

PERCEPTION AND COMMUNICATION OF WATER RECLAMATION FOR THE SUSTAINABLE FUTURE OF WINDHOEK

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ABSTRACT

The City of Windhoek, Namibia has a pioneering reclamation plant capable of recycling most of its wastewater into potable water. The goal of this project, sponsored by the City of Windhoek, was to assess the public perception and acceptability of the reclamation plant. Our findings reveal that the residents of Windhoek are vastly unaware of the reclamation process. It will be necessary for the City of Windhoek to promote public understanding through an effective outreach program.

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AUTHORSHIP PAGE

As with any collective project, the ideas presented within the report reflect the understanding of the authors as a whole. Due to the size of this project, individual sections of writing were separated among members to complete the report in a timely fashion. Individual authors contributed to the following sections:

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Technical Challenges of Reclaimed Water Use

Appendix A

Appendix B

Appendix G

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Drinking Water Provision in Windhoek

The Need for Water Reclamation

Chapter 4

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Executive Summary

Public Response to Reclaimed Water

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The following sections of the report were a combined effort on the part of all three authors:

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EXECUTIVE SUMMARY

Namibia is an extremely arid country located in southern Africa. With only 360 millimeters of rainfall in the country per year, there is an evident need to address the lack of available water. This is especially pertinent in the capital city of Windhoek, which has experienced a steady population increase each year. After researching numerous options to make water more accessible, such as groundwater recharge, desalinization of groundwater from the northern water table, trucking water into Windhoek, fog-harvesting, and others, the City determined that all of these options were economically impractical. Therefore, the City was forced to investigate more innovative solutions. A potable water reclamation plant was finally chosen as the best solution, being the cheapest and most sustainable option. An early plant was put into operation by the City in 1969. This plant had an initial capacity of 1.7 Mm³/year and contributed greatly to the supply of drinking water to the City. After numerous upgrades to this plant, attaining a final capacity of 2.7 Mm³/year, the need for an even higher capacity of water became apparent due to the rapid growth of the City. In 2002, the New Goreangab Water Reclamation Plant (NGWRP) was built with a capacity of 7.6 Mm³/year. This new plant accounts for a substantial amount of the potable water supplied to the City. Without this plant, sustainable water access would be unavailable to many parts of Windhoek, as the City has surpassed the natural water supply limit.

The City of Windhoek, along with NamWater and Windhoek Goreangab Operating Company (WINGOC) are the key organizations that work together to produce potable drinking water for the City. NamWater supplies the bulk of the water to the City. After passing through a conventional water treatment plant owned and operated by the City of Windhoek, so-called grey-water is supplied to WINGOC. WINGOC is in charge of maintaining the plant and cleaning the grey-water. WINGOC is under contract to supply water of specific quality to the City of Windhoek for distribution. Upon leaving this plant, water is then controlled by the City which distributes it to the residents of Windhoek. Although water reclamation has been occurring in Windhoek for more than 40 years, there are many challenges that continue to be addressed. There are potential health hazards that could arise due to the large amount of reclaimed water residents are exposed to. It is also possible that the water pipes maintained by the City could cause health problems because of leakages from the ground. Furthermore, incomplete knowledge of recycling wastewater into drinking water can create psychological misconceptions among the public. Given these various problems that could arise, there is a perception of uncertainty among Windhoek's residents about the safety of their water.

The City of Windhoek Department of Infrastructure, Water and Technical Services had desired to gauge the public acceptance of their water supply for years. A survey would allow officials to understand how to make the reclamation process more transparent by assessing the knowledge that the residents of Windhoek possess. This survey could sample citizens' opinions on the water they receive, what they would like to know, and how the City can transmit the information to the community in the most reliable manner (i.e. newspaper, radio, television). From the creation of a survey and the understanding of the water treatment process, we intended to determine the perception of the potable drinking water. From the understanding of the residents' perception, we recommended ways in which the City can now communicate with the residents in a more reliable way about their drinking water supply.

Understanding and Communicating Reclaimed Water

This project was completed with four main objectives, each having a key role in assessing the perception of the citizens' water supply. The first objective was to interview City of Windhoek professionals and plant engineers to further our technical understanding of the water treatment plant and the City's role in the water distribution process. This was accomplished through two visits to the NGWRP to meet with plant engineers and quality control engineers, as well as a visit with city officials regarding an understanding of the history of reclamation throughout the world, and more importantly in Windhoek. With several arranged interviews during our first few weeks in Windhoek, we learned about the water treatment process and other pertinent information that could not be found in research articles or websites that were previously investigated.

Our second objective was to conduct informal interviews with residents to identify key issues concerning awareness and perception of water reclamation to help gain insight for survey questions. This was done at two different locations in Windhoek: Wernhil Park Shopping Mall and the Polytechnic of Namibia. We asked four different questions: a) if they had ever heard about the NGWRP and if so, b) how, c) how long they have lived in Windhoek, and d) if they prefer to drink tap or bottled water. Approximately 50 of these conversations supplied us with sufficient information to devise a targeted list of pertinent questions.

After conducting our preliminary informal interviews, we embarked on our third objective: we designed and conducted a survey to quantitatively and qualitatively assess key issues regarding various demographic data. The original survey had first been designed in the United States; unfortunately, it included minimal knowledge of what the sponsor and the City would like to learn. After completing objectives one and two, the team compiled a more refined survey that

was better suited for the citizens of Windhoek. After this survey was created, we pursued the second half our third objective: the distribution of the survey to six locations, including University campuses, local shopping centers, and informal settlements. Following several days of surveying, 346 surveys were collected and compiled into an Excel spreadsheet allowing for extensive analysis and identification of trends.

Perception of Reclaimed Drinking Water

After collecting and analyzing the surveys, the team made a number of observations from the data collected. Some of the conclusions drawn from our results were incorporated as recommendations to the City of Windhoek to better communicate and connect with the residents about their water sources. Concluding that the majority of the residents surveyed do not know about the New Goreangab Water Reclamation Plant and what water reclamation is, the distribution of factual information needs to be implemented in order to reach the residents more effectively than in the past. With specific questions asking how often residents use public transportation, read the newspaper, listen to the radio and watch television, the City can now identify the most effective way to communicate the knowledge needed to the citizens. It was found that people who live closer to the plant have a greater knowledge of it. This could be due to the fact that the people who live close to it drive by it, or maybe even have taken tours and asked questions. Residents who live closer may think that it affects them more than other people in the City, even though proximity to the plant does not play a role. The City should ensure that tours of the plant are offered and information from WINGOC is being distributed to the residents.

Most people surveyed, responded that their water was generally of good quality. With this positive feedback, the City should rest assured that they are delivering what is perceived as clean and reliable water to their residents. In addition, approximately three-fourths of the residents surveyed state that their water is safe to drink. With the open ended responses to this question, we can track why people thought their water was or was not safe. Looking at commonalities between resident responses with regard to different demographics, it seems as though there are a few conclusions that can be reached. Residents living closer to the NGWRP were observed as not having more knowledge of the plant than residents who live farther away. Another interesting observation is that the female residents thought that the water was less safe to drink than the male residents.

Recommendations for the future of the City of Windhoek

After processing all the commonalities in our collected data, the team drew conclusions and developed recommendations based on our survey results. There are six recommendations that can be made from the survey results and the team's observations during the researching and surveying process.

Update survey to be more tailored and simplified for the residents of the City of Windhoek

While processing the 346 completed surveys, the team came up with suggestions on ways to update and change the survey to get better responses from the residents of Windhoek. For instance, replacing “tap” and “standpipe” with “faucet” and “communal tap” as the two responses to how people get their water will be less confusing and give more accurate results. Another change would be to either change the question “do you know what water reclamation is?” to “do you know what recycling of water is?” or add another question about recycling of water.

Continue surveying the residents of the City of Windhoek to obtain a larger sample size

With limited time and resources for this project, the team could only achieve surveying 346 residents. With more time and resources, reaching approximately 3,000 residents would make for a statistically more reliable sample size of a city approaching 400,000 inhabitants.

Disclose water quality information to Windhoek residents while educating Windhoek residents on water reclamation and the NGWRP

After drawing conclusions from the 346 surveys, we found that the residents have no knowledge about water reclamation or the NGWRP. To educate the residents about the plant and its basic functionality will be a major step in making the process of water reclamation more transparent.

Implement water reclamation advertising campaign

There are several ways that the City of Windhoek can advertise water reclamation and the NGWRP derived from our research and surveying. Specific examples of advertising methods researched by the team are television commercials, radio songs,

newspaper articles, and letters in the monthly water bill. Any combination of those advertising methods can be deployed to further reach the residents, and thereby contact more residents than any single method.

Implement system of customer feedback

Customer feedback will be necessary to gauge whether or not the advertising information is effective. Based on the responses already obtained from the initial surveying, most residents would prefer a contact number to call with questions regarding their water.

Conduct longitudinal surveying after implementation of advertising/education via survey action plan

The team developed a system that the City can follow when they gauge the final knowledge of the residents. With this system, there are three paths to follow once the average knowledge of the residents is known: one if there is no knowledge, one if there is basic knowledge, and one if there is vast knowledge.

CHAPTER 1: INTRODUCTION

Namibia is the most arid country south of the Sahara. The capital city of Windhoek currently supports approximately 330,000 people and is growing rapidly at just over four percent annually (City of Windhoek, 1996). Only 360 mm of rain falls in the country per year (P. L. du Pisani, 2005). Of this rainfall, 83 percent evaporates, 14 percent is used by vegetation, one percent recharges groundwater, leaving only two percent (7.2 mm) for useable surface runoff. Due to Namibia's extremely arid environment, evapotranspiration can often exceed rainfall, leading to a depletion of groundwater (Frenken, 2005). This harsh climate, along with limited city budgets, makes sustainable water access difficult for much of the country. Windhoek has an even harsher climate than much of the country, since it is located in central Namibia, 500 km away from any substantial body of water. It is also just over one mile above sea level, therefore having a higher evaporation rate than the rest of the country (Frenken, 2005; Lahnsteiner, Lempert, Kim, Cho, & Kim, 2007). Windhoek's distance from reliable water sources makes transportation of water from these sources into the City economically unreasonable. Consequently, another system is needed to give the City a reliable, clean water source.

Over time, various methods have been implemented which enable people to have access to clean water in Windhoek. The first major effort made by the City to allow all members in the community to gain access to sustainable, clean water came to fruition in 1969. In 1969, a water reclamation plant was established in the City of Windhoek, with an initial capacity of 1.7 Mm³/yr, supplementing almost 30% of the water demanded. After numerous upgrades, which brought the final capacity of the plant to 2.7 Mm³/yr, the need for water still surpassed this plant's capabilities (P. L. du Pisani, 2005). In 2002, a second water reclamation plant, named the New Goreangab Water Reclamation Plant (NGWRP) was opened. This plant has a much larger output of water at 7.6 Mm³/yr, which accounts for up to 35% of the water provided to the City (Lahnsteiner et al., 2007). This facility recycles wastewater back into useable water for the community. The treated sewage effluent from Gammams Water Care Works gets recycled through a series of treatment steps to be reclaimed into potable water. Most of the industrial waste from the City is recycled through a less stringent process. Industrial wastewater gets recycled through the old water reclamation plant and is cleaned to an extent suitable to irrigate fields throughout the City.

The NGWRP has had no declared failures in the past that would affect consumer health; it takes many measures to ensure the safety of the consumers. However, despite years of use, understanding and acceptance of the public about the plant is still unknown to all. Talking to the plant engineers, City professionals, as well as community members will allow us to help the City

communicate future expansions in the water treatment process better. Since the reclamation of water in Windhoek is a necessity, it is important for the community to understand and accept it. It is thought that if people who consume the water know more information about the health risks and the measures taken by the City in order to ensure safety, more people will understand and therefore accept the process.

The City of Windhoek has implemented methods that allow consumers to see the technical process and understand it more thoroughly by providing tours of the plant. Even though this service is provided, it is grossly underutilized. The opening of the water reclamation facility was televised in 2002, but those without access to television did not see this program. It is also possible for school children to take organized tours of the plant; the intent of the City of Windhoek is to teach them at an early age the safety and importance of water reclamation. Since they can see the process first hand and ask questions, it allows them to feel more comfortable with the consumption of reclaimed water (Gao, Staunch, & Jackson, 2007). Given the nature of the communication methods that have been documented (e.g. television), it seems as though middle and upper-class residents would have more access to facts of the treatment process. In order to find out what local residents know about water supply issues in Windhoek, the health risks of drinking reclaimed water and to make recommendations for the City to better its communication methods, it will be necessary to assess the City's current communication methods, if any, and to which parts of the City they reach.

CHAPTER 2: BACKGROUND

Historically, it has been difficult to support sustainable towns, villages, and cities in arid regions. These regions are found around the world and each possess unique challenges to obtaining easily accessible, clean water sources. Over the past several decades, Namibia has pioneered new approaches to water supply. With the capital city of Windhoek having a rapidly growing population, there is a need to explore increasingly complex methods of water supply, including advanced water reclamation. Through the years, the City of Windhoek has optimized the science of water reclamation from municipal sewage through a pioneering treatment plant. This chapter outlines the social and technical aspects of water reuse. It explains current water provision in the City of Windhoek, future demand, and the need for water reclamation. The technical challenges involved with direct water reclamation are explored, and public response to similar projects is investigated, providing us with a more comprehensive understanding.

2.1 Drinking Water Provision in Windhoek

2.1.1 Water Sources

With only three major perennial rivers found on the borders of Namibia, year-round surface water sources are not easily accessible by a majority of the country's residents (Frenken, 2005). Those living away from perennial rivers are forced to rely on ephemeral rivers, existing only after heavy downpours, or underground water sources accessed via boreholes.

The City of Windhoek was established in 1890 due to its abundance of underground water through naturally occurring hot and cold springs (City of Windhoek, 2004). Over time, Windhoek's access to water attracted many people. As more people migrated to the City, groundwater demand soon outstripped supply. Just as a lake or river can be drained from overuse, groundwater over-abstraction became a concern for the City of Windhoek. Located over 550 km from the closest perennial river (see Figure 1), the problems of sufficient water and a sustained supply of water are critical. The City supports approximately 330,000 people (projected from a 2006 city planning survey at a 4.05% annual growth rate) and water supply is more pertinent now than ever (City of Windhoek, Department of Planning, Urbanisation, and Environment & Maanda, 2010).

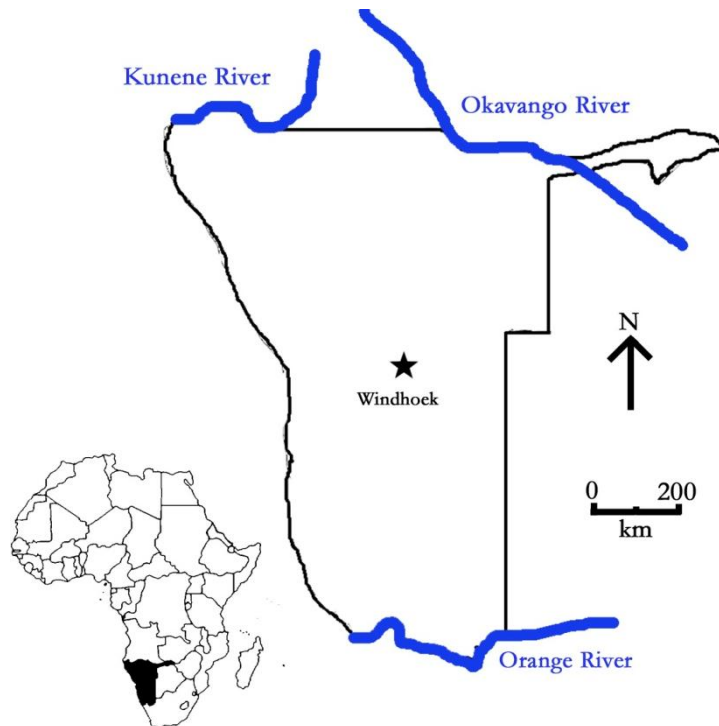


Figure 1: Perennial Rivers Near Windhoek, Namibia.
Distances from Windhoek are:
550 km (Okavango), 600 km (Orange), and 630 km (Kunene)

2.1.2 Infrastructure

Due to the fact that rainfall is scarce, and intermittent water sources in the internal part of Namibia are difficult to predict, the City of Windhoek in conjunction with the state government have taken several measures to secure the availability of water for future generations. These measures include the development of dams, pipelines, and water treatment facilities. From 1890 until 1933 the City of Windhoek relied solely on groundwater. In 1933, Windhoek's first dam, Avis Dam (total capacity of 2.4 Mm³), was constructed to help ensure adequate water supply to the City. Due to a small catchment area, the dam failed to provide a large enough sustainable water source and is no longer used to supply water to the City. In 1958, another small dam was constructed, Goreangab Dam (total capacity of 3.6 Mm³), to store water for Windhoek's conventional water treatment plant (P. L. du Pisani, 2005).

A large dam capable of supporting the growing needs of Windhoek was not constructed until 1970, and was called the Von Bach Dam (total capacity of 48.6 Mm³). The Von Bach Dam is located 70 km north of Windhoek and fed by the ephemeral Swakop River (NamWater, Date Unknown). Since the Von Bach Dam is fed only by sporadic rainfall through the Swakop River, capacities vary from year to year. Two more dams, the Swakoppoort Dam (total capacity of 63.5 Mm³) and Omatako Dam (total capacity of 43.5 Mm³), were constructed in 1977 and 1982,

respectively, and lie 100 and 200 km north of Windhoek (Central Areas JV Consultants, 2004). These three dams are interconnected via pipelines and when operated together they form the backbone of the water supply to the central area of Namibia and the City of Windhoek (Central Areas JV Consultants, 2004). Water capacities may vary throughout the year, but the dams provide a solution to water loss due to evaporation over large watershed areas (Lahnsteiner et al., 2007). This three-dam system can safely and reliably supply (with a 95% assurance) approximately 20 Mm³/yr of water to the City of Windhoek (Central Areas JV Consultants, 2004). Although the three-dam system can supply more water during prolonged periods of drought, increases in water demand require further augmentation for a long-term sustainable solution.

In addition to the three dam system, there are several conventional wastewater treatment plants utilized by the City of Windhoek. These plants treat two different types of wastewater from separate city sewers: industrial wastewater and municipal wastewater (Haarhoff & Van der Merwe, 1996). Industrial waste is treated in a series of ponds designed to process water for use in irrigation of pastures (Lahnsteiner et al., 2007). For municipal wastewater there are three treatment plants that process all other sewage flows for reuse in other applications such as city irrigation (City of Windhoek, 2004); (P. L. du Pisani, 2005).

2.1.3 Pertinent Organizations

To deliver useable water to the City of Windhoek, many different organizations work together in securing, storing, and supplying this important commodity. The three main organizations are:

NamWater

A major supply affiliate that contributes to Windhoek's bulk water demand is NamWater. Of the total water supplied to the City of Windhoek, approximately 70% is purchased in bulk through NamWater (Frenken, 2005); (City of Windhoek, 2004). The remaining 30% is supplied by the City of Windhoek through city boreholes and water reclamation (P. L. du Pisani, 2005).

Windhoek Goreangab Operating Company (PTY) Ltd. (WINGOC)

A Public Private Partnership between the City of Windhoek and Windhoek Goreangab Operating Company (PTY) Ltd. (WINGOC) was established for operation of the New Goreangab Water Reclamation Plant, which will be discussed later.

WINGOC operates under contract to supply reclaimed water of a specific quality to the City of Windhoek.

The City of Windhoek Department of Infrastructure, Water, and Technical Services

The City of Windhoek Department of Infrastructure, Water, and Technical Services handles all aspects of water distribution to the citizens of Windhoek. The city is also responsible for collection, treatment, and quality of all wastewater. This includes the maintenance and upkeep of all water delivery and sewer infrastructure. The major improvement projects for water systems (i.e. dams, treatment plants, etc.) are explored and developed through The Department of Water Affairs (DWA). These projects are executed under The National Development Corporation (NDC) (City of Windhoek, 2004).

2.1.4 Demand

Managing a precious resource such as water in Namibia requires constant attention to the overall sourcing and supply of water. However, the consumption, or demand, for water is just as critical. Lahnsteiner provides the most recent publically available statistics concerning Windhoek's demand for water—which agree with the City of Windhoek's data—roughly 21 Mm³/yr (Lahnsteiner et al., 2007). The City of Windhoek has recognized the importance of curtailing demand and instituted several programs to promote conservation. These programs utilized schools, radio, television, and printed media to educate the public on proper water conserving practices. The education/awareness programs along with a carefully crafted graduated tariff program, which encourages water conservation through economic means, has greatly reduced water demand (Lahnsteiner et al., 2007; Lange, 1998). From the inception of these programs in the early 1990s until today the per capita water consumption has dropped from approximately 328 L/day to a consistent 180 L/day for the past four years (City of Windhoek, 2007). According to Lahnsteiner, "Per capita consumption has already been reduced to a minimum by technical improvements and exemplary public relation activities". This means that the current per capita consumption can be expected to remain relatively constant and low over time (180 L/person/day), allowing reasonable projections to be made into the future.

Using the City of Windhoek and Lahnsteiner's statistics on water demand, the 2006 Namibian population survey data from the City of Windhoek's urban planning department, and the accepted city growth rate from the urban planning department of 4.05%, consumption projections can be completed. **Error! Reference source not found.** summarizes these

projections (City of Windhoek, 1996; City of Windhoek, 2007; Lahnsteiner et al., 2007; National Planning Commission, 2003):

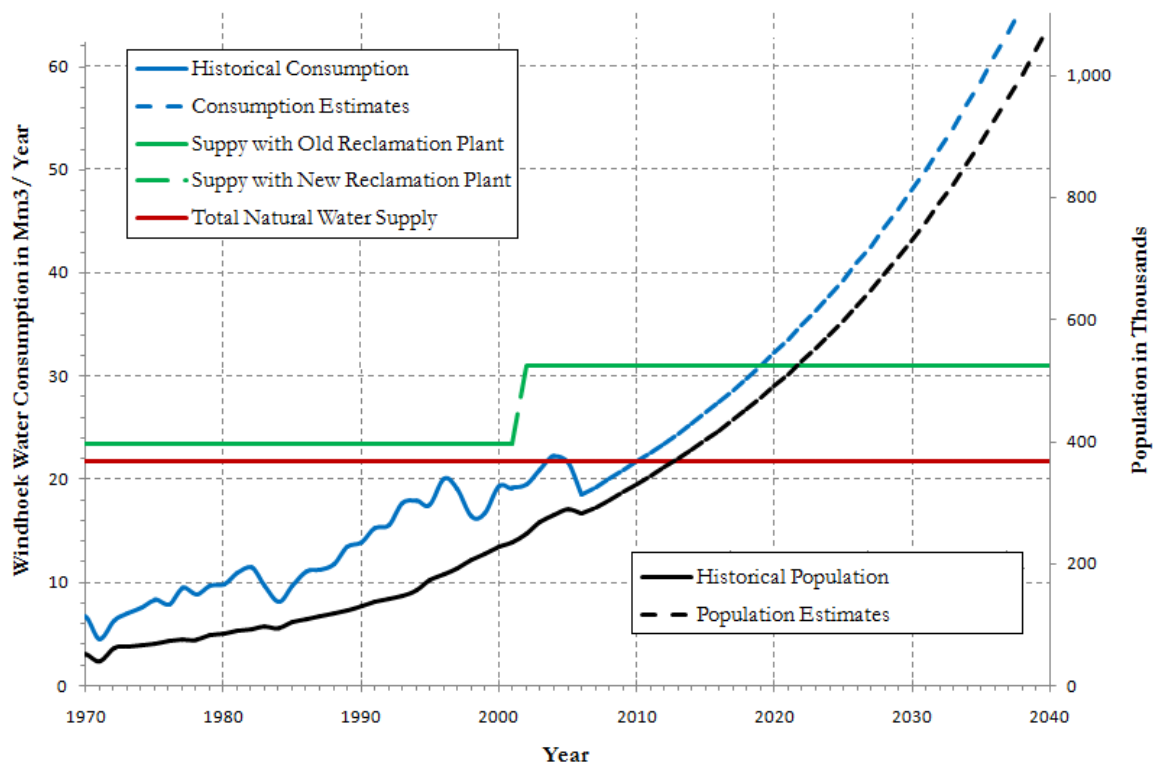


Figure 2: Water Supply, Demand, and Population Projections for Windhoek through 2040
(Consumption is recorded on the left axis; Population is recorded on the right axis)

As seen in **Error! Reference source not found.**, water demand is predicted to increase exponentially alongside population. However, rapid water demand increases, which appear inevitable, are difficult to meet, as increases in supply (construction of dams, reclamation plants, etc.) do not match the exponential growth. In order for Windhoek to provide water to its residents, alternative water sources must be explored; this is a challenge not foreign to the arid City of Windhoek. Ample supply of water has always been, and will continue to be, a real and critical concern for Windhoek.

2.2 The Need for Water Reclamation

2.2.1 Sustainability

With annual rainfall unpredictable and droughts occurring approximately every ten years, the City of Windhoek must address the procurement of water from diverse sources to prevent

over exploitation of any one source. Although little to no geotechnical information is known about the Windhoek aquifer size, the general policy for the past 50 years has been to carefully monitor the water levels. The monitoring is carried out in an effort to avoid over-abstraction, which would take years to naturally recharge (Lahnsteiner et al., 2007). Although surrounding dams have large capacities, utilized during excessively wet seasons, dam levels vary from year to year, and care must be exercised to depend on such a risky source as little as possible.

With Windhoek's three-dam system operating at 95% assurance, surface water sources can provide 20 Mm³ per year. Along with surface water resources, the City exploits over 60 municipal boreholes into underground aquifers which can supply 1.7 Mm³/yr. Therefore, Windhoek's natural water supply reaches a ceiling at just over 21.7 Mm³ (Lahnsteiner et al., 2007; Menge, Date Unknown). **Error! Reference source not found.** documents that Windhoek's demand for water in 2010 has reached the limit of what surface water and aquifers can safely provide. If Windhoek is to support the City's rapidly growing population, sustainable long-term solutions will have to be implemented.

2.2.2 Potential Solutions

Demand outpacing supply is not just a recent concern. During the 1960s, before the construction of the Von Bach Dam, Windhoek reached the supply limit of its naturally occurring aquifers and surface water (Haarhoff & Van der Merwe, 1996). This strain inevitably forced the City to consider innovative solutions for its increasing water demand. With the closest perennial rivers located on the northern and southern borders of Namibia (550 and 600km away), Windhoek had to entertain elaborate solutions to procure more water for the City (P. du Pisani, 2004). Groundwater recharge, desalinization of groundwater from the northern water table, a pipeline to the perennial Kunene or Okavango Rivers, weather modifications, trucking water into Windhoek, and even fog-harvesting are options available to increase the water supply into Windhoek. However, as with many large-scale investments, capital and operating costs heavily influence the adoption of various options, and in the end these solutions were not deemed economically feasible (Eales, Forster, & Du Mhango, 1996).

2.2.3 Windhoek's Solution to a More Secure Water Future

Since securing more water resources over long distances are difficult to justify economically, Windhoek was forced to explore unconventional means to increase the water supply into the City. In 1968, Windhoek implemented an unprecedented, sustainable, and environmentally friendly alternative through recycling water within the City. A water treatment

facility, the Goreangab Water Reclamation Plant, was commissioned in October of 1968, which had the ability to treat municipal sewage to potable standards. The Goreangab Water Reclamation Plant was the first of its kind in the world and had a capacity to offset over 1.7 Mm³/yr of water demand.

The plant was reconfigured and upgraded three times and was regarded as the most economically viable option to improve the water supply (Haarhoff & Van der Merwe, 1996; Lahnsteiner et al., 2007). In the late 1990s, the water supply reached another ceiling, and Windhoek turned again to reclaimed water to alleviate some of the resource strain. The New Goreangab Water Reclamation Plant (NGWRP) was commissioned in 2002 and replaced the now termed Old Goreangab Water Reclamation Plant (OGWRP) with a yearly supply of over 7.6 Mm³/yr, as seen in **Error! Reference source not found.** (City of Windhoek, Date Unknown).

2.3 Technical Challenges of Reclaimed Water Use

2.3.1 Reclaimed Water in Windhoek

Although there has been a method in place for reclaiming all possible wastewater in Windhoek for more than 40 years, there are many challenges that continue to be addressed. There are potential health hazards that could arise due to the amount of reclaimed water people are exposed to (T. Asano, Date Unknown). This reclaimed water is used for various purposes and the City takes many preventative steps to ensure the safety of the consumers. One of the methods that Windhoek undertook at the beginning of the reclamation plant's history was monitoring patients who visited hospitals and clinics between 1968 and 1982 for any illnesses that could be related to reused water (Haarhoff & Van der Merwe, 1996). The study found that none of the illnesses reported could be linked in any way to the consumption of reclaimed water. Also, in the New Goreangab Water Reclamation Plant, there are two barriers for all bacteria, fungi and viruses that are tested for to ensure that as many of these pathogens are filtered out as possible (Lahnsteiner et al., 2007). To this day, there are no negative health impacts known that can be linked to reclaimed water consumption. Details of the treatment process can be found in Appendix A.

2.3.2 Pathogens

Many pathogens are found in water prior to the treatment process. These pathogens typically include protozoa, bacteria, and fungi. Since these three classes of microorganisms are transmitted through water, they need to be monitored efficiently (World Health Organization,

2008). Many emerging diseases are not caused by pathogens that are actually new but rather existing pathogens that are now known to cause disease through the consumption of water (World Health Organization, 2008). Although the risk from pathogens is generally well documented, it is unclear how to ensure microbiological safety to the people when the water is recycled (World Health Organization, 2008). One aspect of this uncertainty is due to potential transmission from animals. These animals can transmit parasites through feces that are washed into the dam systems and subsequently passed through the water to the humans who consume them (World Health Organization., 2006). This could affect the people of Windhoek because agriculture is a major contributor to Namibia's economy. Furthermore, if the animals are raised with the reused water, it is possible that the person who consumes that animal could get the disease. An example of a pathogen that is transmitted through the consumption of water is *Cryptosporidium*, which will be discussed later. Another pathogen that is transmitted through the consumption of water is *Giardia*. These two pathogens are particularly important to note because people with suppressed immune systems, such as those living with HIV or AIDS, are particularly susceptible to them. All of the potential pathogens being tested for in the New Goreangab Water Reclamation Plant can be found in Appendix B.

Bacteria

Bacteria are single-celled microorganisms that can grow and reproduce in a wide variety of conditions. Often, bacteria are not pathogenic; however, pathogenic bacteria can be found in feces of infected individuals (World Health Organization, 2008). The most common of the pathogenic bacteria found in wastewater is *Salmonella*. It affects both humans and animals and can cause typhoid fever and diarrhea as well as other illnesses. *Salmonella* is only one of many pathogenic bacteria found in water. Various other bacteria can also cause serious illnesses, although their presence is encountered less frequently. Coliforms, which are a type of bacteria, are often used as indicators of fecal contamination. When coliforms are found in the water, it is likely that other pathogenic organisms, including other bacteria are present (World Health Organization, 2008).

Viruses

Viruses are the smallest infectious agents, and they cannot be easily monitored through testing. It is also possible that they can slip through screens in the water reclamation screening process. For this reason, processes such as ultra-filtration are implemented in the New Goreangab Water Reclamation Plant, which effectively collect

nearly all the viruses that are present in water. Viruses do not reproduce in the environment, but can be present nonetheless. Since they are obligate intracellular parasites and therefore can only multiply inside an infected host cell, they are often detected in feces (World Health Organization, 2008). Certain fecal pathogens are tested for, but not all can be found and eliminated from the treated water. There are over 100 viruses that are transmitted through feces, and are therefore extremely important to test for and remove from the water that will be consumed. Viruses transmitted through feces can cause illnesses that are as common as diarrhea or as serious as hepatitis, and are extremely resistant to disinfection (World Health Organization, 2008). It is very difficult to identify and quantify these viruses because of an extremely high cost and a long processing time associated with laboratory testing (World Health Organization, 2008). Nonetheless, the New Goreangab Water Reclamation Plant sends water samples to South Africa to test for viral content, which allows for extremely accurate testing.

Protozoa

Protozoa are common infectious agents that, similar to viruses, do not reproduce in the environment. Protozoa are uncommon in well-treated water; however, if a person is infected, they may show no symptoms and consequently pass along the agents unknowingly. Protozoa are often difficult to test for in recycled water because a large sample size is needed in order to retain enough protozoa to identify the type that is present (World Health Organization, 2008). *Cryptosporidium* is one type of protozoa that is very infectious, and it is often found in reused water. It can cause infection with as few as ten particles, and can be transmitted through direct consumption of water containing this parasite, or through an animal that has been exposed to water containing *Cryptosporidium* and then consumed by a human (Toze, 2005). *Cryptosporidium* and *Giardia* are tested for through water samples sent to a South African laboratory. Like the viral testing, the results take up to two months to receive, but the accuracy of the testing outweighs the test time.

2.3.3 Industrial Waste

Industrial waste, which originates from the small food and beverage industry, is treated in a series of treatment ponds that have various bacteria added in order to eat the hazardous part of the waste. In the first ponds, anaerobic bacteria, which do not need oxygen, are added to the waste, while in the second set of ponds aerobic bacteria, which need oxygen, are added. The

bacteria are then filtered out with the hazards that they have eaten, and some of the cleaner water is sent to the sewer treatment plant and then is used to irrigate fields (Lahnsteiner et al., 2007). Though the water is strictly used for irrigation, it is necessary that it be cleaned properly. The cleaning does not have to reach the extent of potable water, since it is not being used as such. However, if this water was not cleaned properly and then was used to irrigate, e.g., a soccer field, it is possible that people who spend a significant amount of time on the field could be negatively affected by this water. For this reason, when Windhoek was industrialized, the main industries were mostly established in the northern industrial area. Since all of the major industries are located in one section of the City, it keeps industrial wastewater out of the dams that supply the reclamation plant. This avoids the potential problem of industrial waste being reclaimed to make drinking water.

2.3.4 Monitoring

There are many steps in the water monitoring process which are summarized in Appendix A. Monitoring for various pathogens has specific values for which the pathogen content cannot surpass. Each pathogen has an independent value, which is designated in the contract between the City of Windhoek and WINGOC. In order for WINGOC to receive payment for operation of the plant, the water has to remain at a certain quality, which is also specified in the contract. Water quality is continually monitored through online instrumentation and composite samples are taken after every step in the reclamation process, testing for what the step should change in the water (e.g. pH, salinity) (P. L. du Pisani, 2005). WINGOC conducts its own tests on water samples, and the City also runs independent tests to ensure that the online instrumentation is reporting correct values. Bimonthly samples are taken to test for water flea lethality, urease enzyme activity and bacterial growth inhibition, which are three toxicity problems that the plant needs to test for (Haarhoff & Van der Merwe, 1996). Chlorophyll levels are tested twice a week at six different sampling spots while *Salmonella* is tested for monthly at three different sampling spots (Haarhoff & Van der Merwe, 1996). The testing of each of these different chemicals helps keep the City of Windhoek officials accountable for clean and healthy water. The monitoring and testing process accounts for 20 percent of the overall production cost of the plant (Haarhoff & Van der Merwe, 1996). These measures are taken to ensure the highest quality of water is delivered to the people of the City (Haarhoff & Van der Merwe, 1996).

Even with all the measures taken it is possible that a pathogen, especially a virus, could slip through conventional barriers and cause the outbreak of a disease. Viruses, however, need to be in a living cell in order to replicate, and therefore with the measures taken to ensure the safety

of consumers, it seems unlikely that such a problem would arise, except for possibly in people with suppressed immune systems.

2.3.5 Organoleptic Qualities

Color and taste are both important aspects in water quality due to the perception that clear water is safer for you. Although water that has a slight color tint to it is not necessarily harmful to the health of a person, it makes people uneasy and therefore affects the economic impact of reclaimed water. People will always use organoleptic qualities to judge the quality of their water. In order to purify taste and color and to remove odors, chlorine is often used in a final stage of reclamation, although it is unknown if this has a major affect or not (Oestman, E., Schweitzer, L., Tomboulia, P., Corado, A., Suffet, I.H., 2004).

2.4 Public Response to Reclaimed Water

2.4.1 Benchmark Cases on Reclaimed Water Use

The use of reclaimed water is not just a technical matter; it affects people in their everyday lives. By analyzing other instances of reclaimed water use, we can begin to understand the conditions for public acceptance of reclaimed water. The following three cases briefly detail the history of several communities' water use and how they either overcame or fought the water reclamation process.

Sydney, Australia

Australia is known as one of the driest continents in the world. With a growing population, the government officials decided that they had no choice but to start developing water treatment and reuse options. In September of 1999, a special interest group was formed to look into the process of recycling water and how it would affect the community (Dillon, 2000). In Australia, recycled water is used more in commercial applications than for drinking water. Drinking water accounts for only three percent of the recycled water supply. Since only a small percent of recycled water is consumed, people in Australia are more accepting of water reuse (Dillon, 2000).

Singapore

Singapore is an island in the South Pacific which has historically limited natural resources. They depend greatly on importing many of these valuable resources from neighboring countries, such as Malaysia. Drinking water is one of the many resources

that is limited, and has been for years. In 2003, the government of Singapore decided to open up a water treatment plant for drinking water and many other uses such as irrigation. Having seen rising prices on imports of resources, such as water, the country needed to support the idea of the water treatment plant and have a greater assurance of their reclaimed water process. The Singapore Public Utility Board (PUB) started NEWater to raise the awareness of the new drinking water that people are using on a daily basis. This name was a major factor in getting the public's support of the system because it kept the reclaimed or reused part of the treatment out of the name, instead using NEWater to show that the water is new and safe for all to drink and use (Dingfelder, 2004). To help assist in raising awareness, the PUB decided to use several strategic methods to inform the public of their water and the need for reclaimed water in the country. Some of the awareness solutions were to hold education campaigns, use a documentary feature film, media exposure, information briefings at community centers and schools, and a NEWater visitor center. The government oversaw the cleaning and processing of water, with hired scientists acting as consultants for the government over a two year time period. They were hired to verify that the potable water met the government and the World Health Organization (WHO) standards for drinking water (Po, Kaercher, & Nancarrow, 2003). Even though the sales of bottled water increased during the initial output of the treated water, NEWater and the government of Singapore worked together to supply the residents with clean municipal drinking water (Po et al., 2003). This project helped lower the dependence of Singapore on the Malaysian rivers that would import the water needed for the country. The community now appears to feel safer with their potable water and can rest assured in the quality of the water they drink.

San Gabriel, California

San Gabriel Valley is located in southern California. It is a very arid region in California, having encountered several droughts in its history. The idea of a water treatment plant became a reality when, during a drought in the region, the aquifer was not holding enough water for the community. To gain community support, the San Gabriel Valley took several steps to inform the public. Newspaper articles and letters were mailed out to residents with a brief overview of the process and a questionnaire. The area also got support from local organizations and industries in the area that would be using the treatment plant water. Public tours of the facility were held to show that there are no secrets as to where the water is coming from, how it is being treated and

where it is going. The government also distributed a survey for community members to take; most of the respondents replied that they do not want to drink water that once had feces in it, even if it has been properly cleaned and purified (Zimmerman, 2008). Then, weeks before the plant was to officially open, a group of hostile residents placed an article in the newspaper and highlighted that the project contained unnecessary processes. Even though the public was aware of potential health risks associated with the reclaimed water, the government failed to disclose the specifics of these risks. The people declared the project “Toilets to Tap” which ceased all desire to complete the project (Po et al., 2003). This project was defeated by members of the public who were against drinking reclaimed water and who managed to reframe the issue in ways that played upon public concerns. This defeat spread to other Californian communities, including San Diego and Los Angeles. In 2000, people in the Los Angeles area forced their city to stop a \$55 million dollar project that would have provided enough water for 120,000 homes and helped with the lack of water in the area. Similar reluctance among San Diego residents led the mayor to veto the City council's approval of a pilot program to use recycled water to supplement their city drinking water, because the mayor did not want to see uproar of the citizens like in other cities throughout California (Zimmerman, 2008).

From these three case studies a common trend is observed: water reclamation projects are more likely to be successful with community support and knowledge of the process. The City of Windhoek can learn from these failures to ensure the public is aware of the problems concerning water reclamation, and be able to circumvent a dissenting community before an extreme article gets published.

2.4.2 Common Public Responses

The majority of the citizens of any particular region will likely respond differently given essential information regarding water quality and risks associated with water reuse in the community. In Windhoek, the City has implemented a water safety plan to turn off the reclamation process if any contaminant, such as a pathogen, is found in a concentration above the normal levels seen in the water at each of the steps in the process. Safety limits have been established on the basis of preexisting national and international standards from the United States, South Africa and the World Health Organization (Menge, 2010). The safety plan gives the community assurance that if their water quality is below what the WINGOC and City of

Windhoek officials have declared safe, the water will not be in their taps to use as drinking water. In the event of a failure, the City of Windhoek is responsible for notifying the community and declaring the water unsafe.

“Water should be judged not by its history, but by its quality,” said Dr. Lucas Van Vuuren, pioneer of water reclamation research in South Africa throughout the 1970s (Law, 2003). The feeling of disgust associated with reclaimed water originates from knowledge of the water's origin. People believe that the longer the cycle takes to process the water, the safer the water is. The general public is also more accepting of natural water sources than of artificial cleaning processes, i.e. groundwater filtration over reclaimed water plants (Daughton, 2004). There is no specific set of guidelines that holds water treatment plants around the world accountable to the same standard. Each plant varies in the water reclamation guidelines employed. Thus, worldwide water treatment plants are missing specific criteria and guidelines necessary to ensure that every treatment facility is following uniform regulations and procedures (T. Asano & Cotruvo, 2004).

2.4.3 Communicating Developments and Expansion

The best way to assess the residents' perceptions is through direct interaction with the community through meetings, focus groups, print and electronic media (Daughton, 2004). This approach can be applied to many global regions that are using reclaimed water. Direct community feedback lets the organizations and government know what the residents understand, what they do not understand, and what questions they have about the water reclamation processes. Online public forums are an emerging method that allows people in the community to take interest in any topic. They can then communicate their concerns or questions to a large group, which the officials or other members of the community can see and address to the entire forum (Daughton, 2004). The most difficult part of the communication process is the difference in beliefs that each person has. For this reason there will always be disagreements on controversial topics. Favoring one side over another tends to make people uncomfortable. Therefore, remaining neutral is essential for the officials in the community so that all parties involved can voice their opinions, be heard, and find some common ground.

In the City of Windhoek, public officials are finding ways to make the process of water reclamation more transparent to the community. In the first years of the 21st century, the City of Windhoek Department of Infrastructure, Water and Technical Services had their workers read the water meter at every household in the City to get an exact measure of water use in various locations. The City of Windhoek showed the exact amount of water used by the consumer as

well as the average amount of water used by other people in the community on each monthly water bill. It was shown for each individual household on their personal bill, but the City presently shows simply an overall average of water use, no individual data.

The City has never implemented a survey, or questionnaire, to evaluate what people in Windhoek think of the quality of water they are receiving. A survey would allow officials to understand how to make the reclamation process more transparent by assessing the knowledge that the citizens of Windhoek have pertaining to the process of reclamation. This survey could sample citizen opinions on the water they receive, what the residents would like to know, and how to get the information to the community in the most reliable manner (i.e. newspaper, television).

CHAPTER 3: OBJECTIVES

The goal of our project is to assist the City of Windhoek in assessing the perception and acceptance of water reuse by its citizens. Specifically we would like to explore the most effective methods of communication to keep the public informed of developments and expansions of reclaimed water use in the City. This is carried out by researching the current water reuse program and assessing current public perceptions. Our goals are pursued through the following specific objectives over an eight-week time period:

1. Interview City of Windhoek professionals and plant engineers to further our understanding of the water treatment plant and the City's role in the water treatment process.
2. Conduct informal interviews with residents to identify key issues concerning awareness and perception of water reuse to help gain insight for survey questions.
3. Design and conduct a survey to quantitatively and qualitatively assess the key issues with regard to various demographic data.
4. Propose targeted strategies to keep the public informed of future plans and developments in its water supply.

The practical aspects of how we intend to meet each of our objectives will be discussed in the following chapter.

CHAPTER 4: METHODS OF IMPLEMENTATION

With a limited amount of time at our disposal, the development of intentional and streamlined methods of implementation became a necessity for successfully completing the aforementioned objectives. Each objective contains unique outcomes that call for the development of methods to uniquely address that need. The following sections describe the methods of implementation conducted to meet each of the objectives.

4.1 Meeting City of Windhoek Professionals and WINGOC Plant Engineers

The main outcome of Objective One was an increased understanding of the water treatment plant and the City's role in the water treatment process. This information allowed us to communicate effectively with Windhoek residents, provide accurate information to those that ask, and develop pertinent survey questions. Due to the technical nature of this outcome, personal interviews and tours were conducted with City professionals and plant engineers. In order to understand the current population and growth of the City of Windhoek and obtain information on suburb locations we interviewed Faniel Maanda, a town planner from the City of Windhoek Department of Planning, Urbanisation, and Environment. A personal tour of the New Goreangab Water Reclamation Plant by John Esterhuizen, a plant engineer, provided us with a concrete understanding of the water purification process and allowed us to ask technical questions. To better understand the development of water quality guidelines, we interviewed Jürgen Menge, a water quality professional at the City owned Gammams Water Care Works facility. These three interviews provided us with the technical knowledge to complete Objective One.

4.2 Informal Interviews with Residents

The main outcome of Objective Two was the identification of key issues concerning awareness and perception of water reuse. The recognition of issues voiced by residents proved beneficial in the development of a survey that addressed real and pertinent issues of water reclamation. Informal interviews via conversations were conducted at locations with high traffic density, allowing for a quick and varied sampling. The Wernhil Park Mall, located just outside of downtown Windhoek, and the Polytechnic of Namibia, provided us with a varied array of responses from residents of different ages, locations, and education levels. Interviewees were asked if they had ever heard of the plant, and if yes, how they had originally heard about it. They were also asked how long they have lived in Windhoek, and if they drink mainly tap or bottled

water. Approximately 50 conversations supplied us with sufficient information to successfully complete Objective Two. The results from these informal interviews can be seen in Table C1 and C2 in Appendix C.

4.3 Designing and Conducting the Survey

The main outcome of Objective Three was to collect demographic, water use, perception of water quality, and knowledge of reclamation plant data. Due to the need of a large and varied sample size, a single page survey (front and back) was designed to quickly and accurately collect data. Questions were designed via data obtained in Objective Two, our overall project goal, and sponsor input. The first draft of the survey was designed in the United States, and then was updated twice in a collaborative effort of the team and Mr. Ferdi Brinkman, the Chief Engineer of the City of Windhoek Department of Infrastructure, Water and Technical Services. The third draft was tested at the Polytechnic of Namibia Campus. Input from this testing phase allowed us to make minor changes for readability and completion accuracy. All drafts of the survey, including the fourth and final version, can be seen in Appendix D. The survey was administered in six different City locations over the course of several days, allowing for the completion of Objective Three. Details of the survey implementation and its analysis are discussed in Chapter Five.

4.4 Propose Targeted Strategies for the City of Windhoek

The main outcome of Objective Four was to provide the City of Windhoek with recommendations for keeping the public informed of their water supply. Recommendations were considered based on several key factors, including:

- the public's right to know the status of the City's water quality
- advertising effectiveness
- existing communication channels
- financial cost, and
- ability for future changes to meet the shifting needs of the City.

Information and observations from the survey proved to be beneficial in developing strategies that were unique to the City of Windhoek. Details of the proposed strategies can be seen in Chapter 7.

CHAPTER 5: RESULTS AND ANALYSIS

Surveying was conducted at six different locations, including post-secondary education institutions, shopping malls and informal settlements. There were a total of 346 surveys returned to the team, which is one tenth of one percent of the total City population. All the data was then input to an Excel spreadsheet and analyzed. The data collection is summarized in Table 1 and detailed analysis will be discussed in subsequent sections.

Table 1: Summary of all Surveys

Location	Reason for Specific Location	Draft Of Survey Distributed	Time Spent Surveying	Survey ID Numbers	Number of Surveys Collected
Polytechnic of Namibia	Test Survey, Provide Diverse Sample	3 rd	3 hours	001-148	148
Wernhil Park Shopping Mall	Increase Age Range Diversity	4 th	1 hour	149-168	20
Okuryangava	Increase Demographic Diversity	4 th	3 hours	169-199	31
University of Namibia	Provide Diverse Sample	4 th	2 hours	200-315	116
Havana	Increase Demographic Diversity	4 th	1.5 hours	316-334	19
Hakahana	Increase Demographic Diversity	4 th	1 hour	335-346	12

5.1 Observations Made While Administering Survey

There were various trends seen throughout the process of surveying residents in different areas. Besides correlations in data retrieved from the survey, trends were seen in survey locations while administering the survey.

5.1.1 Polytechnic of Namibia

While administering the survey at the Polytechnic of Namibia, it was clear that many of the people were quite educated, and spoke English clearly and effectively. For this reason, respondents were more likely to complete the survey. Although several school administrators were asked to complete the survey, they frequently appeared too busy and declined. Therefore, it was found that the students were far more likely to take an interest. Students at this location seemed to understand that we were also students carrying out a research project, and that the outcome of our research would benefit them. We further observed that respondents from the Polytechnic of Namibia would ask clarifying questions about the survey and its purpose.

5.1.2 Wernhil Park Shopping Mall

Respondents at Wernhil Park shopping mall were significantly more skeptical of the survey; when asked, most were not willing to complete it. From our observations, it was concluded that most people at this location did not understand English well or at all. This resulted in confusion as to the purpose of the survey, its benefit to them, and skepticism as to what their responses would be used for. At this location it became evident that for effective communication throughout the City, a translator would be needed.

5.1.3 Informal Settlement in Okuryangava

Residents in the informal settlement of Okuryangava were surveyed with the help of a translator. Translation of the survey from English to Oshiwambo helped greatly in the understanding and acceptance of the survey. With the help of our translator and children from the area who learned English in school, the survey was administered much more effectively than in the Wernhil Park shopping mall. Here, people were quite willing to complete surveys, even though it was more work for them. Residents allowed us into their homes, were very kind, and thoroughly answered all questions to the best of their ability.

Although the translation via school children was effective in completing a larger number of surveys, limited English vocabularies seem to force respondents to answer with limited understanding of the possible replies. This was most apparent in the “Water Quality” section of the survey which included five quality descriptors (Unacceptable, Poor, Fair, Good, and Excellent) which were translated to only good and bad on some occasions. On several occasions the school children lacked the authority or community respect to be taken seriously. Thus, it was useful to have an adult or a City professional with us to translate. People seemed more responsive to adults of higher authority than of local school children.

5.1.4 University of Namibia

At the University of Namibia, the trends seen among the students were similar to those seen when we surveyed at the Polytechnic of Namibia. Students were quite willing to fill out the surveys and were interested in what we were doing. Many students asked questions and made conversation while completing the survey. Due to either their increased willingness or disproportionate campus gender distribution, survey respondents were primarily female, with 88 of the 116 surveyed being females.

5.1.5 Informal Settlements of Havana and Hakahana

Our last day of surveying was conducted in the informal settlements of Havana and Hakahana. As in Okuryangava, most people did not speak English or would not speak English directly to us. Local school children once again volunteered to help with the translation. It was observed that residents of Havana and Hakahana were less inclined to fill out the surveys when compared to Okuryangava. In Havana, it took an extended amount of time for the translation to occur, and the survey to be filled out due to questions as to the purpose of the survey. Residents who did speak some English took a longer time filling out the survey, trying to read it and understand the questions that were asked. Once again, translation via school children proved to be difficult due to translational and authority limitations.

5.2 Resulting Data from Survey

Data from survey respondents was gathered through four distinct survey sections (“Background Information”, “Household Water Use”, “Water Quality”, and “Water Reclamation”). For a basis of investigation, and to explore the validity of the data obtained, responses from each of these sections are expanded upon in the following respective sections.

5.2.1 Responses from “Background Information” Section

The first section of the survey dealt with background information specific to each resident. The demographics investigated in this section of the survey were:

- Gender
- Age
- Household location
- Years of residence in Windhoek
- Household size
- Highest level of education and
- Frequency of use of common advertising media

The breakdown of these results can be seen below.

Gender

Gender distribution is shown in Figure 3. A higher percentage of females are noted to have taken the survey due to several possible reasons, i.e. survey location and time of day. A large proportion of surveys were completed at the University of Namibia campus where it was observed that over 75 percent of survey respondents were female.

This could be due to an increased willingness of females to complete the survey or a larger proportion of females attending the University of Namibia. The second reason for an increased proportion of females in the overall sample was due to the time of day that the survey was administered. All surveys were administered between the hours of 10:00 and 16:00. This is during the workday where males (commonly the primary financial provider) are gone to work.

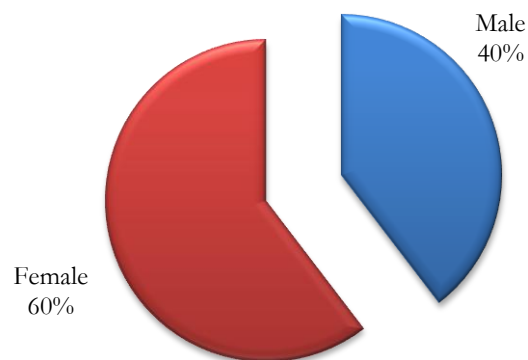


Figure 3: Gender Distribution of the Survey

Age

Respondent ages are shown in Figure 4. Most of the responses to the survey were gathered at post-secondary institutions (i.e. The Polytechnic of Namibia and the University of Namibia) which were selected for respondents with diverse household locations. Although this provided diverse household location statistics, it inevitably skewed results toward the younger residents. As shown in Figure 4, 68 percent of the responses are in the 18-23 year old age bracket. In addition to a large proportion of younger residents taking the survey, older citizens were found to be more hesitant when asked to fill out the form. This could have been due to many reasons, including not being

able to speak English and/or general skepticism about the purpose of the survey.

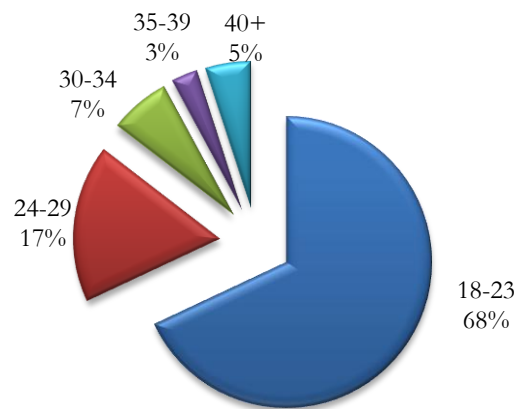


Figure 4: Respondent Ages of the Conducted Survey

Household Location

Within Windhoek there are a total of 23 municipal suburbs which are shown in Figure 5 along with the location of NGWRP.

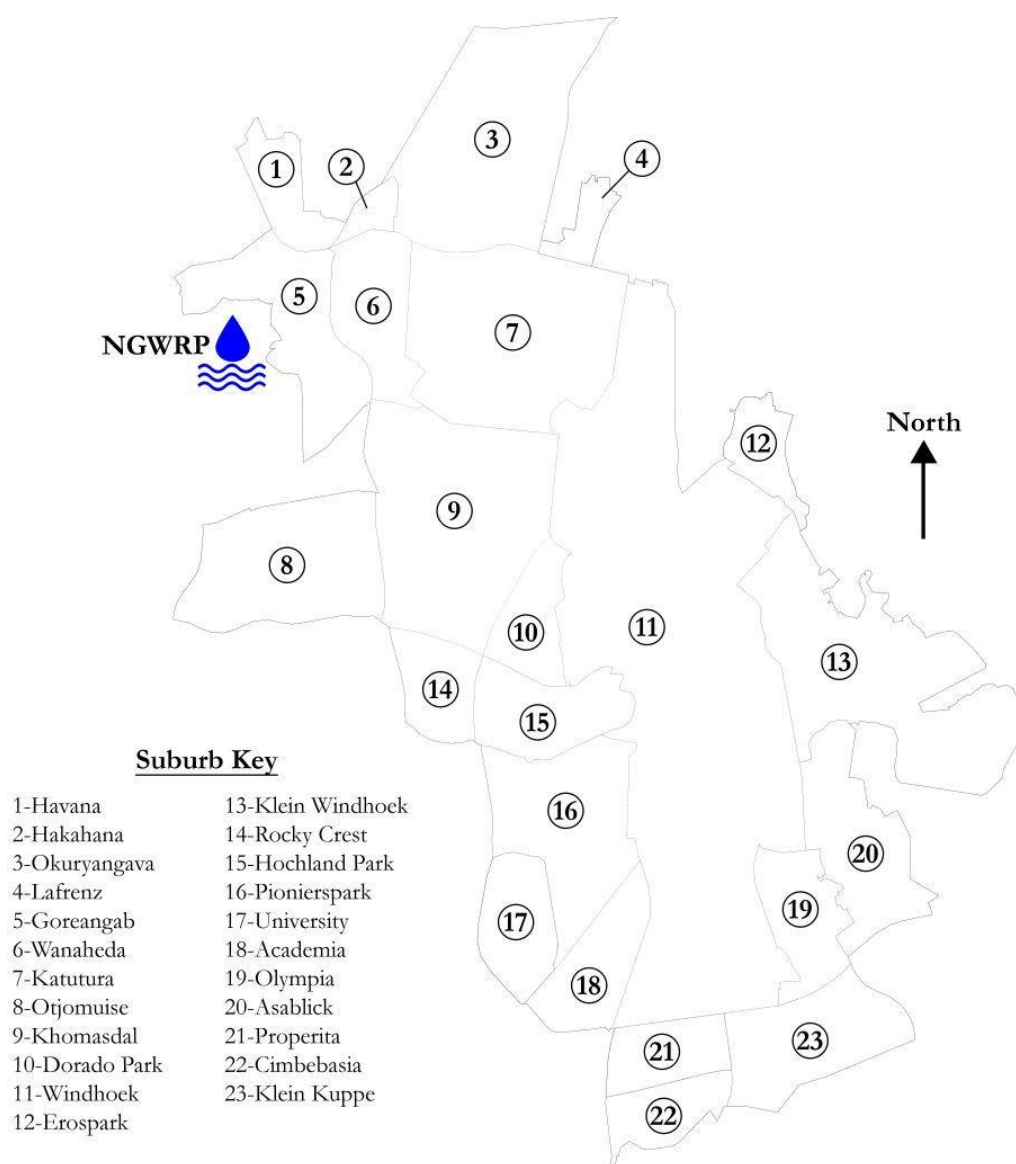


Figure 5: Suburbs of Windhoek (Maanda, 2010)

Although interview locations were not chosen in all suburbs due to logistical constraints, we did identify locations where residents from varying suburbs would congregate, namely schools and malls. This was done in an attempt to create an accurate cross-section of Windhoek residents. Percentages of total survey respondents for each suburb were then compared to percentages of total population taken from a 2006 Namibian population survey. The results are summarized in Table 2: Survey Distribution With Respect To Location Table 2:

Table 2: Survey Distribution With Respect To Location

Suburb	Surveys	Percent of Total Surveys	Percent of 2006 Total Population	Difference
Katutura	89	26.8%	23.7%	3.1%
Okuryangava	46	13.9%	18.9%	-5.1%
Khomasdal	34	10.2%	8.8%	1.4%
Windhoek	49	14.8%	7.5%	7.3%
Wanaheda	16	4.8%	6.9%	-2.0%
Goreangab	2	0.6%	6.4%	-5.8%
Havana	20	6.0%	5.6%	0.4%
Pionierspark	19	5.7%	3.2%	2.6%
Hakahana	9	2.7%	3.2%	-0.4%
Klein Windhoek	3	0.9%	2.7%	-1.8%
Otjomuise	2	0.6%	2.5%	-1.9%
Hochland Park	6	1.8%	2.4%	-0.6%
Dorado Park	9	2.7%	1.8%	0.9%
Rocky Crest	13	3.9%	1.6%	2.3%
Olympia	2	0.6%	1.1%	-0.5%
Cimbebasia	6	1.8%	0.9%	0.9%
Academia	3	0.9%	0.8%	0.1%
Kleine Kuppe	1	0.3%	0.6%	-0.3%
Erospark	0	0.0%	0.6%	-0.6%
Auasblick	3	0.9%	0.1%	0.8%
Lafrenz	0	0.0%	n/a	n/a
Properita	0	0.0%	n/a	n/a
University	0	0.0%	n/a	n/a

Table 2 shows that the cross-section of residents obtained via the surveys follows the population density found in the various suburbs. The “Difference” column highlights the discrepancy between the survey and the total population. A positive value indicates that that suburb was oversampled (e.g. Windhoek), and a negative value indicates that the suburb was under-sampled (e.g. Goreangab). Although all suburbs were sampled to within less than eight percent difference, it should be noted that only 0.1 percent of the total population of Windhoek was sampled. This caused some suburbs to have only a few respondents or none at all. Unfortunately, these suburbs will inevitably contain highly polarized data due to the lack of responses.

Years of Residence in Windhoek

Figure 6 shows an overview of the years of residence within the City of Windhoek broken down into five categories, including born and raised in Windhoek. A

large portion, 52 percent, was shown to have moved into the City less than five years ago. This is due to the fact that over 75 percent of the respondents were college students who most likely moved to Windhoek when starting college. Windhoek's increasing population, via emigration into the City, would also account for a smaller portion of residents stating that they were born and raised in Windhoek.

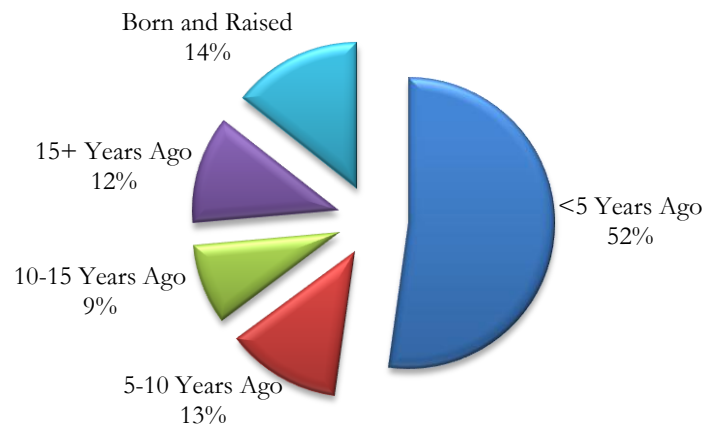


Figure 6: Years of Residence in the City of Windhoek

Household Size

Household size distribution is shown in Figure 7. Household size statistics are evenly distributed showing that the survey sample was indicative of large and small families. The average household size using this data was found to approximately 5.1 which is considerably higher than the value of 4.1 found in the 2006 Namibia population survey.

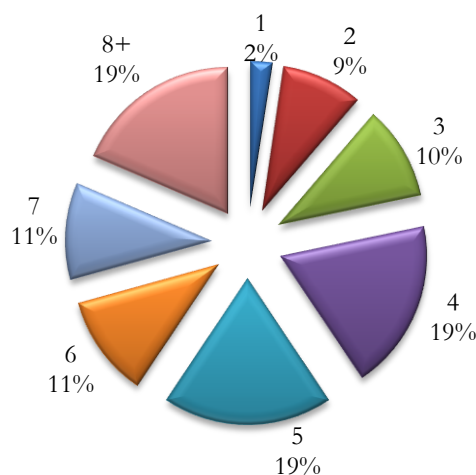


Figure 7: Household Size Distribution

Highest Level of Education

Survey respondent's highest level of education is shown in Figure 8. Although 33 percent of those surveyed marked that their highest level of education was "University", it should be noted that 75 percent of survey respondents were encountered on university campuses. This inevitably skews the results toward the higher educated population of Namibia and must be considered when drawing conclusions.

It should also be noted that the third draft of the survey administered to students at the Polytechnic of Namibia campus contained "some college" and "college degree" as the two highest levels of education. After noticing some confusion on the part of survey respondents, and consulting with our sponsor, the two responses were changed to "Vocational School" and "University". These changes were found to better reflect the available schooling in Windhoek.

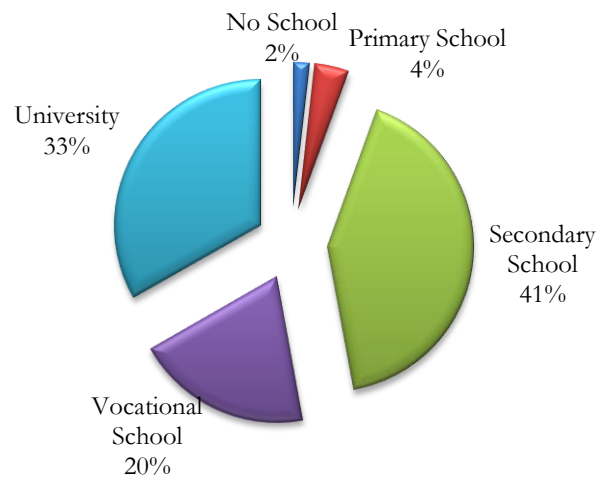


Figure 8: Highest Level of Education of the Survey Respondents

Frequency of Use of Common Advertising Media

The following four pie charts (Figure 9 - Figure 12) show how often the survey respondents use public transportation, read the newspaper, listen to the radio, and watch television. Despite lack of electricity in some of the informal settlements to the north of Windhoek, data shows that radio and television are frequently watched every day. Public transportation was often used every day, whereas reading the newspaper seemed to be less frequently used.

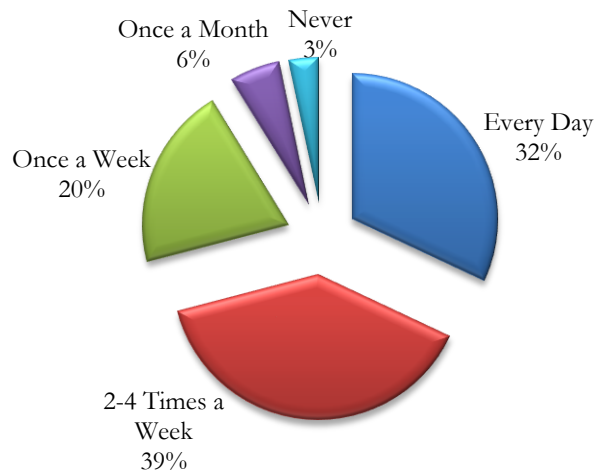


Figure 9: Frequency of Reading the Newspaper

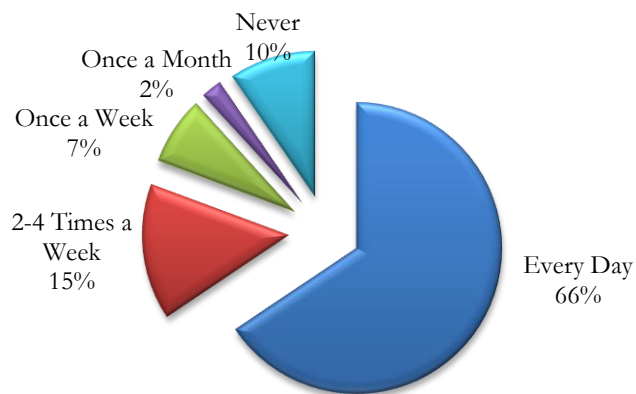


Figure 10: Frequency of Television Use

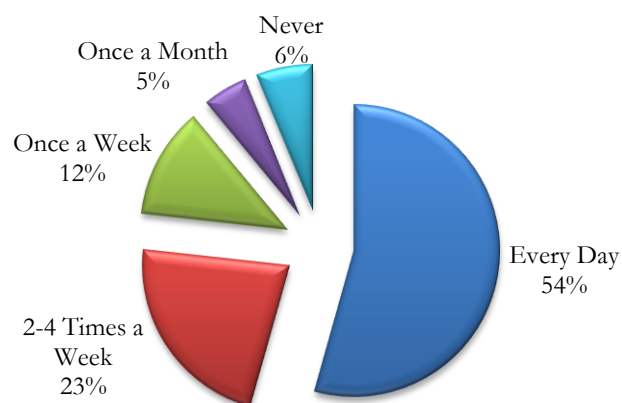


Figure 11: Frequency of Radio Use

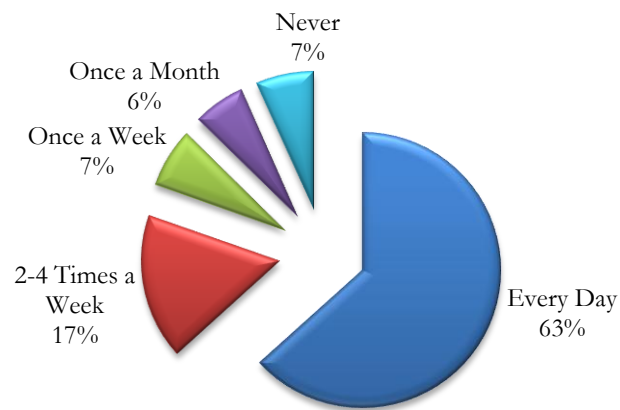


Figure 12: Frequency of Public Transportation Use

5.2.2 Response from “Household Water Use” Section

The next section of the survey asked about each resident’s water use. Four questions were asked about how they receive their water and how they use the water supplied by the City.

Method of Household Water Supply

Resident’s means of receiving water from the City can be seen in Figure 13. The overwhelming response to receiving water via a tap was found due to several reasons; affluence of respondents and confusion of survey wording. Seeing that 75 percent of survey responses were from college campuses, it can be reasonably assumed that those attending college are more affluent. Due to the fact that informal settlements are the only regions to receive water via standpipe, increased affluence outside of the informal regions would skew results toward receiving water via tap. Furthermore, there seemed to be confusion in the wording of the survey as to what a standpipe was. Many residents surveyed most likely received water from a communal tap (aka standpipe) and therefore marked tap instead of standpipe. Thus, the responses from this question were not as accurate as they could have been. Many people were confused as to how they receive their water from the City and therefore may have marked the incorrect way of receiving water.

The labeled “other” open ended category was answered with responses such as card water, pre-paid tap water, and water meter. Through conversations in the informal settlements it was learned that residents can receive water by using a card at a communal tap. This is done by placing a small silver button (the card) into the water meter located on a standpipe and then pressing a button to withdrawal one liter of water at a time.

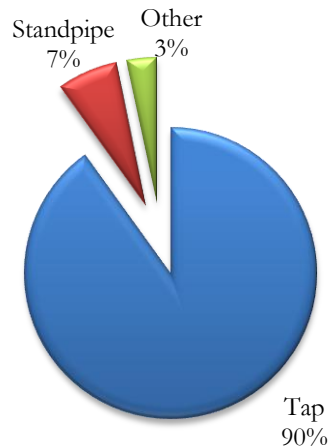


Figure 13: Method of Water Supply in the Household

Household Water Uses

The next question investigated how the residents were using their household water supply. Over 90 percent of the responses from the survey indicated that people use the City of Windhoek water for cleaning, bathing, and cooking. 87 percent of respondents also use the water for drinking, while less than 50 percent use it for watering their plants. Some other responses for how household water is used include laundry and washing cars.

Primary Source of Drinking Water

Figure 14 indicates the primary source of drinking water. Three quarters of the Windhoek population use straight tap water as their primary drinking water source. Nearly 15 percent boil their tap water, meaning that close to 80 percent of residents use tap water in some way as their primary drinking water source.

It should be noted that the third survey draft employed on the Polytechnic of Namibia campus had respondents rank their use of water sources. This proved to be confusing, so the question was modified to have the respondent mark their primary source only. This format was more effective in gathering responses from residents.

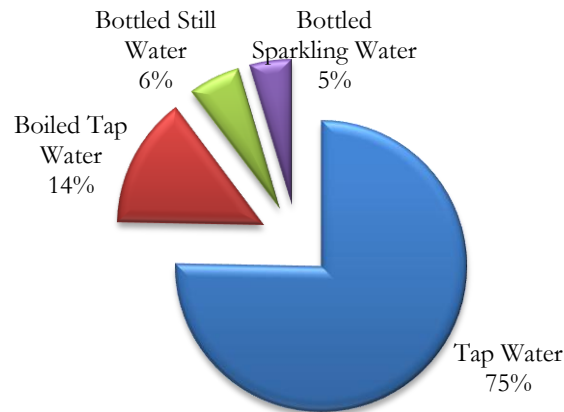


Figure 14: Primary Source of Drinking Water

Water Tariff Pricing

Each resident was asked to estimate their average monthly water bill and then mark their feeling towards this price. The average monthly water bill from the 263 residents that answered this question is N\$578.00, with the highest response being N\$5000.00 and the lowest at N\$5. A summary of resident's perception of the water tariff prices can be seen in Figure 15. Most residents thought that their average water bill was "fair" or "acceptable" and 29 percent felt as though the price they paid for water was unacceptable.

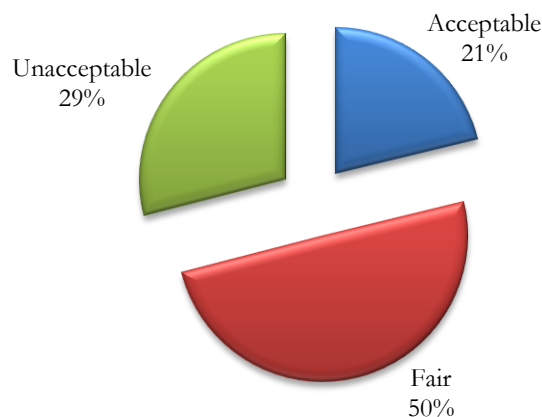


Figure 15: Feeling Towards the Water Tariff Prices

5.2.3 Response from “Water Quality” Section

Residents were also asked about various aspects of their water quality. This section was divided into four categories: color, taste, smell, and overall quality; all ranked from unacceptable to excellent. A final question on the perceived safety of water was asked to conclude this section of the survey.

Organoleptic and quality results can be seen in Figure 16, Figure 17, Figure 18, and Figure 19. Most City of Windhoek Residents perceived the individual organoleptic qualities as well as the overall quality as being “Good” or “Excellent”. It should be noted that in water smell, color, and overall quality the percentage of residents perceiving the water to be “Unacceptable” or “Poor” was less than eight percent. This contrasts sharply with the 20 percent of residents who thought the water taste was “Unacceptable” or “Poor”.

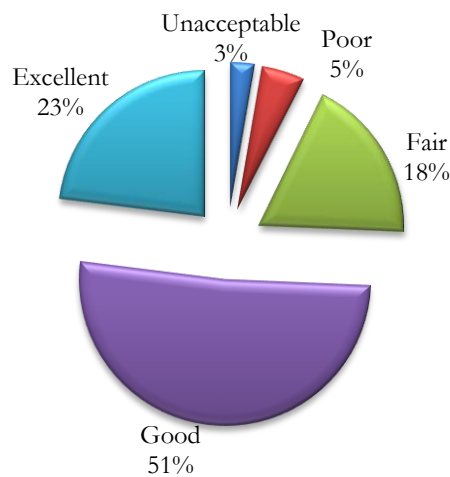


Figure 16: Quality of Water Color

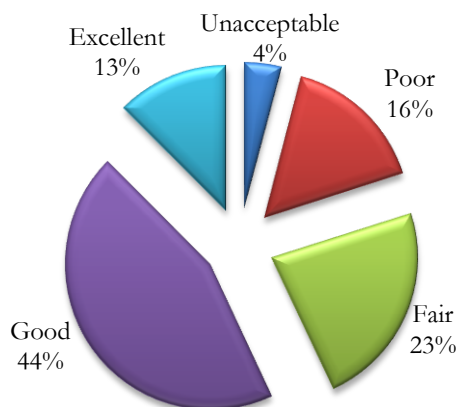


Figure 17: Quality of the Water Taste



Figure 18: Quality of the Water Smell

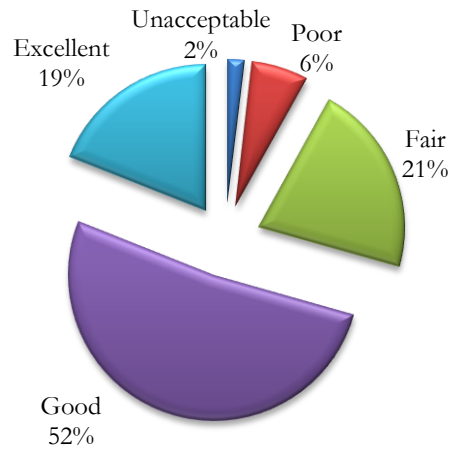


Figure 19: Overall Water Quality

Water Safety

Resident's responses to whether or not the water was safe to drink can be observed in Figure 20.

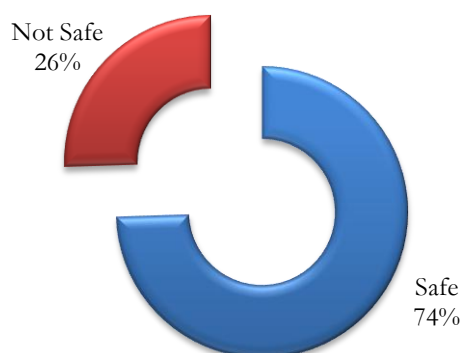


Figure 20: Opinion of Water Safety

About three-fourths of the citizens think that their water is safe to drink. The open ended question as to why residents thought the water was either safe or unsafe to drink was filled in by just over 60 percent of survey respondents. A sample selection of reasons as to why the water is safe to drink is summarized below:

- “Because it has a certain taste that we are not sure where it is resulting from”
- “Because some people/residents get a stomach problem after drinking it”
- “to much chemicals can damage human health”
- “because of its colour sometimes (brownish)”
- “im adviced to boil it because it is not healthy to drink”

A sample selection of responses as to why the water is unsafe to drink is summarized below:

- “Think it went through proper methods of waster supply”
- “It doesn't cause any stomach pain after taking it in”
- “It's clean/clear and there are chemicals used to clean the water”
- “Yes because we are assured that it's not contaimeinated”
- “Because it is purified and some different tests were done before its considered consumable”

All open ended responses as to the safety of the water are recorded in Appendix E. It should be noted that the open ended responses are quoted verbatim; they were not edited grammatically; this was done to preserve the respondents’ original voice.

5.2.4 Response from “Water Reclamation” Section

To gauge how much Windhoek’s residents know about water reclamation, including the process of water reclamation and knowledge related to where the City gets its water, questions were asked pertaining to Windhoek’s water supply in general and then more specifically about the water reclamation process and the New Goreangab Water Reclamation Plant.

Water Supply Sources

Resident’s knowledge of Windhoek’s water supply is reported in Figure 21. From this figure, it is clear that more than half of the residents surveyed do not know where the City of Windhoek receives its water. Since this question is answered by self proclaimed knowledge, it is impossible to know how many people are aware of the many sources contributing to Windhoek’s water supply. Considering this fact, it can reasonably be assumed that far fewer residents are actually aware of Windhoek’s three-dam system, boreholes, and water reclamation systems implemented for the supply of water to the City.

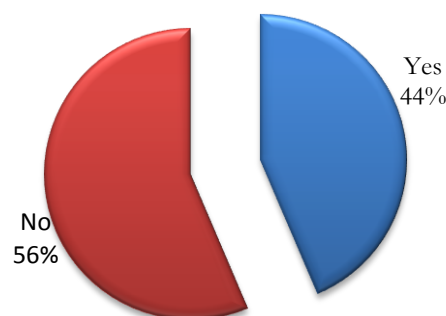


Figure 21: Knowledge of Where the City of Windhoek Receives Its Water From

Water Supply for the Future

Perception of water supply for the future can be seen in Figure 22. Nearly half of the residents surveyed felt as though there was enough water for the future needs of Windhoek. This question was followed with an open-ended response to allow residents to give their reasons as to why or why not. A selection of results as to why residents believe that there is not enough water, are reported below:

- “Because people waste water for unnecessary reasons”
- “Because everyday the City population is increasing”

- “Because the population in windhoek is high and city of windhoek does not supply water to everyone/household”
- “cause the are people who don't have enough money to pay the water bill”
- “since some popel don't have water in their house like in Havana”

A selection of results as to why residents believed that there was enough water, are seen below:

- “because in Windhoek there is a dam full of water”
- “because namwater is trying hard to provide enough water for the future”
- “because it is recycled”
- “Because we receive enough rain”
- “because we stil have a high level of ground water and receive enough rainfall”

Once again, all of the open-ended responses can be seen in Appendix E and are recorded verbatim.



Figure 22: Future Water Needs

Knowledge of Water Reclamation

Knowledge of water reclamation is summarized in Figure 25. An overwhelming majority (80 percent) were unaware of what water reclamation is. Despite educational programs employed by the City in years past, many residents still did not know what water reclamation implies. While administering the survey it was observed that many residents struggled with the highly technical term of “reclamation”. In conversations with residents after completing the survey many were far more understanding of the term “water recycle” or “water reuse”. Respondents were also given an open ended section as to explain what reclamation meant to them. These open ended responses can be seen in

Appendix E and it was found that for the most part those that did know about water reclamation equated it to recycling.

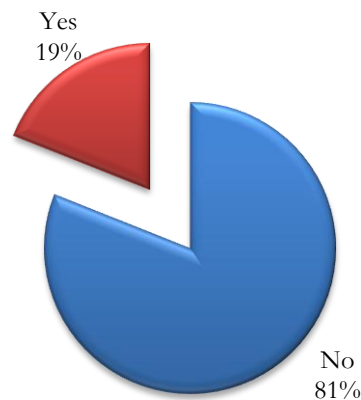


Figure 23: Knowledge of Water Reclamation

Knowledge of the New Goreangab Water Reclamation Plant

Knowledge of the NGWRP is summarized in Figure 24. More than half of the residents surveyed were unaware of the New Goreangab Water Reclamation Plant. It was observed that many who did know about the plant knew water was being recycled there but still did not understand the term “reclamation”. This was surprising as reclamation is in the title of the plant and demonstrates further that the euphemistic term “reclamation” is not understood by a majority of the population. This question further shows that residents know more about the plant than they do about the process that takes place there.

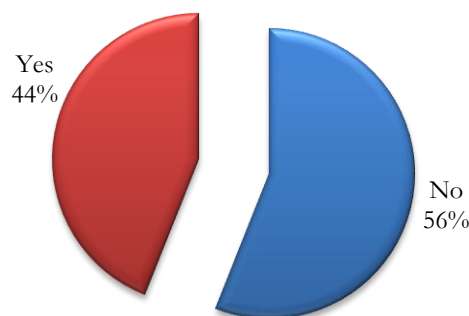


Figure 24: Knowledge of the Goreangab Water Reclamation Plant

Communication Methods for Advertising Information about the NGWRP

The best methods for communicating information about the NGWRP are shown in Figure 25. Windhoek residents were then asked the best way to advertise information about the plant. There were five choices that were given to the residents and then another option to fill in other ways that the team did not think of. The responses are shown in a bar graph in Figure 25. The three largest responses are television with 189 responses, radio with 108 responses and newspaper with 106 responses. Some of the “other” suggestions included community announcements, Facebook, word of mouth, pamphlets, internet, notice boards and at schools.

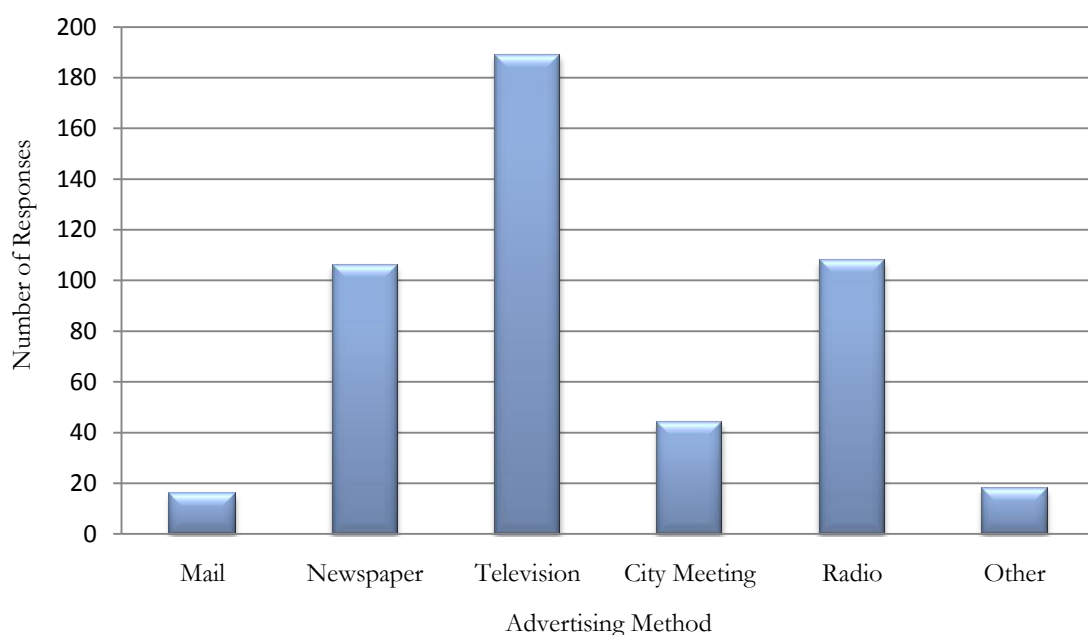


Figure 25: Most Effective Way to Advertise Information about the Plant

Contact Number Use

This final question was added per request of Mr. Ferdi Brinkman and asked if residents would make use of a City maintained contact number to call with questions regarding water usage. Figure 26 highlights these results below. Seventy percent of residents surveyed replied that they would make use of a contact number. On several occasions residents asked if this number would be toll-free or whether they would have to personally pay for this service. This is a valid and pertinent question as many would not make use of a number if they were required to pay.

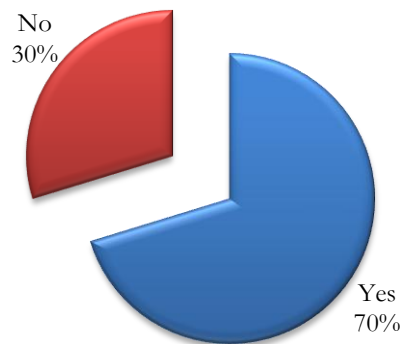


Figure 26: Potential Use of a City Contact Number

5.3 Discussion of Resulting Data

After the data from the survey responses was reviewed, we began our search for commonalities between resident responses with regard to the following demographics:

- Location
- Gender
- Age and
- Years of residence in Windhoek

Each of these demographics was compared against seven key survey questions. These are as follows:

- Overall water quality
- Perceived water safety
- Knowledge of water supply
- Perception of future water supply
- Knowledge of water reclamation
- Knowledge of New Goreangab Water Reclamation Plant and
- Best way to advertise

Trends were not found for all comparisons and thus only pertinent commonalities will be elaborated upon in the following sections.

5.3.1 Location Related Commonalities

Location data was investigated through the use of gradient maps. These maps indicate the regions where residents have common or drastically different responses to questions. Several suburbs have only a couple of respondents (i.e. Goreangab, Otjomuise, Olympia, & Klein Kuppe) and thus have very polarized results. When reading the maps it must be understood that

these regions may be outliers and no single suburb should be used in drawing conclusions. This being the case, trends for the City of Windhoek as a whole can still be read from these maps.

Overall Water Quality

Figure 27 shows the overall quality for the City of Windhoek. This map shows there are no regions of the City that have poor or unacceptable water quality on the suburb level. This agrees with the City's distribution system which equally distributes borehole, surface water, and reclaimed water to all suburbs.

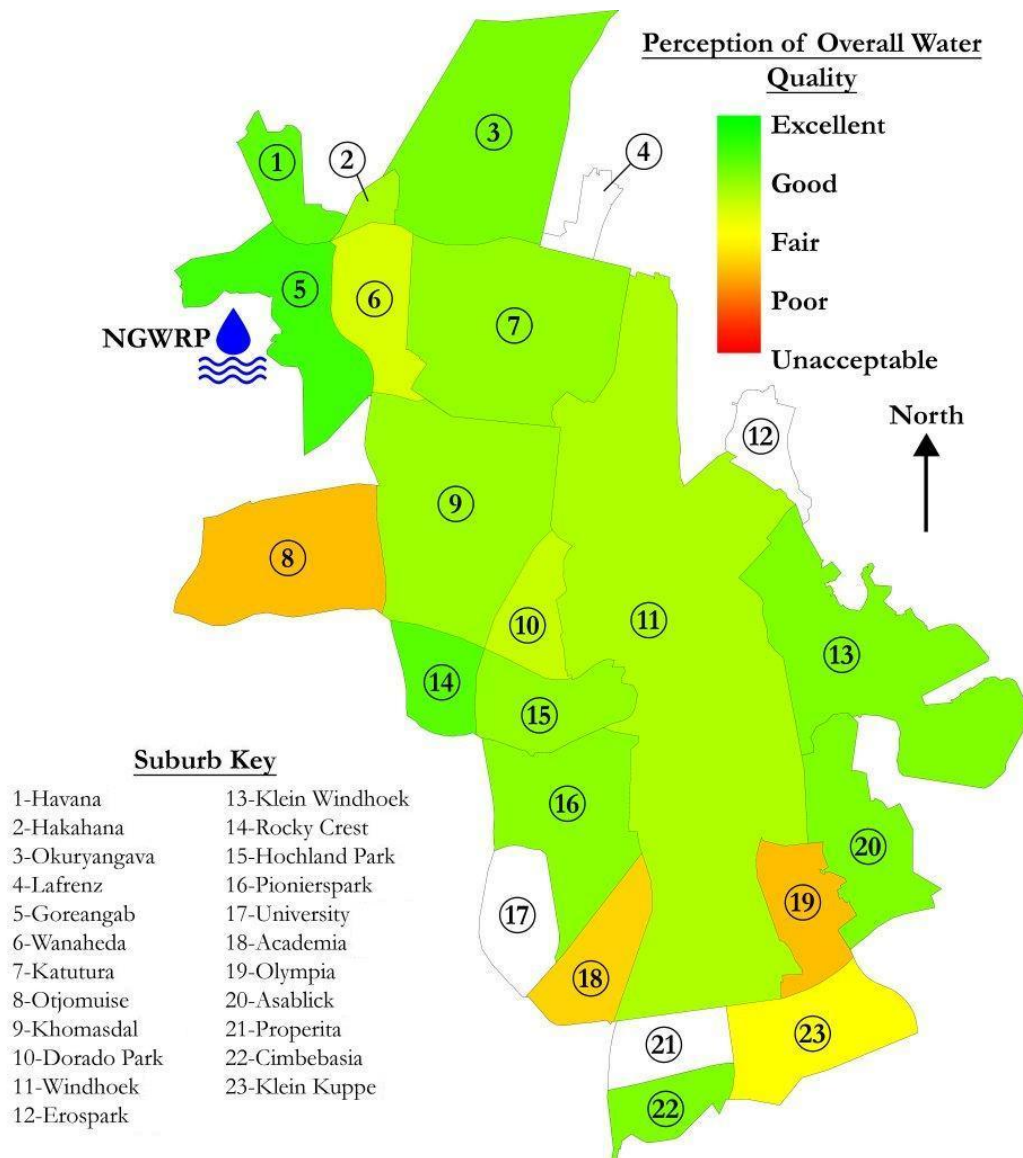


Figure 27: Overall Water Quality Gradient Map

Perception of Future Water Supply

Resident perception of Windhoek's future water supply with respect to suburb location is shown in Figure 28. This map shows that approximately one half of the residents living in suburb of Windhoek (No. 11 on map) do not think there is enough water for the future. It is also interesting to note that the informal settlements where water is received primarily via communal tap, i.e. Havana (No. 1) and Hakahana (No. 2) there is a strong feeling that there is not enough water for the future.

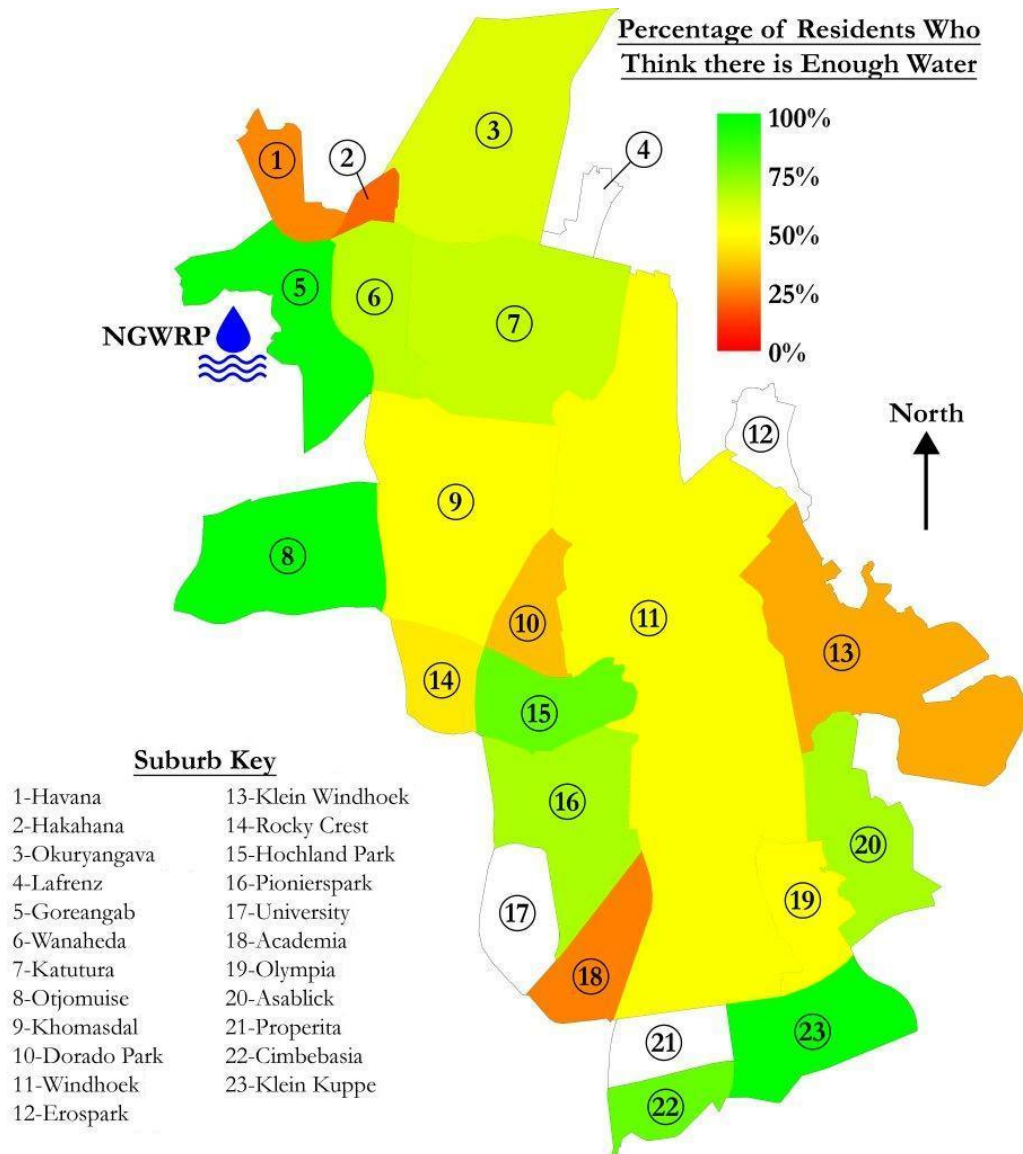


Figure 28: Perception of Future Water Supply Gradient Map

Knowledge of Water Reclamation

Figure 29 shows resident's knowledge of water reclamation. As seen by the overall color of the map, there is widespread ignorance to the term and/or the process of water reclamation.

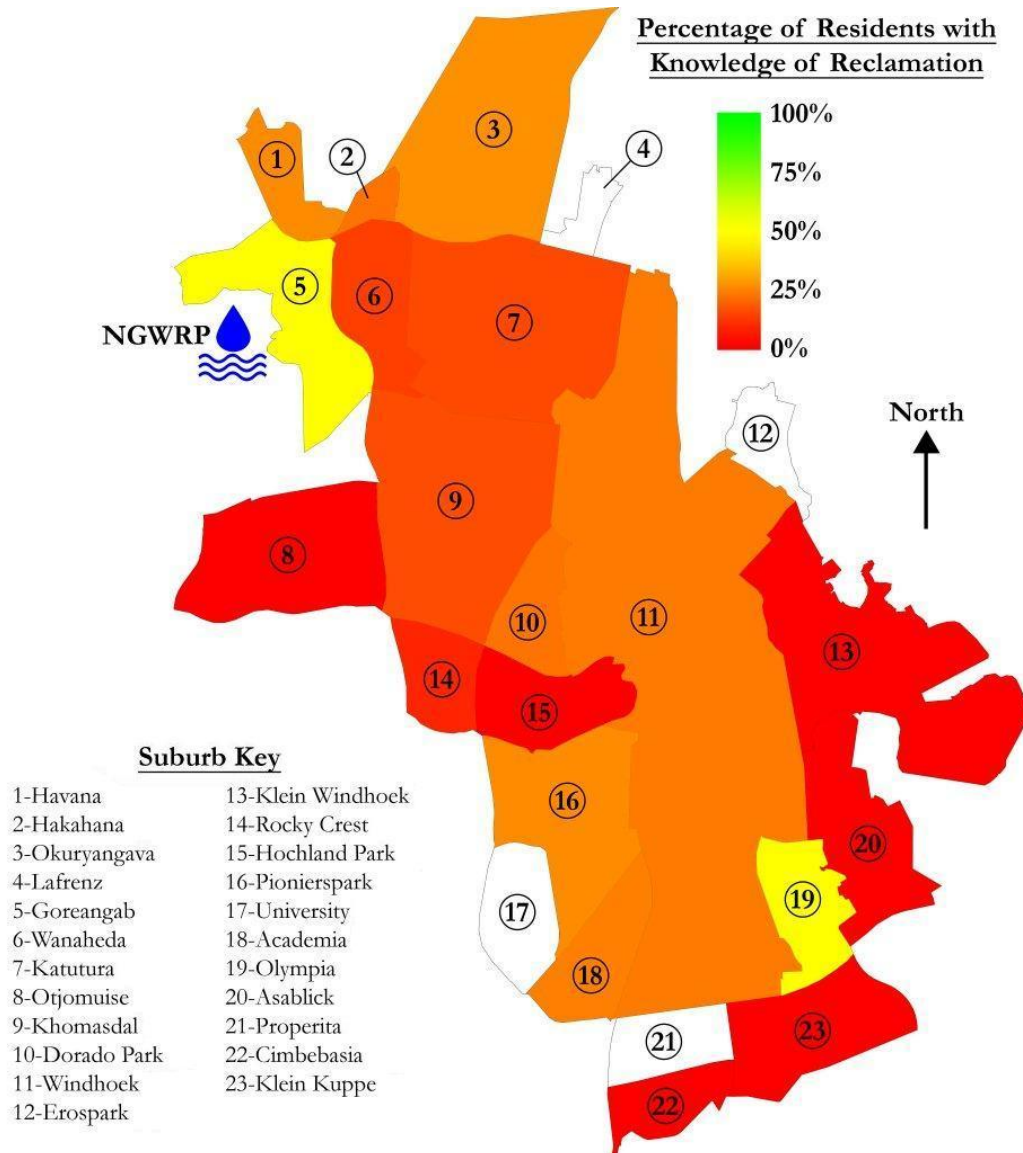


Figure 29: Knowledge of Water Reclamation Gradient Map

Knowledge of New Goreangab Water Reclamation Plant

The percentage of residents who know about the NGWRP in each suburb is shown in Figure 30. From this map, it is apparent that the closer to the NGWRP they live, the more they know about it. This could be due to the fact that these residents see the plant on a daily basis and then either asked about what it is or looked into more information on it. This observation is critical in regards to affluence. Overall, affluence increases from the northern suburbs toward the southern suburbs. Based on this map it is found that affluence (and possibly education) have no major role in affecting knowledge of the NGWRP.

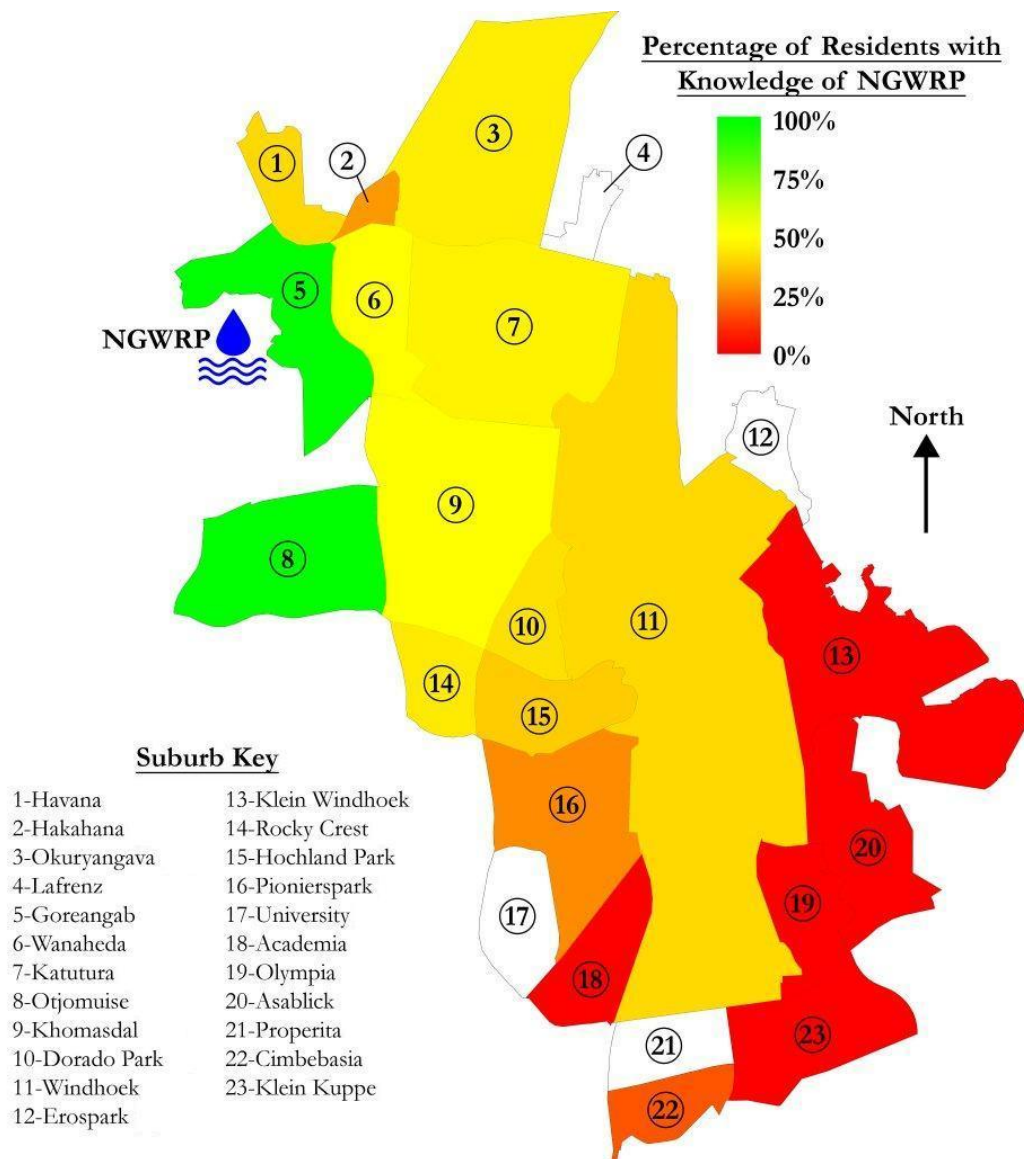


Figure 30: Knowledge of New Goreangab Water Reclamation Plant Gradient Map

5.3.2 Education Related Commonalities

Before the results were compiled, it had been theorized that the more education is attained by individual respondents, the more they would know about reclamation. This was concluded because the education systems in the schools near Windhoek often teach about reclamation.

Overall Water Quality

When asked about the overall quality of the water, there was no trend in what people thought of their water quality. Overall, the majority of people believed their water was of good quality, and did not correlate to education level at all.

Perceived Water Safety

When education level was compared to the perceived safety of the water, there was no overall trend in this data. If there were to be a trend, it would seem that the more educated the person, the more the person may understand the risks involved. However, this was not the case in our data.

Knowledge of Water Supply

Education level was thought to correlate with knowledge of where the City gets its water. However, this trend was not seen either.

Perception of Future Water Supply

The residents were asked if they believed that there would be enough water for the future needs of the City. There was no trend seen between the answers to this question and the level of education the people had received.

Knowledge of New Goreangab Water Reclamation Plant

Knowledge of the plant or of water reclamation also did not correlate to education level, although we expected that it would. The younger residents, who were not surveyed, may know more about the plant than older residents due to the fact that many schools take the children on tours of the reclamation plant. Older people who were already out of school, or moved here at a later date, probably are not as likely to have taken a tour of the plant, and therefore would not know about it.

Best Way to Advertise

Lastly, the best way to advertise information about the plant was investigated. It may seem as though the more educated the residents are, the better job they have, and consequently the higher their earnings, making various resources available to the person. It would seem that these residents would have sustained access to television and radio, while others may not. However, when processing our data we found that this correlation does not apply.

5.3.3 Gender Related Commonalities

Looking at the gender of the respondent's versus different questions from the survey was another correlation that was of interest to the team. There were significantly higher responses from the females than males, a 60 percent to 40 percent break-down.

Perceived Water Safety

Investigating each of the questions versus gender did not show clear trends. The one graph of interest is linked to the question “Do you think the water is safe to drink”. The graph can be seen in Figure 31. More females were hesitant to drink the water, thinking it was unsafe, than most male responses. Only 14.6 percent of males thought the water was not safe, while 32.54 percent of females surveyed thought the water was unsafe to drink. This could be because some mothers who were surveyed and interviewed stated that they would not give their children tap water because of a bad experience they had with the tap water.

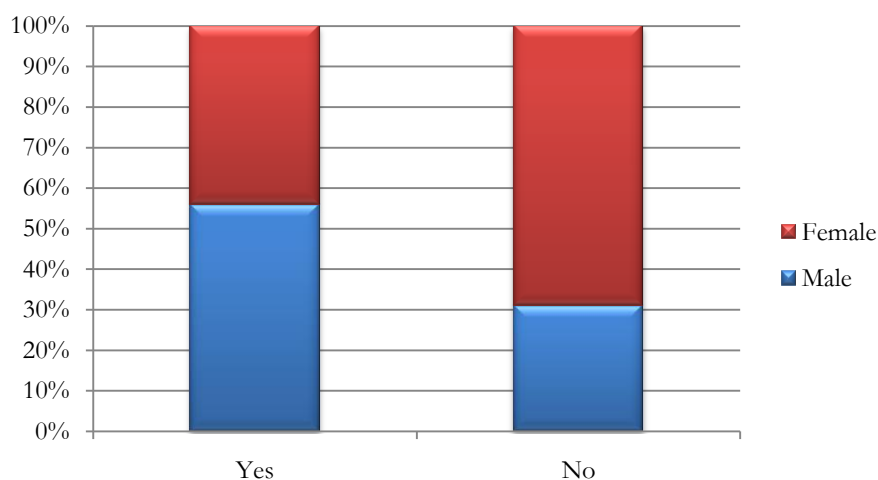


Figure 31: Do You Think the Water is Safe to Drink versus Gender

Perception of Future Water Supply

Looking at this correlation, the female survey responses suggest that the City of Windhoek does not have sufficient water for the future. In Figure 32, the female “no” responses are much larger than the male responses, and they are about even on the “yes” responses.

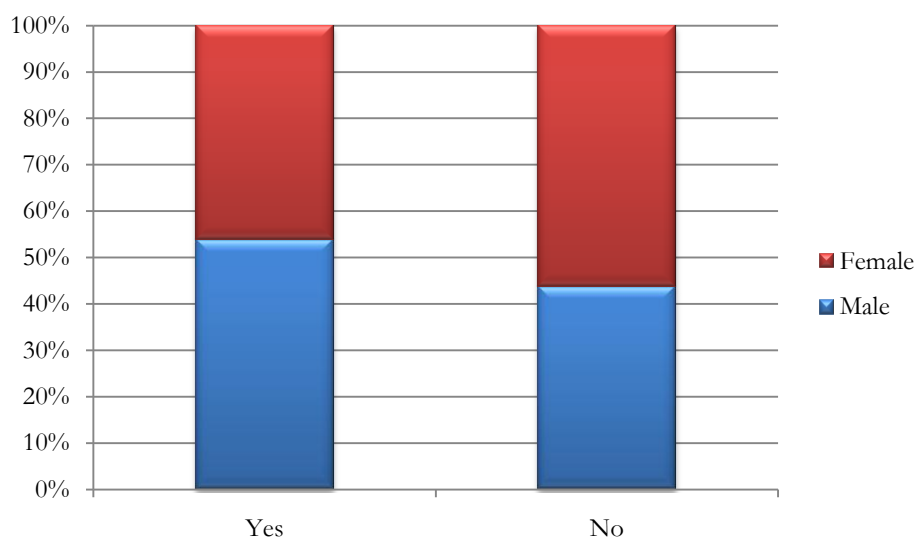


Figure 32: Is There Enough Water for the Future of Windhoek versus Gender

Knowledge of Water Reclamation

A higher percentage of males know what water reclamation is than females. This shows that males are more educated and have a better understanding of where the water is actually coming from than the female population. We can see this trend displayed in Figure 33.

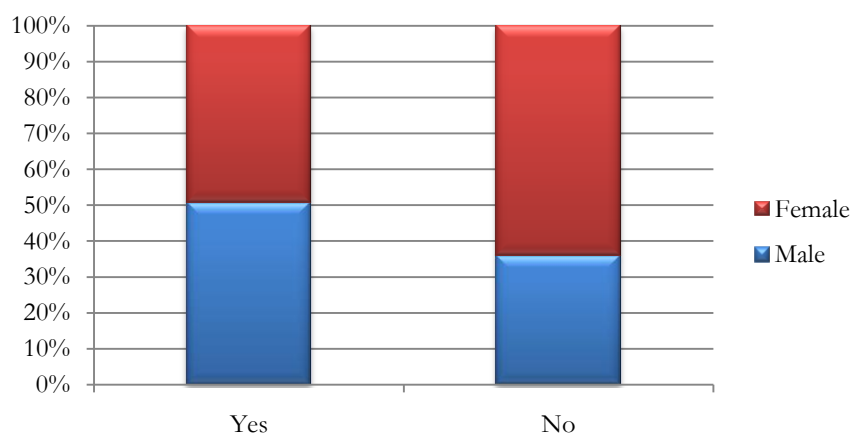


Figure 33: Do You Know What Water Reclamation Is versus Gender

Knowledge of New Goreangab Water Reclamation Plant

The knowledge of the plant goes along the same lines as the knowledge of water reclamation. The male survey responses showed that they knew what the plant was more so than the females. The data can be seen in Figure 34.

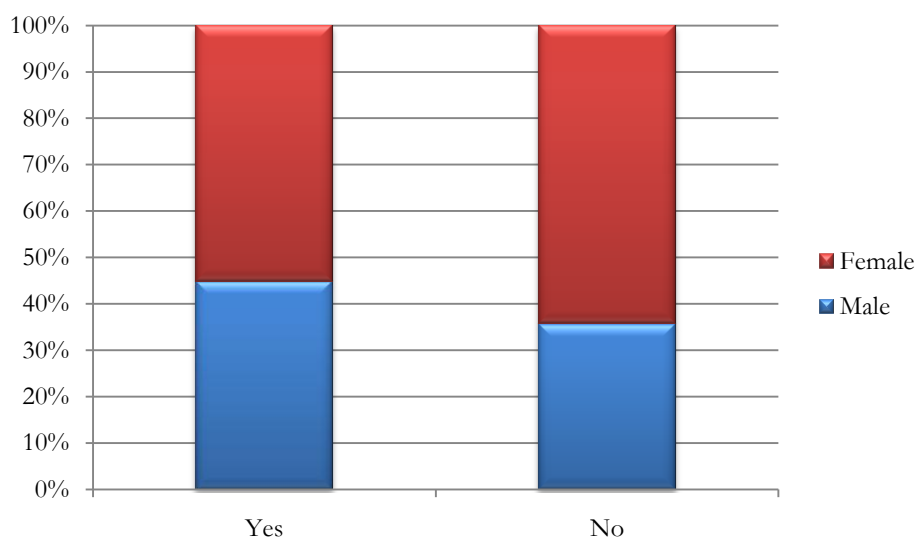


Figure 34: Have You Ever Heard About the NGWRP versus Gender

5.3.4 Age Related Commonalities

Due to the fact that a majority of surveys were completed on post-secondary campuses, age related data was clustered primarily in the 18-29 year old range. The number of surveys returned for each age bracket within the survey is seen in Table 3.

Table 3: Distribution of Resident's Age

Age	No. of Responses
18-23	234
24-29	60
35-39	33
40-44	6
45-49	3
50-54	5
55+	3

Thus with limited data in the higher age ranges it is statistically inappropriate to draw any conclusions with respect to age without further data.

5.3.5 Years of Residence Commonalities

The next set of data that was analyzed was the knowledge of the plant versus the time the residents have lived in Windhoek. The deliberation was that the longer one is a resident of Windhoek, the more knowledgeable he or she should be about the plant. This data was placed in a bar graph and analyzed for trends; it can be seen in Figure 35. However, with this data, there is no apparent trend. With more surveys collected, it is expected that a trend would emerge but with lacking data from 2000 until 2006, the data does not show anything conclusive.

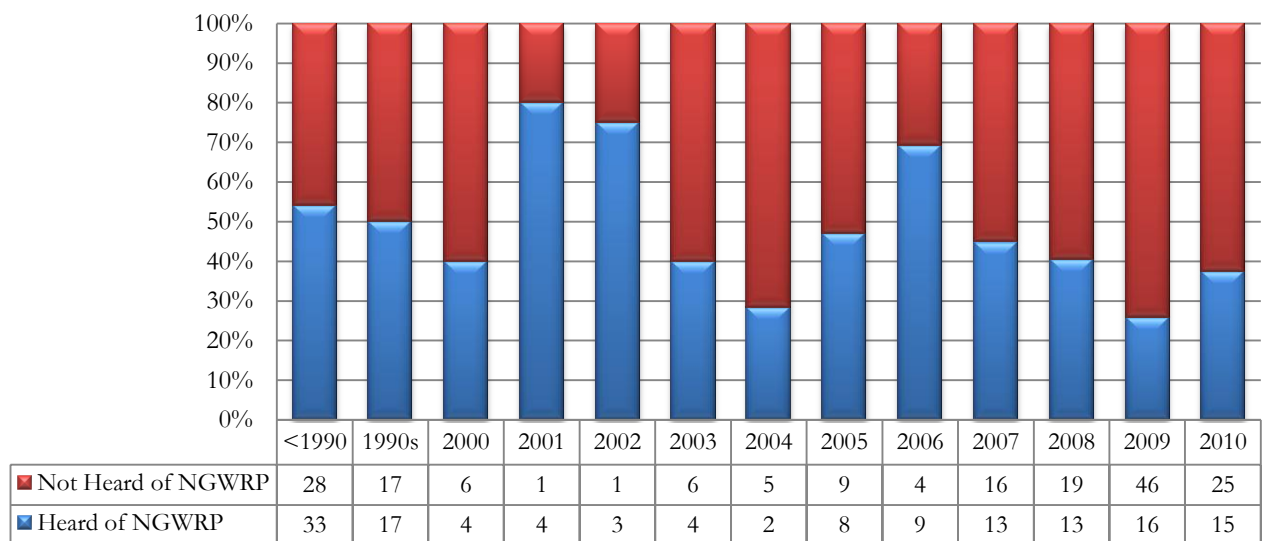


Figure 35: Knowledge of NGWRP Over Time

CHAPTER 6: CONCLUSIONS

Based on our extensive data analysis conducted in Chapter 5, the team arrived at the following conclusions:

- There were 346 surveys collected by our team, representing approximately one tenth of one percent of the total City of Windhoek population. Obviously, more surveys could be used to draw better statistically valid conclusions.
- Residents surveyed most frequently use the television on an everyday basis. With a 66 percent response rate it outnumbers by far listening to radio or reading newspapers.
- Seventy-five percent of resident's primary source of drinking water is tap water, showing that three-fourths of the residents use the reclaimed water primarily for drinking water.
- With an average of N\$578.00, half of the residents were found to think their water tariff price is fair.
- The overall water quality was found to be "good" throughout the City
- About three-fourths of the residents believe that the water is safe to drink.
- More than half of the residents do not know where the City of Windhoek receives its water.
- Nearly half of the residents thought that there was sufficient water available for the future.
- Eighty percent of residents did not know the meaning of water reclamation.
- More than half of the residents surveyed were unaware of the New Goreangab Water Reclamation Plant.
- Seventy percent of the residents would make use of a City of Windhoek maintained contact number to call with questions regarding water reclamation.
- The closer the residents lived to the NGWRP, the more likely they were to know of the facility.
- More female respondents thought that the water was not safe to drink (32.54 percent) than male respondents (14.6 percent).

CHAPTER 7: RECOMMENDATIONS

Based on the aforementioned conclusions, we would recommend that the City of Windhoek take the following actions:

- Update survey questionnaire
- Continue surveying the residents of Windhoek
- Disclose water quality information to Windhoek residents while educating Windhoek residents on water reclamation and the NGWRP
- Implement a water reclamation advertising campaign
- Implement a system of customer feedback
- Conduct longitudinal surveying after implementation of advertising/education via survey action plan

These action points can be completed in the following manner:

Update survey to be more tailored and simplified for the residents of the City of Windhoek

While processing the first 346 surveys, the team came up with several suggestions of ways to update and change the survey to get better responses from the residents of Windhoek. While marking how a resident's household receives its water, the word "tap" and "standpipe" were confusing to some residents. Since some residents in the informal settlements call their standpipes communal taps, they assumed that tap was the correct response. Having faucet and communal tap as the two responses instead of tap and standpipe might give for more accurate results. Another change would be to either change the question "do you know what water reclamation is?" to "do you know what recycling of water is?" or add another question about the recycling of water. This change could make for a better response regarding knowledge of the recycling process, since when residents would ask questions about what reclamation meant, they would often know what the recycling of water was, but did not know the term reclamation. We would also recommend that the survey be translated into Afrikaans, German, Oshiwambo, Herero, and Dimara, the primary languages of Windhoek residents. This would allow the minimization of translation error.

Continue surveying the residents of the City of Windhoek to obtain a larger sample size

With limited time and resources for this project, the team could only reach a sample size of 346 residents. With more time and manpower, having a response of around 3,000 residents (1% of Windhoek's total population) would make for a much better sample size. These surveys

should be taken in direct proportion to the size of the suburbs to obtain accurately weighted data. Most conclusions were drawn with the minimal data and some assumptions based on the data collected. The more surveys that are answered, the more reliable the data will be.

Disclose water quality information to Windhoek residents while educating Windhoek residents on water reclamation and the NGWRP

After drawing the conclusions from the surveys, the residents were generally found to have no knowledge about water reclamation or the NGWRP. To educate the residents about the plant and the process will be a major step in making the process of water reclamation more transparent. Having both the water quality and education processes happening at the same time will be key so that the residents do not feel apprehensive toward the drinking of the water once they know the underlying technical processes. Instead of assuming the City wants to disclose this information because of a problem, they will learn that many measures are being taken to ensure the safety of the consumers and therefore be more likely to accept it.

Implement water reclamation advertising campaign

There are several ways that the City of Windhoek can advertise water reclamation and the NGWRP that we believe would be most effective based on what was found through surveying. Some examples of advertising methods investigated by the team are as follows:

Television commercials

In our results, seeing that residents watch television the most everyday makes the point that a television commercial about the City of Windhoek's water and the NGWRP would have the best impact on the community. With outreach on television and local channels, residents can see in a creative, more entertaining way that people might remember more and talk about with their friends.

Radio Song

Having established that the radio is listened to quite frequently, a jingle or song on the radio about water reclamation and the NGWRP would be another effective media outreach effort. While surveying in the informal settlements, we frequently heard radios being played in houses and at general centralized areas populated by many residents. With a catchy jingle or song, the residents can be exposed to water-related topics and likely remember what they have heard.

Newspaper

Even though most people read the newspaper two to four times a week, having an ad in the newspaper would make for good advertisement. If residents want facts or information on what is happening in the City, the newspaper is the place to look for those facts. Putting an article on the water and being transparent about the process would be another outreach for communication with the residents. This would also allow for a phone number to be distributed in the newspaper for which the community members could call with questions. Instead of having the paper and pen ready if the number was seen on television, the person could take the newspaper home with them.

Letter in Monthly Water Bill

The most effective way to reach the current water consumers with water meters would be through their monthly bill. Inserting a pamphlet with information about the water sources, future supply and water quality could be contained within the bill. This would be distributed to each resident receiving a monthly water bill and therefore would reach many people effectively.

Any combination of those advertising methods can be used to further outreach the residents and possibly reach even more residents than one method alone.

Implement system of customer feedback

Customer feedback will be necessary to gauge if the advertising campaign is working. Seeing the responses already from initial surveying, most residents would use a contact number to call with questions regarding their water. Having this contact number would allow residents to give more feedback as well as ask questions to City officials about water in general. While getting the feedback from the residents, the City needs to take note of what they say and implement some further changes in the outreach of the City's water.

Conduct longitudinal surveying after implementation of advertising/education via a survey action plan

As seen in Appendix F, we devised a system that the City can follow when they gauge the final knowledge of the residents. With no knowledge, the City would need to implement the recommended advertising methods to educate the residents with the facts, then send out a

second survey to see if the implemented methods worked or did not work, and then evaluate its further course of action. If there was basic knowledge found, the City would need to follow up and see what the residents knew and what else they would like to know or did not care about learning. If they were satisfied with the information given, then the City would keep their current communication methods that they are using. If they were not satisfied, then the City would implement the methods of communication advised above from the team and then survey the residents once more to see if the implemented methods worked or did not work, then evaluate from there. The same steps as before can be implemented based on the various levels of knowledge that the City of Windhoek observes.

Communicating factual information and the various processes corresponding to the water reuse effort is one of the most important aspects of the entire process. The objective of any water utility is to inform the public what the utility knows and to ensure that the logical human health risks, along with environmental aspects are conveyed in a clear and concise manner (Daughton, 2004). It is important to understand that in certain societies people are more comfortable with numbers and statistics rather than just facts and testimonials and vice versa. On the other hand, attempting to find data on the exposure risks involving reused water are not well documented (Asano & Cotruvo, 2004). For this reason, it is extremely important that the information is presented to the community by the water utility in a manner that is best for the person receiving the information to understand.

Although cities implementing a water reuse program attempt to communicate all developments and expansions of the project and the processes of reclaiming water, there is always a need for dynamic evaluation. Some citizens will inevitably know more than others due to varied access to communication channels. It is important for the members of the community to fully understand and accept reclamation because it is a vital component in ensuring that the City will have sufficient water for future generations. Through the continuation of the survey created for the City of Windhoek and an increase in communication about reclamation, the majority of the public will likely grow to understand and accept the process, leading to less resistance to the consumption of reclaimed water.

APPENDIX A: STEPS IN THE WATER TREATMENT PROCESS

In this appendix we first review how the water, which starts out as waste, is turned into potable water, see Figure A1. Following that, a diagram shows a schematic representation of this process and finally, a schematic representation shows how the water in Windhoek is reused for all purposes, including reclamation to potable water, see Figure A2.



Figure A1: New Goreangab Water Reclamation Plant Process
(WINGOC, Date Unknown)

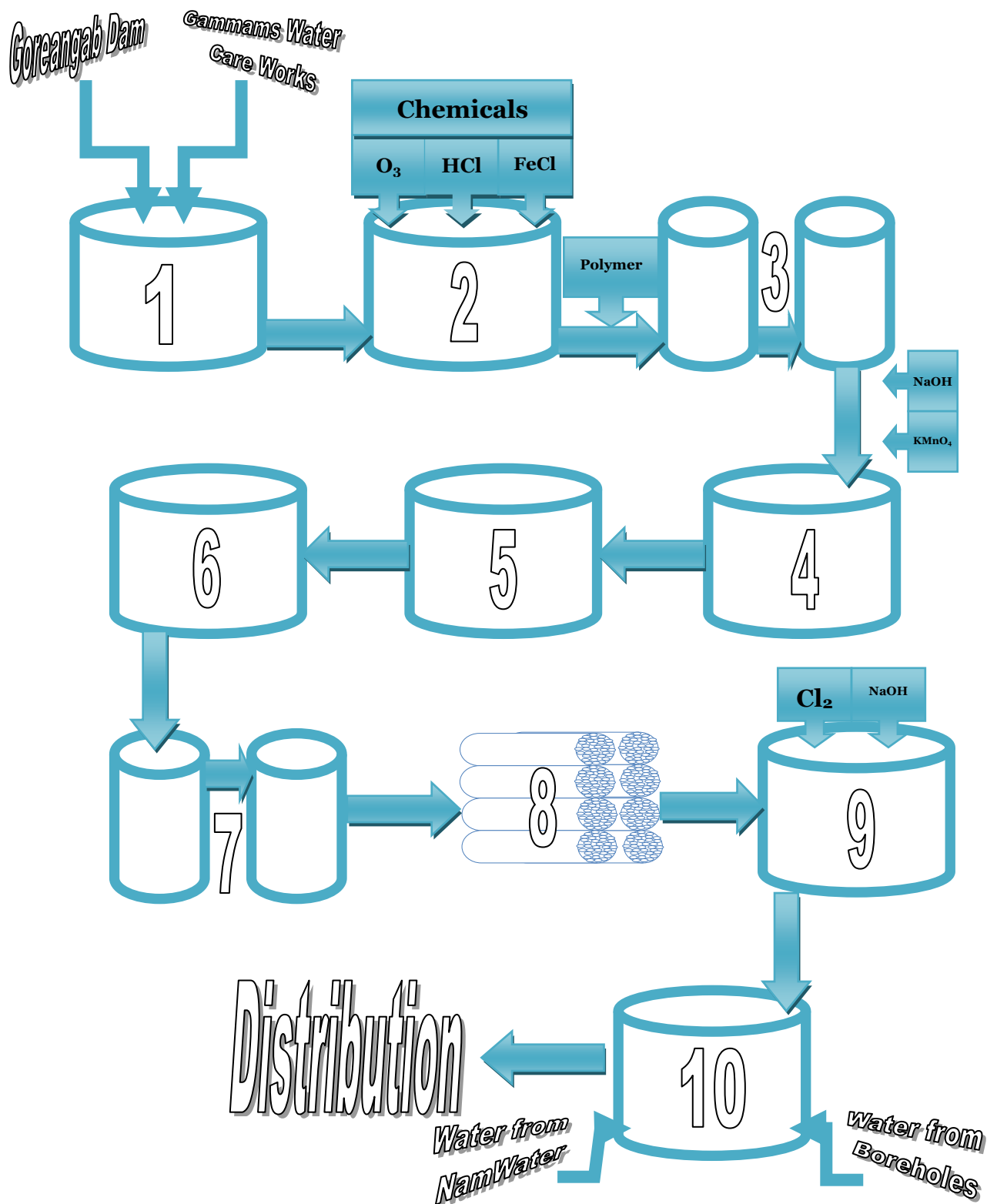
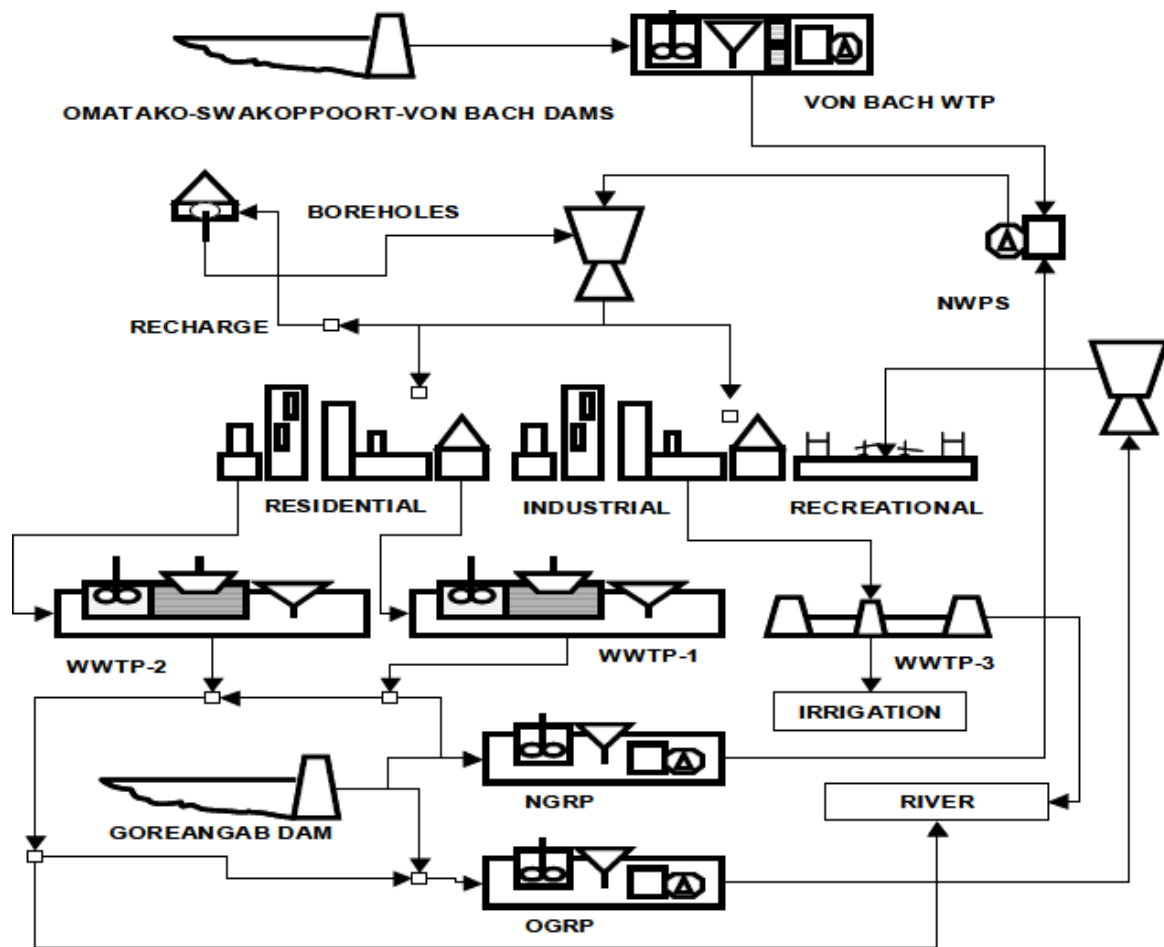


Figure A2: New Goreangab Water Reclamation Plant Process Diagram
(WINGOC, Date Unknown)

Figure A3 depicts Windhoek's overall water distribution system (Menge, Date Unknown):



FigureA3: Windhoek Water Distribution System

APPENDIX B: WATER SPECIFICATION GUIDELINES

Table B1 reports the treated water specification guidelines that the New Goreangab Water Reclamation Plant strives to achieve. All values mentioned are compiled from relevant organizations' drinking water standards such as the WHO and the Namibian Guideline as well as the United States Environmental Protection Agency (EPA) and others. The target values are those which the plant aims for, while the absolute values are the maximum value that any one constituent can reach. If the absolute value for any of the criteria is surpassed, the plant stops water delivery and goes into recycle mode until the values are below the threshold (P. L. du Pisani, 2005).

Table B1: Water Quality Standards

Physical and Organoleptic Constituents	Units	Target Values	Absolute Values
Calcium Carbonate Precipitation Potential	CaCO ₃ mg/L	N/A	Must lie between 0 and 8
Chemical Oxygen Demand	mg/L	10	15
Color	mg/L Platinum	8	10
Dissolved Organic Carbon	mg/L	3	5
Total Dissolved Solids	mg/L	Greater than 1000 or 200 above Raw Water	Greater than 1200 or 250 above Raw Water
Turbidity	Nephelometric Turbidity Units	0.1	0.2
UV ₂₅₄	Abs/cm	N/A	0.06
Macro Elements			
Aluminum	mg/L Al	N/A	0.15
Ammonia	mg/L N	N/A	0.10
Chloride	mg/L Cl	Not removed by process	
Iron	mg/L Fe	0.05	0.1
Manganese	mg/L Mn	0.01	0.025
Nitrate	mg/L N	Not removed by process	
Nitrite	mg/L N	Not removed by process	
Sulfate	mg/L SO ₄	Not removed by process	
Microbiological Indicators			
Heterotrophic Plate Count	per 1mL	80	100
Total Coliforms	per 100mL	N/A	0
Fecal Coliforms	per 100mL	N/A	0
<i>E. coli</i>	per 100mL	N/A	0
Coliphage	per 100mL	N/A	0
Enteric Viruses	per 10L	N/A	Greater than 0 per 10L or a 4 log removal
Fecal <i>Streptococci</i>	per 100mL	N/A	0
<i>Clostridium</i> Spores	per 100mL	N/A	0
<i>Clostridium</i> Viable Cells	per 100mL	N/A	0
Disinfection By-Products			
Total Trihalomethanes	µg/L	20	40
Biological Indicators			
Chlorophyll <i>a</i>	µg/L	N/A	1
<i>Giardia</i>	per 100L	Greater than 0 per 100L or a 6 log removal	Greater than 0 per 100L or a 5 log removal
<i>Cryptosporidium</i>	per 100L	Greater than 0 per 100L or a 6 log removal	Greater than 0 per 100L or a 5 log removal

APPENDIX C: INFORMAL INTERVIEWS

Table C1: Informal Interviews at Wernhil Park Shopping Mall Over One Hour's Time

Approximate Age	Sex	Know about the plant?	If yes, how?	Lived here how long?	Tap/Bottled Water	Extra
55	F	Nothing		Since the 70s		No water quality bulletins
25	F	Heard about it			Boils water	Doesn't give child tap water because
40	M	Heard about it	TV	Entire life	Tap water	
25	F	Nothing		Doesn't		
25	M	Knows it exists		Entire life	Bottled water	Drinks bottled water because of
25	M	Heard about it	People	Entire life	Tap water	
30	F	Never heard of it		4 years		
25	M	Never heard of it		Entire life	Mostly tap water	
25	M	Never heard of it		13 years	Mostly tap water	
35	F	Never heard of it		15 years	Both	
25	M	Heard about it	School	7 years	Tap water	Knew name and location
25	F	Nothing		21 years	Tap water	
30	F	Nothing		5 years	Tap water	
35	M	Heard of it			Bottled water	Drinks bottled water because of
40	F	Never heard of it		Entire life	Tap water	
25	F	Never heard of it		5+ years	Tap water	
20	F	Never heard of it		Entire life	Both	
20	F	Never heard of it		Entire life	Tap water	Asked us questions
20	M	Never heard of it		Entire life	Both	
30	M	Never heard of it		29 years	Tap water	Bottled water everywhere outside
35	F	Heard of it		20+ years	Tap water	Uses a filter in the home
30	M	Never heard of it		Just works in the City	Tap water	
65	F	Knows sewage is reused	School		Tap water	
30	F			Doesn't	Bottled water	Drinks bottled water because it is

25	F	Never heard of it		Entire life	Both	
30	M	Knows about it	Lives near it	Entire life	Tap water	Knew name and location

Table C2: Informal Interviews Conducted at the Polytechnic of Namibia in One Hour's Time

18-23	F	Heard about it	Seen it	For college	Tap water	Extra
18-23	F	Yes	High School Tour		Tap water	Drinks bottled water outside
18-23	F	Yes	Drove by it		Tap water	
18-23	M	Yes	School/ People	Entire life	Mostly tap water	
18-23	M	Yes	Friends	4 years	Tap water	
18-23	M	Never heard of it		1 year	Tap water	
18-23	M	Yes	Poly	For college	Tap water	
18-23	M	Yes	Newspaper/ School	2 years	Tap water	
18-23	F	Never heard of it		For college	Mostly tap water	
18-23	F	Heard of it	People	Not from Windhoek	Tap water	
18-23	M	Yes	TV	For college	Tap water	Boils the water first
18-23	F	Never heard of it		For college	Tap water	
18-23	M	Heard of it	Primary School	Entire life	Tap water	
18-23	F	Never heard of it		2 years	Tap water	
18-23	F	Never heard of it		2 years	Tap water	
18-23	M	Never heard of it		For college	Mostly tap water	
18-23	F	Never heard of it		For college	Tap water	
18-23	F	Yes		For college	Tap water	
18-23	M	Never heard of it		2 years	Both	
18-23	M	Never heard of it		2 years	Both	
18-23	F	Never heard of it		A few years	Tap water	
18-23	M	Yes	People/ Drives by it	5 years	Tap water	
18-23	M	Never heard of it		4 years	Both	
18-23	F	Yes	Newspaper	7 years	Tap water	

APPENDIX D: SURVEY

City Water Survey

We are a group of students from Worcester Polytechnic Institute in Massachusetts, USA. We are conducting a survey to learn more about the public understanding and acceptance of water in Windhoek. By gaining your input, we will be making recommendations to the City of Windhoek officials on more effective ways that the City can communicate with its customers about the water supply.

We would appreciate you answering the following questions to the best of your ability to aid in our recommendations to the City. **All survey responses are anonymous and confidential** unless you indicate that you would like to be contacted later. You may refuse to answer any or all of the questions at any time—simply leave them blank.

We will be back at the same time tomorrow to pick up the survey and answer any other questions that you may have.

If you have any further questions, please feel free to SMS or call Joshua Davidson at 081-622-4755.



Background Information

(all answers are confidential and anonymous)

1. Please mark your gender:

☐ Male ☐ Female

2. Please mark your age range:

☐ 18-23 ☐ 24-29 ☐ 30-34 ☐ 35-39 ☐ 40-44 ☐ 45-49 ☐ 50-54 ☐ 55+

3. Please mark your ethnicity:

☐ X ☐ X ☐ X ☐ X ☐ Other: _____

4. Please mark when you first started living in or around Windhoek:

☐ I was born and raised here ☐ I moved here in: _____(year)

5. Please mark the number of people in your household including yourself:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8+

6. Please mark the number items that you or your household owns (mark all that apply, example 2 Radio(s)):

___ Radio(s) ___ Television(s) ___ Cell Phone(s) ___ Computer(s) with Internet ___ Vehicle(s)

7. Please mark approximately how often you use public transportation (taxis, buses, etc.):

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

8. Please mark approximately how often you read the newspaper:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

9. Please mark approximately how often you listen to the radio:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

10. Please mark approximately how often you watch television:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

Survey Continued on Back

«Survey ID

Figure D1: 1st Draft of Survey (Page 1)

Household Water Use

1. Please mark how your household receives water from the City of Windhoek:

☐ Tap ☐ Standpipe ☐ Other: _____

2. Please mark the household uses of the water supplied by the City (mark all that apply):

☐ Cleaning ☐ Bathing ☐ Cooking ☐ Watering plants ☐ Drinking ☐ Other: _____

3. Please rank (1-4) the primary sources of drinking water for your household (1=Used most often, 4=rarely used):

___ Boiled tap water ___ Bottled still water ___ Tap water ___ Bottled sparkling water

Water Quality

Please rank the following about the City of Windhoek water supply:

	Unacceptable	Poor	Fair	Good	Excellent
1. Quality of water color:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Quality of water taste:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Quality of water smell:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Water tariff price:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Overall water quality:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

City Communication

Please rank your satisfaction of the City of Windhoek's communication regarding:

	Very Unsatisfied	Unsatisfied	Neutral	Satisfied	Very Satisfied
1. Current sources of water:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Water treatment plant changes:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. City water demand:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Safety of water:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5. Changes in tariff pricing:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6. Potential risks of re-used water:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7. Securing water for the future:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Goreangab Water Reclamation Plant

In 1969, the City of Windhoek opened a Water Reclamation Plant to treat recycled water into potable drinking water to help with the lack of water in the City. This plant went through numerous renovations until 2002 when the New Goreangab Reclamation Plant was built to treat even more recycled water than the first plant could. The water that comes out of your water sources throughout the city is made up of 33% potable water from the plant and 67% surface water from the three dams in the area.

1. Have you ever heard about the Goreangab Water Reclamation Plant before this survey?

☐ Yes ☐ No

2. If you answered Yes to the above question, how did you hear about it?

☐ School ☐ Newspaper ☐ Television ☐ Word of Mouth ☐ Other: _____

3. What would be the best way to advertise information about the plant?

☐ Mail ☐ Newspaper ☐ Television ☐ City Meeting ☐ Other: _____

«Survey ID

FigureD2: 1st Draft of Survey (Page 2)

Topic

Instructions here

	Never	Rarely	Neutral	Most of the Time	Always
1. Do you think the price you pay for City of Windhoek water is equal to its quality?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Would you be willing to pay more for non-recycled water?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Would you be willing to be contacted again for a more in-depth interview?					
<input type="checkbox"/> Yes <input type="checkbox"/> No					

Additional Comments or Concerns

Please use the space provided to state any additional comments or concerns regarding this survey:

Thank you for taking the time to complete this survey. Your input is greatly appreciated.

Figure D3: 1st Draft of Survey (Page 3)

City of Windhoek Water Survey

The City of Windhoek, in partnership with Worcester Polytechnic Institute in the USA is conducting the following survey. The purpose of this survey is to learn more about public understanding and acceptance of water in Windhoek. Through this survey, the City will be able to apply more effective communication methods with customers about the water supply. All survey responses are anonymous and confidential. You may refuse to answer any or all of the questions at any time – simply leave them blank. If you have any further questions or comments that you think of after this survey is completed, feel free to contact



Background Information (all answers are confidential and anonymous)

1. Please mark your gender:

☐ Male ☐ Female

2. Please mark your age range:

☐ 18-23 ☐ 24-29 ☐ 30-34 ☐ 35-39 ☐ 40-44 ☐ 45-49 ☐ 50-54 ☐ 55+

3. Please mark the Suburb of Windhoek you reside in:

☐ Khomasdal ☐ Pioneers Park ☐ Klein Windhoek ☐ Other: _____
☐ Katutura ☐ Okuryangava ☐ Windhoek

4. Please mark when you first started living in or around Windhoek:

☐ I was born and raised here ☐ I moved here in: _____(year)

5. Please mark the number of people in your household including yourself:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8+

6. Please mark the highest level of education you have received:

☐ No School ☐ Primary School ☐ Secondary School ☐ Some College ☐ College Degree

7. Please mark approximately how often you use public transportation (taxis, buses, etc.):

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

8. Please mark approximately how often you read the newspaper:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

9. Please mark approximately how often you listen to the radio:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

10. Please mark approximately how often you watch television:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

Household Water Use

1. Please mark how your household receives water from the City of Windhoek:

☐ Tap ☐ Standpipe ☐ Other: _____

Survey Continued on Back

«Survey ID

Figure D4: 2nd Draft of Survey (Page 1)

2. Please mark the household uses of the water supplied by the City (mark all that apply):

☐ Cleaning ☐ Bathing ☐ Cooking ☐ Watering plants ☐ Drinking ☐ Other: _____

3. Please rank (1-4) the primary sources of drinking water for your household (1=Used most often, 4=rarely used):

___ Tap Water ___ Boiled Tap Water ___ Bottled Still Water ___ Bottled Sparkling Water

4. Please write your approximate monthly water bill and mark your feeling toward the water tariff prices:

Approximate monthly bill: N\$ _____ ☐ Acceptable ☐ Fair ☐ Unacceptable

Water Quality

Please rank the following about the City of Windhoek water supply:

	Unacceptable	Poor	Fair	Good	Excellent
1. Quality of water color:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Quality of water taste:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Quality of water smell:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Overall water quality:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Is the price you pay for City of Windhoek water equal to its quality?

☐ Yes ☐ No ☐ Sometimes

6. Do you think the water is safe to drink?

☐ Yes ☐ No Why or why not? _____

Further Questions

1. Are you aware of where the City of Windhoek gets its water?

☐ Yes ☐ No

2. Do you think there is enough water for the future needs of Windhoek?

☐ Yes ☐ No Why or why not? _____

3. Have you ever heard about the Goreangab Water Reclamation Plant? If "Yes" answer how:

☐ No ☐ Yes, I heard about it through _____

4. In your opinion, what would be the best way to advertise information about the plant?

☐ Mail ☐ Newspaper ☐ Television ☐ City Meeting ☐ Other: _____

5. What do you think about drinking recycled water?

☐ What is it? ☐ I don't mind ☐ I am opposed to recycled water because _____

Feel free to write any comments or concerns in the box below:

Thank you for taking the time to complete this survey. Your input is greatly appreciated.

«Survey ID

Figure D5: 2nd Draft of Survey (Page 2)

Date:

Time:

Location:

City of Windhoek Water Survey

The City of Windhoek is conducting the following City Water Survey in conjunction with the Polytechnic of Namibia and Worcester Polytechnic Institute in the USA. The purpose of this survey is to learn more about public understanding and acceptance of water in Windhoek. Through this survey, the City will be able to apply more effective communication methods with customers about the water supply. All survey responses are **anonymous and confidential**. You may refuse to answer any or all of the questions at any time – simply leave them blank.



Background Information

All answers are confidential and anonymous:

1. Please mark your gender:

☐ Male ☐ Female

2. Please mark your age range:

☐ 18-23 ☐ 24-29 ☐ 30-34 ☐ 35-39 ☐ 40-44 ☐ 45-49 ☐ 50-54 ☐ 55+

3. Please mark the Suburb of Windhoek you reside in:

☐ Khomasdal ☐ Pioneers Park ☐ Klein Windhoek ☐ Other: _____
☐ Katutura ☐ Okuryangava ☐ Windhoek

4. Please mark when you first started living in or around Windhoek:

☐ I was born and raised here ☐ I moved here in: _____(year)

5. Please mark the number of people in your household including yourself:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8+

6. Please mark the highest level of education you have received:

☐ No School ☐ Primary School ☐ Secondary School ☐ Some College ☐ College Degree

7. Please mark approximately how often you use public transportation (taxis, buses, etc.):

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

8. Please mark approximately how often you read the newspaper:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

9. Please mark approximately how often you listen to the radio:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

10. Please mark approximately how often you watch television:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

Survey Continued on Back

Figure D6: 3rd Draft of Survey (Page 1)

Household Water Use

1. Please mark how your household receives water from the City of Windhoek:

☐ Tap ☐ Standpipe ☐ Other: _____

2. Please mark the household uses of the water supplied by the City (mark all that apply):

☐ Cleaning ☐ Bathing ☐ Cooking ☐ Watering plants ☐ Drinking ☐ Other: _____

3. Please rank (1-4) the primary sources of drinking water for your household (1=Used most often, 4=rarely used):

___ Tap Water ___ Boiled Tap Water ___ Bottled Still Water ___ Bottled Sparkling Water

4. Please write your approximate monthly water bill and mark your feeling toward the water tariff prices:

Approximate monthly bill: N\$ _____ ☐ Acceptable ☐ Fair ☐ Unacceptable

Water Quality

Please rank the following about the City of Windhoek water supply:

	Unacceptable	Poor	Fair	Good	Excellent
1. Quality of water color:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Quality of water taste:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Quality of water smell:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Overall water quality:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Do you think the water is safe to drink?

☐ Yes ☐ No Why or why not? _____

Water Reclamation

1. Are you aware of where the City of Windhoek gets its water from?

☐ Yes ☐ No

2. Do you think there is enough water for the future needs of Windhoek?

☐ Yes ☐ No Why or why not? _____

3. Do you know what water reclamation is? If yes what do you know?

☐ No ☐ Yes, it is _____

4. Have you ever heard about the Goreangab Water Reclamation Plant? If "Yes" answer how:

☐ No ☐ Yes, I heard about it through _____

5. In your opinion, what would be the best way to advertise information about the plant?

☐ Mail ☐ Newspaper ☐ Television ☐ City Meeting ☐ Other: _____

6. Would you make use of a contact number to call with questions regarding water reclamation?

☐ Yes ☐ No

Thank you for taking the time to complete this survey. Your input is greatly appreciated.

Figure D7: 3rd Draft of Survey (Page 2)

Date:

Time:

Location:

ID Number:

City of Windhoek Water Survey

The City of Windhoek is conducting the following City Water Survey in conjunction with the Polytechnic of Namibia and Worcester Polytechnic Institute in the USA. The purpose of this survey is to learn more about public understanding and acceptance of water in Windhoek. Through this survey, the City will be able to apply more effective communication methods with customers about the water supply. All survey responses are **anonymous and confidential**. You may refuse to answer any or all of the questions at any time – simply leave them blank.



Background Information

All answers are confidential and anonymous:

1. Please mark your gender:

☐ Male ☐ Female

2. Please mark your age range:

☐ 18-23 ☐ 24-29 ☐ 30-34 ☐ 35-39 ☐ 40-44 ☐ 45-49 ☐ 50-54 ☐ 55+

3. Please mark the Suburb of Windhoek you reside in:

☐ Khomasdal ☐ Pioneers Park ☐ Wanaheda ☐ Rocky Crest
☐ Katutura ☐ Okuryangava ☐ Windhoek _____ ☐ Other: _____

4. Please mark when you first started living in or around Windhoek:

☐ I was born and raised here ☐ I moved here in: _____(year)

5. Please mark the number of people in your household including yourself:

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8+

6. Please mark the highest level of education you have received:

☐ No School ☐ Primary School ☐ Secondary School ☐ Vocational School ☐ University

7. Please mark approximately how often you use public transportation (taxis, buses, etc.):

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

8. Please mark approximately how often you read the newspaper:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

9. Please mark approximately how often you listen to the radio:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

10. Please mark approximately how often you watch television:

☐ Everyday ☐ 2-4 times a week ☐ Once a week ☐ Once a month ☐ Never

Survey Continued on Back

Figure D8: 4th Draft of Survey (Page 1)

Household Water Use

1. Please mark how your household receives water from the City of Windhoek:

☐ Tap ☐ Standpipe ☐ Other: _____

2. Please mark the household uses of the water supplied by the City (mark all that apply):

☐ Cleaning ☐ Bathing ☐ Cooking ☐ Watering plants ☐ Drinking ☐ Other: _____

3. Please mark the primary source of drinking water in your household:

☐ Tap Water ☐ Boiled Tap Water ☐ Bottled Still Water ☐ Bottled Sparkling Water

4. Please write your approximate monthly water bill and mark your feeling toward the water tariff prices:

Approximate monthly bill: N\$ _____ ☐ Acceptable ☐ Fair ☐ Unacceptable

Water Quality

Please rank the following about the City of Windhoek water supply:

	Unacceptable	Poor	Fair	Good	Excellent
1. Quality of water color:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2. Quality of water taste:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3. Quality of water smell:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4. Overall water quality:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Do you think the water is safe to drink?

☐ Yes ☐ No Why or why not? _____

Water Reclamation

1. Are you aware of where the City of Windhoek gets its water from?

☐ Yes ☐ No

2. Do you think there is enough water for the future needs of Windhoek?

☐ Yes ☐ No Why or why not? _____

3. Do you know what water reclamation is? If yes what do you know?

☐ No ☐ Yes, it is _____

4. Have you ever heard about the Goreangab Water Reclamation Plant? If "Yes" answer how:

☐ No ☐ Yes, I heard about it through _____

5. In your opinion, what would be the best way to advertise information about the plant?

☐ Mail ☐ Newspaper ☐ Television ☐ City Meeting ☐ Radio ☐ Other: _____

6. Would you make use of a contact number to call with questions regarding water reclamation?

☐ Yes ☐ No

Thank you for taking the time to complete this survey. Your input is greatly appreciated.

Figure D9: 4th Draft of Survey (Page 2)

APPENDIX E: OPEN ENDED RESULTS OF SURVEY

Do you think the water is safe to drink?

Why:

- It's Windhoek
- Cos its cleaned before distribution among the people
- Its Purified
- It is clean
- Yes because is treated
- Because it is purified and filtered
- Think it went through proper methods of waster supply
- Can not really harm people
- Because it did not cause any problems
- it's purified
- they are not harmful
- because it does not cause any harm
- coz it's purified
- It is properly cleaned
- Because its clean
- because free from germs (bacteria)
- It has been purified
- It doesn't cause any stomach pain after taking it in
- because they are purified to be consumed
- Looks safe
- It's clean
- They are treated
- Keeps me going
- It's clean/clear and there are chemicals used to clean the water
- It looks clean
- Tastes perfect!
- Because it is clean and healthy
- Because it taste good and water is life
- It is pure
- Because I don't findy something wrong
- Because they are clean
- Because they do not have bad smell
- Because it is purified
- Because it's clean and I didn't get sick from it yet
- Water is of good quality and healthy & clean.
- Because water appear to be clean

- Because it's purified
- Yes because we are assured that it's not contaminated
- I did not experienced any illness on consuming them
- Because it make lot of part of our bodies
- It's healthy
- It does not affect as badly really
- I don't experience any problems
- water is process well
- I think it's clean enough and harmless
- it's purified and you can't complain
- somehow put there a lot of chemicals
- no health risk felt yet
- as long as one doesn't get sick of drinking the water provided then yes, it is safe
- it never got me sick
- the water taste is fair
- because water is life, and for the blood circulation in the body
- it help us to be healthy and it help every household to
- because it is purified
- water is safe because it's good for our health
- because it's clean
- safe enough, because its purified
- because I have not been ill or anything from drinking the water
- I never experience any thing negative from it
- never get sick from it
- because its purified
- because they are purified
- it gives energy and life
- It's purified and its safe and clean in pipeline
- It should be. Fact
- because its clean
- its safe and clean
- so far no problem occurred from water
- Course Water is Life
- It help in body need
- Because I never got ill since I started drinking it
- because it is well cleaned
- it maintain health to our body
- because it looks clean
- because it very clean
- Because there is no chief

- because the clean no smell
- it's a safe place
- someone look after it
- it's clear
- no disease yet
- because its clean
- never been sick because of tap water
- because water is clean for drinking
- since I have been drinking it I never had problems
- it think it is well treated
- it doesn't contain bacteria
- good for a healthy diet
- because it is purified
- is purified
- the water is clean
- no signs of illnes experienced
- usable
- because the water is treated
- I don't find anything wrong with it where I live
- cause it tastes nice
- Because it looks clean
- It's made healthy for use to drink
- It has not caused any health hazards toward me
- because it's purified!!!
- because they are well purified
- apart from the chorine smell it shows its being treated at least so I can say it is safe to drink
- because it is sterille and clean
- yes, because it is sterile
- it went through a lot of processes
- because they cann't make us sick
- because it doesn't cause problems in our stomach
- is safe and clean
- its purified
- essential to life
- yes because they are purified
- it does not contain bacteria
- it is clean and safe to use
- because water is life
- because they have no germs

- because its free from germs
- it's just safe
- Because I've never had problems with my health
- Because I don't/didn't experience any problem with the water that I drink
- because is clean (purified)
- Because it is purified and some different tests were done before its considered consumable
- because the water is clean as ever
- it's usually distilled
- because it is clean
- because they are clean
- it appear to be clean through it may contain some organisms
- Unsure because it is near the toliet and I don't boil it
- because water is needed in the person it used in digestine
- because the is needed to use it in digested

Why Not:

- Becase they are acidic
- Contain some impurity
- because it's sour
- Because it used to have a bad taste
- cause diarheah
- They are not excellent purified
- because they aint well purified
- Because it sometimes tastes funny. E.g. Everday a different taste
- It's got a funny taste at times and colour differs as well
- It has a different taste everyday
- Because they are recycled
- Due to that this water states very funny. 1st time come in whk got stomach achs
- Because it has a certain taste that we are not sure where it is resulting from
- Because it's not very clean
- They have a bad smell
- Because sometimes it is very dirty
- Because some people/residents get a stomach problem after drinking it
- Its not absolute clean compared to bottled water
- Not fresh
- it's recycled H2O
- it's not from a well source
- it doesn't taste nice
- unless otherwise boiled

- to much chemicals can damage human health
- because it is recycled
- it needs to be boiled due to poor circulation
- it might contain some germs
- has toilets tissues when cold
- because this water don't have oucility taste and if you boiled, you will find out that its not clean/pure
- because I have to boiled first
- Cos I have to boil it first
- it has lot of chemicals
- because the place is dirty
- because the place is dirty
- it's unprotected place
- the water is over in the location
- the place is not safe
- its only tap along the place
- dirty place
- it's dirty
- dirty
- it has an unusual color and smell
- because of its colour sometimes (brownish)
- the water has some funny colour
- because of the way it's produce
- because it has the awful fishy smell
- because it does not taste good at all
- because of the chemicals put in
- im adviced to boil it because it is not healthy to drink
- because this water is purified from toilet water/dirty water
- because I have got no idea if there is an purification done before provided to us
- I don't know if the are 100% purified
- it has a weird taste
- recycled water can only remain fresh for so long
- coz the dam is dirty most of the time
- because it is recycled
- because it's being recycled don't how its done
- I'm not sure where it comes from
- Because it is constantly recycled
- A bad taste might mean something is wrong
- The colour looks unhealthy
- it is not 100% pure

- because It's sewage water
- it's not really clean
- Bad smell and poor quality
- Because it's recycled it still contains bacteria
- I don't trust purification method
- technology might fail
- because it s bit thick and has smell
- is testless you have to boil it
- they are salty
- because it needs to be boiled
- they are kind of salty
- because sometimes it used to be kind dirty
- it often has a bad smell
- Not always because some water pipes can have holes and h2o start dripping out mixing with external chemicals or harmful substances found in the soil
- Because of the water they taste
- because it is re-used water
- it taste salt
- because they are clean mos
- Salty
- Not safe unless boiled, they may get sick
- Sometimes it is white

Is there enough water for the future needs of Windhoek?

Why:

- becace I have never heard of any water shortage in whk
- because
- because
- Because a lot of people are coming in the City
- because everybody in Windhoek used to drink water
- because in Windhoek there is a dam full of water
- Because it is everywhere
- because it is recycled
- because it recyle
- because its enough water
- because its rainy these years
- because namwater is trying hard to provide enough water for the future
- because of water reclamation
- because our dam is full

- because people conserve
- because people don't abuse water
- because residents never experienced water problems
- Because the City uses recycle method of water
- because the water we use is recycled
- Because there are new ways to cleaning water to drink
- because they are recycled
- because they are recycling it
- because they can make use of water from Ruacana waterfall!
- because they do recycling of water
- because they recycle
- Because they recycle it will be enough
- because they recycling
- because water can be recycled
- because water is available for use due to the rainfall and we use water effective
- because water recycling over and over again
- because we get supplied by water daily
- because we got plenty
- because we have water
- because we often receive rain
- Because we receive enough rain
- because we still have a high level of ground water and receive enough rainfall
- Because Windhoek recycles its water
- cause of more rainfall
- cause they bring tap near house
- clean
- Course is lot of water
- cause the dam is big, the population is small
- Coz I saw the dam is fully of water
- Coz rain it's ever raining
- due to its continuation of water supply
- earth consists of 70% water, why not?
- everyone is having its own tap
- haven't heard of any water shortages
- houses are given taps
- it is always available
- it is just enough
- It rains enough in the City
- It rains in Namibia, so why not?
- It well conserved yes!

- it's enough
- it's just enough
- its raining alway they can use reservior to store water
- like fire extinguishers use water to prevent fire
- not everyone in windhoek affort to pay for water bill
- Our dam is full
- our population is not that much
- Population growth is not that much in Windhoek
- probably because it still rain & they recycle
- Rain
- Recycle taking place
- recycled
- recycling occurs
- The dam is still having water
- The dams have good supplies
- the rainfall we rectcle annually
- The rainy seasons are fairly good
- the system remains the same
- the tap is at a safe place
- There are dams that can be used
- there are lots of dams, rainfall
- there aren't really any sign of water shortage
- There is a lot more dams in Winhoek
- There is little adverts warning inhabitants to save water
- They re-use the water at gammas water plant
- This is because people are using water wisely
- untaped resources
- water in Windhoek is recycled
- water is always available
- Water is like 80 of global coverage
- we have water reseviour
- we receive enough rain
- yes because WHK water are just recycling

Why Not:

- Becauase people waste water for unnecassary reasons
- Because everyday the City population is increasing
- because everyone has a problem with the tap
- because I don't know

- because I don't know
- because I don't know where the City of Windhoek get water
- because I don't know where the source is
- because I have no idea where they get water
- because I think the source might be poor
- because if we did not receive enough rain it affected also
- because it just recteled and it comes from far
- because it's not clean
- because lots of water is wasted in industries and watering
- because of population growth
- because of the decrease in rainfall
- because of urbanization/overcrwding in the City
- because people are wasting water
- because people migrate to urban arease in extremly
- Because people waste water too much, even with the recycle process, much water is still wasted
- because she doesn't know where it came from
- because some people ? Not have water their places
- because some people walk long distances to get their water, especially those who live in squarter area
- because sometimes they use to stop water
- Because the population in windhoek is high and city of windhoek does not supply water to everyone/household
- because the population is growing rapidly then the source of water
- because the water bill is very expensive
- because there are still people without water
- because there are still several places which are not linked with water
- because there is no natural source
- because water is slowly running out not all people have water in windhoek
- because we can't afford to pay
- Because we have so many informal settles around in Windhoek
- Because Windhoek is increasing at an alarming rate
- because you find that at some places people don't have enough water
- besides my opinion some of te people in some location are finding it difficult to get water
- besides our primary source of water, WHK is a growig city, thus should have excess strategies thereto
- cause the are people who don't have enough money to pay the water bill
- Depending on the number of immigrants
- Don't know where and how they get it

- Duh I just know
- everything will be polluted and then...
- I am not aware of where they take the water from
- I don't think so. Isn't this a desert??
- if there was, they would recycle sewage water
- I'm not sure
- Increase population in town
- It's being exploited
- it's not a safe place
- It's not even enough for the current people living in Windhoek
- just opened the waer now
- lack of resources
- Many people are moving to Windhoek
- misuse of water, broken pipes
- more people in the City
- Namibian's Don't save water
- Namibia's a dry country as it is, with many needs for water
- No, high population growth
- nope people are being born
- Not a lot of rain so dams are not full
- not a safe place
- Not a whole lot of people can afford it
- Not everyone in WHK is access to clean drinking water
- Not really sure if there is or not
- nothing is never enough
- overpopulation in the City
- people are becoming a lot because of migration
- people are crowding
- people are migrating from different places
- People misuese water so much & Don't practice sustaniable development
- population growth
- population in windhoek is expanding rapidly
- Population is growing
- Population is growing fast
- population is increasing
- Population is increasing everyday
- scarcity
- Since a lot of H2O is wanted
- since a lot of people in locations don't have water
- since some popel don't have water in their house like in Havana

- some of us waste water unnecessarily
- Some people walk long distances to get water
- soon our source will lack water since we get them from sewage & the kavango river
- still a large% who don't have excess to clean drinking water
- the City's population is increasing fast
- the population is forever growing
- the population is getting too big
- the population is increasing around the City
- The population is increasing everyday
- there are some points were there is no water supply in some areas
- There isn't enough supply
- they will get finished, since people are not using it wisely
- This city is increasing in population
- used by many people
- Water gets expensive sometimes forcing to not use for other purposes
- Water is scarce or that what we at least got told now + then
- water is so expensive wich might be a result of high demand
- water is wasted
- water is wasted in some parts of town
- we don't get enough of it yet
- we have a scares H2O supply
- we rely mainly on rain

Do you know what water reclamation is? If yes what do you know?

Yes, it is:

- a process of recycling water in a clean state
- because it came from munisiparitin
- because its not safe
- bring water nearby to houses
- cleansing of water, purifying recycling
- I visited the recycling plant near goragab dam
- if the is no water the is no life
- is the system used to clean water
- it is more like recycling
- it purifies water for easy drinking
- It's the place water gets recycled
- Its where the water is being purified
- just the recycling of water
- mainly about recycling of wter, water project, campaigns

- more or less recycling of water, re-using
- not sure
- purification
- Recycling used water
- recycling
- recycling
- recycling
- recycling and purification unhygienic water for consumption
- recycling of used water
- recycling of water
- recycling of water
- recycling of water
- recycling of water
- recycling of water
- recycling of water
- recycling water
- recycling water
- recycling
- reused the water that we use already
- reusing water over, dirty water that is cleaned to use again
- safe
- Saving water
- Saving water
- Saving water
- Saving water, use sustainably, purity.
- the cleaning of water & making it safe to drink
- the place is not protected
- the place where suitable consumable water is supplied
- the process of conserve water
- The provision of clean drinking water
- the recycling of water
- they say they will move it
- to purify and recycle water for human consumption
- to the people
- when water is cleaned and recycled
- where water is recycled
- Where windhoek gets it water

Have you ever heard about the Goreangab Water Reclamation Plant? If

“Yes” answer how:

Yes, I heard about it through

- a friend
- a radio
- asking other people
- Been there
- being there
- city meetings
- class
- community people
- daily newspapers
- drive past it
- driving past it with my daddy
- Education system
- facebook
- friend
- Friend & I visited the place
- friends
- Friends & Relatives
- from my friends
- from the people
- geography
- I actually know where it is
- I don't know how it works
- I don't know where it is
- I have been there before
- I have seen it myself
- I saw it
- I was there once, heard it from the TV though
- in a taxi
- is where water is purified
- it near my resident
- means of my parents
- Media
- media
- media
- media
- media

- media
- media
- Media
- Media
- media
- medias
- municipality workers and newspaper
- My dad since I'm not Namibian
- my family
- my friend
- my husband
- my parents
- my self
- NBC (tv)
- newspaper
- newspaper
- newspaper
- newspapers
- Other People
- Other people
- pamphlets that read
- people
- people
- people
- people
- people and study
- people talking
- people talking
- people talking
- people talking about it
- public
- radio
- Radio
- radio
- radio
- radio
- radio
- radio
- radio

- radio
- Radio
- Radio
- radio and newspaper
- radio, classes and friend
- radio, newspaper, tv
- radio, people
- Radio, People and TV
- radio, people talking
- Residents
- Saw it
- School
- school
- school
- school
- School
- school
- School, a project we did
- School, friends
- School, I was there
- see it myself
- seen it myself
- swimming pool
- Television
- television
- television
- television
- television
- the local papers
- the media
- the people that work there and through my family
- the radio
- the radio
- the radio and television
- the radio recycle process
- the radio, tv
- the television
- the television
- they take water for watering plants
- TV

- tv & radio
- TV and Radio, and I see it myself
- tv, radio
- University of Namibia
- water purification
- where water is purified
- where water is purified
- where water we drink have been purified

APPENDIX F: FLOW CHART

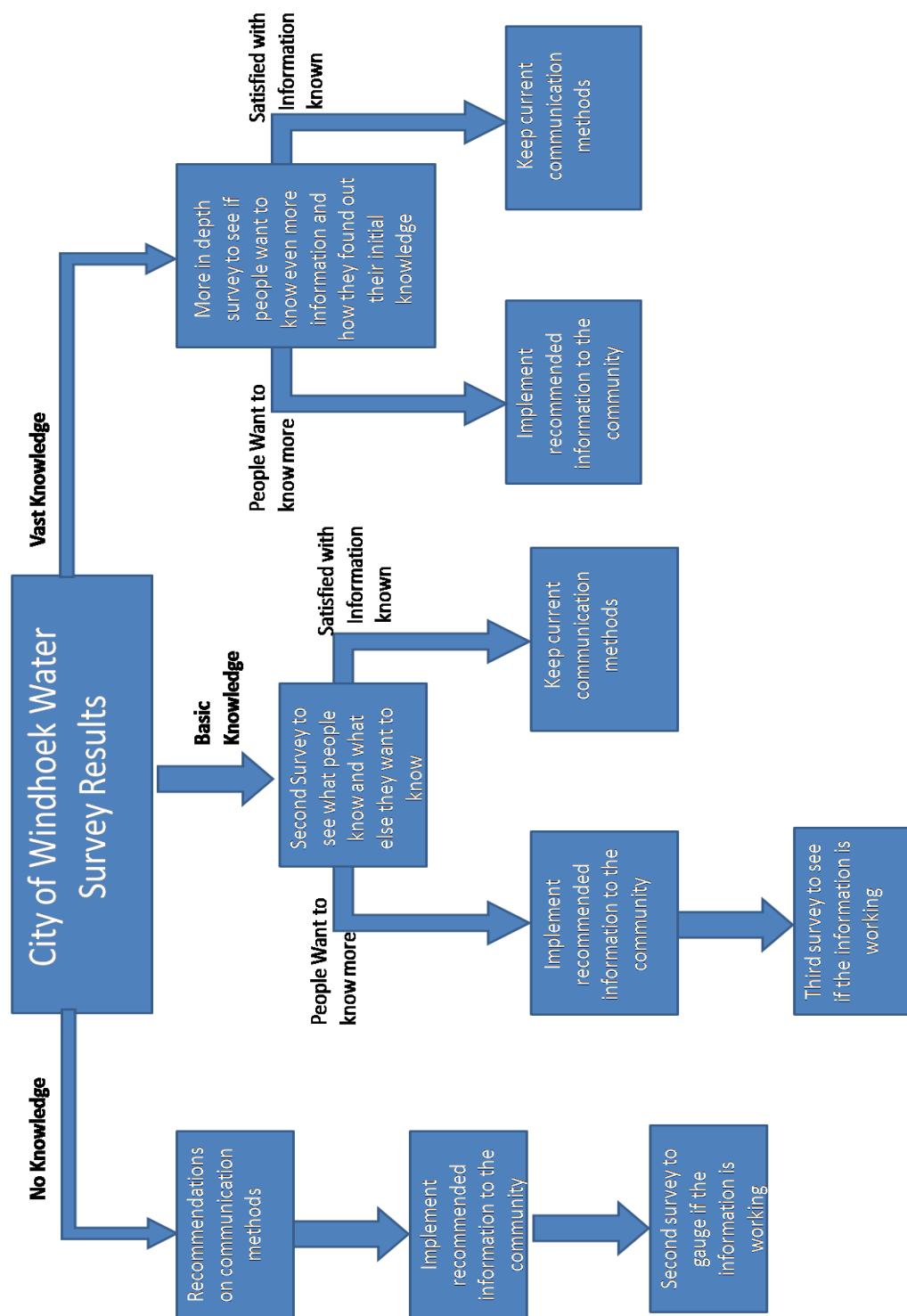


Figure F1: Surveying Flow Chart

APPENDIX G: DEFINITIONS

When dealing with water-related topics, professionals frequently use terms that are not commonly known to the public. The following provides a listing of the most important terms with brief definitions. For a more detailed list, the reader is referred to a more comprehensive reference such as Asano's text *Water Reuse: Issues, Technologies, and Applications* published by McGraw-Hill, New York 2007 (Natural Resource Management Ministerial Council & Environment Protection and Heritage Council, 2005).

- 1) Potable water – water intended primarily for human consumption
- 2) Non-drinking water – water that is not intended for drinking but may be suitable for other purposes
- 3) Recycled water – the planned use of treated sewage, grey water or storm water
- 4) Reclaimed water – effluent from sewage treatment plants that can be used for recycling
- 5) Grey water – water sourced from kitchen, laundry and bathroom drains, but not toilets
 - May contain feces from nappy washing or showering, kitchen scraps, soil, hair, detergents, etc
 - Cleaning products discharged can contain boron and phosphates
 - Water is often alkaline and saline
- 6) Sewage – material collected from all internal household drains
 - Contains all the contaminants of grey water and urine in addition to high concentrations of fecal matter
 - Contains a high range of human infectious enteric pathogens
 - High nutrient loading, particularly of phosphates and nitrogen
- 7) Storm water – water resulting from rain draining into the system from roofs, roads, footpaths and other ground surfaces
 - Carries rubbish, animal feces, motor oil, soil and debris
 - May contain high concentrations of enteric pathogens and contaminants
- 8) Direct drinking water reuse – the discharge of reclaimed water directly into a drinking water treatment facility or into a drinking water distribution system
- 9) Indirect drinking water reuse – the discharge of reclaimed water directly into an aquifer or water impoundment used for drinking water storage
- 10) Hazard – a biological, chemical, physical or radiological agent that has the potential to cause harm to people, animals, crops or plants, other terrestrial biota, aquatic biota, soils or the general environment

- *Cryptosporidium parvum*
 - Salinity
- 11) Hazardous event – an incident or situation that can lead to the presence of a hazard
- Failure at a recycled water treatment plant, leading to *Cryptosporidium parvum* passing into the distribution system of a domestic non-drinking supply
- 12) Risk – the likelihood of identified hazards causing harm in exposed populations or receiving environments in a specified timeframe, including the severity of the consequences
- Likelihood of the organism being present in source water and passing through the treatment plant in sufficient numbers to cause illness in users of recycled water
- 13) Maximum risk – risk in the absence of preventative measures
- Useful for identifying high priority risks, determining where attention should be focused and preparing for emergencies
- 14) Residual risk – risk after consideration of existing preventative measures
- Provides an indication of the safety and sustainability of the recycled water scheme or the need for additional preventive measures
- 15) Variability – represents true differences that can occur in the specific values of parameters that contribute to a risk
- Changes in contaminant concentrations over time and space, flows and number of people exposed
 - Cannot be reduced by more accurate measurement
- 16) Knowledge uncertainty – represents an inadequate state of knowledge about the values of parameters measured
- Counting *Cryptosporidium* oocysts; whether they are viable and if so, if they are effective
 - Can be reduced by a better measurement and research
- 17) Primary treatment – physical treatment process, with or without chemical assistance
- Some heavy metals removed
- 18) Secondary treatment – typically a process that removes dissolved and suspended organic material by biological treatment and sedimentation; biodegradable organics, volatile organics
- Some nitrogen and phosphorous removed

- 19) Tertiary treatment – filtration, membrane filtration, and detention in polishing lagoons or wetlands; usually combined with coagulation, sedimentation or flotation, filtration and disinfection
- More removal of nitrogen and phosphorous, dissolved solids and heavy metals
 - If lagoons are used, salts can be concentrated through evaporation
- 20) End-use restrictions – do not prevent entry or remove hazards physically, but instead reduce risk by controlling exposure
- 21) Multiple barrier approach – used to manage hazards so that a failure of one barrier can be compensated for by effective operation of the remaining barriers
- Minimizes the likelihood that hazards will pass through the system and harm humans or the environment
- 22) Critical limits – tolerance that distinguishes acceptable from unacceptable performance
- 23) Target criteria – provides an early warning that a critical limit is being approached
- 24) Operational monitoring – used to confirm that preventive measures implemented to control hazards are functioning properly and effectively
- 25) Surrogates – used as operational parameters rather than direct measurement of the hazards themselves
- Turbidity is an indicator of filtration plant performance
 - Can be used as a surrogate for *Cryptosporidium*, *Giardia* and viruses
- 26) DALYs – Disability adjusted life years
- Used to define health risks and health impacts associated with recycled water
 - Measure of impacts on both quality and quantity of life
 - Zero = normal health
 - One = death
 - Used by the WHO to assess disease burdens associated with environmental exposures to hazards and hazardous events
 - 10^{-6} is a tolerable level of risk
- 27) Hazard identification – identification of hazards that might be present and the associated effects on human health
- 28) Dose response – establishment of the relationship between the dose of the hazard and the incidence or likelihood of illness
- 29) Exposure assessment – determination of the size and nature of the population exposed to the hazard, and the route, amount and duration of exposure

- 30) Risk characterization – integration of data on hazard presence, dose response and exposure
- 31) Baseline monitoring – gather information that will underpin the risk assessment process, and provide a basis for assessing potential impacts of the use of recycled water
 - Provides evidence that there are no detrimental effects now or in the future
- 32) Validation monitoring – obtain evidence that the elements of the recycled water quality management plan will achieve performance requirements
 - Used to determine whether treatment processes meet target criteria or critical values
 - Should be overseen by an independent professional
- 33) Operational monitoring – conduct a planned sequence of observations or measurements of control parameters to assess whether a preventive measure is operating within design specifications and is under control
 - Routine monitoring of control parameters identified, in order to confirm that processes are under control
- 34) Verification monitoring – apply methods, procedures, tests and other evaluations, in addition to those used in operational monitoring, to determine compliance with the recycled water quality management plan, and to determine whether the plan needs to be modified
 - Assesses the overall performance of the recycled water system

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