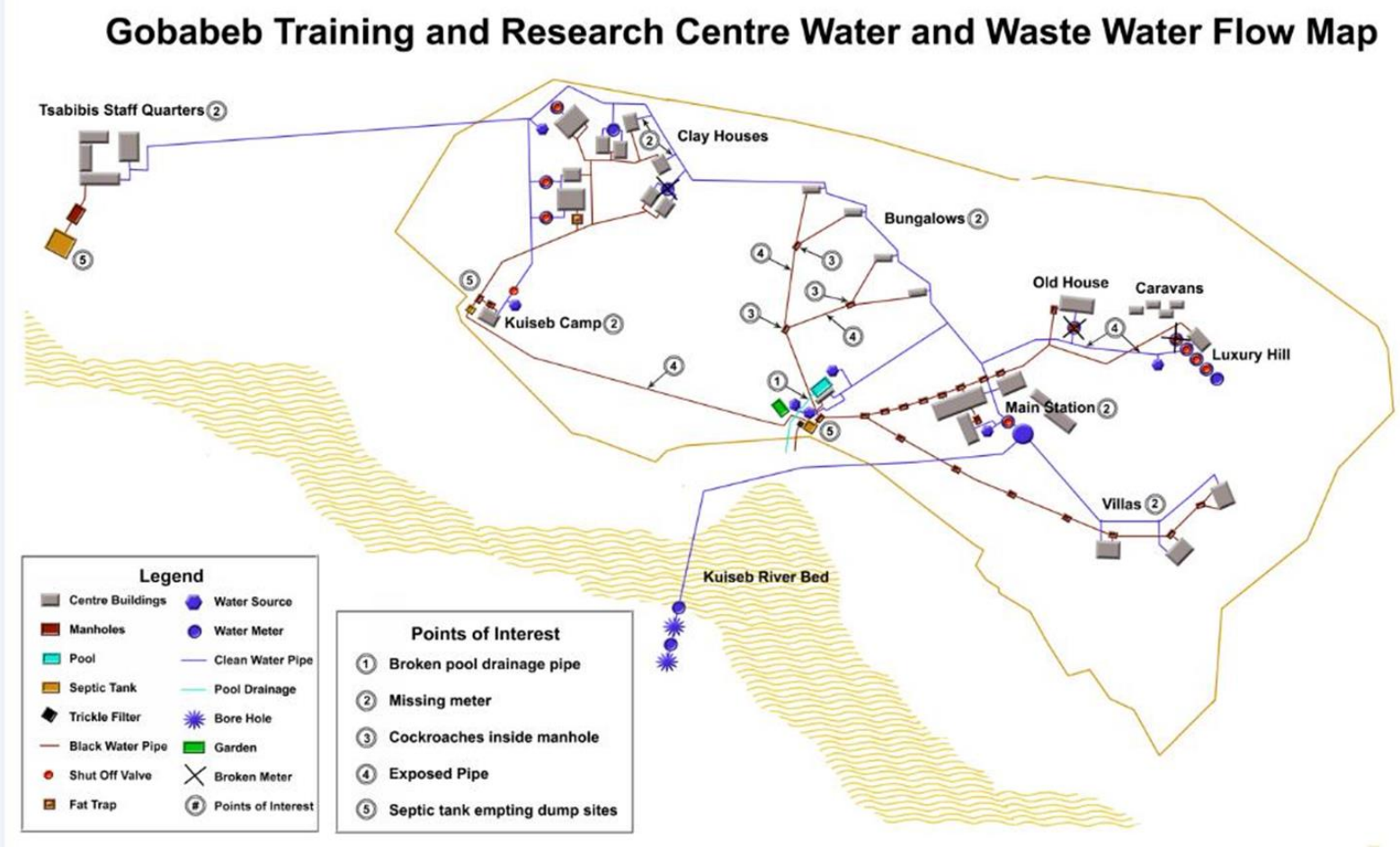
SOLID WASTE

- Where do you throw away things you no longer use?
- What types of things do you throw away?
- Do you reuse anything that could be considered waste? What do you recycle?
- Does getting rid of things you do not want any more cause an inconvenience to you? If so how?
- Do discarded items or materials provide a hazard or problem for members of the community? If yes, why and how?
- Would you like to change your methods of throwing away things you no longer want/need? If yes, how and why?

HUMAN WASTE

- Are you satisfied with the ways people manage their human waste in your village? If so, why? If not, why not?
- What do you think could be improved? How?
- Do you think a latrine should be for the whole community or for one person or for one household? Explain why.
- Who should be responsible for keeping the latrine clean and working properly?
    - Do you know how to do this?
    - Do other people in this settlement know how to manage the latrine properly?
- Is there any other method for managing people's human waste that you would prefer? If so, what is that?
- Do you like the idea of the dry toilets? Why or why not?
- Why do you not use the dry toilet in your village regularly?
    - How do you feel this situation could be improved?

APPENDIX M: MAP OF THE WATER AND WASTE WATER SYSTEM AT THE GRTC



APPENDIX N: INFORMATION FROM THE WATER TOUR WITH SAMEÜL

Date: 3/18/2013

RESIDENCE: ***TSABIBIS***
ROLE AT GOBABEB: ***MAINTENANCE, WORKS WITH THE TRICKLE FILTER (WASTEWATER SYSTEM) AND WATER SYSTEM***
TIME AT GOBABEB: ***3 YEARS***

Samuel walked us around the station and showed us all of the elements of the system. Below is a compilation of the questions we asked while on this walking tour with Samuel. Samuel explain to us that there is three septic tank systems. One for the Upper Station area, one for the Kuiseb Camp area and one for the Tsabibis staff quarters. The Upper station area feeds the trickle filter. There is Kuiseb and Tsabibis feed simple septic tanks. The water from the Kuiseb septic system also feeds into the trickle filter.

Water System:

How often is the water tower filled?

Mon, Wed, and Friday. They also fill it more often when there are large groups.

What are your thoughts on water quality at the Centre?
The bore hole has never run dry, they have never had an issue with that.

Waste Water:

What happens to the water once is goes through the trickle filter?
When the water is good enough quality for gardening the trickle filter water can be pumped up to the garden and recycled. Right now it is too salty and is not being used for gardening. The water is just being put back into the aquifer (the river bed). This drain site is across the river from the bore hole.

How do you know when the water is of good enough quality to use in the garden?

The rate of water flowing through the trickle filter needs to be high enough so that the water coming out is not as salty.

How often are the tanks below the trickle filter cleaned?

Monday, Wednesday, Friday and more often when there are large groups. The 3rd tank is pumped into the sludge drying tank when the 3rd tank is too full. It dries there, when that fills up they shovel it out.

What happens when the septic tanks are full?

The sludge is pumped out on to the sand and left to dry at both the Tsabibis and Kuiseb septic tanks. Tsabibis septic tank is pumped out and cleaned every year. And the Kuiseb one is pumped out every five years and cleaned.

When you clean the pool where does the water drain?

The pool water drains right into the Kuiseb River bed. This drain site is directly across the river from the bore hole.

What are the old pipes by the trickle filter used for?

These pumps used to connect the system by the Tsabibis staff quarters to the main system by the Centre, but there is no longer any connection.

What are the dried up manholes by the Tsabibis staff quarters used for?

This was the former system that connected to the main system by the Centre, however these are no longer used.

There are some parts of the PVC piping which are no longer covered by cement and exposed. Do these pipes often break and is it hard to fix them?

The pipes do break sometimes when the cement protecting them is broken off, we can go in and just replace the PVC pipes.

<u>Solid Waste:</u>
Are the separation bins working?

No, we just take all of the waste and put it in bins to be brought to walvis bay. It is brought by interns into Walvis Bay whenever they are doing a trip into town. Usually every week or two depending on need. The bio bins do get put into the compost pile and are supposed to be used in the garden.

How often do you remove garbage?

The bins are emptied every morning and put into the big bins in the back of the upper station.

APPENDIX O: COMPLETE WATER METER DATA

2009-2011 Water Meter Readings												
	Clay House			**Amabilis**		**Old House**	**Luxury Hill**					
Date	1	2	3	Front	Back		1	2	3	4	5	
17/11/09	905	629	723	683	367	1065	65	94	65	63	213	
24/11/09	907	631	723	684	369	1065	65	94	65	63	213	
1/12/2009	907	631	723	684	369	1065	66	94	65	63	214	
7/12/2009	908	632	723	686	371	1065	66	94	65	63	215	
14/12/09	908	632	723	686	371	1065	66	94	65	63	215	
21/12/09	909	633	724	687	372	1065	66	94	65	63	216	
28/12/09	909	633	723	687	372	1065	67	94	65	63	216	
4/1/2010	909	633	723	687	372	1065	67	94	66	63	216	
12/1/2010	909	634	723	687	372	1065	67	95	66	63	217	
18/1/10	909	634	723	687	373	1065	67	95	66	63	217	
26/1/10	909	634	724	689	374	1065	67	95	66	63	217	
1/2/2010	910	635	723	689	374	1065	67	95	67	63	218	
8/2/2010	910	635	723	690	375	1065	67	95	67	63	218	
15/2/10	913	637	723	694	378	1065	67	95	67	63	218	
22/2/10	913	638	723	695	380	1065	68	95	68	63	219	

1/3/2010	914	638	723	696	384	1065	68	95	68	63	219
8/3/2010	915	639	723	697	384	1065	68	95	68	63	220
15/3/10	915	639	723	697	385	1065	68	95	68	63	220
23/3/10	916	642	723	699	386	1065	68	95	68	63	221
29/3/10	917	642	723	699	387	1065	68	95	68	63	221
6/4/2010	917	642	723	699	387	1065	68	95	68	63	222
12/4/2010	917	643	723	699	387	1065	68	95	69	63	222
19/4/10	918	643	723	700	388	1065	68	95	69	63	222
26/4/10	922	647	723	706	391	1065	69	96	69	63	223
3/5/2010	923	647	723	706	391	1065	69	96	69	63	223
10/5/2010	923	647	723	706	392	1065	69	96	70	63	224
17/5/10	924	647	723	706	392	1065	69	96	70	63	224
24/5/10	924	647	723	706	392	1065	69	96	70	63	225
31/5/10	924	647	723	706	393	1065	69	96	70	63	225
7/6/2010	924	648	723	706	393	1065	69	96	70	63	225
14/6/10	924	648	723	706	393	1065	69	96	71	63	226
21/6/10	924	648	723	706	393	1065	69	96	71	63	226
28/6/10	924	649	723	706	394	1065	69	96	71	63	226
5/7/2010	924	649	723	707	395	1065	69	96	71	63	227
12/7/2010	924	649	726	707	395	1065	69	96	71	63	228
19/7/10	925	649	726	707	395	1065	69	96	71	63	228
26/7/10	925	650	726	708	395	1065	69	96	72	63	229
2/8/2010	926	651	726	709	397	1065	69	97	72	63	229

9/8/2010	933	654	726	713	398	1065	69	97	72	63	229
17/8/10	935	654	726	715	400	1065	69	97	72	63	229
23/8/10	935	654	726	715	400	1065	69	97	72	63	230
30/8/10	936	655	726	716	400	1065	69	97	72	63	230
6/9/2010	936	655	726	716	401	1065	69	97	73	63	231
13/9/10	936	655	726	716	401	1065	69	97	73	63	231
28/9/10	940	659	726	717	403	1065	69	97	73	63	232
4/10/2010	941	659	726	717	404	1065	69	97	73	64	232
19/10/10						1065	69	97	73	64	232
27/10/10	945	664	726	723	409	1065	69	97	73	64	233
2/11/2010	947	665	726	726	411	1065	69	98	73	64	234
8/11/2010	947	666	726	726	411	1065	69	98	73	64	234
16/11/10	950	668	726	727	412	1065	69	98	74	64	235
25/11/10	952	669	733	727	413	1065	69	98	74	65	236
3/12/2010	952	669	733	727	413	1065	70	98	74	65	236
8/12/2010	954	670	727	733	413	1065	70	98	74	65	236

2011 Water Meter Readings

		Amabilis		Clay House				Luxury Hill				
Date	Main Tank	Back	Front	1	2	3	Old House	1	2	3	4	5 (Solar Geysers)
4/1/2011		414	734	960	673	727	1065	70	98	74	65	237
30/05/2011	34464	429	743	729	689	981	1065	73	100	75	67	248
11/07/2011	34923	432	748	728	692	985	1065	70	101	76	68	250
18/7/2011	34985	433	748	728	692	985	1065	74	101	76	68	250
25/7/2011	35015	433	748	728	692	986	1065	74	101	76	68	251
1/08/2011	35059	433	749	729	692	986	1065	74	101	76	68	252
8/08/2011	35085	434	749	729	692	986	1065	74	101	76	68	253
15/8/2011	35109	434	749	729	692	986	1065	74	101	76	68	253
22/8/2011	35142	436	753	728	693	987	1065	74	101	77	68	254
29/8/2011	35194	441	762	729	698	991	1065	73	101	77	68	255
5/09/2011	35230	445	767	728	700	993		74	102	77	68	250
12/09/2011	35269	446	769	728	701	996		74	102	77	68	256
19/09/2011	35300	446	772	728	701	995		74	102	77	69	257
26/09/2011	35351	449	772	728	705	996		74	102	78	69	257
3/10/2011	35386	449	773	728	707	1001		74	102	78	69	258
10/10/2011	35420.6	450	774	728	707	1007		74	101	78	69	258
17/10/2011	35451.9	451	776	728	708	1008		75	100	79	69	259

24/10/2011		452	777	728	708	1009		75	103	79	69	260
31/10/2011	35510	453	777	728	708	1009		72	103	79	69	260
16/11/2011	35595	454	778	720	710	1010		75	103	80	70	263
21/11/2011	35671	450	770	720	710	1010		75	104	80	71	263
?/?/2011		453	777	728	710	1010		75	103	80	69	261
28/11/2011	35701	456	783	729	716	1012		75	103	80	71	260
?/?/2011	35705	458	788	728	719	1016		76	103	80	71	264
12/12/2011		461	791	728	723	1020		76	104	81	72	265

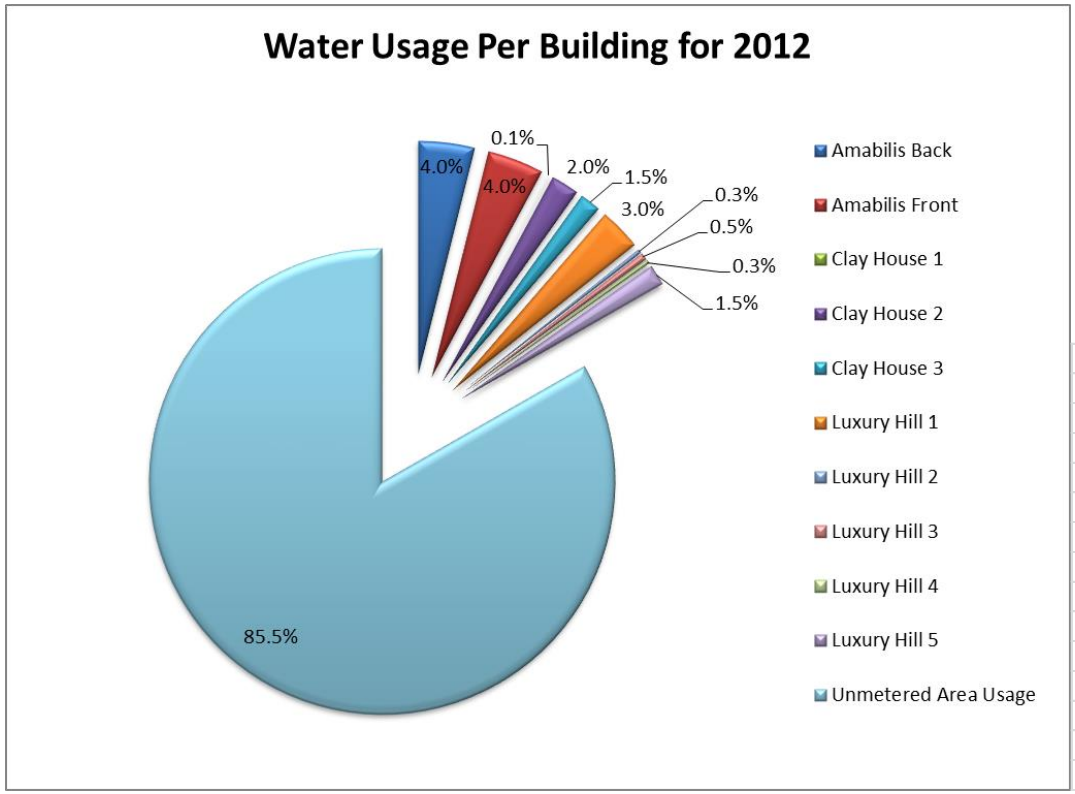
Monthly And Yearly Total Water Usage for 2012:												
January	Main Tank	Amabalis Back	Amabilis Front	Clay House 1	Clay House 2	Clay House 3	Old House	Luxury Hill 1	Luxury Hill 2	Luxury Hill 3	Luxury Hill 4	Luxury Hill 5 (Solar Geysers)
3/1/2012		462	793	728	727	1022		76	104	81	72	266
9/1/2012	35987.2	463	793	729	728	1028	1065	73	104	82	72	267
16/01/2012	36033	463	793	728	729	1028		73	104	82	72	267
23/01/2012	36102.5	463	793	728	730	1031	1065	78	104	82	73	268
30/01/2012	36159.7	465	797	729	734	1038		72	103	83	73	269
Total Used In January:	172.5											
February												
/02/2012 ?		469	802	728	736	1044		77	105	84	73	270
20/02/2012	36319	470	803	728	737	1045	1065	77	105	84	73	271

27/02/2012	36380.4	472	805	728	737	1045	1065	74	105	85	73	271
Total Used In February:	220.7											
March												
5/3/2012	36463.3	473	807	728	737	1043	1065	78	106	85	74	272
12/3/2012		476	809	728	738	1049	1065	78	106	85	74	272
19/3/2012	36564	478	811	728	738	1047	1065	78	106	86	74	272
26/03/2012	36600.3	749	812	728	739	1049	1065	78	106	86	75	273
Total Used In March:	137											
April												
/04/2012 ?		480	813	728	739	1049	1065	78	107	87	76	273
10/4/2012	36796.3	480	813	728	739	1049		77	107	87	75	274
16/04/12		480	814	729	740	1049	1065	77	107	87	75	274
23/04/2012	37014.9	481	816	728	740	1050		77	107	88	76	275
Total Used In April:	414.6											
May												
/05/2012 ?		468	801	728	736	1043		77	105	83	73	270
/05/2012 ?		487	825	728	741	1054		79	108	89	76	277
14/05/2012		488	827	728	741	1057	1065	79	108	89	76	278
/05/2012 ?		489	827	729	741	1058	1065	77	108	90	76	279
/05/2012 ?		490	829	728	742	1060	1065	79	108	90	77	280
Total Used In May:	370.1											

June												
4/6/2012	37385	491	832	729	743	1060	1065	79	108	90	77	281
11/6/2012	37433.8	423	836	729	743	1060	1065	79	108	90	77	282
18/06/2012	37461.6	497	839	729	743	1061	1065	79	108	90	77	283
25/06/12		503	842	729	744	1061		79	108	80	77	283
Total Used In June:	145.8											
July												
/07/2012 ?	37530.8	504	843	729	744	1064	1065	78	108	90	77	284
/07/2012 ?		504	843	729	752	1062	1065	78	108	90	77	286
17/07/2012		506	850	729	754	1064	1065	80	108	91	77	287
23/07/2012		508	854	729	754	1064	1065	80	109	91	77	288
/07/2012 ?		511	859	729	758	1067	1065	80	109	91	78	291
Total Used In July:												
August												
6/8/2012		510	858	729	757	1067	1065	80	109	91	78	290
10/8/2012	38184	555	897	773	730		1065	81	110	93	79	31
20/08/2012		513	863	729	760	1078		86	109	91	78	292
Total Used In August:												
September												
10/9/2012		529	876	728	763	138		90	110	92	78	295
Total Used In September:												

October												
7/10/2012	38148.3	551	893	730	771		1065.5469	80	10	92	19	300
15/10/2012	38247	557	899	430	774		1065	81	111	93	79	302
22/10/2012	38247	557	899	730	774		1065	81	111	93	79	302
29/10/2012		560	901	730	774		1065	81	111	94	79	304
Total Used In October:												
November												
5/11/2011		560	902	730	776		1065	81	12	94	79	305
?/?/2012		561	902	730	777			87	112	94	79	305
Total Used In November:												
December												
17/12/12	38638.9	563	907	730	786		1065	81	113	96	80	309
Total Used In December:												
Total Used in 2012:	2651.7	100	114	2	58	39	0	8	9	14	8	42

APPENDIX P: WATER METER DATA ANALYSIS FOR 2012



Percentage of Water Used per Building in 2012:	
Location:	Percent:
Amabilis Back	3.77
Amabilis Front	4.3
Clay House 1	0.08
Clay House 2	2.19
Clay House 3	1.47
Luxury Hill 1	0.3
Luxury Hill 2	0.34
Luxury Hill 3	0.53
Luxury Hill 4	0.3
Luxury Hill 5	1.58
Total Guest	**11.81**
Total Excluding Other	**14.86**
Other	**85.14**

*We collected this data to validate the total water usage from 2009-2012 as we were unsure if all of the meters were started at the same time. As the percentages were very similar we could conclude that our data from 2009-2011 was an accurate representation of water usage based on the data provided.

APPENDIX Q: THE EFFECTS OF OUTLIERS ON DATA ANALYSIS

Below is a sample compilation of meter readings taken in 2012, we annotated it to point out flaws in the data collected.

Date	Main Tank	Amabilis Back	Amabilis Front	Clay House 1	Clay House 2	Clay House 3	Old House	Luxury Hill 1	Luxury Hill 2	Luxury Hill 3	Luxury Hill 4	Luxury Hill 5
3/01/2012		462	793	728	727	1022		76	104	81	72	266
9/01/2012	35987.2	463	793	729	728	1028	1065	73	104	82	72	267
16/01/2012	36033	463	793	728	729	1028		73	104	82	72	267
23/01/2012	36102.5	1	793	728	730	1031	1065	78	104	82	73	268
30/01/2012	36159.7	465	797	729	734	1038		72	103	83	73	269
/02/2012 ?		469	802	728	736	1044		77	105	84	73	270
20/02/2012	36319	470	803	728	737	1045	1065	77	105	84	73	271
27/02/2012	36380.4	472	805	728	737	1045	1065	74	105	85	73	271
5/3/2012	36463.3	473	807	728	737	1043	1065	78	106	85	74	272
12/3/2012		476	809	728	738	1049	1065	78	106	85	74	272
19/3/2012	36564	478	811	728	738	1047	1065	78	106	86	74	272
26/03/2012	36600.3	749	812	728	739	1049	1065	78	106	86	75	273
/04/2012 ?		480	813	728	739	1049	1065	78	107	87	76	273
10/4/2012	36796.3	480	813	728	739	1049		77	107	87	75	274
16/04/12		480	814	729	740	1049	1065	77	107	87	75	274
23/04/2012	37014.9	481	816	728	740	1050		77	107	88	76	275
/05/2012 ?		468	801	728	736	1043		77	105	83	73	270
/05/2012 ?		487	825	728	741	1054		79	108	89	76	277
14/05/2012		488	827	728	741	1057	1065	79	108	89	76	278
/05/2012 ?		489	827	729	741	1058	1065	77	108	90	76	279
/05/2012 ?		490	829	728	742	1060	1065	79	108	90	77	280
4/6/2012	37385	491	832	729	743	1060	1065	79	108	90	77	281
11/6/2012	37433.8	423	836	729	743	1060	1065	79	108	90	77	282
18/06/2012	37461.6	497	839	729	743	1061	1065	79	108	90	77	283
25/06/12		503	842	729	744	1061		79	108	80	77	283
/07/2012 ?	37530.8	504	843	729	744	1064	1065	78	108	90	77	284
/07/2012 ?		504	843	729	752	1062	1065	78	108	90	77	286
17/07/2012		506	850	729	754	1064	1065	80	108	91	77	287
23/07/2012		508	854	729	754	1064	1065	80	109	91	77	288
/07/2012 ?		511	859	729	758	1067	1065	80	109	91	78	291
6/8/2012		510	858	729	757	1067	1065	80	109	91	78	290
10/8/2012	38184	555	897	773	730		1065	81	110	93	79	31
20/08/2012		513	863	729	760	1078		86	109	91	78	292
10/9/2012		529	876	728	763	138		90	110	92	78	295
7/10/2012	38148.3	551	893	730	771		1065.5469	80	10	92	19	300
15/10/2012	38247	557	899	430	774		1065	81	111	93	79	302
22/10/2012	38247	557	899	730	774		1065	81	111	93	79	302
29/10/2012		560	901	730	774		1065	81	111	94	79	304
5/11/2012		560	902	730	776		1065	81	12	94	79	305
?/?/2012		561	902	730	777			87	112	94	79	305
17/12/12	38638.9	563	907	730	786		1065	81	113	96	80	309

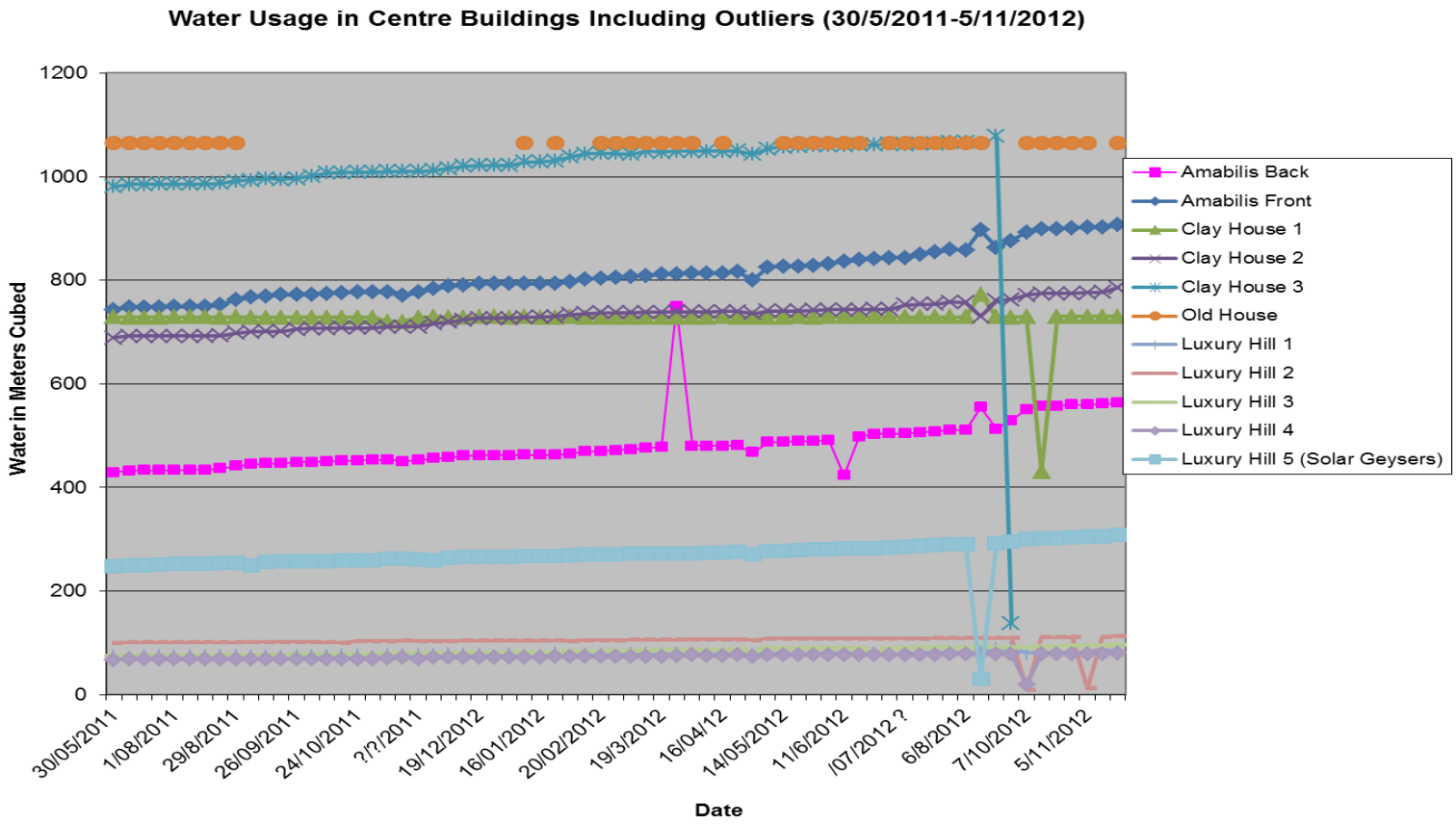
Note: The different colors demonstrate different inconsistancies in the data; the shaded data is not included in the filtered raw data

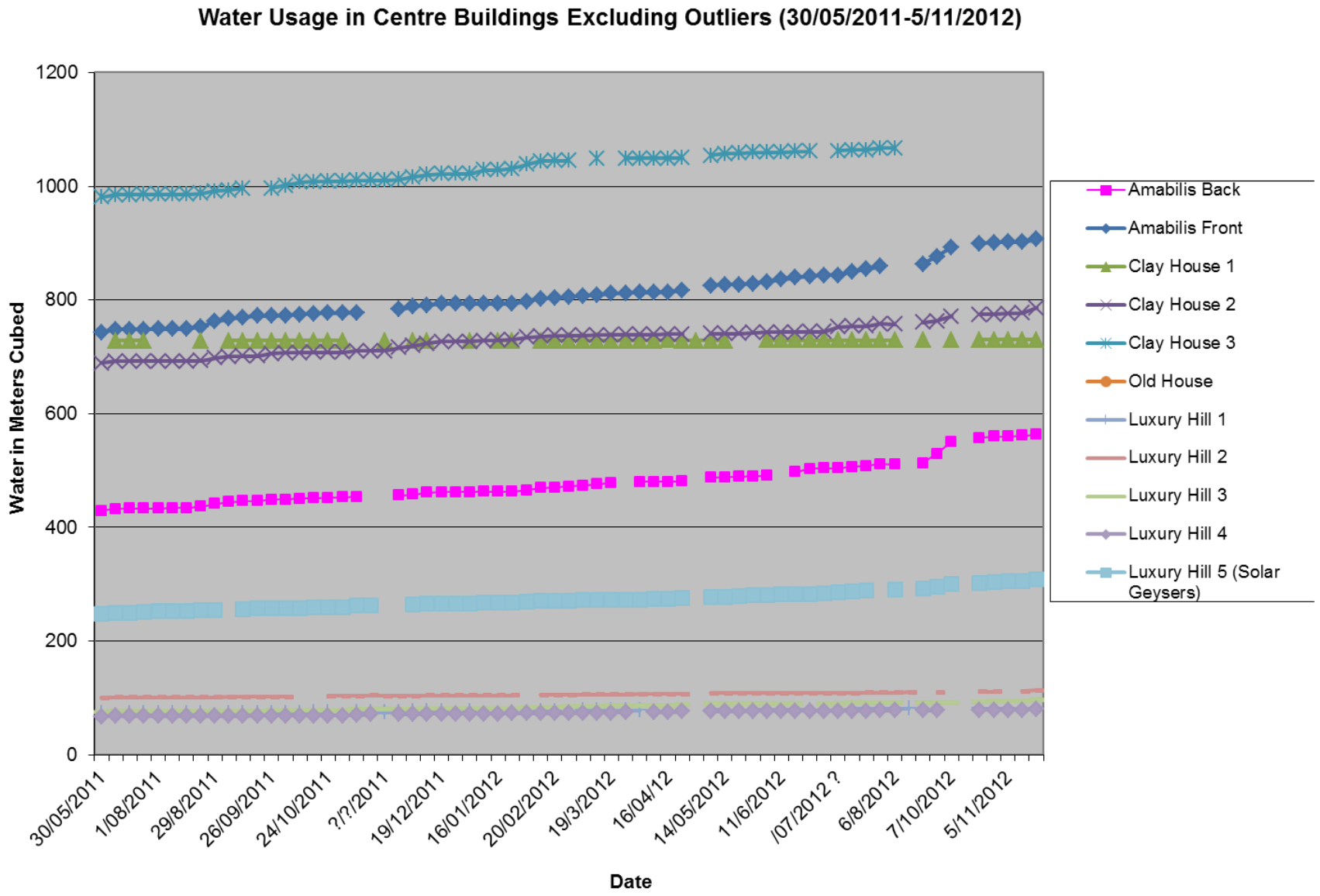
Periwinkle: Missing date, organized to correct position based off of month it was placed in, in the binder and main water meter reading
Salmon: No change at all in total water use between the 15th and 22 of December, except sharp difference between Clay House 1 Readings, this doesn't make sense (data from the 22nd kept)

Red: No change in data (meter broken), or meter known to be broken after this point

Purple: Sharp increase or decrease in data that stabilizes after this point (at least 3 m^3 difference from surrounding points)
Green: Small inconsistency, a 1 or 2 m^3 discrepancy, all of the numbers should gradually rise over time; they shouldn't go up and down; went with the trend in these cases

The flaws shown in the data table above significantly alter the results you get when analyzing the data. The comparison of a graph with outliers compared to one with outliers removed, seen below, illustrates this.


Water Usage in Centre Buildings Including Outliers (30/5/2011-5/11/2012)
Water in Meters Cubed
1200
1000
800
600
400
200
0
30/05/2011
1/08/2011
29/8/2011
26/09/2011
24/10/2011
?/?/2011
19/12/2012
16/01/2012
20/02/2012
19/3/2012
16/04/12
14/05/2012
11/6/2012
/07/2012 ?
6/8/2012
7/10/2012
5/11/2012
Date
Amabilis Back
Amabilis Front
Clay House 1
Clay House 2
Clay House 3
Old House
Luxury Hill 1
Luxury Hill 2
Luxury Hill 3
Luxury Hill 4
Luxury Hill 5 (Solar Geysers)


Water Usage in Centre Buildings Excluding Outliers (30/05/2011-5/11/2012)
Water in Meters Cubed
1200
1000
800
600
400
200
0
30/05/2011
1/08/2011
29/8/2011
26/09/2011
24/10/2011
?/?/2011
19/12/2011
16/01/2012
20/02/2012
19/3/2012
16/04/12
14/05/2012
11/6/2012
/07/2012 ?
6/8/2012
7/10/2012
5/11/2012
Date
Amabilis Back
Amabilis Front
Clay House 1
Clay House 2
Clay House 3
Old House
Luxury Hill 1
Luxury Hill 2
Luxury Hill 3
Luxury Hill 4
Luxury Hill 5 (Solar Geysers)

APPENDIX R: HOURLY MAIN WATER TOWER READINGS

Time	**Main Water Tower**	
12 Hour Water Meter Reading	**Tower (L*100)**	**H2O used (L)**
8:00 AM	393954	
9:00 AM	393966	1200
10:00 AM	393981	1500
11:00 AM	393982	100
12:00 PM	393983	100
1:00 PM	393983.3	30
2:00 PM	393986.5	320
3:00 PM	393988	150
4:00 PM	393989	100
5:00 PM	393990	100
6:00 PM	393999	900
7:00 PM	393999.6	60
8:00 PM	394002	240

APPENDIX S: INFORMATION FROM INFORMAL INTERVIEWS WITH STAFF WHILE CLEANING

What is Cleaned, When it's Cleaned, and How It's Cleaned:

Old House: Is cleaned once a week, but the staff needs to use a lot of soap. They mop the floors, dust, and clean the different rooms of Old House in the same manner as the Guest Quarters.

Main Centre: Is cleaned twice a week; Monday and Friday. They mop the floors, dust, and clean the different rooms of the Main Centre in the same manner as the Guest Quarters.

Guest Quarters: They clean the Guest Quarters with soap and water after the guests leave. Before guests come they dust the rooms and check the sheets and blankets. If there is any bird poop just outside the guest quarters they use clean water to wipe it off. The staff uses floor polish once a month in the Guest Quarters and the offices of the Main Centre. Also at the Kuiseb Camp they clean the bathrooms and the kitchens before guest come.

How Things are Cleaned:

To clean they use a general cleaner. They combine Mop & Shine, Floor Strip, and Handy Andy into one container (usually coke bottles, around 16 ounces). Not all of the staff do this however, some just use the Mop & Shine for cleaning the floors, and Handy Andy for the bathrooms. They generally use two to three dabs of cleaner on a single washcloth, which they dip in a 5 litre bucket. They use this single washcloth for a single specific area (for example a toilet, or a shower). Then they reapply the soap when they are working on another area. This does not use much soap, as they do not just pour soap into the bucket. However, some staff have been seen pouring soap into buckets of water. This uses considerably more soap, but only one staff member was seen to do this, and she used this soapy water to clean the entire Main Centre. Generally, the staffuse a single bucket of water for each room they clean, because after they clean each specific area (such as a toilet, shower, etc.) they use the left over soapy water to mop the floor. They usually pour the extra water from cleaning out under the trees, but sometimes they pour the water into an outdoor sink, or a nearby toilet. They use a new bucket of water for each room that they clean. When they use floor polish they first clean the floors of the rooms with Mop & Shine, then they splash a small amount of floor polish in

each section of the room. They don't use floor polish remover on the floors anymore, however they used to like using it because it was effective at removing grease from stoves. They used to use the floor polish and remover more last year, but they have started to use less.

What they Understand & Staff Recommendations:

They understand that soap is bad for the trickle filter and, as a side note, that they shouldn't use the washer-machine at night, but they don't really understand why. They would like to know about the trickle filter and why soap is bad for it, because sometimes when they go to clean something they use more soap because something is particularly dirty, and since they don't really understand why the soap is bad for the trickle filter, and how bad it is, they put a higher priority on cleaning. They would therefore like for someone to explain the trickle filter, as well as the energy system, to them. Even if someone wrote something down to explain the trickle filter and the energy system in English, Sebedeus would be able to help them read it and translate it for them. Also the soaps are continuously changed and it's hard to keep up with all of the changes. No one sits them down and explains which soaps they should use, which they shouldn't, and why. Generally, they will be cleaning and someone will just tell them to stop using a certain kind of soap. They do know which soaps to use, but if it was explained to them all at once, it would be less confusing and there would be fewer initial mistakes. Also, when new developments happen at the Centre they generally don't know about them. It would be good for someone, preferably Joseph (he speaks English well and understands the systems at Gobabeb the best), sit in on the weekly meetings. Then he could tell the rest of the staff what is going on at the Centre, and bring up any of the staff's concerns during the meeting. Other concerns that they had, were that the saltiness of the water sometimes leaves a residue in the shower that they cannot completely clean off.

Additional Interview With the Head Housekeeper About Cleaning Practices at the Main Centre:

Time at Gobabeb: Three years

What do you use to clean the floors?

We use Handy Andy.

How much do you use to clean the floors?

She didn't give a number, but showed an amount equivalent to about two inches on her hand. She had two bottles, a 1.25 litre bottle and a 16 ounce bottle, I would say this means she uses roughly a quarter of a 16 ounce bottle (approx.4 ounces per bucket of water). She tries to use one bucket for the office floors.

How often do you clean the floors at the Centre?

We clean the office floors once a week. We clean the tile floors once a month with the leftover water from cleaning the office floors.

Where do you throw away the water left over from cleaning?

We throw away the extra water from washing the floors out on the sand. We only flush the Handy-Andy when we use it in the sinks, toilets, and showers. The Handy Andy shouldn't go in the trickle filter.

How much do you use to clean the sinks, toilets, and showers?

We put a little bit onto a rag, and then it foams up a lot. We use less than we use on the floors.

How often do you use floor polish?

We used to use it often, we used to polish the floors after every time we washed them. Now we usually just use Handy Andy. We use the polish when we get the soap from Elso, so every fourth month. We never use it on the tile floor in the main Centre. (She originally started to say that she used it every time after she washed the floor- unsure how to interpret this)

How often do you use polish remover?

We use that occasionally. We use it less than Handy Andy, but more than the floor polish. Maybe we use it once every three weeks or once a month.

*We are not sure how valid this information is, we saw them washing the main tile floor the day we conducted this interviews, but we had also seen them cleaning it on previous visits.

APPENDIX T: DETERGENTS OBSERVED IN WALVIS BAY

Location	Photograph
Pick n' Pay Walvis Bay	
Pick n' Pay Walvis Bay	

Pick n' Pay Walvis Bay	
Pick n' Pay Walvis Bay	

Additional Notes:

Above are laundry, personal, dishwashing, and general cleaning detergents found in stores in Walvis Bay, the two only products that were advertised as biodegradable were the bio-classic laundry detergent and the bio-Crystal dishwashing liquid, and even those detergents did not display how biodegradable they were. Non-biodegradable brands found and displayed above were:

For Laundry:

Skip and PnP Brand

For dishwashing:

Finish, Sun Bright, Ajax, Sunlight, Sun Gel, Axion, Classic, Polagric, PnP Dishwashing Liquid, and Thunder.

For personal use:

Lux, Dove, Nivea, Sanex, Radox, Savion, Johnson & Johnson, Protex, Satiskin, Palmolive, and Dettol

APPENDIX U: CERNOL CHEMICALS DETERGENT OPTIONS

Possible Biodegradable Detergents for Gobabeb:

Elite:

Description: Is a 70% biodegradable all-purpose cleaner that is suitable, in different concentrations, for hand-washing, dishwashing, and general cleaning.

Geldet:

Description: Is a more potent biodegradable detergent that can be used for disinfection. It has a nice scent and would be used when a stronger detergent than Elite is necessary, i.e. cleaning toilets.

Sypo:

Description: Is a sodium hypochlorite solution that can be used in place of chlorine. Sypo is a good alternative to treating drinking water because it is more effective at killing algae than chlorine, it is more stable in hot conditions, and reduces the poor taste of chlorinated water.

Additional Detergent Information:

When we first contacted Cernol we had compiled a list of possible detergents that we thought would be compatible with the Centre's needs, which we reviewed with a representative name Heike Baumann. The list is as follows:

- Chemkleen
- Bubble Bath
- Bioblitz
- GPL Detergent
- Robust
- Chembleach
- Geldet
- Elite

The general use detergents were Elite, GPL Detergent, Robust, and Geldet. Through consultation we determined that Elite was the best option for a general use detergent because, it had the highest level of biodegradability and had the most applications. Geldet was recommended as a supporting option for Elite, because it is a more potent detergent and would be more suitable for cleaning toilets and removing stronger odors.

The personal usage detergents were Chemkleen, a shampoo/body wash, and Bubble Bath, a body wash. Mrs. Baumann informed us that neither of these options were biodegradable and could damage the trickle filter.

The laundry detergent, Bioblitz, was the only available biodegradable laundry detergent available. However, on inspection of the product data sheet; we realized that Bioblitz has bactericides, which would damage the bacteria in the trickle filter.

The bleach alternative that we had found online was Chembleach, but on further consultation, it was revealed that Sypo was a more environmentally friendly option.

Contact Information:

Detergents from Cernol can be easily ordered from Windhoek and picked up in Walvis Bay. After the initial order, the Centre would then only need to contact the Cernol office in Windhoek for refills. The office in Windhoek would send the supplies to Walvis Bay where the Centre could retrieve it.

Windhoek Office:

Etienne Rosseau Street, Northern Industrial Area

Telephone: (061) 262985

E-mail: cernolsales@swacogroup.com

Representatives:

Heike Baumann

Tony Farmer

Walvis Bay Supplier:

Lubrication Chemical Services

257 Ben Gurirab Street

Telephone: (264) 64 203879

E-mail: lizzard@namibnet.com

Pricing Information and Product Data Sheets:

- As a note on pricing, the chemicals are highly concentrated, so only a very small amount needs to be used per cleaning. Proper usage amounts are seen in the Product Data Sheets.

CERNOL
CHEMICALS (NAMIBIA) (PTY) LTD.
Co. Reg. No. 78/3847

☎ (061) 262985/6 • Fax (061) 217615
E-mail: bblack@swacogroup.com
Website: www.cernolnamibia.com
Sales E-mail: cernolsales@swacogroup.com
Etienne Rosseau Street, Northern Industrial Area
✉ 22880, Windhoek, Namibia

Date : **11 APRIL 2011**

Attention : **KELSEY WALL**

Company : **GOBABEB RESEARCH AND TRAINING CENTRE**

E - MAIL : **BYHAND**

Pages: ONE

QUOTATION : CLEANING MATERIA

WE HEREBY OFFER THE FOLLOWING QUOTATION F.O.R. WINDHOEK SUBJECT TO ACCEPTANCE:

Products	Qty	Pack Size	Price per Pack Size	Sub Total	VAT 15%	Total Amount
ELITE	1	5LTR	84.85	84.85	12.73	97.58
ELITE	1	25LT	407.18	407.18	61.08	468.26
ELITE	1	200 LTR	2432.86	2432.86	364.93	2797.79
SYPO	1	5LTR	125.44	125.44	18.82	144.26
SYPO	1	25LTR	573.60	573.60	86.04	659.64
GELDET	1	5LTR	93.43	93.43	14.01	107.44
GELDET	1	25LTR	423.76	423.76	63.56	487.32

LEAD TIME: ONE (1) WORKING DAY FROM RECEIPT OF ORDER.

PRICE VALID FOR: 60 (SIXTY) DAYS FROM DATE OF QUOTATION.

PRODUCT DATA SHEET

Unilegal

ELITE

CONCENTRATED ALL-PURPOSE LIQUID CLEANER

PRODUCT USE:

ELITE is a highly concentrated liquid cleaner for manual dishwashing, pot and pan washing and general cleaning, in all water conditions. It dissolves instantly and is non-irritating to the hands. Eliminates waste because **ELITE** is concentrated and contains built-in "foam feature". It is a more economical detergent than the average granular type cleaners.

PRODUCT DESCRIPTION:

Form:	Liquid.	Biodegradable:	Yes.
Colour:	Blue.	Wetting ability:	Excellent.
Odour:	None.	S.G.:	1.03.

DIRECTIONS FOR USE:

Manual dishwashing: For glass and light dishwashing: 7 ml per 5 litres warm water. For heavy dishwashing: 7 ml per 3 litres warm water.Renew washing solution when water gets excessively dirty. Rinse thoroughly in potable water.
Pot and pan washing: Normal soil loads: 7 ml per 5 litres water. Heavy duty : 7 ml per 2 litres. Renew solution when necessary. Rinse thoroughly in potable water.
General cleaning: Light duty: 7 ml per 12 litres warm water. Heavy duty: 7 ml per 8 litres water.

Ref.No. 01/04 HB

Safety:
Caution:
Keep out of reach of children.
Antidotes:
Eyes: Flush eyes with plenty of water.
Internal: If swallowed, immediately drink a large quantity of water. Do not induce vomiting.
GET MEDICAL ATTENTION!

SECTION I	**BASIC INFORMATION**
MANUFACTURER	**CERNOL CHEMICALS (NAMIBIA) (PTY) LTD**
ADDRESS	**P.O. BOX 22880, WINDHOEK, NAMIBIA**
TELEPHONE NUMBER	**0926461-262985 (INTERNATIONAL)**
PRODUCT NAME / TRADENAME	**ELITE**
CHEMICAL FAMILY	**FORMULATED CLEANING CHEMICAL**
APPLICATION	**LIQUID CLEANER FOR MANUAL DISHWASHING, POT AND PAN WASHING AND GENERAL CLEANING**
SECTION II	
THRESHOLD LIMIT VALUE OF PRODUCT	**N/A**
THRESHOLD LIMIT OF HAZARDOUS INGREDIENTS	**N/A**
INHALATION	**N/A**
EYE CONTACT	**IMMEDIATELY FLUSH WITH PLENTY OF WATER**
SKIN CONTACT	**N/A**
INGESTION	**DO NOT INDUCE VOMMITING. IMMEDIATELY DRINK LARGE QUANTITIES OF WATER. SEEK MEDICAL ATTENTION IMMEDIATELY!**
SECTION III	
APPEARANCE	**BLUE LIQUID**
SG	**1.03**
SECTION IV	
POTENTIAL FOR ACCIDENTAL OR SPONTANEOUS IGNITION OR DETONATION: N/A	
RECOMMENDED FIRE FIGHTING PROCEDURES AND PRECAUTIONS: N/A	
SECTION V	
VENTILATION REQUIREMENTS:	**N/A**
RESPIRATORY PROTECTION:	**N/A**
OTHER PROTECTIVE EQUIPMENT AND PRECATIONS:	**WEAR EYE GOGGLES**

MATERIAL SAFETY – DATA SHEET

SECTION VI	
INCOMPATIBILITY	**DO NOT MIX WITH ANYTHING EXCEPT WATER**
HAZARDOUS DECOMPOSITION PRODUCT	**N/A**
SECTION VII	
SPECIAL PROCEDURES	**N/A**
ENVIRONMENTAL EFFECTS	**N/A**
NEUTRALISING CHEMICALS	**DILUTE WITH PLENTY OF WATER**
WASTE DISPOSAL	**DILUTE WITH RUNNING WATER**

70% biodegradable

universal
- dishwashing
- hand

GELDET

PINE PERFUMED JELLY DETERGENT

PRODUCT USE:
GELDET is a neutral jelly detergent with a fresh pine odour. It is used for cleaning, deodorising and disinfecting floors, tiles, walls, marble steps etc.. Especially recommended for hotels bathrooms and toilets and change-rooms where a lingering fresh smell is desirable.

ADVANTAGES:
Disinfects.
Very economical to use.
Pleasant lingering fresh smell.
Cleans with a simple wipe on wipe off operation.
Very easy to train staff in the use of this product.

PRODUCT DESCRIPTION:

Form: Viscous Gel.
Colour: Amber.
Foam: Good.
Odour: Pine.
Biodegradable: Yes.

DIRECTIONS FOR USE:

Use 6 - 12 grams per litre of water (1 Tablespoon per litre water) , hot or cold. Painted or tiled surfaces require no rinse - simply wipe off.

Ref. No. 01/04 HB

Precautions:
KEEP OUT OF REACH OF CHILDREN.
First Aid:
External: Immediately flush skin with plenty of cool running water.
Eyes: Immediately flush eyes with plenty of cool running water.
Internal: Immediately get medical attention if swallowed. DO NOT INDUCE VOMITING.
Inhalation: Immediately move to fresh air.
GET MEDICAL ATTENTION IMMEDIATELY!

SECTION I	BASIC INFORMATION
MANUFACTURER ADDRESS TELEPHONE NUMBER	CERNOL CHEMICALS (NAMIBIA) (PTY) LTD P.O. BOX 22880, WINDHOEK, NAMIBIA 0926461-262985 (INTERNATIONAL)
PRODUCT NAME / TRADENAME	**GELDET**
CHEMICAL FAMILY	Ammonium based amber gel containing pine oil.
APPLICATION	It is used for cleaning, deodorizing and disinfecting floors, tiles, walls, marble steps etc..
SECTION II	
THRESHOLD LIMIT VALUE OF PRODUCT	N/A
THRESHOLD LIMIT OF HAZARDOUS INGREDIENTS	N/A
INHALATION	Immediately move to fresh air
EYE CONTACT	Immediately flush with plenty of cool running water
SKIN CONTACT	Flush skin with plenty of cool water
INGESTION	Immediately get medical attention if swallowed. DO NOT INDUCE VOMITING
SECTION III	
APPEARANCE	Viscous Amber Gel
SG	1.00

SECTION IV

POTENTIAL FOR ACCIDENTAL OR SPONTANEOUS IGNITION OR DETONATION: N/A
RECOMMENDED FIRE FIGHTING PROCEDURES AND PRECAUTIONS: N/A

SECTION V	
VENTILATION REQUIREMENTS: RESPIRATORY PROTECTION: OTHER PROTECTIVE EQUIPMENT AND	Store out of direct sunlight. Store at room temperature.

MATERIAL SAFETY – DATA SHEET

SECTION VI	
INCOMPATIBILITY	Mix with water only
HAZARDOUS DECOMPOSITION PRODUCT	N/A
SECTION VII	
SPECIAL PROCEDURES	Use 6 – 12 grams per liter of water (1 Tablespoon per liter of water), hot or cold. Painted or tiled surfaces require no rinse – simply wipe off.
ENVIRONMENTAL EFFECTS	N/A
NEUTRALISING CHEMICALS	Dilute with water.
WASTE DISPOSAL	

SYPO

SODIUM HYPOCHLORITE SANITIZER

PRODUCT USE:
SYPO is a high strength liquid chlorine sanitizer for the control of microbial contamination on all food and beverage processing equipment as well as for enhancing the detergency of alkaline cleaning solutions. This uniform, aqueous solution is easily proportioned through sprayers, feeders or chlorinators.

ADVANTAGES:
Combats a broad spectrum of micro-organisms.
Ideal for automatic dispensing.
Rapid bacteria kill.
Economical.
Aqueous solution assures ease of use.
Clear, free rinsing.
Excellent alkaline detergent additive.

STATEMENT OF INGREDIENTS:

Active ingredient:	Sodium hypochlorite	9,4 %
Inert ingredients:		90,6 %

PROPERTIES:

Form:	Aqueous liquid.
Colour:	Clear greenish yellow.
Odour:	Chlorine.
Foam:	None.
S.G.:	1,14.
pH 1% solution:	10,5
Avail. chlorine:	9 % by weight.

DIRECTIONS FOR USE:
Clean all surfaces thoroughly with a suitable detergent and rinse with water. Sanitize with a 200 ppm solution, all non-porous surfaces and a 800 ppm solution for all porous surfaces. Food contact surfaces sanitized with solutions exceeding 200 ppm must be rinsed with potable water before re-use!
For water chlorination, use 0,1 to 0,5 ppm of available chlorine.

Dilution factors for parts per million of available chlorine:

1000 ppm	1 litre in	72 litres water
800 ppm	1 litre in	90 litres water
500 ppm	1 litre in	144 litres water
200 ppm	1 litre in	360 litres water
100 ppm	1 litre in	720 litres water
0,5 ppm	1 litre in	144000 litres water

Ref.No. 01/04 HB

Precautions:
May be harmful if swallowed. Avoid contact with skin and eyes. Irritation to lungs. Do not use acid detergents, ammonia or bowl cleaners with this product, to do so will release hazardous gases. Store in cool dry place.
First Aid:
External: In case of contact with skin or eyes, flush with plenty of cool running water.
Internal: Drink raw egg white, milk or milk of magnesia.
Follow with emetic (tablespoon of salt or mustard in a glass of water).
GET MEDICAL ATTENTION IMMEDIATELY!
KEEP OUT OF REACH OF CHILDREN!

MATERIAL SAFETY - DATA SHEET

SECTION I	:	BASIC INFORMATION
MANUFACTURER	:	CERNOL CHEMICALS (NAMIBIA) (PTY) LTD
ADDRESS	:	P.O. BOX 22880, WINDHOEK-NAMIBIA
TELEPHONE NUMBER	:	0926461-262985 (International)
PRODUCT NAME/TRADE NAME	:	SYPO
CHEMICAL FAMILY	:	SODIUM HYPOCHLORITE
APPLICATION	:	CHLORINE SANITIZER FOR MICROBIAL CONTROL

SECTION II	:	HEALTH HAZARD DATA EMERGENCY AND FIRST AID PROCEDURES
THRESHOLD LIMIT VALUE OF PRODUCT	:	NONE KNOWN
THRESHOLD LIMIT OF HAZARDOUS INGREDIENTS:		NONE KNOWN
INHALATION	:	IRRITANT TO SOFT TISSUE
EYE CONTACT	:	WASH WITH PLENTY OF WATER.GET MEDICAL ATTENTION
SKIN CONTACT	:	WASH WITH COPIOUS AMOUNTS OF WATER
INGESTION	:	DRINK RAW EGG WHITE, MILK/OF MAGNESIA GET MEDICAL ATTENTION

SECTION III	:	PHYSICAL PROPERTIES
APPEARANCE	:	CLEAR GREENISH YELLOW LIQUID
pH	:	10.5 (1%SOLUTION)
SG	:	1.15

SECTION IV	:	FIRE AND EXPLOSION DATA

POTENTIAL FOR ACCIDENTAL OR SPONTANEOUS IGNITION OR DETONATION : FIRE RISK WHEN IN CONTACT WITH ORGANIC MATERIALS

RECOMMENDED FIRE FIGHTING PROCEDURES AND PRECAUTIONS: USE DRY CHEMICAL POWDER OR FOAM

SECTION V	:	SPECIAL PRECAUTIONS, RECOMMENDATIONS FOR HANDLING AND STORAGE
VENTILATION REQUIREMENTS	:	NONE
RESPIRATORY PROTECTION	:	NONE
OTHER PROTECTIVE EQUIPMENT AND PRECAUTIONS	:	PROTECT EYES AND EXPOSED SKIN WHEN HANDLING CONCENTRATED PRODUCT

Continued on Next Page

MATERIAL SAFETY DATA SHEET

SECTION VI	:	REACTIVITY DATA
INCOMPATIBILITY	:	ACIDS/AMMONIA
HAZARDOUS DECOMPOSITION PRODUCTS	:	NONE

SECTION VII	:	LEAKS AND SPILLAGES
SPECIAL PROCEDURES	:	WASH AREA WITH CLEAN WATER
ENVIRONMENTAL EFFECTS	:	NONE
NEUTRALISING CHEMICALS	:	WATER
WASTE DISPOSAL	:	WASH AREA WITH WATER AND RUN TO WASTE

Ref.No. 01/04 HB

APPENDIX V: DOCUMENTED INTERVIEW NOTES

Gobabeb Research and Training Centre Interview

Date: 3/25/2013

RESIDENCE: ***OLD HOUSE***
ROLE AT GOBABEB: ***INTERN WORKING ON FORESTRY RELATED PROJECTS***
TIME AT GOBABEB: ***9 MONTHS***

WATER

What do you think about the drinking water quality at the Centre?

The water can be pretty bad sometimes Chlorine taste or a salty taste.

What types of detergent do you use? (Example for Shampoo)

He uses some sort of lemon shampoo that is not biodegradable.

If Gobabeb provided a Biodegradable detergent to all of the people that stayed there would you we willing to use it?

He would not use a GBB provided shampoo.

Do you have any other suggestions about what could be better at the Centre?

He says that some people will drain oil down the sink after they are done using it instead of throwing it out. He said maybe there should be a sign reminding people not to do that or a place to dispose of oil.

Gobabeb Research and Training Centre Interview

Date: 3/26/2013

RESIDENCE: ***BUNGALOWS***
ROLE AT GOBABEB: ***RESEARCHER – WORKING ON HIS PHD IN HERPETOLOGY***
TIME AT GOBABEB: ***3 WEEKS***

Can you tell us a little about your work at Gobabeb?

He is from Germany and has been here for a few months collecting lizards, doing temperature tests and doing lab work. He is the current primary user of the lab. There is a microbiologist who works with lichen that flies in every couple of months to do work in the lab as well. She works with more chemicals and keeps weird things in the fridge that no one seems to know what they are.*

WATER

What do you think of the Centre encouraging people to use biodegradable detergents? Would you use them?

Sebastian uses a biodegradable soap he bought in Germany in a camping store, although he recently ran out. He also used to use soap nuts for his laundry. Soap nuts or soap berries (sapindus) have a natural surfactant and work as natural washing machine detergents. Sebastian said you just but some in a cloth bag and put it through the washing machine with a load of clothes.

He also looked up the soaps that he has used in the past. Ortec travel Siefe, Fibertec smart wash and oekoseifen were all ones he told us. Most of them were plant based. He said that some of the girls at the Centre use a lot of hair product to keep their hair nice and he thought that might be an issue.

*This could have been a cause of the strange growth in the trickle filter system.

Gobabeb Research and Training Centre Interview

Date: 3/18/2013

RESIDENCE: ***CARAVANS***
ROLE AT GOBABEB: ***INTERN/RESEARCHER***
TIME AT GOBABEB: ***13 MONTHS OVER TWO STAYS***

WATER

What are your thoughts on water quality at the Centre?

- It would be good if we could find some way to educate people on the importance of maintaining proper water sanitation
- Some times when they are filling the main water tank they leave the hatch on the top open
- Also don't pay close attention to filling the tank and they often over flow it for a while
- The drinking water quality is poor, it can be very salty at times, once it would not freeze in the freezer, and often tastes of chlorine
- He thinks that if they got four efficient dishwashers that would cut down on the amount of water and detergents used to clean, and that it would be easier for the staff
- He also noted that nearby miners also consume a lot of water mining uranium

How do you dispose of your dirty or used water at the Centre?

- Goes down the drain to the trickle filter
- Water from the trickle filter is rarely ever recycled in the garden and is usually released straight into the Kuiseb, near the borehole, and leaches into the aquifer
- Water from the pool is directly released into the Kuiseb River basin, near to the borehole. He is concerned about the effects of this, and about the amount of water being used with the pool

How often do you shower? Use the Sink? Or flush the toilets?

- Showers once a day, tries to shower for three to six minutes, but sometimes he needs longer showers after playing volleyball
- Some people shower twice a day

Are there any limitations in place on how much water you can use?

- No, there are no limitations
- If you want to take a 20 minutes shower you can
- Most interns know that you should take shorter showers, but guests that come do not always know, or do not think it is important

Is there any form of educational methods or orientations for the people that come to stay at the Centre in regards to water?

- There is a mini orientation for guests and a longer one for interns, but it does not include anything about water consumption or detergent use
- He thinks that a pamphlet for new staff with important information about recycling as well as water and detergent practices would be helpful, as it would increase institutional memory as the staff rotates consistently

Are there any limits on the types of detergents you can use? Examples: shampoos, soaps, conditioners, toothpastes, etc.

- No, didn't even know that that was causing a problem for the trickle filter

What do you think of the Centre providing biodegradable detergents? Example soap dispensers in the showers?

- People would either use them or they wouldn't
- Educational facts next to the dispensers might encourage people to use them

Since the interns have to buy supplies for a month at a time, do you think the centre should buy biodegradable detergents in bulk and provide them for the interns? Would this make it easier for you to buy supplies?

- I think it would be easier, and a good way to get the staff to use biodegradable detergents, but there is no current system of organization to buy things in bulk, everyone provides their own supplies, so actually doing this may be difficult.

Would timers in the shower help make people more conscious of their water usage?

- It would encourage people to take shorter showers, but he did think people needed more of an incentive to use them, and that they would be expensive to install

SOLID WASTE

Where do you throw away your garbage?

- He sorts waste into piles, but since there is no established recycling at the dump in Walvis bay all of the garbage gets mixed back together
- Thinks the bio waste is just used in the garden, but is unsure, he had never heard of using the bio waste to feed the Topnaar goats

What types of garbage do you throw away?

- Mainly plastics from food wastes
- Bottles from beer – a potential idea to make money is to bring the bottles to a place where you can get money for recycling them
- He thinks that since recycling, beyond bio wastes, is not actually carried out when the waste is brought to Walvis Bay, there should be more of a focus on reducing waste and recycling products within the centre

Do you recycle/reuse anything that could be considered waste? What do you recycle?

- Developed his own compost system and garden because he does not trust the compost system at the centre
- Plastic often gets into the bi-degradable waste and that ruins the compost they use in the garden

Can you use the donkey manure for fertilizer in the garden?

- There is a lot of manure and it would be good if they could use it in the garden but he didn't think it could be used

Would you like to change your methods of throwing away garbage? If yes, why?

- Find a more practical way of recycling
- He thinks that many people at the centre find recycling important, but that not everyone does. For example boxes for newly installed computers were left out for awhile, and were causing a waste problem
- He thinks they could reduce waste through possible use of canvas bag instead of plastics ones for shopping

Gobabeb Research and Training Centre Interview

Date: 3/18/2013

RESIDENCE: ***LUXURY HILL EMPLOYEE QUARTERS***
ROLE AT GOBABEB: ***TRAINING COORDINATOR***
TIME AT GOBABEB: ***7 MONTHS***

WATER

What are your thoughts on water quality at the Centre?
The water is often salty or has high levels of chlorine. He was also concerned about how the student groups visiting the Centre affected the water quality of the pool, especially since the water is directly drained to the Kuiseb.

How do you dispose of your dirty or used water at the Centre?
It goes into the trickle filter. The filter often isn't working and the water is generally released straight back into the aquifer instead of being used in the garden. The gardens aren't used as often as they could be, if it output better produce then maybe it would be.

When school groups/visitors come to the Centre do you teach them about the importance of limiting their usage and saving water?

Yes, we generally tell them that it is important to conserve water at the Centre due to the arid environment, as well as telling them to stay on the walkway paths to preserve the desert eco-system. There are also some informational signs in the guest residences, though most of the student groups stay in tents.

SOLID WASTE
When school groups come to Gobabeb do you do any activities with them to teach them about recycling?

The students know about recycling before they come to the Centre, so we don't do many educational programs about it. Education on recycling is seen as low on the list of priorities because it is seen as a success if the children can just remember to throw things away.

Where do you throw away your garbage?
He throws away his garbage in the correct sorting bins, but doesn't see much purpose in it.

He was saying that if the garbage stays sorted at the Centre it just gets mixed up again when it is thrown away in Walvis Bay. He says that the interns generally drive the garbage to Walvis Bay around twice a month, generally when they have to go into town for other reasons. He says that there may be some other recycling programs along the coast and a possible program that recycles aluminum in Windhoek, but he is not sure.

What types of garbage do you throw away?

The majority of his garbage comes from packaging from food that he buys, also beer bottles. He noted that there is a lot of waste coming from the plastic shopping bags they get at the markets.

Would you like to change your methods of throwing away garbage? If yes, why?
Yes, he would like there to be a smaller buildup of waste at the Centre. He does not believe that sorting the garbage has much of an effect. He believed that reducing the amount of waste the Centre produced would probably be the most practical solution.

Gobabeb Research and Training Centre Interview

Date: 3/18/2013

*RESIDENCE: **OLD HOUSE***
*ROLE AT GOBABEB: **INTERN***
*TIME AT GOBABEB: **1 MONTHS***

Did you receive any sort of orientation when you first got here?

She did not get any kind of orientation when she got here.

WATER

What do you think about the drinking water quality at the Centre?

She doesn't like how the water tastes and she said she thought about boiling it before drinking it but it was to much work and it didn't really work, but she thinks its clean enough.

What types of detergent do you use? (Example for Shampoo)

She says she uses Organics Root Stimulator shampoo and Sanex soap, the one for sensitive skin.

If Gobabeb provided a Biodegradable detergent to all of the people that stayed there would you we willing to use it?

She is a little worried about the biodegradable shampoo being okay for people with sensitive skin but she thinks that people, especially the visitors would use the shampoos and biodegradable soaps if they were made available at the Centre.

How long do you typically shower for?

She takes about 12 minute showers, but when the water to warm she will take longer ones. Or if its cold she will take shorter ones.

WASTE

Do you have any suggestions in regards to improving solid waste management?

One change she thinks could be made is make the bio bin signs more clear because there are a lot of things she isn't sure if she can put in there. She thinks the paper and plastic bins are the ones that fill up the fastest.

Gobabeb Research and Training Centre Interview

Date: 3/18/2013

Residence: Old House – Often takes long trips into the field
Role at Gobabeb: Researcher **-** working to set a base line environment status on areas where mining may be influencing the well being of the environment

*TIME AT GOBABEB: **8 MONTHS***

Did you receive any sort of orientation when you first got here?

He did get a station tour when we got here but that was about it. They did say to conserve water.

WATER

If Gobabeb provided a Biodegradable detergent to all of the people that stayed there would you we willing to use it?

He uses something biodegradable as his soap and would definitely use a biodegradable one if the Centre provided one.

WASTE

Do you have any suggestions in regards to improving solid waste management?

He says the thing he throws away the most of is plastic and food packages. An improvement he'd like to see is reusable bags for shopping in town. He would like to take part in the Topnaar clean up.

Gobabeb Research and Training Centre Interview

Date: 3/27/2013

RESIDENCE: ***OLD HOUSE***
ROLE AT GOBABEB: ***IT SUPPORT***
TIME AT GOBABEB: ***3 MONTHS (VISITED GOBABEB DURING THE OPEN HOUSE LAST YEAR)***
Did you receive a tour of the GRTC when you first arrived? Did they inform you about conserving water and proper garbage disposal?

I had an orientation, but was not told about water usage. Maybe they assumed I knew about conserving water and sorting waste because I had been to the GRTC open house the year before.

WATER
What are your thoughts on water quality at the Centre, do you do any additional treatment to your water or do you drink it straight from the tap?
It is good quality drinking water; except sometimes the water tastes like salt and chlorine. I don't filter it, but if you freeze the water and then leave it out it tastes better.

How long do you usually shower for?
I love the water, so I usually take longer showers. I think my average shower lasts around 10-15 minutes. I know that some people at the Centre take up to 20 minute showers.

Do you think using timers in the showers would be a good idea?
Yes it would be a good idea; then people would know how long their showers take.

Did you know that non biodegradable detergents were bad for the trickle filter? Do you use biodegradable detergents?

The type of detergents I use change frequently between shopping trips. So sometimes my detergents are bio-degradeable and sometimes they aren't. Someone had told me about how detergents effect the system, and there used to be posters in the kitchens about detergent use.

Do you think it would be a good idea for Gobabeb to buy biodegradable detergents in bulk and provide them to residents and visitors?

I think it would be a good idea, because currently Gobabeb has no way to keep track of what detergents people are using. It is also hard to find biodegradable detergents. If Gobabeb can't buy detergents in bulk for people they should at least provide staff and

visitors with a list of what types of detergents they should use, and where they can buy them.

Did anyone tell you that pouring cooking grease down the sinks drain was bad for the waste water system? Do you ever pour grease from cooking down the drain?

No one told me, but I usually avoid pouring grease down the sink anyway.

SOLID WASTE

Do you use the sorting bins?

Yes.

What is your biggest source of waste/garbage?

Most of my waste comes from food packaging and plastic bags from shopping.

Have you driven the garbage to Walvis Bay? What do you know about the garbage system here?

The garbage gets mixed up before it even gets to Walvis Bay. They used to drive the garbage out twice a month, but now they are only trying to drive it out once a month.

Do you use the garden? Would you use it if it was healthier and had more plants?

Yes, I use the garden.

Gobabeb Research and Training Centre Interview

Date: 3/27/2013

RESIDENCE: ***CARAVANS***
ROLE AT GOBABEB: ***DESERT SCIENCE & RESEARCH TRAINING (DESERT) STUDENTS***
TIME AT GOBABEB: ***3 MONTHS***

Did you receive a tour of the GRTC when you first arrived? Did they inform you about conserving water and proper garbage disposal?

I had an orientation, but was not told about water usage.

WATER

What are your thoughts on water quality at the Centre, do you do any additional treatment to your water or do you drink it straight from the tap?
The water quality is good, but sometimes it is salty. I don't filter it; I just drink it straight from the tap.

Do you think using timers in the showers would be a good idea?
Yes, I think it would be a good idea. It would help people realize how long their showers are actually taking.

How long do you usually shower for?

I take medium length showers. They probably last between 6-10 minutes.

Did you know that non biodegradable detergents were bad for the trickle filter? Do you use biodegradable detergents?

I don't use biodegradable detergents and never knew that it was an issue.

Do you think it would be a good idea for Gobabeb to buy biodegradable detergents in bulk and provide them to residents and visitors?
I think it would be a good solution for short term visitors, but not for people living at the Centre for longer periods of time. Some people have sensitive skin and hair, so I don't know if these biodegradable detergents would be good for them to use.

Did anyone tell you that pouring cooking grease down the sinks drain was bad for the waste water system? Do you ever pour grease from cooking down the drain?

I know that it's bad, I usually don't, but I occasionally forget.

SOLID WASTE

Do you use the sorting bins?

Yes.

What is your biggest source of waste/garbage?

Plastic packaging from my food and the bags I bring supplies back with.

Would you be interested in participating in a community clean up in the nearby Topnaar village?

Yes.

Gobabeb Research and Training Centre Interview

Date: 3/26/2013

RESIDENCE: ***CARAVANS***
ROLE AT GOBABEB: ***TRAINING ASSISTANT***
TIME AT GOBABEB: ***5 MONTHS***

Did you receive a tour of the GRTC when you first arrived? Did they inform you about conserving water and proper garbage disposal?

Yes, I received a station tour when I first arrived that included that explained that I should conserve water as well as energy because of the limited resources of the desert environment.

WATER

What are your thoughts on water quality at the Centre, do you do any additional treatment to your water or do you drink it straight from the tap?
The water is of good drinking quality and I drink it straight from the tap without treating it.

Do you think using timers in the showers would be a good idea?
No, timers in the showers seem to stressful. Also people should be old enough by now to manage their own water usage without a prompt.

Did you know that non biodegradable detergents were bad for the trickle filter? Do you use biodegradable detergents?

Yes, Walter Holch told me about how non biodegradable detergents are bad for the trickling filter, but I still use generic non-biodegradable detergents. We have limited time in Walvis Bay to shop and it is more difficult and time consuming to find biodegradable detergents.

Do you think it would be a good idea for Gobabeb to buy biodegradable detergents in bulk and provide them to residents and visitors?
Yes, it would be an easy way to make sure people were using biodegradable detergents that would be convenient for the long term residents.

Did anyone tell you that pouring cooking grease down the sinks drain was bad for the waste water system? Do you ever pour grease from cooking down the drain?

Yes, I was told that pouring grease down the drains is bad for the house and plumbing in general. However, I sometimes still occasionally pour the grease down the sink because I forget, so I think there should be reminder signs in the kitchens.

SOLID WASTE

Do you use the sorting bins?

Yes, but there doesn't seem to be much of a point to it because the waste eventually just ends up being recombined. It does make Gobabeb look good though.

What is your biggest source of waste/garbage?

My biggest source of garbage is the packaging that my food comes in.

Have you driven the garbage to Walvis Bay? What do you know about the garbage system here?

I've never driven the garbage into town and I don't know much about it. I believe they are trying to make less trips then they used to.

Do you use the garden? Would you use it if it was healthier and had more plants?

No, I don't use the garden and don't think I ever would. I just like preparing my own food from the things I buy in town.

Gobabeb Research and Training Centre Interview

Date: 3/26/2013

RESIDENCE: ***LUXURY HILL***
ROLE AT GOBABEB: ***CONSULTANT RESEARCH TECHNICIAN***
TIME AT GOBABEB: ***2 YEARS***

Did you receive a tour of the GRTC when you first arrived? Did they inform you about conserving water and proper garbage disposal?

I didn't receive any orientation.

WATER

Do you think using timers in the showers would be a good idea?
Yes, it would help keep shower times down.

Did you know that non biodegradable detergents were bad for the trickle filter? Do you use biodegradable detergents?

They change frequently and are not biodegradable.

Do you think it would be a good idea for Gobabeb to buy biodegradable detergents in bulk and provide them to residents and visitors?
Yes, it would be a good idea and I would use it.

SOLID WASTE

What is your biggest source of waste/garbage?

I notice that the plastic and paper bins fill up the fastest,

Additional ideas?

I would like to see individual water meters to see the amount of water I use.

Gobabeb Research and Training Centre Interview

Date: 3/26/2013

Residence: Caravans
Role at Gobabeb: Libirain Assistant

Time at Gobabeb: 9 Months (Will be there for 1 year July 2012-July 2013)

What are your main projects at the Centre?

- Work as a library assistant
    - Small projects in the library
    - Currently working on digitalizing information and research

Was there any sort of orientation when you first arrived here for interns?

- No – There is now that Anna set something up
- It was actually really akward when I first got here because no one actually knew I was coming

WATER
How do you feel water conservation at the Centre could be improved?

- Stop using drinking water in the toilets
- Improve the inefficiencies with the trickle filter so the water can be recycled

Do you think the interns and visitors to the Centre would use biodegradable detergents if the Centre provided them?

- Definitely people would use laundry detergent and dish soap if the centre provided it
- Shampoo on the other hand is questionable
    - Short term visitors probably would
    - Longer term people will want to use their own
    - Especially girls because they like to keep their hair nice

What it the shampoo was in a dispenser in the shower?

- Some people might not use it but think most would

SOLID WASTE

What are your thoughts on garbage management and recycling at the centre?

- Waste Management is inefficient
- Sort the garbage and then it is mixed back together again
- Her German group studying abroad went to a place called Rent-a-drum
    - Recycling in Namibia

Gobabeb Research and Training Centre Interview

Date: 3/26/2013

Residence: Bungalow
Role at Gobabeb: Maintenance, works with the trickle filter (wastewater system) and water system
Time at Gobabeb: 1 Year

What are your thoughts about water conservation at the Centre?

- Years ago we used to have a coin system set up where you had to use a coin to pay for a certain amount of time in the shower
- Controlled the amount of water individuals use
- Don't think it would work anymore because long term residents would not want to pay for every shower they took

* She used to only flush the toilet when she defecated and wouldn't flush when she just urinated in the toilet but her pipe got clogged because the toilet paper dried in it because not that much water was flowing down the pipe – She was told to flush more

How many times do you shower?

- I shower for a long time every other day
    - I end up using the same amount of water as someone who showers everyday
    - Would not like to use the coin system because she would pay more for a longer shower

What are your thoughts on the water quality here at the Centre?

- I am concerned about the Chlorine amount
    - I feel like the dosing is off of the amount that Nam Water puts in each month
- Also the biological bacteria and things in the water as well

Are there any unnecessary water usages?

- The Gobabeb Staff uses hose water to wash the cars and the windows

Do you think they could use the trickle filter water to wash the cars?

- They could but it would probably cost more to pump it up the hill then to just use the drinking water

- Lack of awareness with the staff in regards to water conservation
    - Needs to be an educational program to inform them
    - Too much change over of the interns
    - No person to manage these issues

What types of improvements do you think could be made?

- Use trickle filter water in the toilets
- Swapomund uses partial clean water in their public gardens

Do you think the interns and visitors to the Centre would use biodegradable detergents if the Centre provided them?

- Definitely people would use laundry detergent and dish soap if the Centre provided it
- Shampoo on the other hand is questionable
    - She probably wouldn't

What it the shampoo was in a dispenser in the shower?

- Thought that was a great Idea

SOLID WASTE

Do you think that the waste could be manage in a more effective way?

I think that the current practices are not very efficient because we are forced to sort the garbage and it doesn't remain sorted

Do you have any suggestions on how to improve it?

I think that we could look into other recycling options like Rent-a-Drum

Gobabeb Research and Training Centre Interview

Date: 4/16/2013

Residence: Tsabibis Staff Quarters
Role at Gobabeb: Site Maintenance Assistant
Time at Gobabeb: 4 Years

When you came to Gobabeb were you told about saving water, energy, and sorting the garbage?

Yes, when one of the interns started talking about the garbage sorting system I was told all of these things

Water Consumption

What do you use water for? How much do you use?

The things I use water most for is bathing, washing clothes. Cooking food doesn't use much water.

Did anyone tell you that pouring cooking grease down the sinks drain was bad for the waste water system? Do you ever pour grease from cooking down the drain?

No one ever told me that pouring cooking grease down the drain was bad. I do sometimes.

Solid Waste management
Do you use the sorting bins?

Yes, I also collect them.
What is your biggest source of waste/garbage?

Packaging from food and shopping bags is where most of my waste comes from. I also know that a lot of waste comes from catering.

Do you use the garden? Would you use it if it was healthier and had more plants?

Yes, I use the garden sometimes.

Any other suggestions?

People don’t sort the garbage correctly and the garbage collectors don’t have time to go through and sort it. Also the buildings in the main Centre have 6 litre flush toilets, while the ones at Tsabibis are 9 litres; having 6 litre flush toilets would save a lot of water.

APPENDIX W: COMPILED INTERVIEW DATA

Did you get an orientation?	Opinion on water quality?	How long do you shower?	In favor of timer showers?	What shampoo do you use?	Opposed to GBB supplied detergent?	Most of your waste is?	Any improvement ideas?
Not right away but yes	Its salty and has a lot of chlorine, but it's okay		Yes it's a good idea			Food packages and bottles	GBB should focus more on the garden and cutting down on waste produced
Sort of; not a good one though	Poor, salty and chlorinated. Sometimes it doesn't freeze	3-6 minutes a day	Yes, it's a good idea; might be expensive to install	Not biodegradable, didn't know it was an issue	There is no current system to buy things in bulk; might be difficult to implement	Food packages	Recycling bottles in Walvis
Yes, station tour of energy and water use	The water quality is good		No, they are stressful	Non-biodegradable even though Walter Holch told him to	Good idea to buy in bulk	Packages of food, plastic bags	There should be a sign to remind people not to pour grease down the sink
No ; No one knew she was coming	Water taste very chlorinated		Yes, Maybe just for short term visitors	non biodegradable	good idea but not for shampoo		Rent-a-drum
Yes	Its okay				Good idea because currently the interns buy it		
Yes	It's okay	Not very long	Yes	A German biodegradable shampoo	I'd use it, but other people might have an issue with it	Food packages	

No	Pretty bad; sometimes there's a chlorinated and/or salty taste.			Non-biodegradable lemon scented	Would not use it		There needs to be a sign about not drain oil down the sink
No	Doesn't taste good	12 minutes sometimes longer	Yes, they would help people shower for less time!	Organics - Root stimulator Sanex Soap	people would probably use it!	The paper/plastic fills up pretty fast.	Make bio bins more clear
Yes, station tour		around 5 minutes		Something biodegradable	Would use it	Plastic bags and food packages	Re-useable bags for shopping in town
	I think Nam water has the treatment wrong - Very chlorine tasting would like us to test it	Longer shower every other day so it averages out	Yes - used to have paying ones	not biodegradable	I think short term visitors would use it but especially girls like to have there hair nice		Rent-a-drum - compost system could be improve don't want to use human poop in the garden
Yes, station tour, water conservations but no detergents	Good but sometimes its salty	Around 6-10 minutes	Yes it's a good idea	Not biodegradable, didn't know it was an issue	good for short term visitors, but not really for long term people	Plastic packaging and bags	Nothing
She had an orientation, but was not told about water usage.	It is good quality drinking water; except	She takes longer showers (10-15 minutes); some people	Yes; then people would know how long their showers take.	The type of detergents she uses changes frequently between	She thinks it would be a good idea, because currently GBB has no way to keep	Most of her waste comes from food packaging and plastic	Provide staff and visitors with a list of detergents they should use, and where they can

	sometimes the water tastes like salt and chlorine.	take up to 20 minute showers.		shopping trips; so not always biodegradable.	track of what detergents people are using. It is also hard to find biodegradable detergents	bags from shopping.	buy them
No orientation		10 minutes	Yes it would help keep shower times down	They change a lot but they are not biodegradable	She would use a soap if it was provided by the centre	plastic and paper bin are the ones that fill up the fastest	Wants individual water meters to see the amount that she uses
Yes, told about sorting system	good					Packaging from food, shopping bags, and catering makes a lot of waste	Better sorting; 6 litre flush toilets at Tsabibis

Stats:

Timers in Showers:7/9 Approve of timers in showers, 1/9 approves for short term visitors, 1/9 disapproves

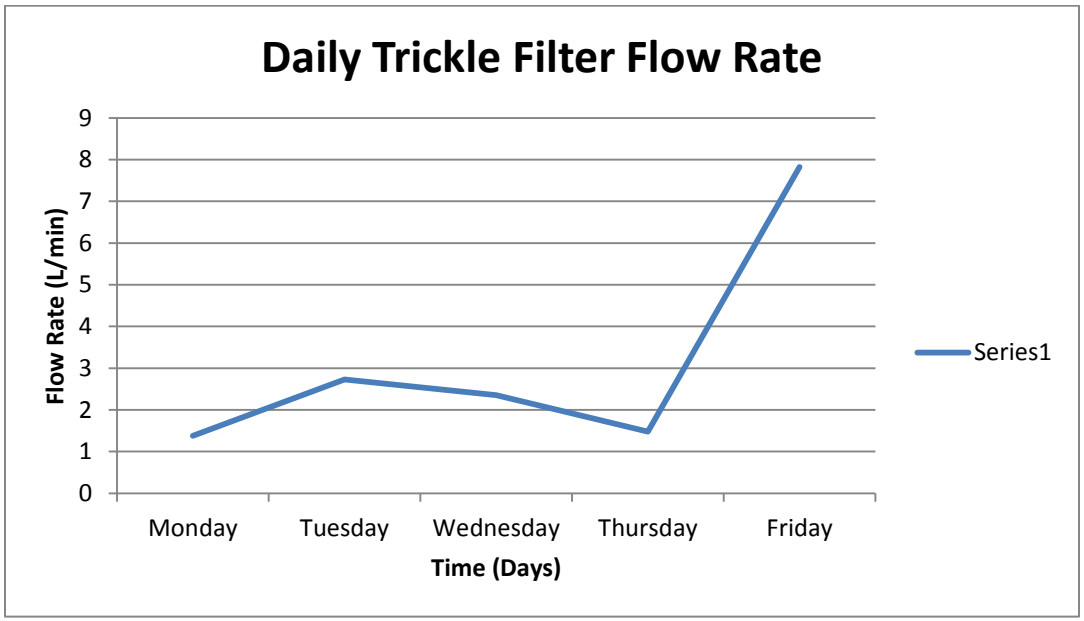
Orientations: 5/13 had satisfactory orientations, 4/13 Had delayed, unsatisfactory, or incomplete, missing conservation practices information, 4/13 had no orientation

Daily Shower Length: 2/8 3-6 min, 2/8 6-10 min, 2/8 10-15 min, 1/8 short unspecified, 1/8 longer showers every other day

APPENDIX X: DAILY & HOURLY TRICKLE FILTER FLOW RATE DATA

Daily Readings:

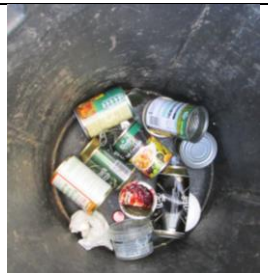
Date	Time	Volume (L)	Time (Sec.)	Time (Min.)	Flow Rate (L/min)
Mon. 15/4	09:00	10	435	7.25	1.38
Tues 16/4	09:00	4	88	1.47	2.73
Wed. 17/4	09:00	2	51	0.85	2.35
Thurs. 18/4	09:00	2	81	1.35	1.48
Fri. 19/4	09:00	3	23	0.38	7.83



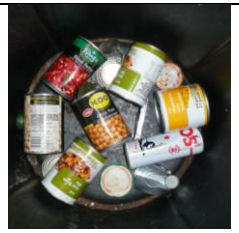
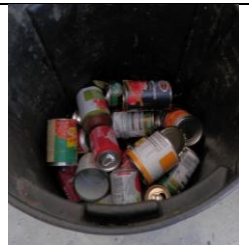
Hourly Readings:

Date	Time	Volume (L)	Time (Sec.)	Time (Min.)	Flow Rate (L/min)
Tues 16/4	08:00	4.5	109	1.82	2.48
Tues 16/4	09:00	4	88	1.47	2.73
Tues 16/4	10:00	5	85	1.42	3.53
Tues 16/4	11:00	4	65	1.08	3.69
Tues 16/4	12:00	4	81	1.35	2.96
Tues 16/4	13:00	3	61	1.02	2.95
Tues 16/4	14:00	6	145	2.42	2.48
Tues 16/4	15:00	3	62	1.03	2.90
Tues 16/4	16:00	2	48	0.8	2.5
Tues 16/4	17:00	2	40	0.67	3
Tues 16/4	18:00	3	68	1.13	2.65
Tues 16/4	19:00	2	44	0.73	2.73
Tues 16/4	20:00	2	50	0.83	2.4

APPENDIX Y: WASTE AUDIT

Types					
Week 1 Old House					
Notes:	1/3 full, plus a metal can	Full, plus glass bottle	¼ full	1/5 full	Empty

Week 1 Clay House Kitchens					
Notes:	¼ full	½ full	1/3 full	¼ full	¼ full
Weekend 1 Old House					
Notes:	1/10 full	Completely full	1/5 full	¼ full	1/5 full
Week 2 Old House					
Notes:	¼ full	1 ¼ full plus glass bottle	¼ full	½ full	¾ full

					
Notes:	¼ full	1/3 full	1/5 full	1/10 full	¼ full
					
Notes:	¼ full	1/3 full	1/3 full	1/5 full	1/3 full
					
Notes:	1/5 full	1 1/5	1/3 full	¼ full	1/5 full
		Incorrectly sorted can			

APPENDIX Z: OBSERVATIONS OF SOLID WASTE BUILDUP AT THE GRTC

Location	Photograph
Tsabibis Staff Quarters	
Tsabibis Staff Quarters	
Tsabibis Staff Quarters	
Tsabibis Staff Quarters	

Additional Notes:

*Types of waste found: glass, paper, plastic, animal droppings, two dead baby donkeys, and multiple broken cars.

APPENDIX AA: INFORMATION FROM CONVERSATIONS WITH SEBEDEUS AND THE TOPNAAR OF THE SALT RIVER VILLAGE:

The following is information that we compiled through talking with Sebedeus Swartbooi and through interviews with the residents of the Salt River Topnaar village.

Background on Sebedeus:

Sebedues grew up in one of the Topnaar settlements along the Kuiseb River and has worked with the DRFN and the GRTC on and off for 5 years. He is a Topnaar craftsman and is working on a proposal for the GRTC. He is also working with the communities on a proposal for sanitation and water in the communities.

Background information on the Topnaar:

The ≠Aonin Topnaar of the lower Kuiseb River Basin have their own internal government system. There is one chief for all the communities along the Kuiseb River. Before the 1980s and before independence they went a long time without a chief but they elected one in 1981 and the current one is that chief's son. The chief is also a chairman within a Namibian Chiefs council. There is a group of council members below the chief called the Cultural Authority, which calls meetings. Some of these council members live somewhat locally and work at the offices between Walvis Bay and the settlements, but some of them are in Walvis Bay with the chief who runs an office there. Due to the great distance between the settlements and Walvis Bay, the communication between the governing body and the members of the community is not very good.

The settlements are also in the process of organizing committees to discuss different issues including water, sanitation, tourism, electricity and other things. They are looking to create a five year plan that details all of the improvements they wish to make in these areas. This list is supposed to be compiled by April of 2013.

Information on Solid Waste Management:

There are a lot of bottles, cans, animal hides, and bones, as well as other solid waste in the settlements. There used to be garbage collection service for the settlements run by the Ministry of Environment and Tourism (MET), but that stopped a long time ago when the land was given over to the people. Now the different residents

employ different methods to manage their waste; some residents burn solid waste, some bury the solid waste, and some pile it in areas just outside their main village.

Mary Seely tried to make a proposal for better solid waste management and sanitation for the settlements to the UN last year, 2012, however the proposal was unfortunately, denied funding.

Human Waste Management:

There are some government provided dry toilets in the settlements. In the settlements where dry toilets are not present sometimes makeshift human waste management efforts are made. There are homemade "toilets" in place, that consist of open holes in which fire ash is placed after usage, to dry it out. When the hole is full they fill it in with dirt and dig a new hole. One man was even in the process of trying to create a flush toilet. When these efforts are not made the bush is used. Using the bush is most difficult for the women and elderly. There is also a nearby kindergarten that does not have toilets.

Sebedeus explained that the residents have reasons for waste and sanitation management to be important to them like tourism, health, and the safety of animals and children. Currently, the residents are aware of these reasons to some extent, but not fully. If more education on the topic could be brought to the communities he said there would be potential for a community disposal Centre.

Water Management:

There are different water systems for the different settlements. Some villages have government provided solar-powered water pumps and storage tanks and some rely on piping from Namwater. Namwater charges the villagers fees which they sometimes cannot pay and are then subsequently cut off from the water supply. Sebedeus noted that some mining companies may be able to help with the water situation as many residents of the settlements work at the mines.

In the villages with solar-powered water pumps the solar panel system sometimes breaks. Sebedeus explained that when the systems were first installed some elders were taught how to fix them. Unfortunately, over time the people with the knowledge on how to fix the system either passed or moved away. This means that when the system breaks residents need to go to neighboring villages for water, sometimes for extended periods of time, as the government is very slow to provide help with repairs.

There is also sometimes slight concern about the brackishness of the water.

Sebedeus then provided us with a short anecdote that showed the lack of education about sanitation. He said that once he was walking up-stream to a village and got thirsty, so he decided to drink water from the river. Later, when he walked further upstream, he saw some villagers throwing used baby nappies into the river.

Primary Concerns of the Settlements:

Sanitation and waste management are very pressing issues facing the Topnaar settlements. Unfortunately, the issues of the lack of communication and funding are considered to be the most important to address. Sebedeus mentioned that in order for any improvements to be made to the sanitation and waste management issues facing the settlements, the lack of communication among the settlements, between the settlements and their government, and the settlements and Gobabeb, as well as the lack of funding, have to be addressed.

Lack of Communication:

Beyond the lack of communication previously mentioned between the communities and their internal government, there is also a lack of communication among the communities.

Some of the villagers go to Walvis Bay to work, so families are broken up, and with there being no electricity in the communities and no landlines, keeping in touch is difficult. Some members of the communities have cell-phones, but keeping them charged and finding a signal are very difficult. The lack of transport between the settlements and between the settlements and Walvis Bay also reduces the ability to communicate.

Due to this lack of communication there is some obscurity on the amount of people living in the area. They thus want to conduct a census to set up some kind of member benefit system to distribute benefits coming in from future tourism ventures or some other source of income.

Lack of Funding:

Sebedeus listed lack of funding as another one of the main issues facing the settlements. He mentioned that efforts have been made on the part of the GRTC and others to improve conditions at the settlements, but because of a lack of funding, these efforts have all fallen through. The fact that these efforts have fallen through

has discouraged some community members and has damaged the trust between the communities and the GRTC.

Possible Income Sources:

In regards to tourism there is an interest in expanding upon Sebedeus' cultural walk and developing a cultural village where people staying at Gobabeb could come and visit to learn about the ≠Aonin culture, crafts, and !nara melons.

The settlements currently gain money through goat husbandry and farming. The government has also recommended that they sheer sheep at the farms to raise additional funds. However, the settlements are worried about the environmental effects of adding sheep. They don't want to deplete the grass, shrubs, and other resources in the area by possibly overgrazing, as they already have a large number of goats. There needs to be research done in this area before this can be implemented.

The settlements were also recommended to sell dead wood, but there are unsure if they can obtain a permit for this, so now they are looking in to other uses or projects for the dead wood.

Organizations That Should be Investigated for Future Funding:

Living Culture Foundation of Namibia

Ministry of Environment and Tourism

Mission Association of Namibia

APPENDIX AB: THE WATER MANAGEMENT DATA EXPLANATION

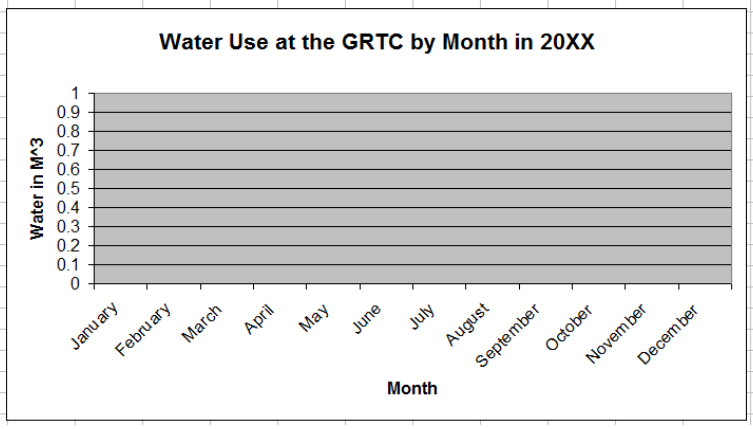
The template excel file that organizes and analyzes the water meter data has two spread sheets. The first sheet, "20XX Data", is just for logging and compiling all the meter readings. 20XX Data is separated into months and has a purple box to place the date the meter reading was taken on the left as shown below. The light blue boxes are for the actual meter readings. There are 5 spaces for meter readings for each month, not all boxes need to be filled it is much more important to have metering readings under the correct month. **Meter readings need to be taken every week for the tool to produce an accurate bar chart of the water usage at the center per month.** Any meter location along the top that is highlighted in

	Monthly And Yearly Water Use at GRTC																		
2	Date	Main Tank	Amabalis Back	Amabilis Front	Clay House 1	Clay House 2	Clay House 3	Old House	Luxury Hill 1	Luxury Hill 2	Luxury Hill 3	Luxury Hill 4	Luxury Hill 5 (Solar Geysers)	Tsabibis	Pool	Kuiseb Camp	Villas	Bungalow	Main Station
3	**January**																		
4																			
5																			
6																			
7																			
8																			
9																			
10	**February**																		
11																			
12																			

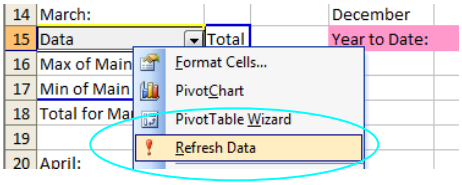
yellow is missing or broken. Clay House 1 is the furthest clay houses from the main station, making clay house 3 the closest one to the center. Luxury Hill meters are numbered from left to right, ending with the solar geysers.

The second sheet, "20XX Monthly Totals" compiles the total water consumed by month and presents it on a bar chart. It also totals the total water used at the Centre that year to the current date.

January:			Month	Total
Data	Total		January	0
Max of Main Tank			February	0
Min of Main Tank			March	0
Total for January:	0		April	0
			May	0
February:			June	0
Data	Total		July	0
Max of Main Tank			August	0
Min of Main Tank2			September	0
Total for February:	0		October	0
			November	0
March:			December	0
Data	Total		Year to Date:	0
Max of Main Tank				
Min of Main Tank2				
Total for March:	0			
April:				
Data	Total			



The "Water Use at the GRTC by month in 20XX" bar chart should automatically populate each month after there are two readings in one month. If the chart is not automatically populating the "Data" boxes on the left side of the "20XX Monthly Totals" sheet may need to be updated.



This can be done by right clicking the data box for the month that is not populating and clicking “Refresh Data”.

APPENDIX AC: RENT-A-DRUM INFORMATION

Recyclables should remain separated and delivered in separated bulk bags (pictured below) to the drop off Centre in Walvis Bay through Rent-A-Drum

Rent-A-Drum Service Information

<u>Recyclables must be delivered in Rent-A-Drum's Bulk Bags</u>

- N$ 50.00 each bulk bag , **one time fee**, one per type of recyclable (so four bags total)
- The full Bulk Bags will be taken to Swakopmund and emptied at the Recycling Plant and sent back
- Johan Lemmer is the Swakopmund Branch Supervisor there and his contact number is
  081 - 128- 2755
- Our e-mail correspondence with Rent-A-Drum suggested you could request payments for recyclables, but more follow up is necessary.

<u>Gobabeb must re-organize their recyclables to correspond with Rent-A-Drum's organization:</u>

- **Glass**– Cold drink/beer bottles and any other Glass bottles as long as there is no liquid in anymore.
- **Plastic** – water/col drink bottles, milk bottles, wrap and any clear plastic bottles as long as it is not contaminated with food or have any liquid inside.
- **Paper** – White Office generated paper, books, newspapers, magazines, small cartons (dry porridge boxes) and then also milk and fruit juice boxes.
- **Cans** – Cold drink, food cans, jam cans, as long as it is not contaminated with some remaining's inside.

<u>The Following CANNOT be Recycled:</u>

- Any type of batteries
- Mirrors
- Plate glass
- Windscreens of vehicles
- Crockery
- Light Bulbs
- Foam elite/ Styrofoam
- Tools
- Electric goods
- Toys
- Glazed paper

APPENDIX AD: RECYCLING SIGNS

CANS

Food Cans
Jam Cans
Soda/Beer Cans

Must be Clean

No Batteries, tools, and electrical goods

GLASS

Bottles
Jars

No Liquids

No mirrors, plate glass, or light bulbs

PAPER

Office Paper
Books
Newspaper
Magazines
Small Cartons
Milk Cartons
Milk and Fruit Juice Boxes

No Glazed Paper

PLASTICS

Drink Bottles
Milk Bottles
Plastic Wraps

Must be clean and contain no liquids or food

NON

RECYCLABLES

Styrofoam	Meat
Ashes	Bones
Toys	Cheeses
Crockery	Citrus Fruits
Mirrors	Plate Glass

ALL OTHER WASTE WITHOUT CATEGORY

APPENDIX AE: COMPOSTING AND OIL USAGE SIGNS

PLEASE DO NOT POUR

FATS
OILS
GREASE

DOWN THE SINK!

ORGANIC WASTE


Put in this Bin	Do NOT put this in the Bin
Vegetables	Dairy Products
Fruits	Meats
Egg Shells	Oils
Tea Bags	Fats
Seeds	Bones
Nut/Legumes	Citrus Fruit
Plants	Ashes
Peels	Hides






APPENDIX AF: MOVIE SCRIPT

SCRIPT:

Located in the middle of the driest area in sub Saharan Africa, The Gobabeb Research and Training Centre receives an average of only 28 millimeters of rain each year. Despite these harsh conditions, Gobabeb has plenty to offer!

Gobabeb lies between three starkly different ecosystems: the Namib Desert's dune sea, the gravel plains, and the Kuiseb River bed. These environments are what make Gobabeb so unique and we strive to minimize our negative effects on these surrounding ecosystems in everything we do**.** So do please remember to stay on the marked trails while exploring the Centre, and pay attention to this video for important sustainability information.

Gobabeb is known for its sustainability and has adapted to its environment by gathering energy from the strong desert sun. The first solar diesel hybrid system in Namibia is used to power everything at the Centre. During the day, the solar panels absorb sunlight to generate electricity. This energy is then stored in batteries, which are charged during the day to provide electricity at night. When people at the Centre use too much energy, the nonrenewable diesel generator must turn on, which releases harmful byproducts into the environment: so it is important to conserve energy during your stay!

There are many ways in which you can conserve energy at the Centre. Here are some of the main conservation practices we hope you will follow while at Gobabeb:

- Turn off all indoor and outdoor lighting when not in use;
- Unplug all unused appliances or turn off the outlet switches;
- Turn off your monitor when you are away from your computer; and
- Make sure your refrigerator and freezer are shut tightly.

In addition, please do not use toasters, hair driers or any other high voltage appliances.

A large amount of solar power is used to pump the Centre's water supply into Gobabeb's iconic water tower, so water conservation is essential. Gobabeb conserves water through low flow showerheads and toilets. We encourage you to help us conserve water by being conscious of your water use- but remember to stay hydrated! For long-term visitors, there is a laundry machine available.

All wastewater at the Centre passes through a trickle filter, and when everyone uses biodegradable shampoos, soaps and detergents, the recycled wastewater will be clean enough to be reused in the garden. Besides harmful detergents, fats and oils also have a negative effect on the trickle filter and the surrounding environment, so please dispose of them separately, not down the drain.

At Gobabeb, we separate our recyclables into glass, plastic, paper, and metal, which are brought to Swakopmund to be recycled. All biodegradable waste is either used in the compost for the garden or is fed to the Topnaar's goats. If you are interested in learning more about the Topnaar, you can take a guided cultural walk to the nearby Village.

Gobabeb's primary focus is research and training, and is home to students and researchers alike, along with many long-term climate monitoring systems and labs that can be seen on our station tour.

After your day in the sun, you can relax by the Gobabeb pool, which is covered when not in use to combat the high evaporation rates of the Namib Desert. In the late afternoon, the dunes are cool enough to walk on providing a spectacular place to watch the sunset and see the stars. Once the sun is gone, the fun isn't over yet- you may choose to go on a scorpion walk!

Now that you've had your fill of the desert creatures and sun, it's time for rest. There are many different accommodations available at Gobabeb: we have villas, clay houses, bungalows, caravans, and camping sites available.

The Gobabeb Research and Training Centre welcomes you to our oasis of learning! We hope you enjoy your stay!

APPENDIX AG: CLEAN-UP DAY PROCEDURE

Organization:

- Work with Sebedeus to find the dates in which the children will be back from school; the children are key because they are the main targets of education and would be a great help in the actual clean-up.
- Only have the clean-up day at one village, possibly Salt River, near the Centre to start. If successful it could be spread out to different communities.
- Talk to interns and staff at Gobabeb and find out who would be interested in attending, and what days they would be able to help during the time the children are back.
- Have interns/ staff who are willing to go to the clean-up day come up with educational activities/talks for the children about sanitation, waste management, and protecting and preserving the desert environment. This would be a good opportunity for staff/interns involved with school groups to test out new talks/programs.

Activities:

- To boost interest this should be a fun event. We recommend having a competition among the people attending on who can collect the most garbage. There could also be a competition for the children where they have to come up with a creative way to describe why waste management is important, both for people and the environment.
- People coming could bring different foods to share.
- People could volunteer to perform music, dancing, or other talents during the clean-up day. Making this a fun event would encourage people to come and would help to build relations between the villages and the Centre.