TAMPEREEN TEKNILLINEN YLIOPISTO
TAMPERE UNIVERSITY OF TECHNOLOGY

MIRKA TUOVINEN

PREPAID WATER METERS AND WATER LOSS MANAGEMENT – CASE KEETMANSHOOP, NAMIBIA

Master of Science Thesis

Examiners: Professor Jukka Rintala and Development Manager Saila Kallioinen
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ABSTRACT

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This study aims to reduce Non-revenue water (NRW) in the municipality of Keetmanshoop, Namibia. The main objectives of this thesis are to implement the water loss management plan in Keetmanshoop, and research the impacts of prepaid water meters on water tariffs and unpaid water bills in other municipalities in Namibia.

NRW consists mostly of leaks in the water distribution system, overflows from water reservoirs, metering errors, water thefts and illegal connections. This research aims to reduce those losses by water distribution network management, improving water finances, locating leaks and repairing them and gathering other information to help solve these issues.

On the other hand, unpaid bills are a significant problem in the municipality of Keetmanshoop, and this thesis includes research on prepaid water meters in other Namibian municipalities. Prepaid water meters are one solution to increase income in water sector by forcing users to pay their water use beforehand and thus reducing the need for tariff increase. This research aims to answer the question if prepaid water meters could be the solution for Keetmanshoop water sector.

The thesis is divided into two sections. The first section focuses on prepaid water meters and the other section describes the case in Keetmanshoop and discusses the current issues in the municipality.

Methods used in this project included literature survey, semi-structured interviews, observation and analysis on the water distribution system. The research included field work in Keetmanshoop between June 24th and August 23rd, 2013. The theory part of the thesis describes the factors affecting Non-revenue water and the methods used to reduce it.

The results of this study reveal that non-revenue water in Keetmanshoop is around 33% (July 2012 - June 2013). The results of this thesis also show that prepaid water meters have not been sufficient enough for the other municipalities that were studied. Because of this, the prepaid water meter system is not recommended for Keetmanshoop.

As a conclusion new suggestions for the water sector improvement plan are presented for Keetmanshoop. Based on the studies on the prepaid water meters the effects of them are discussed in monetary and other terms.

TIIVISTELMÄ

TAMPEREEN TEKNILLINEN YLIOPISTO
Rakennustekniikan koulutusohjelma
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Tämän työn tarkoituksena oli vähentää laskuttamattoman veden määrää Keetmanshoopin kunnassa Namibiassa. Tutkimuksen päätavoitteet olivat vesihukan vähentämisen suunnitelman käyttöönotto Keetmanshoopissa sekä selvittää minkälaisia vaikutuksia prepaid vesimittareiden käyttöönotolla on ollut muissa Namibian kunnissa veden hintaan ja maksamattomiin vesilaskuihin.

Laskuttamattoman veden määrä koostuu verkostovuodoista, ylivuodoista, mittarivirheistä, veden varastamisesta ja laittomista yhteyksistä sekä muista tekijöistä. Tämän tutkimuksen tavoitteena oli vähentää näitä hävikkejä verkoston hallinnalla, tehostamalla vesilaskutusta, vuotojen paikantamisella ja korjaamisella, sekä keräämällä muuta oleellista tietoa ongelmien ratkaisemiseksi.

Toisaalta myös maksamattomien laskujen määrä on ongelma Keetmanshoopin kunnassa; tämä työ sisältääkin tutkimuksen prepaid vesimittareista muissa Namibian kunnissa. Prepaid vesimittarit ovat yksi vaihtoehto vedestä saatavien tulojen lisäämiseksi ilman veden käyttöhinnan korottamista vuosittain. Tutkimuksessa selvitetään auttaisivatko prepaid vesimittarit Keetmanshoopin kuntaa vesisektorin ongelmien ratkaisussa.

Diplomityö on jaettu kahteen osioon. Ensimmäinen osio keskittyy prepaid vesimittareihin ja toinen osio kuvaa Keetmanshoopin tilannetta ja pohtii kunnan nykyisiä vesijohtoverkoston ongelmia.

Työ on toteutettu kirjallisuustutkimuksena, haastatteluina, havainnoimalla ja analysoimalla vesijohtoverkostoa mittauksin. Tutkimus sisälsi kenttätyötä Keetmanshoopissa 24.6.-23.8.2013 välisenä aikana. Työn teoriaosuudessa selvitetään taustatietoja sekä teoriaa laskuttamattoman veden määrän vähentämiselle.

Työn tuloksena saatu laskuttamattoman veden määrä Keetmanshoopissa oli noin 33 % (tilikaudella heinäkuusta 2012 kesäkuuhun 2013). Tämän työn tulos osoittaa, että prepaid vesimittarit eivät ole ole toteuttaneet tarkoitustaan tarpeeksi tehokkaasti. Tämän takia prepaid mittareita ei suositellla otettavaksi käyttöön Keetmanshoopissa.

Työn lopussa esitellään ehdotuksia vesihuollon vesihukan vähentämiseksi ja laskutuksen parantamiseksi Keetmanshoopissa. Prepaid vesimittarien rahallisia ja muita vaikutuksia pohditaan niistä tehdyn tutkimuksen perusteella.

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Espoo 4.8.2014

Mirka Tuovinen

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ABBREVIATIONS AND NOTATIONS

ADB	African Development Bank
ALC	Active leakage control
CAD	Computer aided design
DMA	District metering area
EU	European Union
IWRM	Integrated Water Resources Management
NamWater	Namibian Water Corporation Ltd (bulk water supplier)
NRW	Non-revenue water
PLDDSI	Partnership for Local Democracy & Development and Social Innovation
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization

1 INTRODUCTION

In practice in every distribution system some water is lost mainly through leaks in the network. There is also other water use that is not billed. That consists of metering inaccuracies and broken water meters, water use for fire fighting, water thefts, municipality's own water use and some other unknown reasons. That is the case also in the municipality of Keetmanshoop in Namibia where one third of the water is lost somewhere along the way from the supplier to the customers. In Keetmanshoop this share is exceptionally high compared to the national level.

The water loss problem from the water distribution systems is a worldwide interest. Especially during water shortages and in dry regions like Namibia both technical and financial aspects of the problem should receive attention. Indicators describing these losses are standardized to evaluate the quantity of water lost. Calculating water balance evaluates the water distribution efficiency and it is also used to calculate Non-revenue water (NRW). Non-revenue water is an indicator to present the water being lost in the water distribution system; it is the difference between system input volume and billed authorized consumption. (Lambert & Hirner, 2000)

Namibia is a dry country in Africa. The small amount of rain water is collected to dams, but it barely is enough for the whole country's demand for water. Water to most of the Namibia's urban cities is supplied by state-owned bulk water supply company, NamWater. Urban municipalities, such as Keetmanshoop, are responsible for water and wastewater services. The water is distributed to resident through pipe networks and some of the water gets lost on the way. This thesis is part of an EU-project "Development of water services in Keetmanshoop - Namibia" to reduce NRW in Keetmanshoop. This activity is also supported by development co-operation between Finland and Namibia.

1.1 Background on the project

Development co-operation between Namibia and Finland goes way back in years. The co-operation related to this thesis has been started as part of Partnership for Local Democracy & Development and Social Innovation (PLDDSI) project between two municipalities in Namibia (Keetmanshoop and Ondangwa) and two in Finland (Lempäälä and Kangasala).

During PLDDSI project information about the water distribution system in Keetmanshoop was collected by students from Finland and Namibia with the help of professionals. This co-operation started in 2007 with the drawing of the water distribution network map by students from Tampere University of Technology and Polytechnic of Namibia. Also Master's Theses have been produced in this project (Löppönen 2010 and Seppänen 2008). The distribution map has been updated and adraft plan of improvement of the water services in Keetmanshoop has been made. At this stage the water loss management plan was aimed to be implemented in Keetmashoop but the progress of the improvement has been slow.

Previous studies on prepaid water meters in Namibia have been produced as a part of PLDDSI project in previous years. This report was used as background information for this thesis about prepaid water meters.

1.2 Objectives

The aim of this thesis was to find solutions for reducing NRW in the municipality of Keetmanshoop in Namibia. The plan for water loss reduction was based on previous studies in Keetmanshoop. The original aim of the EU supported project is to decrease NRW to less than 20 % but that goal is still distant.

The EU-supported project started in 2012, and it is build on Finnish-Namibian development co-operation and it aims to reduce water loss in Keetmanshoop with the help of Finnish engineering skills. This EU-project aims to reduce NRW in Keetmanshoop. Planned actions in the EU-project included analyzing the water distribution network (including modeling the water distribution system, flow and pressure measurements), water use survey, division of the water distribution network to pressure zones and installation of pressure reduction valves, zonal water metering, leak detection, training of staff (using AutoCAD and map reading), piloting prepaid meters, developing municipality own borehole water use and development of operation and management plan.

Some of the actions have already been started but they are still continuing. This thesis aims to give information mostly on prepaid water meters and it includes also some measurements and discussion on issues on water distribution network in Keetmanshoop.

The previous Master's Theses have produced draft water loss management plans for Keetmanshoop. At this stage those plans were supposed to be implemented in the municipality. The implementation of those plans is still under work.

1.3 Research questions

The questions that this research aims to answer are the following:

- How to improve the water distribution in the municipality of Keetmanshoop to reduce the amount of Non-revenue water?
- What kinds of effects have prepaid water meters have had on water finances in Namibian municipalities?
- Could prepaid water metering solve the Keetmanshoop water services financial issues when people are not paying their water bills?

1.4 Structure of the research

The first chapter of the study introduces this thesis and its background and the research goals.

The second chapter describes the theory behind the research. The chapter will introduce the reader to water loss management and leakage control, prepaid water and different water tariff structures, and explain the terms Water Balance and Non-revenue water.

Chapter three describes research methods and materials used in this study. The chapter describes how the data was collected and then analyzed.

Chapter four describes the water services in Namibia in general and gives background information of the water resources and suppliers in Namibia.

In chapter five the prepaid water meters are reviewed. This part of the thesis includes the research results from a number of Namibian municipalities. The chapter also includes technical information on prepaid water meters as well as monetary effects of them for the municipalities in Namibia.

The sixth chapter is a case study of the municipality of Keetmanshoop. The different components of Non-revenue water are discussed separately. The chapter presents the water balance of Keetmanshoop. Also the issue of unpaid bills in the municipality of Keetmanshoop is discussed. Keetmanshoop water distribution infrastructure is also analysed. This chapter presents the field measurement results and gives information on the leakages of the network and reservoirs, and also reviews the issues with water meters, valves and the quality of water in Keetmanshoop. Chapter six also describes management issues of the water sector in Keetmanshoop. The chapter discusses the organization of the municipality's technical sector and improvements for the management are presented. Water tariff development in Keetmanshoop is also reviewed.

Chapter seven discusses the overall results of the research as well as the benefits of this project.

As a conclusion in chapter eight the results are summarized and recommendations for the future are discussed.

2 THEORY

A leak-free water distribution network is not an overall aim when speaking in financial and technical terms, but a low level of water leaks is an objective of sustainable water supply system. A low level of water lost is a rather reliable goal in water loss management and when aiming to an economically efficient distribution system. (Lambert & Himer, 2000)

The volume of water that is lost in the network plays an important role in evaluating water distribution system's efficiency. Measuring the quantity of water lost should be included in every water distribution system but it is not always self-evident for water services operators. (Lambert & Himer, 2000)

Water loss management includes standard terminology that is introduced in this chapter. The definition of water balance is presented as it acts as an important tool when analyzing water losses. This chapter also describes what Non-revenue water is.

Operating and maintaining water distribution system efficiently requires cost recovery for the water operator. Setting water tariffs equally and economically on a sustainable level is an objective for the operator to achieve. Different types of water tariff structures are presented in this chapter. Also the concept of prepaid water is explained.

2.1 Definition of water balance

Water balance describes the quantities of water produced and put in to the system, water imported and water exported, water that is really consumed and water that is lost. Water balance is calculated by estimating every component of it (shown in Figure 2.1.). Water balance is advised to estimate over a 12-month period. (Lambert & Himer, 2000)

<table>
<tr><td rowspan="8">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled metered Consumption</td><td rowspan="6">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled unmetered Consumption</td></tr>
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<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and/or Distribution mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections up to point of Customer metering</td></tr>
</table>

Figure 2.1. *Definition of water balance* (Lambert & Hirner, 2000)

System input volume includes all the water that is put in to the water distribution system. Input volume can be divided in authorized consumption and water losses. (Lambert & Himer, 2000)

Authorized consumption includes billed and unbilled authorized consumption. Authorized consumption can be metered or unmetered. Authorized consumption can be billed or unbilled. It should be noted that it also includes functions like firefighting, street cleaning, flushing of the pipelines, which can be billed or unbilled according to the local practice. (Lambert & Himer, 2000)

Water losses are divided in real losses and apparent losses. Real losses (physical water losses) include leakages of the network mains, leakages and overflow of the water reservoirs and leaks on service connections up to the point of customer water meter. Apparent losses (non-physical water losses) include unauthorized consumption and inaccuracies in metering. (Lambert & Himer, 2000)

To calculate the quantity of Non-revenue water (NRW) all factors in water balance should be measured or estimated as accurate as possible. The estimations should be based on realistic assumptions to determine an accurate level of NRW. (Lambert & Himer, 2000)

2.2 Non-revenue water

Non-revenue water (NRW) is the difference between system input volume and billed authorized consumption. NRW is a good indicator of how efficient the water distribution system is. (Lambert & Himer, 2000)

NRW is basically an indicator of how much water gets lost on the way to customer. NRW is usually presented in percentages or as volume of water lost per kilometer of water distribution network per day.

2.3 Water loss management

In a dry country, like Namibia, water loss management plays an important role. Managing the water losses in the water distribution system should be done systematically with a short-term and long-term planning. The managing program should involve leakage detection and repairing, and other systematic maintenance work including replacing water meters, valves and pipes before the problems occur. This leakage control is a crucial factor in water loss management. The age of the pipes and old pipe materials play an important role in water loss management. The older the pipelines get, the more there will be pipe bursts. Water loss reduction also results in economic benefits.

Pipe bursts cause pressure variations in the network which can lead to even more pipe bursts and they can harm other infrastructure too. Leaks in the network are either background leaks or visible pipe bursts.

Measuring night time water flow in the network is a rather good indicator of the water that is lost. The difference between the total night flow and evaluated real night time water use gives the estimate of water lost in the network.

Active leakage control means that the leaks are being searched in order and repaired before severe pipe bursts even occur. It is still not a practice used everywhere and also in this case example in Keetmashoop, the leaks are only repaired when they get visible on ground. Active leakage control should be done on some level to avoid the worst cases, but it should not be carried out too extensively, because it is not cost-efficient to search through the network completely all the time. Also the equipments to do this are not always available in developing countries.

2.4 Water pressure control

One of the key factors in reducing water loss is pressure controlling in the water distribution system. Higher pressures are linked to higher volumes of leaking water. Pressure reduction significantly reduces water leakages. High water pressures also causes pipe bursts more frequently. Pressure reduction in the water network reduces water losses effectively by affecting both leakage flow rate and burst frequency. (van Zyl & Clayton, 2007) Pressure control reduces real losses (in the water balance definition) since it effects are directly on the leakages.

There are visible pipe bursts in the network as well as background leaks which are not visible on the ground. Pipe bursts come to the surface and are easier to locate. (van Zyl & Clayton, 2007)

Background leakage is a sum of all minor leakages in the network. Background leakage is more difficult or even impossible to locate without excavating the pipe. There are ways to locate these leaks but those methods might be too expensive to use in countries such as Namibia. Background leakage includes numerous small leaks and it may lead to a big amount of water leakage if the problem is not taken care of. Pressure control serves a great conclusion to reduce background leakage and reduce the amount of visible pipe bursts also. (van Zyl & Clayton, 2007)

Though the method of pressure reduction leakages can be reduced, but the water pressure has to be kept high enough for functions like irrigation sprinklers and washing machines. The network has to have enough water pressure also for firefighting. Usually it is referred that the pressure in the water network should be at least 200 kPa for these kinds of functions. Pressure control should be done based on water pressure measurements and elevation levels.

It should also be taken in consideration that the water pressure varies during different times of the day. Pressure is higher during low consumption at nights and it is at its lowest during high consumption which usually occurs in the mornings.

Controlling leakage can be done with pressure controlling by dividing the network in pressure zones and installing pressure reduction valves where needed. This requires a large amount of background information and systematic planning.

2.5 Water tariff structures

For cost recovery for the water operator, choosing water tariff structure type plays an important role. Setting water tariff is important because customers are the most important source of income for water operators and water should be affordable for all customers. There are different types of rate structures in use and they all have their own benefits. Water prices can be calculated for example based on the number of people in a household or the household income, according to consumption or based on the source of water. Some tariff basics are introduced in this chapter.

Flat rate is the simplest way to charge water fess and usually there are no water meters in these systems. Customers are charged on a fixed rate which is not based on the volume of water use. If this flat rate does not include water meters the water meter installation and reading meters costs are avoided. But since water is not metered the customers are not provided with usage information which usually leads to inefficient use of water, and the flat rate system can be unequal towards those who use less water. (Full-Cost Water Pricing Guidebook, 2012)

Another option when the water is not metered is to use **graded rates** in which the consumers are classified into categories and different categories have their own water tariffs. Categories can be based on the income of the household or the income-classes can be estimated based on the land-holdings for instance. The categories are based on the assumption of the higher-income households' larger water consumption. (ADB, 2010)

Volumetric rate is based on the volume of water consumed. It includes uniform rate, block rate, decreasing block rate and increasing block rate.

- **Uniform rate** means that water is charged based on constant unit per volume. The uniform rate structure has a benefit of being easy for customers to understand and it provides revenue stability for the operator, but at the same time it might be slightly unequal system for different consumer classes. The problem can be avoided when using different uniform rates for different classes of users (for example a different uniform rate for domestic and industrial consumers).
- **Block rate** means that the customer is charged based on a unit price for water which changes according to the volume of water used. Water use is divided in blocks based on water use volume and each block has a different tariff and the volumes of them can vary. Block rate has two types where the price is either decreasing or increasing according to the water use.
    - **Decreasing block rate** has a decreasing water price when the water use increases and it offers the lowest water price for biggest consumers giving a discount for the biggest consumers.

- **Increasing block rate** is a tariff structure in which the water price increases as the water consumption increases. (Full-Cost Water Pricing Guidebook, 2012)

A **two-part rate** is a combination of fixed charge and volumetric rate. Fixed charge, similar to flat rate, is a fixed amount of payment each billing period. The fixed charge can be a charge of the services, charge of the meter (which can differ based on the meter size), or a minimum charge regardless of water consumption. Variable charge is based on consumption, like in volumetric rate, and needs to be metered. The variable amount of the two-part rate can also be based on increasing or decreasing block rates. (Full-Cost Water Pricing Guidebook, 2012)

Seasonal rate has different water tariffs in different times of seasons; usually water price is higher during summer on the peak season. It has the advantage of limiting the exploitation of water during peak season to even the seasonal changes is water consumption. (Full-Cost Water Pricing Guidebook, 2012)

Zonal pricing has different water tariffs for different parts of the town, since some customers are further away from the distribution mains so that the costs of pumping and constructing the distribution are higher. (Full-Cost Water Pricing Guidebook, 2012)

There can be also some extra charges, for example connection charges in new service areas and fire charges included in the customer's water bill.

2.6 Prepaid water meters

Prepaid water meters are one solution for cost recovery for the water operator. With prepaid water meters the consumer pays for water in advance. With conventional water meters the water is billed from the user afterwards.

Prepaid water metering system usually includes a chip or card system, on which the amount of payment is then transferred to the water meter of the user. There are several types of prepaid meters with different special features available in Namibia, and some of them are presented in the Chapter 5.

It is possible to include different water tariff rates in prepaid water system, also. For example, industrial and household consumers may be using a different water tariffs with the prepaid metering system.

3 RESEARCH METHODS AND MATERIALS

This chapter describes the methods used during this study and the measurements that were done during the case study in Namibia. Research data was collected from literature, with semi-structured interviews, by observing and doing measurements. Data collection was done be searching previous researches as a literature survey and from other case studies.

This research is a case study itself of the municipality of Keetmanshoop in Namibia. Other data has been collected besides from literature, but also doing semi-structured interviews in other Namibian municipalities.

This thesis includes also an analysis of the water distribution system of Keetmanhoop. Analyzing the water distribution system in Keetmahsoop was done with measurements and by observing.

3.1 Case region

The case study was examined in Namibia. Population in Namibia is 2 104 900 (Namibia 2011 Population and Housing Census Preliminary Results, 2012). Total surface area of Namibia is 824 292 km^2.

Namibia receives very little perspiration annually and relies mostly on groundwater resources. The average annual rainfall in Namibia is 285 mm, meaning that Namibia is the most arid country south of the Sahara Desert. 61 % of the land in Namibia is classified as dry. (UNEP, 2010)

Namibia is divided into 13 districts. The municipality of Keetmanshoop is situated in the Karas region in southern Namibia.

Regions of Namibia and the neighboring countries are shown in Figure 3.1.

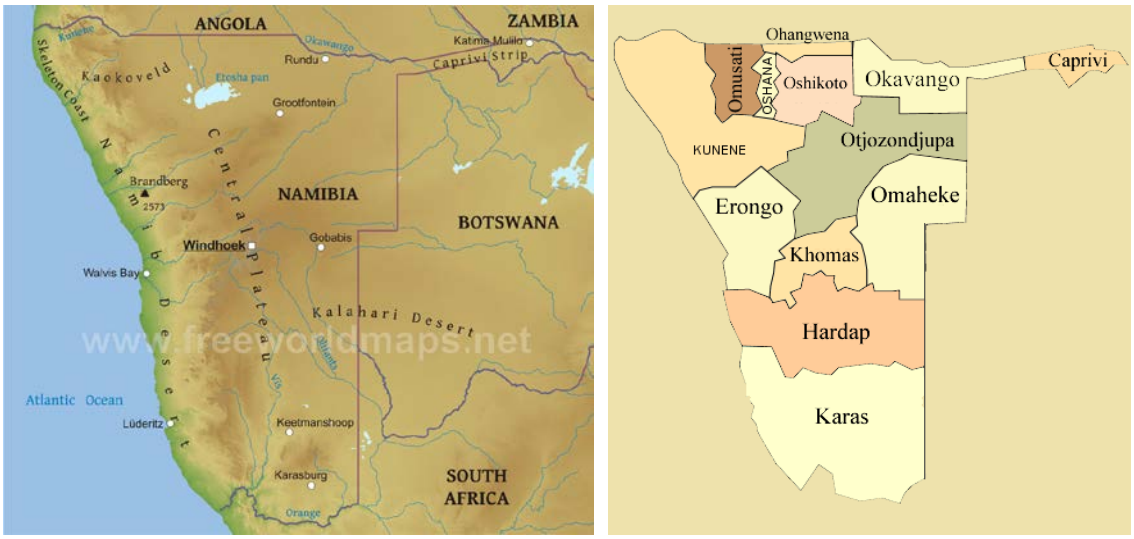

Figure 3.1. *Map and regions of Namibia* (Left: Free World Maps. Right: Government of Namibia, 2013)

This thesis focuses on the water distribution in Keetmanshoop. Keetmanshoop has a population of 18 900 in 2012. Keetmanshoop is the capital of the Karas region (Namibia 2011 Population and Housing Census Preliminary Results, 2012).

Other municipalities studied were Ondangwa, Otjiwarongo, Tsumeb, Mariental, Henties Bay and Tses.

3.2 Literature survey

There is a great deal of information on the theory behind water loss management and also some cases with prepaid water meters in literature. There are for example various cases researched from South-African prepaid meters.

Also the previous material from this EU-project offered a lot of base information for the work done in 2013.

3.3 Semi-structured interview

Staff members of several municipalities in Namibia were interviewed about water finances and prepaid water meters. The semi-structured interviews included open questions about prepaid meters and gathering key numbers about the water finances.

Semi-structured interviews were done in Namibia in the municipalities of Ondangwa, Otjiwarongo, Tsumeb, Mariental, Henties Bay and Tses.

3.4 Observation

The problems with the water distribution and water billing were observed during the field work between June 24th and August 23rd, 2013. The work was mostly done with the help of the municipal staff in all of the locations visited.

Special attention was paid on the municipality's operation and maintenance habits in the water sector in Keetmanshoop by observing the current situation there.

3.5 Measurements and tools

The water reservoirs were leaking heavily because of their old concrete structures, and overflowing because of malfunctioning shut valves. Volumes of water leakages from the reservoirs were measured with a stopwatch and a two-liter container. By doing this the flows of the leaks were calculated, and estimations of how much water is being lost in different times of a day because of leaks were done.

The water distribution network was searched with a metal detector and by digging to find missing valves that were not marked on the water distribution map.

Water pressures in the water distribution network were measured during the field work in Keetmanshoop. Water pressures were measured with a pressure measurement gauge (Figure 3.2). The measurement gauge was installed mostly at household connections inside the lots where the pipeline and water meter are visible above the ground.

Water level measurements at Donkie Drai water reservoir were done with a measuring tool (Figure 3.2).

Figures of the pressure measurement gauge and water level measurement tool are shown below.

Figure 3.2. *Water pressure measurements and water level measurement tool (Tuovinen)*

4 WATER SERVICES IN NAMBIA

Namibia is located in the south of Africa and is one of the world's driest countries. In Namibia 38 % of the population live in urban areas. Since 2010 United Nations have recognized safe and clean drinking water and sanitation as a human right and the same year UNICEF reported that 93 % of the population in Namibia has access to improved water sources and 32 % of the population has access to improved sanitation. (UNICEF & WHO, 2012)

A state-owned company, NamWater, is responsible for supplying water to several municipalities in Namibia. The municipalities' responsibility is to provide water to the residents. Some municipalities also use only their own borehole water.

Keetmanshoop is also dependent on water supplied by NamWater. Keetmanshoop has three boreholes but the water from those is not connected to the distribution network and is only used for irrigational purposes and watering the streets.

Besides the water scarcities, drought and lack of full coverage of water and sanitation services in the country, there are other problems in this sector as well. Because of the cultural background and habits, the willingness to pay bills is not very high. People do not necessarily have a habit of saving money for their bills and the water bill might be the last thing for them to pay. People also feel that the cost of the water bill is usually relatively high even though they might pay more for their mobile phone services, for example. There needs to be a change of attitudes in addition for the municipality to get their bills collected and costs of the water services to be covered.

4.1 General information

Namibia is a dry country and also in August 2013 severe droughts have been reported. The summer season (September 2012 - May 2013) in Namibia was reported to have been the second driest in the last 25 years, and the government stated that Namibia was in an emergency state. The droughts resulted in losses of crop and livestock, decrease of access to water for human and livestock, children malnutrition cases and even two cases of cholera in result of poor hygiene. (UNICEF, 2013)

Between 1990 and 2008 water and sanitation services have improved in Namibia significantly even though the coverage is not still sufficient enough. In 1990 the total population with access to improved water sources was 64 % and in 2008 the percentage was 92 %. Population using sanitation facilities grew from 25 % to 33 % between 1990 and 2008. (UNEP, 2010)

In Namibia 71 % of the water is used for agricultural purposes, 24.3 % for municipalities and only 4.7 % of the water used in industry. With almost half of the Namibian population working on agriculture, the agricultural practices would be most vulnerable in case of limited water availability. (UNEP, 2010)

Keetmanshoop is responsible for the distribution from NamWater's reservoirs all the way to the customer's water meter. After that the customer is responsible of the conditions of the pipes and water connections on the property.

All the municipality services, including water, are billed from the resident on the same bill in Keetmahsoop. The residents collect the bill from the municipality once a month from the municipality building in the town center. The bill includes monthly fees for water, sewerage and the lot.

4.2 Water resources and suppliers

NamWater was established in 1997 to provide water to industries and municipalities in Namibia. NamWater is a state-owned private company responsible of bulk water production and distribution. It is supplying water to most of the communities in Namibia but some areas have their own water supplies. Prior to the establishment of this state owned company, water was supplied by state Department of Water Affairs. NamWater inherited a well functioning water supply infrastructure from the state. NamWater has 16 dams, 17 water treatment plants and more than 500 boreholes. NamWater has 14 water supply networks with more than 3 500 km of pipelines. (NamWater brochure, 2012)

Water to Keetmanshoop comes currently from Naute Dam from where water is pumped to the terminal reservoirs at Keetmanshoop. The pipeline from Naute purification plant to Keetmanshoop is 44 km long. In the reservoirs in Keetmanshoop the water is still further disinfected.

In the future Keetmanshoop will also receive water for irrigation from the new Neckertal Dam. The date to start the construction for the new dam was not yet agreed on.

5 PREPAID WATER IN NAMIBIA

Prepaid water meter differs from a conventional water meter. With conventional water meter you usually pay your water bill in the end of the month or after a couple of months. With prepaid water meter you buy water in advance and charge it to your own meter with a token, chip or a card.

There are domestic prepaid water meters as well as prepaid water meters for public stand pipes. Public stand pipes are commonly used in informal areas and domestic water meters are on your own household water connection pipe. Prepaid metering technologies are used also in other municipal services widely in developing countries, especially for electricity.

There is a variety of opinions on prepaid water meters. Since Namibia is a dry country it sounds attractive to use prepaid water meters because it helps to save water and monitor water consumption. On the other hand it might reduce your water consumption even too low since water can be more expensive with prepaid meters for poor people. This can lead to bad hygiene and other issues.

Prepaid water meter itself is more expensive than conventional meter. But prepaid water meters are usually considered a fair play for both the municipalities and the residents. It is a good solution for residents for understanding that water is not free and how to keep track on your water consumption habits and how much you are paying for water.

5.1 General information on prepaid water meters

There are several manufacturers and vendors in Africa for prepaid water meters. For example South Africa has been using prepaid water meters for years and has a lot of experiences on them. Many water meters in Namibia are imported from South Africa.

There are also models that enable to use water for some amount for free, and for additional water you charge it with your token. In South Africa there is a National Free Basic Water Strategy, which means that you can have for free water for 6 m^3 per household in a month where this kind of meter is functional.

In the newest models the token or card for the domestic meter can be used only on the exact meter. With public stand pipes the municipality can decide on which meters each token or card is compatible with, so people have one token which can used for a couple of standpipes.

Usually it is suggested that people in informal areas can use their token for a few different public stand pipes in case of malfunctioning meters to ensure 24 hours water access for everyone.

Prepaid water is sometimes associated with privatization of water services and also with increase of the price of water. Prepaid water meters are usually installed in low-income areas where the issues of debt recovery and unpaid bills, illegal connections and such are supposed to exist. Sometimes this leads to inequalities among residents as they feel that they are “punished” with prepaid systems. (Kumwenda, 2006)

Some cases where prepaid systems have proven to be working in cost-recovery in water sector have been recorded. But there are also cases which have ended badly. One case with prepaid water meters has even lead to the spread of cholera since the residents did not have enough clean water for the basic needs and hygienic conditions have worsened. The water was cut for a long period of time in Madlebe, Kwa-Zulu Natal as a conclusion for unaffordable water and breakdowns of the prepaid water system. This made resident use unsafe water sources. (Kumwenda, 2006)

5.2 Special features of prepaid water meters

There is a possibility for emergency water in some of the meters. You can activate the function with your own token and it gives you certain amount of water for emergency use, for example in case of a fire in the house. To avoid the abuse of emergency water, after activating this function you have to still pay for the water next time you go to charge your token. The vendor can see from your token that it was used for launching emergency water. (Thomas, 2013)

Tampering the meter results in water being cut off; if you open the meter yourself the switch inside the meter box activates and cuts of the water. (Thomas, 2013) Vandalizing your own meter usually ends up with the resident’s responsibility to buy a new meter which is relatively expensive. Tagmeter Systems have a similar system of several sensors for detecting tampering. The meter also has a bypass detection system.

With Kent meters you can program the system with eight different tariff levels. You can set a different water tariff for example for domestic and industrial meters. Kent meter gives different reports; sales analysis, monthly consumption profiles, it has maintenance log and it reports about unusual exceptions. The meter also reports on leaks on the meters screen if the meter detects continuous flow. This is a good function to detect leaks inside the house. (Thomas, 2013)

Any municipal resident can be a water vendor with Kent meters if you just invest in handheld battery operated vending machine from the municipality. Then it also gives opportunity to have water sales points throughout the town, not just in one place. (Thomas, 2013)

Kent prepaid meters also have other useful functions. With your own token you can lock the meter if you are for example going out of town. Kent meter gives the resident a warning when the credit is low. (Thomas, 2013)

Also another business model for prepaid water in South Africa has been introduced: some companies rent the prepaid meters straight to residents and the residents payments include a monthly rent for the meter.

5.3 Experiences from Namibian municipalities

Several municipalities in Namibia were interviewed in July and August, 2013 to collect valuable experience on prepaid water meters and water finances. Some information was found in literature and some information was also collected from previous studies in Namibia.

There were both positive and negative experiences on prepaid water meters and the experiences varied between different meter types. Also other financial issues were discovered in the water sectors and in most of the municipalities interviewed there were problems with unpaid bills. Table 5.1. presents the persons interviewed.

Table 5.1. *Interviews in Namibian municipalities*

Municipality	Person interviewed	Date
Ondangwa	N. W. Kandyimbi and Susan Kandi Iihuhwa	August 1st, 2013
Otjiwarongo	Liebenberg, Burgert	July 30th, 2013
Tsumeb	Amutenya, Johannes	August 2nd, 2013
Mariental	Ngozu, Ellen	August 7th, 2013
Henties Bay	de Villiers, Cornel	August 5th, 2013
Tses	Amulungu, Silas Namene	August 20th, 2013

5.3.1 Ondagwa

Technical Services Executive, Mr. N. W. Kandyimbi, and Local Economic Development Officer, Ms. Susan Kandi Iihuhwa, were interviewed on August 1st, 2013 about water finances in Ondangwa.

Ondagwa is in Northern Namibia and has 21 100 inhabitants (Namibia 2011 Population and Housing Census Preliminary Results, 2012). There are 3899 household water connections and six public stand pipes in the town.

The town buys all water from NamWater. There are also boreholes but the water is too salty and it is not treated it for drinking purposes. According to Ms. Kandi the town is growing fast and the population increasing, but there are not enough plots for everyone.

According to Mr. Kandyimbi the prepaid water meters are not working because of tampering. They have the old type Kent public stand pipe prepaid meters. These meters are relatively old. There are at the moment only six out of 22 fully working public stand pipe prepaid meters in informal areas. Still not all people have their own household connection in Ondangwa.

The meter readers go through all the water meters once a month. In Ondangwa people with conventional meters get one bill that includes water basic fee, water usage, sewerage and waste fees, interest and other municipality's fees. The bill is not delivered to the residents but they have to collect them from the municipality. The water basic fee is N$ 41 in a month and the prize for water is around N$ 11 per m^3. Residents are carrying water from public standpipe to their houses in Figure 5.1.

Figure 5.1. *People carrying water from a public standpipe to their houses (Tuovinen)*

These old prepaid standpipe meters are easy to tamper with a coin which leaves the water to flow freely and the municipality's workers have to come to stop the water flow. When the meter is broken there is no way to find out who sabotaged it. Sometimes the municipality's workers have to just drive through all the prepaid meters to check their condition. There has also been a lot of illegal connections and other ways of stealing water. Figures below present a non-functioning prepaid standpipe meter and a typical household conventional water meter.

Figure 5.2. *Non-functioning standpipe prepaid water meter (left) and a typical household conventional water connection in Ondangwa (right)(Tuovinen)*

In 2009 Mr. Kandyimbi was interviewed and then the municiaplity's opinion was that they do not want to invest in more prepaid water meters since they feel that the system might not include other municipality's fees in the prepaid rates. (Mustonen, M. and Shangheta M., 2009).

Ondangwa is trying to get away from the old prepaid water meters. However, those who are using prepaid water are the poor, and they cannot afford a conventional household meter. They are encouraging people to get a conventional household meter by giving discount on them.

Mr. Kandyimbi estimates that the issues in the water sector consist of both leaks and unpaid bills. He estimates that probably 70 % of the municipal water services problems deal with leaks and 30 % with unpaid bills. They have serious problems with old pipes and leaks, but no maintenance plan to replace those pipes. The pipes are replaced only when there is a visible pipe burst. One problem is also that during the rainy season the pipe bursts are hard to locate because all of the water on ground. They are planning to get g a long-term pipe replacing plan.

In Ondangwa not all the public standpipes even have water billing. There are several open taps where people can access water for free, like in other municipalities too.

If a person is not paying the bill, the water is cut off after two unpaid bills. There are around 100 people in a month who are not paying their bills and are being cut off. To avoid getting their water cut off, the people are sometimes only paying the amount of water but not rest of the bill. The municipality has staff hired just to do the cutting off, but Mr. Kandyimbi tells that the procedure has been effective. Majority of the residents are paying their bills, but the ones not paying them are the ones who already have problems with debt. Ondangwa is also using Debt Collections –company to help them to make payment arrangements with people who have debt and problems paying their bills on time.

Ms. Kandi has a concern of the population growth in Ondangwa. It might end up with more informal areas because there is not enough space for incoming people. This also means that they are in trouble with new water and sewerage connections. She is concerned about the future of the town, and that their town planning is not practical enough and not based on an economically stable planning.

As a conclusion on prepaid water meters, it seems that Ondangwa is having a fear of prepaid water meters not working as they should and that they might not get all their fees from the residents, and their previous experiences on the old standpipe prepaid meters are not good, but they are open for other solutions for improving their water finances.

5.3.2 Otjiwarongo

Strategic Executive Finance of Otjiwarongo, Mr. Burgert Liebenberg, was interviewed on July 30th, 2013 about prepaid water meters and water finances in Otjiwarongo.

The municipality of Otjiwarongo is in Northern Namibia and has 28 000 inhabitants (Namibia 2011 Population and Housing Census Preliminary Results, 2012). In Otjiwarongo they first had similar problems with unpaid bills as in Keetmanshoop. They started to invest in prepaid meters for debt collection. First they had prepaid meters from Tag Meter Systems but they changed them after four or five years after having negative experiences on their function. Now the town has prepaid meters from Kent and they are working well.

In overall they have had more good experiences on prepaid meters than negative experiences. The management program with Kent meters, CashFlow, is a fast and user friendly software. If there are problems with the software the system provider imports help even from South Africa. The system allows the management to print out all kinds of useful reports; for example user profiles, water use consumption reports and sales analysis. These prepaid meters are also more accurate than conventional meters. Then you also save money because you do not have to have meter readers and the staff is free for other tasks.

In Otjiwarongo they have two informal areas that are similar to Tseibglaate in Keetmanshoop. Though the difference is that almost everyone in Keetmanshoop has their own household connection and meter and in Otjiwarongo they have 55 public standpipes in informal areas with 3000 users. The large amount of public stand pipes guarantees that everyone has access to water round the clock. The system is not so vulnerable if some parts of the network or some standpipes are not in use.

Mr. Liedenberg also believes that prepaid meters have a good social element for people to understand their water consumption and that now everyone has a better access to water now that municipality is providing more public stand pipes with prepaid meters. At first people had some resistance against prepaid meters but in the end they started to want them. People feel that now they are more in charge of their own water use and are learning to budget on water.

There are three or four water selling points. The town is relatively large, so it is useful that not everyone has to come to municipality office to buy water from one point.
People get one bill in a month, like in most of Namibian towns. The bill includes all fees from basic water fee, sewerage and waste. With conventional meters if people are not paying their bills, the municipality cuts off their water after 60 days. It is also possible to make some payment arrangements if people contact the municipality before they get cut off.

Otjiwarongo also keeps the leaks in the network relatively well under control. Not many municipalities in Namibia have a plan to replacing the old pipes in order, but they have one in Otjiwarongo. They have managed to cut down their water losses, which again helps with the water sales issues. The pipes are old but they are replaced them in order to avoid bigger problems with the network.

They also have a similar replacing plan for old water meters. The only bigger issue with prepaid meters is the price of the meter itself. The meter lasts only up to five to eight years.

Mr. Liedenberg strongly recommends prepaid water meters, and especially the new types of Kent prepaid meters. He also believes that the prepaid water meters and their maintenance requirements get cheaper now that many municipalities are using the same meter providers. In his opinion, it is possibly the only way to recover from all the monetary loss in unpaid bills.

The case of Otjiwarongo's prepaid water meters was studied also in 2012. According to Saes's research, the municipality was able to improve their debt recovery with prepaid meters, but the result were still not as good as hoped for. Also all of the residents in Otjiwarongo were not financially able to buy a prepaid meter so the costs of the meters were included in the increase of water tariffs. The biggest negative issue was affordability to water because with the higher price of the prepaid water meter, water tariffs in Otjiwarongo increased. Prepaid meters gave people more control over their water use but this also resulted in prepaid meter users consuming less water than people with conventional meters. On average, people started to use only half of the volume of water they used to consume with conventional meters. Figure 5.3 shows a woman using a standpipe with prepaid water meter in Otjiwarongo. (Saes, 2012)

Figure 5.3. *A woman using standpipe prepaid water meter* (Saes, 2012)

The overall conclusion of Saes's research was that prepaid water meters had a negative effect on people's quality of life and the high water price resulted in decrease on water consumption volumes as the costs of the prepaid meters were paid by increasing g water tariffs (Saes, 2012). This is a bit controversial to what kind of experiences the staff of the municipality had about prepaid meters.

5.3.3 Tsumeb

Treasurer and Accountant of the municipality of Tsumeb, Johannes Amutenya, was interviewed on August 2nd, 2013. Tsumeb has 19 200 inhabitants (Namibia 2011 Population and Housing Census Preliminary Results, 2012). Tsumeb is only using its own borehole water so they are not buying any water from NamWater. They have 10 to 14 boreholes in use, and water is pumped from them to one reservoir where it is treated. From there water is piped to three reservoirs around the town and supplied to consumers.

There are all together 6000 water meters, from which 15 are public stand pipe prepaid meters in informal areas, and 465 prepaid household meters. The prepaid meters are all from Aqua Services. New public stand pipes were installed in 2010. Household meters were installed after 2012 so they are relatively new.

Mr. Amutenya recommends Kent prepaid meters (which they are ordering from Aqua Services) even though the investing and maintenance costs are high. Prepaid water meters have motivated people to monitor their water consumption more and the amount of unpaid bills has decreased. The new feature of the meters that the token is only working on your own meter has made the system more reliable. Previously prepaid meters had a problem that people could still borrow water from neighbors and then the high cost prepaid water meter was useless. In the informal areas the public stand pipe meter tokens work on a few of the prepaid meters, so that if one of the meters is out of order, people can still get water from another meter in that area. This feature can be programmed to work on either one or many public stand pipes.

People come to the municipality office to charge their prepaid meter tokens by liters. The tariffs with prepaid meters per liter are: N$ 0,02 (which means N$ 20/m^3) and for pensioners N$ 0,01. The prepaid token itself costs N$ 120 for inhabitants. People with household connection have a monthly basic fee of N$ 53,07 with both conventional and prepaid meter, except for pensioners who do not have to pay basic fee.

Tsumeb is using Increasing Block Tariff (IBT) with the conventional water meters. First 0 - 10 m^3 are N$ 5,04/m^3, next 11 – 19 m^3 are N$ 9,07/m^3 and then 20 - 30 m^3 are N$ 10,38/m^3.

So as a conclusion, prepaid water meters in Tsumeb are working as they should. These meters are still quite new so it cannot be yet said whether they will experience any maintenance problems with them.

5.3.4 Mariental

Accountant of the municipality of Mariental, Ellen Ngozu, was interviewed on August 7th, 2013. Mariental is a growing municipality of 12 300 inhabitants (Namibia 2011 Population and Housing Census Preliminary Results, 2012) and it is located 230 kilometers north from Keetmanshoop. In Mariental they are experiencing problems with old conventional meters, old pipelines and a lot of pipe bursts and also problems with prepaid water meters.

Mariental buys all of its water from NamWater. They buy two types of water; purified drinking water and raw water for irrigational purposes. Ms. Ngozu was not able to give the exact water tariffs but estimates instead. Water tariff with the conventional water meter is around N$ 11. The water price from NamWater is just slightly cheaper than in Keetmanshoop because the dam is closer to Mariental. There is some agriculture outside of the town, which would not be possible without this cheaper raw water.

The tariff for raw water from NamWater is just under N$ 1/m^3 and the municipality sells it with a prize of just over N$ 1/m^3. This seems to be very effective way to enable some cultivation in such a dry place and also to cut down the excess use of purified water. This practice could be used more also in other municipalities in Namibia if there is a possibility for raw water piping to towns.

In the municipality of Mariental they have had only negative experiences of prepaid water meters. They have now prepaid meters from Telbit with the Cash Flow 3 - management program. They have around 15 to 20 public standpipe prepaid meters and only a few household prepaid meters for the elderly which are provided by the municipality. These meters have been installed after 2010. The municipality is undergoing some problems with them. Previously they had Conlog prepaid meters from Water Master which had even more problems.

In 2009, the municipality was going through some big issues with Conlog prepaid water meters and they were planning to get rid of the prepaid water meter system. They felt that they do not get enough maintenance support from the manufacturer and supplier. The plan was to replace a prepaid meter with a conventional meter when it brakes. Water was also more expensive for the residents with prepaid meters than with conventional meters. This also led to hygiene problems when people did not use water for washing themselves or even to flush the toilet. (Mustonen M. and Shangheta M., 2009)

According to Ellen Ngozu, they are experiencing only a few issues with the new backup program, but the problems are mainly on the maintenance. The meters are easy to tamper and people are trying to do that a lot. They always have a water services maintenance team on standby in case of problems. People have tokens to these public stands pipes and they can use the token for all of them. So in case one of them is not in use, they still have the opportunity to use another meter in the area.

They feel at Mariental that the meters were sold to them only as a product but they should get more help with the maintenance issues from the company. They cannot get the company to come to Mariental to fix the broken meters. At this point it is not clear how much service was agreed in the contract but clearly there is a need for more maintenance service from the providers of the prepaid meters.

Another good practice was in use in Mariental with people not paying their bills. In case of people not paying their water bills for the municipality they cut off the electricity, not water. They feel that it is not appropriate to cut off water because it is a basic need for everyone, and you can still live without electricity. If the bill is still not paid, then they cut of the water, but only after many months.

5.3.5 Henties Bay

Senior Accountant and Acting Senior Finance in Henties Bay, Cornel de Villiers, was interviewed on August 5th, 2013. They are currently going to invest in prepaid water meters and have contacted several meter suppliers in Namibia.

Henties bay is a 4 800 (Namibia 2011 Population and Housing Census Preliminary Results, 2012), situated on the coast of Namibia. Henties Bay is not completely compatible with Keetmanshoop since it is a considerably more developed town. They have both household connections and also public stand pipes in the informal areas, but they are aiming to get household connections for everyone in the future. These results still give a lot of important information on what prepaid water meter suppliers currently offer in Namibia.

The old water meters in Henties Bay were IMS Electrical prepaid meters which were very problematic. They were not working at all and the backup was poor. She is not recommending them. There were a lot of illegal bypasses and it was easy to tamper the meter. Also the residents' card for the meter broke easily. She feels that they were expensive and that those meters were a bad investment for the municipality. The installation of those meters was paid by the municipality and the residents did not resist them.

Henties bay is buying all the water from NamWater. They have an ongoing project to replace older water pipelines. They are also focusing on getting rid of the vacuum sewerage system which has a lot of problems. In the next four or five years they are also going to build a new water reservoir. Henties Bay is reusing water from sewerage plants, and the treated waste water is used for example on grave yards and golf course for irrigation. So they have a lot of projects that help the municipality cut their water bill from NamWater and to decrease their NRW.

If people are not paying their bills they are cut off. Henties Bay also has a lot of problems with debt collection, like all the other interviewed municipalities. Debt collection seems to be a slow and problematic issue in all the municipalities.

5.3.6 Tses

Silas Namene Amulungu working for the municipality of Tses was interviewed on August 20th, 2013. Tses is a municipality of around 2 500 inhabitants. Tses is located in the central-southern Namibia.

According to Silas Amulungu, Tses had had positive experiences on prepaid water meters. They have both household and public stand pipe prepaid meters.

Their experiences are based on IMS Electrical prepaid meters which were installed in 2011. Previously they had meters from Nossob River Systems Ltd. Tses has seven public stand pipe prepaid meters, 72 household prepaid meters in formal area and 115 household prepaid meters in informal areas. Mr. Amulungo would recommend these prepaid meters, and the residents also have liked them. They give people some extend to understand their consuming habits. Even in the beginning of installing prepaid meters there was no complaining from people.

Tses is buying all water from NamWater but they also have plans to cut down their water bills by utilizing borehole water in the future.

People are also sometimes trying to do some illegal connections to water pipes. The fee from illegal connection is N$ 1000, and at the second time the municipality takes legal actions to reduce this kind of behavior.

As a conclusion, prepaid water meters in Tses have proved themselves working as they are planned and they are not experiencing problems with IMS Electrical prepaid meters, and even the residents like them.

5.3.7 Other municipalities in Namibia

Other information was also available on a few municipalities in Namibia from previous studies.

Karibib

Previously in the municipality of Karibib there was prepaid water meter system in standpipes. The municipality had from six to eight prepaid standpipe meters which were functional. (Mustonen, M. and Shangheta, M., 2009) But after more than ten years of having them, they decided to remove the prepaid system and went back to conventional water meters. They did not have any major problems with the prepaid system but just decided to go back to conventional water metering.

Gibeon

In the village of Gibeon prepaid meters have been used for approximately six years until 2009 when it was decided to cut out the prepaid system totally. They were not happy with the training for maintenance problems from the supplier, Water Master. (Mustonen, M. and Shangheta, M., 2009)

Okahandja

Okahandja is a municipality north from Windhoek, with a population of 24 300. In Okahandja they had Water Master prepaid meters which they changed due to the fact that there was too much maintenance work and no help from the supplier. They changed to Kent prepaid meters. In Okahandja it is notable that the water price increased by 50 % with the prepaid meter compared to conventional water meters. (Mustonen M. & Shangheta, M., 2009)

5.3.8 Summary of interviews

The information from the interviewed municipalities is presented in the next Table 5.2.

Table 5.2: *Summary of the municipality interviews information*

	Ondangwa	**Otjiwarongo**	**Tsumeb**	**Mariental**	**Henties Bay**	**Tses**
Number of inhabitants	21 100	28 000	19 200	12 300	4 800	2 500
Number of all household water connections	3899	-	6000	-	-	-
Number of prepaid household meters	-	-	465	-	-	187
Number of prepaid public stand pipes in informal areas	6	55 (for 3000 users)	15	around 15 - 20	-	7
Average number of people per connec-tion	5,40	-	3,19	-	-	-
Water basic fee / month [N$]	41	-	53,07	-	-	-
Water tariff [N$/m3]	11	-	20	around 11	-	-

5.4 Maintenance requirements of pre-paid meters

Prepaid water meters need more maintenance than conventional meters. So if it already is hard for a municipality to maintain the condition of their conventional water meters, it is even harder with prepaid water meters. The lifespan of a prepaid meter is slightly shorter than with conventional meters.

Kent prepaid meter has a battery life of five to seven years. They also promise that the maintenance is easy and the meter is extremely resistant to temperature changes (works between -20 °C and +70 °C). The supplier of Kent meters is committed to ensure spare parts which are mainly imported from South Africa. (Thomas, 2013)

Tagmeter Systems provide at least five years long battery life. RFID-technology is used and it provides less service and maintenance requirements. There should also be low costs of spare parts because the volume of production is going up and resulting in lower costs of spare parts. Tagmeter System meters are also supposed to be easy to operate even for untrained people. (Tagmeter)

There were several cases where the prepaid meters were easy to tamper with. Also the meters themselves can broke easily and the help for the maintenance is not always there. Some meter vendors include practice for maintenance for a few municipality workers, but what will happen when they do not work anymore at the municipality? The extra costs of maintenance work can be significant if the supplier has to send their own workers from other towns, and then the costs fall down on the municipality.

5.5 Prepaid water meters in debt collection

At least Kent meters can be programmed in a way that 15 % of the sum charged top the token can be pointed to debt recovery (Thomas, 2013). This sounds attractive for the municipality to get their old debts collected.

This feature might work in Keetmanshoop also. But since in Keetmanshoop a great deal of the debt is never going to be able to be collected since it is from the previous residents who have already died, this function would not work in all cases. The old debt collection problem should be solved in other ways.

In Okahandja the water tariffs increased 50 % with prepaid water meters (Mustonen, 2009). If the situation would be this also in Keetmashoop, with the high water tariff rate and the debt collection function, it sounds like water might be very expensive in the end. The case might be very problematic especially for the poor people in Keetmanshoop.

5.6 Other than monetary effects of pre-paid water meters

Saes's research revealed that people with prepaid meters used less water than residents with conventional meters which had a negative effect on people's quality of life (Saes, 2012). The decrease of water consumption can lead to hygienic problems when the same water is used for example for washing clothes and then for bathing.

The minimum volume of water is 20 liters per capita per day but 100 liters should be available for everyone. This is barely the case in Keetmanshooop's poor areas at the moment where the prepaid meters are planned. Decrease of consumption from that would not have positive results.

Prepaid systems might also have negative impact on pensioners since they are one of the poorest social groups and they do not have so much income to pay their bills for the municipality. So pensioners should be considered separately. The high increases of water tariffs could not exceed the pensions in any case. Also the inhabitants in a municipality have to buy their own chip card in some prepaid water meter models and it might be relatively expensive.

6 CASE KEETMANSHOOP

In Keetmanshoop, Namibia the volume of water being lost in the water distribution network is relatively high and also there are several issues in the water billing system. There are a lot of unpaid bills and issues related to water finances in the municipality. This case study aimed to find solutions for those problems and reduce NRW in Keetmanshoop.

There is enough water available for consumption in Keetmanshoop but the volume of water consumption is not equal within the residents. Previous surveys revealed that different user groups in the municipality use water unequally in terms of volume.

The municipality is increasing water tariffs annually, and the option of introducing prepaid water meters for those resident who are not paying their water bills on time, is still in consideration. These issues are also discussed in this chapter.

In the accounting period of July, 2012 - June, 2013 the municipality of Keetmanshoop bought 1 909 215 m^3 of water from NamWater and sold 1 284 317 m^3 to the customers. The water price from NamWater was N$ 8,60/m^3 and the price for residents was N$ 10,94/m^3. (Poulton, 2013)

The IBNET Water Supply and Sanitation Performance Blue Book reports that NRW in general in Namibia was 19 % in 2003, 11 % in 2004 and 15 % in 2005. The report also reveals that water production in Namibia was 236 liters per person per day and water consumption was 200 liters per person per day. (van den Berg & Danilenko, 2011) Taking this in consideration, NRW in Keetmanshoop is higher than the national average.

In the financial year July 2012 - June 2013 the amount of NRW was approximately 33 %. In previous years the NRW has been near the same 30-35 %.

6.1 Water distribution in Keetmanshoop

NamWater is responsible for supplying treated water to Keetmanshoop and they have three water reservoirs at the western part of Keetmanshoop. Water is distributed from them to the municipality network through a water meter where NamWater's responsibility ends. Treatment chemical is added to water at the NamWater reservoirs, but still the distributed water is not safe enough for drinking.

In the municipality of Keetmanshoop there is around 150 km of main pipelines (Aalto). The responsibility of the municipality ends where there is the user's water connection and water meter. Total number of water meters in Keetmanshoop is 3878. There are 3602 domestic users and 276 business users in Keetmanshoop. Water meters are provided by the municipality but the residents are responsible for costs in illegal sabotage cases. (Poulton, 2013)

To generalize, the northern part of Keetmanshoop is on a higher altitude level and the southern part lower. Industrial area at the south is lower than the rest of the town, and the highest water pressures can be found there.

There is no Active Leakage Control (ALC) practiced by the municipality. If there is a visible pipe burst it is usually repaired relatively fast but the smaller leaks that are not visible on the ground are not search and repaired. The maintenance teams are though relatively effective with repairing the leaks that are visible on the ground.

There is also a sewerage network in Keetmahsoop but there is no existent map of it and it does not cover the whole municipality. The locations of the waste water pipelines are not well known. The same maintenance teams operate both on the water and sewerage pipelines when there are visible leaks. The waste water is distributed to waste water ponds outside the town where the water flows through 16 ponds. The quality of water leaving the ponds is not researched.

6.1.1 Water distribution network map

The water distribution network is presented in Appendix 4. Water comes to Keetmanshoop from the western NamWater reservoirs. There are three reservoirs. Then the water enters the Oxpass Hill reservoir from where it is distributed to the network. Airport has its own supply pipeline with its own pumping station. Rest of the town does not have any pumping stations in the municipality network. In the northern part of the town there is the Donkie Drai water reservoir.

The water distribution network is not divided in specific areas. To make the estimations and calculations about NRW more reliable, the water flows in different parts of the network should be measured. The water distribution network could be divided in district metering areas, and the easiest way to do this would be by the different areas of the town as the boarders of the areas. Flow meters should be installed in all of the pipes to different parts of the town to find out how the water flows in the distribution network and where the flows are unusually high. This also requires using shut valves on the boarders of the metering area boarders, and naturally those shut valves should be then functional. Without this valuable information on the volumes of flows, the estimations of NRW are pretty unreliable and based only on assumptions.

There should be someone working in the municipality who is responsible of updating the AutoCAD-map of the water distribution map. Currently there is nobody who can update the map, and there is no AutoCAD in the municipality.

6.1.2 Valves

It is not currently possible to divide the water distribution network in to sectors with shut valves. For example if there is a leak in a pipe, the maintenance teams do not always know which shut valves to use to cut off the water from that pipe for the repairing. Some of the valves are not working properly or it is not known which direction they close.

Other issue is that a large number of existing valves are not working, so in some areas the water cannot be cut off. To cope with this problem, the maintenance teams have to use in some places the hydrants to release the water pressure for the maintenance work.

Previously the valve boxes were often stolen because of the valuable material but that problem was removed by changing the valve box material to plastic which made them not so attractive for thieves.

6.1.3 Dividing the distribution network in to sectors

Aalto made a plan of how to divide the water distribution network in Keetmanshoop to distinct areas using shut valves. The map is presented in Appendix 7. The plan for dividing the water distribution network in 45 sectors using 104 valves was made in August, 2012 and it included chancing of existing but non-functional valves, adding new valves and checking the condition of a few valves. (Aalto)

The implementation of this plan was not started during the one year period from August, 2012 to August, 2013 even though the instructions for the municipality were given by Aalto. There were not enough valves in the municipality stores and according to the municipality staff there was also some disagreements within the staff members. To carry out the plan the municipality needs some more experienced and educated staff to implement the plan. It is also possible that the staff is not aware of the severe need to conduct this action. There are also a couple of companies in Keetmanshoop that implement this kind of work, so they could be approach to do the changing of the valves according to the existing plan.

6.1.4 Metering incoming water

NamWater has three meters showing the amount of water supplied to Keetmanshoop. One is situated along the pipe line from Naute Dam, one just before the pipe entering NamWater's reservoirs in Keetmanhoop, and one is on the supply pipe from NamWater's reservoirs to municipality. Those meters are relatively reliable, but municipality should also meter the amount of incoming water.

On estimate, the repairing of municipality's own meter would cost around N$ 10 000 and buying a new meter is around N$ 45 000. It is worth investing to buy an own meter for municipality to be sure about the volume of water bought from NamWater.

Metering the incoming water is one of the key elements in estimating NRW. Without knowing the exact incoming water volume, the rest of the NRW estimations are not completely reliable. This should be bear in mind when making conclusions about Keetmanhsoop's NRW which is now calculated based on the volume from NamWater billing.

NamWater was able to provide the municipality graphs about their weekly income of water to Keetmanshoop. Figure 6.1.shows the water use from 24th June to 1st July. 2013. This gives estimations on how much water is put to the water network but it is still recommended that the municipality gets its own water meter.

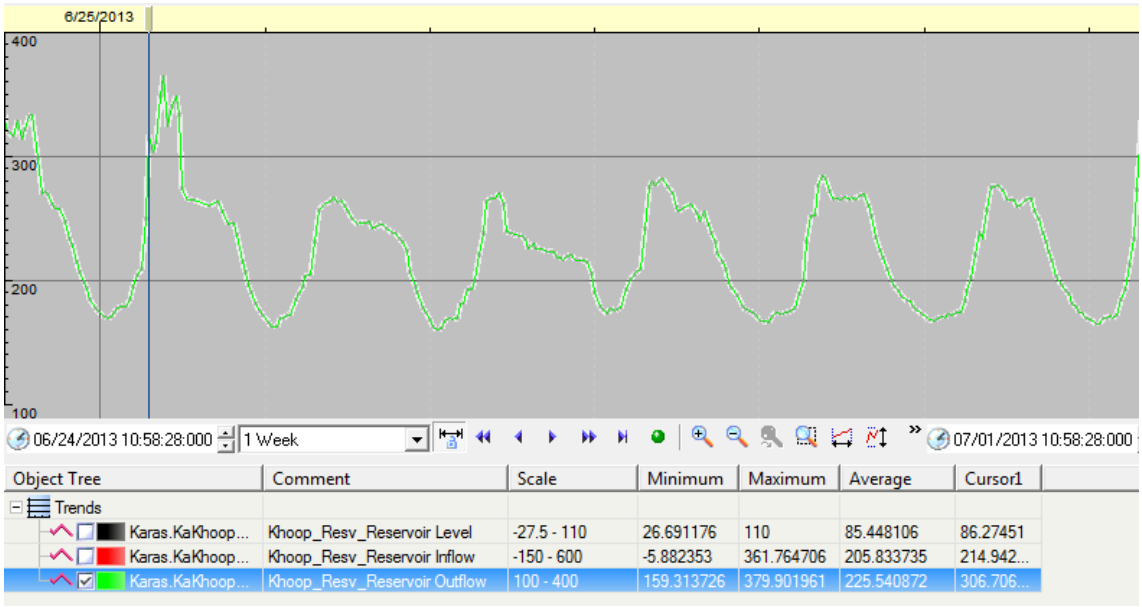

Figure 6.1. *The municipality's weekly use from 24th June to 1st July* (NamWater, 2013)

The weekly use also gives an estimate on how much water is being lost from the network. During the night when there should not be a lot of normal water use, the network is still leaking or some water consumption points are using on estimate 100 - 180 m^3/h.

6.1.5 Repairing the leaks in pipes

The water distribution network in Keetmanshoop is a mixture of asbestos cement pipes and PVC pipes. The old asbestos cement pipes tent to burst frequently nowadays. Estimating the volumes of water being lost because of leaking pipes is very difficult because there is no exact way to measure it and no leaks detection is even in use to get an idea how fragile the pipes are.

Because there is no active leakage control, the leaks are only repaired when they appear on the ground. This means that a lot of the leaks are never found out and can leak underground for long time. Only the leaks that are visible on the ground are currently being repaired in Keetmanshoop. Visible leak in a pipe is shown on a ground level with water or wet sand.

Leaks in the pipes can also lead the purified water to flow to the sewerage pipes. That way the water is just treated twice, but without any use in between.

Figure 6.2. *A visible leak on the ground (left) and an old leaking asbestos cement pipe with a typical fracture (right) (Tuovinen)*

Figure 6.2 on the left shows a visible leak on the ground. Figure 6.2 on the right presents a typical example of old asbestos cement pipe with a fracture which has caused a lot of leaking. Some of these kinds of leaks are visible on the ground but some are not, and they continue to leak underground.

When the water pressure drops unusually low at some parts of the network, some people report to the municipality. Then the maintenance teams or water services coordinator tries to locate the leak just by driving around the town. They start where they usually have pipe bursts, but sometimes it takes hours to find out where the leak is.

In August, 2013 one big pipe burst was reported to the municipality. A report was done by a local person from the industrial area. The water sectors workers started to locate the bursts by driving around the town. In this case it took one hour to find out where the leak was and then it was repaired quickly (on the figure below on the left).

Figure 6.3. *Leak in the industrial area was located in an hour since decrease of water pressure was reported (left) and a pipeline that is not protected (right) (Tuovinen)*

The pipeline has no sand to cover it anymore. The pipelines should be covered if they are visible on the ground. This way the pipes are at least a bit protected and cannot brake so easily.

Repairing the actual pipe burst does not take relatively long time since the pipes are usually not very deep, and if the required materials are available, the maintenance teams are able to work effectively. The difficulty is mostly finding these leaks.

6.1.6 Municipality's water reservoirs

Keetmanshoop has two main reservoirs in the water distribution network. One of them is located just after NamWater's three reservoirs in the western part of the town at Oxpass Hill. This reservoir has been overflowing every now and then during night times. The capacity of Oxpass Hill reservoir is approximately 700 m^3. The other reservoir is in the northern part of the town and it is called Donkie Drai. This reservoir has been leaking somewhere at the bottom structures of the reservoir for over a year. The capacity of Donkie Drai reservoir is approximately 3500 m^3.

Repairing these leakeages should not be such a big issue in a municipality like Keetmanshoop. They could also follow other municipalities' example. For example, according to Mr. Kandyimbi, Ondangwa is not having difficulties with repairing the reservoirs. One of the reservoirs was repaired a while ago and they had a bypass supplying the town that time. Other reservoir had a broken float valve that was fixed and during the repairing this reservoir did not supply any water and the water was cut off for a while from one part of the town. This kind of actions just has to be carried out to prevent water losses. (Kandyimbi, 2013)

And even if there might be a fear of residents getting angry for not getting water, they should be informed beforehand or arrange another way to supply water to those parts where the water is cut off during repairing. The municipality's staff has to prepare to do the work as fast as possible and it would also make sense to do the repairing during night when there is less water consumption.

Donkie Drai water reservoir

The northern water reservoir, Donkie Drai, is leaking from its structures (Figure 6.4.). The reservoir is at least tens of years old and it should be emptied and repaired from inside. There is no exact information on how old the reservoir is but it is estimated to be at least forty years old.

The flow on the ground was measured three times between July 3rd and 4th, 2013. The measurements were done with a two liter bottle and a stopwatch. The measurements indicate that the leak is 0.96 m^3/h, meaning 23.04 m^3/d. So on average 8400 m^3 per year water is lost only through this one leak.

Figure 6.4. *Leaking water reservoir at Donkie Drai (Tuovinen)*

One option is to empty the reservoir and repair it from inside with the help of a water consulting company. It needs to be done from the inside of the reservoir because the whole structures are old and leaking. Other options could also be to cut the reservoir out of the whole network. This could only be done by building new bypass lines because at the moment only one of the outlet pipes is connected to the bypass pipe. The municipality is taking actions to prevent this water loss to continue and the reservoir is estimated to be repaired in 2014.

To estimate whether the reservoir is really even needed, the water surface level was measured during July, 24th and July, 25th. The measurement was taken 21 times during the 24 hours. The inlet valve was somewhat half open and the bypass line was supposed to be closed during the measurements.

The measurement was not reliable and the result not accurate enough because no estimations of the leaks can be done when we cannot say how much water was going to the reservoir. According to the indicating measurements the water level did not change much during the 24 hours. The water consumption peak in the morning can be seen from the results but it does not imply to a very big change in water consumption. After 8:00 a.m. the water flow to the reservoir clearly increased so possibly the float valve opened the inlet that time.

The measurements imply that the reservoir is not functioning as a balancing reservoir as it is expected to do. It is possible that the float valve was at first stuck and the reservoir was not filling during night. But since there is water consumption in the town also during night, the water level was not going down because the bypass might have been open. The bypass valve was leaking so it seems to be broken anyways and some water might have been flowing through it. So no important conclusions were drawn from this measurement.

A new float valve was ordered in July 24th, 2013 but it still has not been replaced. In this case the float valve that was ordered was wrong size and had to be sent back.

The pipe connections at Donkie Drai reservoir were not clear. In July 2013 the connections were searched and partly found out by digging. The connections are now updated to the water distribution map and are shown in Figure 6.5.

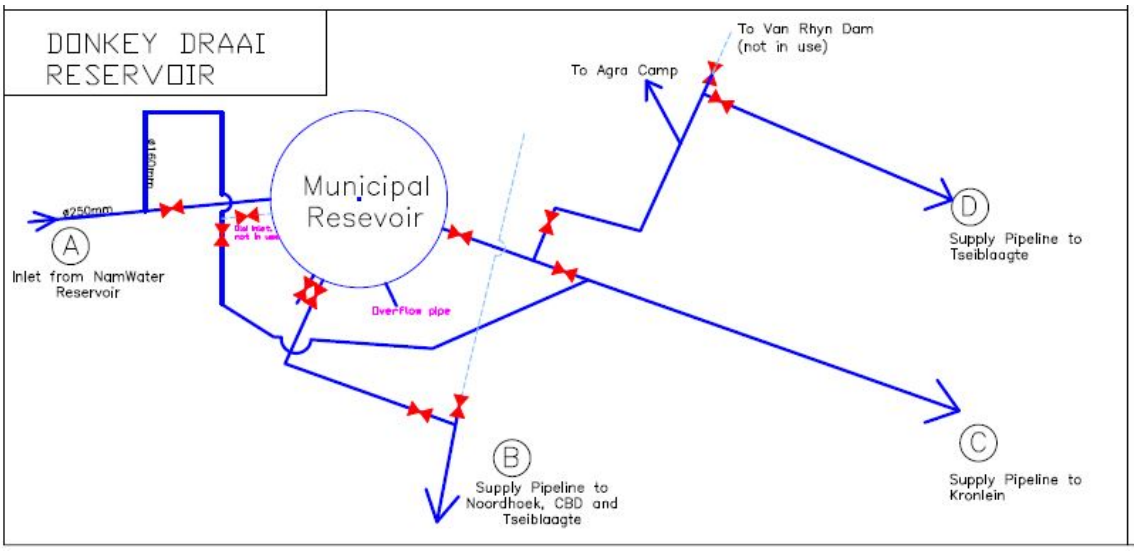

Figure 6.5. *Connections at Donkie Drai water reservoir (Tuovinen)*

Oxpass Hill water reservoir

Oxpass hill reservoir has had a heavily overflow during night time hours. That is because of the corroded float valve in the reservoir is not working and shutting off the inlet when it should. The bypass valves and the inlet valve to the reservoir are not working.

The municipality's reservoir in Oxpass Hill has been seriously overflowing during night times because of a malfunctioning float valve. The flow from this reservoir was estimated in July 2013 and the measurements show that the leak is serious. The overflow was measured 4.5 – 24 l/s but this is only during the night time hours when the reservoir is totally full and the overflow does not happened every night.

The overflow of the reservoir was checked several times during night time July 24th - July 25th, 2013 and that night there was no overflow. The overflow occurred mostly during weekends. During July, 2013 the reservoir was overflowing very often but in August, 2013 the overflow stopped, and started again in September, 2013 (Hauses, 2013). The overflow could easily be checked from the water flow marks on ground on the side of the hill. So clearly the float valve is not working properly and should be replaced.

A new float valve for Oxpass hill reservoir was ordered in July 24th, 2013 but it was the wrong size and had to be reordered. There is also an option of cutting the Oxpass Hill reservoir totally out of the water distribution system. It does not give any more value for the network and it only reduces the water pressure. (Aalto) The municipality staff still wants to keep it as water storage even though there are the three NamWater reservoirs just before it.

6.1.7 Water pressure

Pressures in the network were measured between August 8th and August 15th, 2013 with a pressure measurement gauge. The measurement method is described in the chapter 3.4. The pressures were tested from different parts of the town to get an overview of how the water pressure varies in the network. The results of the pressure measurements are presented in Appendixes 5 and 6. Pressures were mostly measured from household yard taps or the companies' yard taps and municipality's own taps.

Some of the measurements may have had some variation if there was at the same time some unknown water usage during the measurement. To avoid this, the pressure measurement gauge was left to be there for a while before reading the pressure.

Water pressure is at its highest during low consumption at night. The pressures were tested only during daytime between 9:05 a.m. and 16:00 p.m. because night time measurements would have required interaction with the residents during night. Also the results indicate that the highest measurements would have been at the southern part of the town during night time, but the measurements would have been impossible to carry out because the companies at the industrial area are only open daytime.

The pressures in the network varied between 220 and 740 kPa. At the airports measuring points there was even lower water pressure (140 and 150 kPa), but airport is the only part of the network that is not within the same pressure zone as the rest of the town, so it is discussed separately.

Low pressures (lower than 300 kPa) exist in Kroenlain and the lowest results were at the hospital in Kroenlain. The hospital itself is also a multistorage building so the pressures at the second or third floor are not enough, so they have an elevated water reservoir with a pump to keep the pressure at an acceptable level. The water pressure is also not enough for the effective use of fire hydrants.

Also residents from the western part of the town, Westdene, have been complaining about low water pressure. Westdene is a higher-income area, so the pressure requirements there might be higher because there is a need to have higher pressures for example for washing machines.

The highest water pressures can be found at the southern part of the town at the industrial area. The high pressures at industrial area are problematic because the pipes there are very old there. According to the municipality’s staff, that area has a lot of pipe bursts. So it would be wise to replace the pipes at industrial area, at least in the case if the pressure in the network will be increased with a new reservoir. Other option to avoid difficulties in the industrial area when increasing the pressure in the whole network, is to separate industrial area to its own pressure zone and to install a pressure reduction valve before industrial area to keep the pressure not getting higher than a maximum pressure that the pipes can hold.

Keetmanshoop Airport has its own pumping station at Oxpass Hill. The low water pressure results indicate that the pressure is not enough for example for firefighting in case of emergency at the airport. It would be reasonable to increase the water pressure at the airport pipeline. And as the pipeline is recently replaced with new pipes they can hold more pressure.

In previous years there was a plan to reduce water pressure in the network but this is not the plan anymore. Reducing water pressure would reduce water loss from leaks. But since the water pressures are already relatively low, there is no need to reduce the water pressure in the whole network.

6.1.8 Water meters

The water meters for some of the biggest consumers in the municipality are not working properly. This issue had been reported also earlier, but no action has been taken so far; but only a few of the meters were changed or repaired in August, 2012. The reason behind this slow progress is that there is a lack of co-operation within the workers in the municipality and also the quality of the new meters that were ordered. The newly installed meter can break after a month or a few after the installation, which has made the workers non-motivated to do these replacements. The meter suppliers should be reconsidered if these poor quality meters are still in use.

The meter of the municipality's biggest consumer, hospital, had been standing still for a few years, but since that was discovered last year and the meter had been changed, the situation got better. During the financial years 2012-2013 the amount of water used by the hospital was 76 000 m^3, which is now billed consumption. In previous years this water was no billed which affected largely to the water sectors income.

Some of the water meters in Keetmanshoop are inactive and have been standing still for years. In those places the meter readers report the same reading month after month, and in some places the water meters were changed but they were broken again. The bigger water meters were broken because of the poor quality of them, and during repairing of the pipes and valves some stones got in to the pipes and eventually broke the meter.
According to Mrs. Poulton the consumers with non-functional water meters get usually an estimate bill of water use according to previous water use. Mrs. Poulton calculates the estimate bill on her own just based on water use from previous years or moths. (Poulton, 2013)

In one case in August, 2013 a water meter was broken as shown in Figure 6.6. The resident reported not wanting to pay the water bill and that is why the resident had broken the water meter. In this case, the resident had to pay for a new water meter. According to Mrs. Poulton, it is not so unusual to come in front also with these kinds of problems with the residents. Not all the residents understand that the water bill cannot be avoided.

Figure 6.6. *A resident of Keetmanshoop broke the water meter in hope to avoid water bills (Tuovinen)*

6.1.9 Inactive and inaccurate water meters

There was more than 500 inactive conventional water meters in the municipality in August, 2013. This is critical because if they are not maintaining the water meters and replacing them regularly, there is no way to get money recovery from the residents. These broken water meters should be replaced immediately. Besides there totally non-functioning water meters, there are also meter inaccuracies with the functional water meters. In 2012 many water meters were tested for inaccuracies. On average 30.3 % of the water meters tested had inaccuracies. (Aalto)

The few biggest consumers with a non-functioning water meter get an estimate water bill. Though it is difficult to estimate how much water is actually used and how accurate these estimated bills are. The amount of the estimated bill is calculated based on previous water consumption data that the municipality has from those consumers. (Poulton, 2013)

The total number of broken water meters in the whole town is over 500 and it would be profitable to start replacing the inactive meters first from the biggest users list.

6.1.10 Biggest consumers

The list of the consumption of biggest users was updated in August, 2013 (Appendix 2). Some private houses have also very big water consumption but they were left out of the comparison because it is not necessary to point out private persons with big water use. Still it should be noted that these private users could reduce their water usage easily by for example gardening during night time when the water for irrigation purposes reduces because evaporation is less than during day times.

6.1.11 Unpaid bills

Sandra Poulton from municipality's accounting was interviewed several times during the field work. Mrs. Poulton told that unpaid bills are very difficult to handle, and there is not enough actions and manpower in the municipality to cope with this issue. She has to manually go through the unpaid bills and then give instructions for the water sector workers to cut the water from the customers who are not paying their bills.

All the water bills that are not paid on time are reported from finance department to water sector and technical staff. The water from those consumers is cut off with a magnetic trigger valve. After the bill is paid the resident has to pay a reconnection fee and then the maintenance team re-opens the connection.

The big issue also with the unpaid bills is that some of the bills are really old but there are no ways to cope with those situations when a house owes money to the municipality. When an unpaid bill is left to the computer system, it cannot be ever erased even though the bill is from the previous owner of a house.

6.1.12 Municipality's own use

There has not been a lot of record keeping of municipality's own water use but new water meters were installed between December 2012 and August 2013. Municipality's own water use between January and August, 2013 is presented in Appendix 3.

In August 2013 there was altogether 55 municipality's own water consumption points which all had water meters to keep record of the use. These consumption points were some closed and some still open, so people could use water for free from these. All of these taps should have a lock on them.

6.1.13 Illegal connections and water thefts

There have been some illegal connections for households, and they were reported and removed after December, 2012. According to municipality's summary of applicable tariffs, the fine for illegal connection, bypass, tampering or sabotage is relatively high, N$ 2 269,67 but this fine is barely ever used. The illegal connections that were found after December, 2012, were cut off but the fines were not written. At least in the informal, poor settlements it would be impossible for the residents to pay that fee.

There are several leaking valves outside the town center where people continuously steal water from. That does not affect the amount of unaccounted water because it would anyway leak from the valve. But it affects the amount in a way that this amount of water is not bought by that customer.

People also steal water from the graveyards where is a public standpipe for irrigational purposes for the graves. They use big tanks to fill them up during night and take them home.

Also in August, 2013 there was one case when the pipeline in the graveyard was broken by some residents to access free water. In this case, the municipality repaired the leak as soon as it was discovered but the water had been running freely about for a couple of days before it was noticed and everyone could have accessed it. It is very difficult to estimate how much water is lost because of these actions annually.

6.2 Management of water services in Keetmanshoop

Several difficulties in the water distribution in Keemanshoop can be traced back to management issues. There is a lack of sustainability in the technical department management and workforce. There are several posts vacant and there is a lack of education in the staff. For example, town engineer post has been vacant since 2008.

A new water services coordinator was hired in December, 2012. Mr. Vendura started his work to implement the water loss management plan that was done previously. Metering municipality's own water use was improved after he started working. Also cutting-off the water from those consumers who did not pay their bills was started. Several other tasks were also started but since the water services coordinator post was again vacant after August, 2013 after he left, the tasks were not finished.

No long-term plans are made from behalf of the municipality to maintain the water distribution network, sewerage and water meters replacements.

They also lack of a plan for emergencies and there are no preparations for risk cases. If for example the critical points in the network fail (water reservoirs etc.) there are no plans on how to supply water for the people. It would be crucial for the municipality to plan these actions beforehand.

Annual water sector budgeting is done and estimations are somehow based on previous years. Keetmanshoop's budget is presented in Appendix 1. More attentions should be paid on investing on the maintenance and water pipe, meter and valve replacements, and these should be already budgeted for the next year.

6.2.1 Organization of the municipality

Organization chart of the municipality is presented in Appendix 8. The positions that were vacant on August, 2013 are on light grey background colour.

The number of workers in total is large and about half of the staff is acting and placed in a position where they lack of proper education and work experience for that specific position. Sometimes it is not clear for everyone working at the municipality, who is working for who.

6.2.2 Trainig of the staff

Training of the staff to use map was started in 2012, but is still under work. One municipality's staff member should also be trained to update the water distribution AutoCAD-map.

Figure 6.7. *Finding leaking pipes is very time consuming (Tuovinen)*

The above pictures (Figure 6.7.) tell how slow the procedure of finding pipes is. The excavator was not even used when digging out the already broken pipeline. The work was done by hand so it took unnecessarily lot of time. Better planning of how the daily work is done should be introduced.

6.2.3 Town planning

There will be several new areas in the town planning. There are also new areas that already have piping and sewerage installed, but the construction of these areas has been slow. On these areas the municipality is planning to build more houses but there was some oppose from the residents since those houses are very small and build on a poor budget and they ended up being bad quality. The residents preferred to build their own cheaper houses outside these areas.

New areas in the northern part of the town are sometimes facing problems with storm water management. Storm water management has been taken somewhat under consideration by town planning in some measures. During the rainy season the rainfall per month in Karas region is 285 mm, which means heavy rainfall in a short period of time. Some storm water walls were built outside the town to keep the water outside from the town area.

6.2.4 Neckertal Dam construction

Town planning should also pay attention on the effects of the upcoming Neckertal Dam. The estimated 1500 construction site workers are supposed to stay in Keetmanshoop, which will obviously increase the water demand in the municipality. Since the Neckertal Dam is designed for irrigation water, the amount of water used from municipality's existing water distribution for irrigation will decrease.

There was a lot of different information about the Neckertal Dam construction but most likely they will start building 250 houses in Nordhoek for the dam construction workers. There will probably be around 1500 people plus their families in Keetmanshoop during the construction work and they all need housing and water connections.

The construction of the N$ 3 billion Neckertal Dam is going to be done by an Italian firm, Salini SpA. The size of the compacted concrete dam will cover an area of some 39 km^2 and the dam wall will exceed 500 m in length. The dam will be on the Fish River approximately 40 km west of Keetmanshoop. (New Era, 2013)

This will most likely affect the water bought from NamWater when the dam is operating. The dam will increase agriculture in Karas region and also it might bring more people to Keetmanshoop. But at the same time the need to use purified water for irrigation in Keetmanshoop will decrease, when there is a pipeline of non-treated irrigation water coming to Keetmanshoop.

6.3 Quality of water

Water distributed in Keetmanshoop is not recommended for drinking. Some residents boil it and drink it.

There are also a waste water pipelines in Keetmanshoop but the treatment is insufficient and also the pipelines are leaking.

6.3.1 Drinking water

When checking the water levels in the municipality's reservoirs on July 8th, 2013, it was discovered that the roof of Donkie Drai reservoir had a few holes. The other one was approximately 20 cm in diameter, and the other one was around the income pipe. Both of those holes could easily fit a bird or an animal inside the reservoir. It is also an open area around the reservoir, so anyone could climb on top of the reservoir and access the holes in the roof. It is a serious risk for the quality of the water. Those holes should be covered immediately and the access to water reservoirs should be limited and the area around them fenced.

Also according to the technical staff of the municipality, the water reservoirs at the hospital and one school should be cleaned to avoid diseases caused by poor quality of water. Especially the hospital reservoir, which should provide clean water, is said to be very dirty.

It would be useful for the municipality to keep record of the chlorine level in the distribution network. Chlorine is added to the NamWater reservoirs to preserve the good quality and avoid bacteria growth in the distribution. The level of chlorine tells about how clean the network is.

The workers at the municipality did not know how the water pipes and sewerage pipes are installed under the ground in relation to each other. The water pipes should be installed on an upper level compared to the sewerage network but no one seemed to know how the pipes are located or if they even are at the same lines.

Sewerage water can leak to water pipes which can lead to serious health risks. Sewerage leaks that are visible on ground are prioritized to be repaired first by the maintenance teams, and the repairing time is not usually very long. Still there is always a risk of waste water flowing to water pipes or mixing with borehole water that is sometimes used for example as drinking water for animals. Municipality boreholes are not covered and they can be accessed by anyone.

Cases have been reported in Keetmanshoop where the residents started drinking water that had been in contact with waste water. The municipality staff reported a case a few years back where the poorest people started to use the contaminated borehole water for drinking purposes and got ill because of this.

6.3.2 Waste water

Sewerage is inexistent in some parts of the town, at least in Tseibglaate. Some residents there are building their own illegal toilets that are not connected to sewerage and there is no control over where the waste water ends up.

The effectiveness of waste water treatment in Keetmanshoop is concerning and it has been under discussion with the municipal workers in 2013. The waste water treatment plant consists of 16 ponds. There was no clear information on how deep the ponds are and if they are partly anaerobic and aerobic. The ponds are not properly fenced, and animals living on the area can easily access the waste water. The ponds should at least be fenced.

One person is working on the waste water plant to keep the bars clean. The sludge and solid waste that is collected from the process are buried under ground near the ponds. The treated waste water and sludge could be utilized in some measures by the municipality. Some ideas on how the municipality could use this opportunity have been brought up but no actions have been taken at least before August, 2013.

7 DISCUSSION

This chapter discusses the results and gives some answers on how to affect the volumes of leakages and how to solve the issue of unpaid bills in Keetmanshoop. The amount of Non-revenue water was not affected in a way that it was planned during this project. Keetmashoop has a high level of NRW and it should be decreased in the future.

Studies on prepaid water meters show that they are working only in some places in Namibia, but their possible affects in Keetmahsoop are discussed further in this chapter.

7.1 Non-revenue water

NRW was 33 % in the financial year July 2012 - June 2013. It means that the volume of water lost before reaching customers is high.

The level of NRW was not affected in a way that was supposed because there has not been enough leak repairing and pipeline replacements yet. The municipality does not always have the information on which pipes should be replaced. The inactive water meters are a major cause of the high level of NRW as well, and those should be replaced immediately. Then the tested inaccurate meters should follow. Changing of the valves should be done according to the water loss management plan (Aalto).

7.1.1 Water tariffs

Over the years, the income from the water sales has not been sufficient enough to cover the expenses on the water sector in Keetmanshoop. To cope with that, the municipality has increased the water tariffs annually. Also the water price from NamWater has increased annually.

Table 7.1. presents the water tariff changes over the last ten years. For the financial year July, 2013 - June, 2014 municipality decided to increase the water price again with 6 %.

Table 7.1 Water tariffs in Keetmanshoop 2002-2013 *(Seppänen, 2008. Poulton, 2013)*

	NamWater [N$/m^3]	**Municipality [N$/m^3]**
2012-2013	8,60	10,94
2011-2012	7,45	10,22
2010-2011	6,45	10,22
2009-2010	6,45	10,22
2008-2009	5,93	9,46
2007-2008	5,93	8,60
2006-2007	5,32	7,70
2005-2006	5,00	7,00
2004-2005	4,80	6,40
2003-2004	4,20	6,00
2002-2003	3,80	5,30

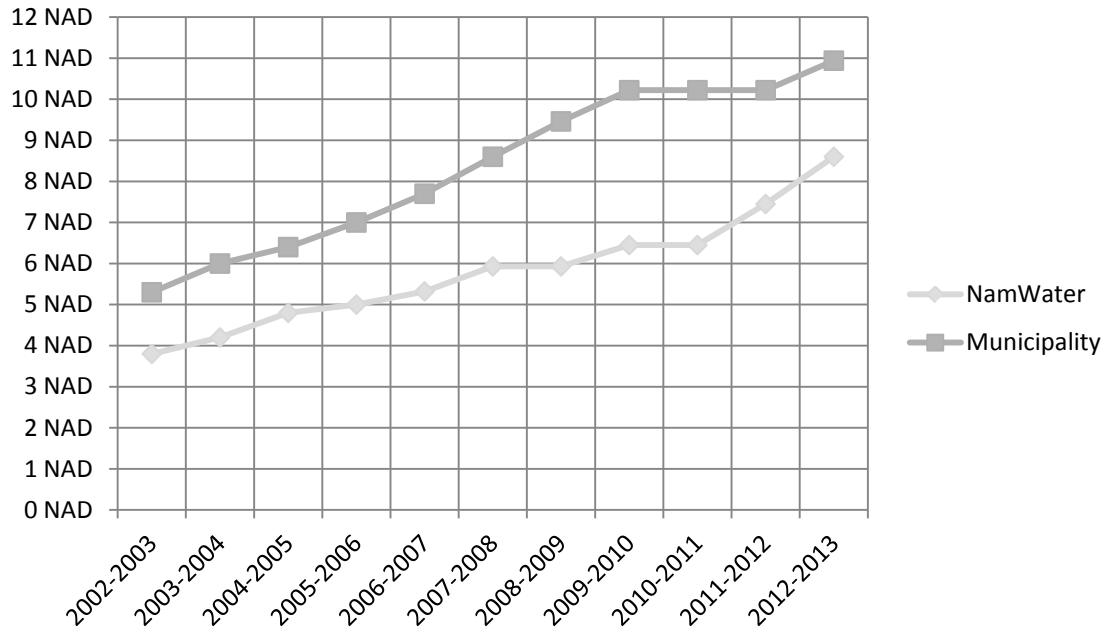

Figure 7.1 ***Water tariffs have approximately doubled in ten years*** *(Seppänen, 2008. Poulton, 2013)*

As the figure above reveals, the water tariffs have increased dramatically. Both NamWater and the municipality are increasing their water tariffs annually.

The municipality gets some income also from other sources, not only from the cubes sold. These other sources of income include fines, connection fees, testing of meters and borehole water sales. However, these other sales and fees are minor compared to the sales from water consumption.

7.1.2 NRW in Windhoek, the capital city of Namibia

In Windhoek, the capital city of Namibia, there has been effective activities to reduce NRW which could also be used as an example in Keetmanshoop. According to Lahnsteiner and Lempert, the city of Windhoek has had systematic pipe replacement programs and proper water meter management. These have resulted water losses being only around 10 % which is very low and even lowest in Southern Africa. (Lahnsteiner & Lempert)

Other water saving efforts in Windhoek were consumption related progressive water pricing (increasing block tariffs), technical improvements including leakage detection and proper watering of gardens. Water use for irrigation of gardens has been limited only to lower evaporation times, meaning that watering should be avoided between 10:00 a.m. and 16:00 p.m. In Windhoek also only low flow showers are allowed, toilet cisterns must be dual flush units and automatic flushing devices without user activation were prohibited. All taps outside non-residential buildings must have been self-closing or lockable, which should also be the case in Keetmanshoop. (Lahnsteiner & Lempert)

In Windhoek educational programs have raised awareness of water saving. The programs were in schools, radio, television and printed media. Biggest benefits were accomplished from school programs. (Lahnsteiner & Lempert)

7.2 Implementation of the water loss management plan

There have been some management difficulties in the municipality during the water loss reduction project which affected the results. It was not always clear to all participants in Keetmanshoop, how important it is to make these needed investments, although they would benefit the whole municipality in the long run also in monetary terms.

The staff should be encouraged to participate in this long term process and work together. There should also be more training of the staff (for example map reading for the maintenance teams, and teaching leak detection processes if the equipment is available). It is also important that the staff is well educated. On the technical side there was no proper equipment for leak detections available, so some improvisations were needed in the field.

Municipality stores are not very comprehensive. A few times in 2013, some parts were ordered from Windhoek and only when they arrived in Keetmanshoop, the staff realized that they were not what were needed. When placing an order the details (size etc.) should be filled in carefully and make sure that the municipality is ordering exactly what is needed. In some cases the quality of meters ordered was very poor, so that should also be taken in consideration.

New water meters and shut valves should be ordered immediately in order to start replacing the old ones. The process of ordering something is also very challenging as only the building inspector and the foreman of water services are allowed to do this. In order to start fully implementing the water loss management plan, there has to spare parts and new pipes, valves and meters available.

7.3 Prepaid water meters

The prepaid water meters as they nowadays are, might not result in positive results in Keetmashoop. The experiences from other municipalities showed that there are a lot of maintenance problems with these meters. The maintenance of the meters requires too much from the municipality and the meters are more expensive than the conventional ones. It is not recommended that Keetmashoop invests in prepaid water systems right now; the problem with the meters is mostly about their maintenance. The old inactive water meters (more than 500) should be replaced in first hand.

There is the function of debt collection in prepaid meters that could be beneficial in Keetmahsoop. If, let's say, 15 % of the credit is appointed to debt recovery every time a person charges the token the debts could be slowly reduced. But this function is still not reasonable enough for the municipality to invest in prepaid meters. The problems in this sector can be avoided in other ways, too. In order to avoid more debts, the municipality should continue the new practice of cutting off the water from those who are not paying their bills.

The price for a conventional water meter is around N$ 400 while a prepaid water meter costs N$ 2400. The payback time of a prepaid meter was also calculated in 2013 and it is 3.5 years. The payback time was calculated by the average water use in Keetmanshoop and it is important to notice that the payback time would be really much longer in the poorest areas where also the water consumption is less than the average. In some places the prepaid meter would not pay itself back in the 15 years of its use. (Aalto)

7.4 Benefits from the project

Without this project the level of NRW could be increasing in Keetmanshoop. Even though the issues are not fixed yet, at least it is now known which the problem areas are and how to improve them. The aim was to reduce NRW to 20 %, but that is still a long term goal.

This project also offers information about prepaid water meters in a way that Keetmashoop can now avoid the unnecessary investment in them. The results about prepaid water meters can also be used in other places, too.

7.5 Non-monetary benefits of water loss reduction

Water loss reduction is not only important in monetary terms but in a dry country like Namibia the effects are more far-reaching. The volume of water saved in the dams during rainy seasons is already scarce so it should definitely not be wasted in water losses such as leaks, but saved in cases of droughts.

Reducing the level of NRW also decreases the volume of water that has to be treated in the beginning of the process. The decrease of the volume of water that needs to be treated and supplied by NamWater also reduces costs of the treatment and volumes of the treatment chemicals.

7.6 Self-evaluation

The work was possible to do in the given time. Some local habits and work practices set their own difficulties, but in the end two months spent in Keetmanshoop was enough time to get to know the municipality, to collect information about prepaid water meters and to point out problems with the water distribution network.

There was a slight problem that the project was executed a bit separately from the rest of the municipality staff of Keetmanshoop. The project's water coordinator was not directly in the municipality's organization of the technical sector, so the project was somewhat disconnected from the municipality. Hopefully this will be fixed in the future and if a new water services coordinator is hired, he/she will be working together with the rest of the municipal staff.

The semi-structured interviews in other Namibian municipalities were relatively short but a lot of information was collected in interviews that took about an hour. Other previous researches also provided quite a lot of information about prepaid meters.

8 CONCLUSIONS AND RECOMMENDATIONS

As a conclusion, the level of NRW was 33 % in Keetmashoop during the accounting period July 2012 - June 2013. Previous year NRW was 35 % (Aalto). The prepaid water meter research revealed that most of the experiences on them in Namibia were quit negative. Still they are ideally an effective tool for municipalities to cope with debts and avoid problems with unpaid bills if they are maintained properly. This chapter summarizes the conclusions of this study and gives recommendations for the future for Keetmashoop.

The level of NRW has been around at the same level for years in Keetmanshoop. With the current practices the level could only result in more negative result and an even higher level of NRW, if no actions are taken to improve the network which is getting older.

The plans that were previously done for the Keetmanshoop water distribution network are still not implemented. There is a lot of work to do in changing the broken water meters and shut valves and improving the water distribution network to decrease the level of NRW.

A conclusion about prepaid water meters is that they are not currently effective enough for debt recovery and their price is too high. As the technologies of the meters improve, the price of a meter could get cheaper, and then the prepaid system can offer a better option. Now the investment in them results in increase of water tariffs when the expenses are include in the tariffs. The increase of the water price leads to decrease of water consumption which may have negative impact on the quality of life of people and even poor hygienic conditions.

These results about prepaid water meters from Namibian municipalities can roughly be generalized in other places, too. The improvement of the prepaid system is still in progress and it can offer a world-wide solution for the debt problems in the water sector in the future but currently the system is not effective enough.

8.1 Recommendations

Next stage is to start doing renovations for the network according to the plans. Broken water meters, shut valves and vulnerable pipelines should be replaced immediately.

The municipality should hire people for the technical sector. The vacant positions should be filled with educated and skilled people. Also the current staff should be trained more.

The water tariff structure should be reviewed. The current water tariff is not efficient enough for cost recovery and to pay for the future renovations. Increasing block tariff could easily offer a solution for this and the option was already discussed with the municipality staff in August, 2013.

Also other ways to decrease the high volume of NRW should be taken in consideration in the municipality and all of these solutions are discussed next.

8.1.1 Long-term plan for water distribution renovation

Pipes

The municipality has no long-term renovation plan for the network. The pipes are only repaired when visible pipe bursts occur. This could be avoided by replacing the oldest and weakest pipelines of the network in an organized way. The oldest pipelines exist in the town center. In the industrial area there are both old pipelines and high water pressures which indicate that there is a need to replace those pipelines. The water sector coordinator pointed out the most vulnerable pipelines to be at the southern areas and the airport pipeline (Vendura, 2013). Most parts of the airport pipeline were replaced in September, 2013 (Hauses, 2013).

Valves and meters

Replacing the old valves and meters has not been taken seriously. It is alarming that there are more than 500 non-working water meters in Keetmanshoop. These should be immediately replaced with new ones. Also new valves and meters should be ordered beforehand to the municipality store house.

The work to divide the water distribution network into sectors with shut valves should be continued. New valves should be installed according to the plan in Appendix 7 (Aalto).

Work habits

The work conducted by the maintenance teams in Keetmashoop should be more effective. When there are no visible pipe bursts, the maintenance teams should repair and replace the broken water meters and shut valves according to the valve changing plan (Aalto). If these tasks are impossible for the teams to carry out, for whatever reason, there are at least three companies in Keetmanshoop that could be hired to do the replacements. The municipality could easily buy this service from these companies if the municipality's maintenance teams are not able to do those replacing.

The municipality should inform the residents in advance when doing maintenance work for the network and reservoirs. The municipality building hall's information wall could be the place to inform resident about upcoming maintenance work.

Water reservoirs and water pressure

It could be a good idea to build a new water tower in the center of Keetmashoop distribution network in the hill near the town center. It would give more water pressure to the network and it could replace the Donkie Drai reservoir. This might even help to solve the problem with the water quality if Donkie Drai reservoir is removed from the system, since it is poorly maintained, dirty and water stays a long time in the reservoir. The structure of the reservoir could be lighter and smaller than the current reservoirs in Keetmanshoop.

Water pressures will be problematic in Nordhoek and Kroenlain with the new University of Namibia campus area and at the hospital. The municipality needs management and supervision in designing the new pipelines and setting up the new water tower to increase water pressure.

8.1.2 Prepaid water meters

Based on the interviews in the other municipalities in Namibia, the prepaid water meters have not been as effective as planned. The municipalities have had serious maintenance problems with the meters and some with the backup programs also. Some municipalities still had also positive experiences on them but those municipalities also had their technical sector in order.

I do not personally recommend the prepaid system for Keetmanshoop, since it seemed that there were some issues on the management of the technical sector and I believe that they could not succeed with the installation and maintenance requirements with the prepaid water meters.

Even the current water meters in Keetmanshoop are not repaired or replaced when they are broken. In Keetmanshoop there are currently over 500 broken conventional water meters which should be replaced before even considering the project of replacing all the meters with prepaid meters. There are just simply not enough staff members or willingness to commit to a new project.

If Keetmanshoop still plans to invest in prepaid water meters one day, I would strongly recommend deciding on a meter that has a debt collection function. It would be profitable if for example 15 % of the amount of water charged on the token could be directed to paying off the resident's debt for the municipality. I believe that the residents would also like that function and they would understand how it would benefit them and the municipality to pay their debts in this way.

I would also recommend choosing a prepaid meter with the function of household leak reporting because that would possibly make people more aware of their water fixtures leaks. It would decrease household leaks in the end if people start to fix their leaking toilets and other fixtures regularly when they are alarmed of those leaks. That would end up in decreasing of overall amount of water being lost.

8.1.3 Other ways to save water in Keetmanshoop

Keetmanshoop should consider using alternative sources of water. There are many ways to utilize municipality's own borehole water in a larger extend than how it is now used. The water from boreholes should be more easily accessed for the resident of Keetmanshoop. Also the domestic users could use borehole water for irrigation and other purposes. At the current practice the borehole water is only used for watering streets and once a year for filling up the municipality's swimming pool. There is already the pipeline from one of the boreholes to the Westdene stadium but the pipeline is not in use. Also the boreholes should be covered and the water quality of water protected from for example animal feces.

In the near future there might be a new pilot project in Keetmanshoop to utilize treated waste water for agricultural purposes. The project already has the funding but it is still lacking of approval from the municipality's council. This might have a slightly positive effect on the volume of water bought from NamWater. The project is still a proposal but if it will come true, there will be an agricultural production unit and 15 fish tanks combined to the current waste water treatment plant in Keetmanshoop. This would a very effective way to improve the current system but it still requires a more detailed work plan since there are some other necessary improvements to be done at the waste water treatment plant (e.g. fencing, guarding, improvements of the treatment). If the project proceeds it will not only utilize the waste water but it will also create new job opportunities and sustainability for the water sector. (Shalumbu, 2013)

The municipality should take Active Leakage Control in practice. Some practices might be expensive and impossible to carry out in Keetmanshoop but for example consulting how Windhoek is currently managing their leaks, could be effective and they could recommend some equipment available in Namibia, and this way Keetmanshoop could improve the current practices.

Managing the water sector in Keetmanshoop is requires some improvements. The municipality could use some help in their finances because the budgets for the resent years have not been effective leaving the result negative. The losses from the poorly designed incomes are covered by increasing water tariff annually. This has been the practice for several years already. As a result of the increases, the residents feel that water is becoming more expensive and some people still cannot afford to pay their bills. There are also many big investments to be done for the network (e.g. new valves, water meters, new pipelines, repairing the old pipelines) and there is no other funding for those. To avoid this problem the municipality should consider alternative ways to increase the water sectors incomes.

Keetmanshoop could consider taking Increasing Block Tariff in use. Setting water tariffs on a more effective basis increases income for the water sector and the annual increase of water fixed tariff could be avoided. With IBT those who use extensively lot water pay more for it, which is usually a fare and understandable way of paying for the residents. The municipality could look for example from other municipalities in Namibia where IBT is in use. There could be for example three or four different blocks with increasing tariffs. The first block usually represent the usual volume of water use in households per month and that block has the lowest rate. Then the rest of the blocks have higher tariffs for those who use more water than a usual household. The municipality should also pay some attention for the industrial consumers; there can be either the same or other tariff structure for the industrial users.

The swimming pool in Keetmanshoop should be repaired. As the swimming pool is using extend amount of water, the yield of the boreholes should be researched for investigating the possibility to increase borehole water use for filling the swimming pool. The borehole water has to be treated before using it for the swimming pool and the costs for that should be researched and compared to the water bought from NamWater for the swimming pool.

All the visible leaking parts of the network should be fixed. For example, a leaking water service point at the industrial area that is used to fill the tanks for watering the streets. This point is leaking heavily as it is also located at the network where the water pressures are the highest. Some of the water being lost could be reduced by repairing these kind of clearly non-working parts of the network.

Harvesting rain water during rainy season is reasonable for decreasing the volume of water bought for irrigation. This could be done by both the municipality and the residents. Also the irrigation should be done during night time to decrease the volume of water used for that, or at least avoid the high evaporation times around at daytime and afternoon.

The municipality was also considering the opportunity to mix NamWater water with borehole water to reduce the volume of water needed from NamWater. In case of serious health problems from this kind of mixed water, it would be really difficult, if not impossible, to trace back what is causing the quality problem and who is responsible for it. Because of this it is not recommended to mix these in to the same network as it is also possible to use them separately. The municipality should bear in mind that it is their responsibility to always serve safe water for the residents.

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APPENDIX 1: MUNICIPALITYS WATER SECTOR BUDGET

INCOME	Budget July 2012 / June 2013	Actual July 2012 / June 2013	Budget July 2013 / June 2014
Sundries	45 000	-50 445,09	45 000
Public sales	15 000 000	15 207 521,93	17 000 000
Contributions	0	640,83	0
Departmental sales	0	183 291,80	0
TOTAL INCOME	**15 045 000**	**15 341 009,47**	**17 045 000**

EXPENDITURE	Budget July 2012 / June 2013	Actual July 2012 / June 2013	Budget July 2013 / June 2014
Staff expences			
Salaries & allowances	2 283 099	2 203 168,68	2 235 000
Total staff expences	2 283 099	2 203 168,68	2 235 000
General expences			
Fuel	80 000	112 171,45	80 000
Protective clothing	20 000	30 071,05	20 000
Termination leave	0	9 231,30	0
Long service allowance	0	3 978,03	0
Cleaning materials	5 000	33 487,45	10 000
Vehicle registration	2 000	3 089	2 000
Water purchase-NamWater	10 000 000	17 024 827,97	11 000 000
Treatment-Water	30 000	5 386,99	30 000
Printing and Stationery	1 000	433,32	1 000
EU funded project contribution	255 000	310 282,80	255 000
Casuals	100 000	15 256,24	20 000
Cellphone credits	1 200	0	0
Unpaid leave	0	-5 073,89	0
Sundry payments	0	24 427,24	0
Total general expences	10 494 200	17 567 568,95	11 418 000
Repairs and maintenance			
R&M-tools & equipment	20 000	23 933,27	20 000
Machinery & Equipment	3 000	4 635,96	3 000
Water - Network	400 000	592 661,22	400 000
Vehicles	10 000	17 962,48	10 000
Total R&M	433 000	639 192,93	433 000

Redemtion and Interest			
Interest on external loan	25 000	20 685,61	1 000
External Loan Redemption	20 000	28 295,81	1 000
Interest HP: vehicles	72 000	0	0
Total redemption & int.	117 000	48 981,42	2 000
Contribution to Capital Spending			
Capital	350 000	0	0
Water network upgrade	2 000 000	0	1 300 000
Water meter NamW/Dam	100 000	0	30 000
Prepaid water meters	0	0	0
Borehole mix with NamWater	0	0	20 000
Total capital outlay	2 450 000	0	1350000
Contrib			
Water network upgrade	2 000 000	0	0
Vehicle EU Water project	0	195 175,60	0
Total contrib	2 000 000	195 175,60	0
TOTAL EXPENDITURE	**17 777 299,00**	**20 654 087,58**	**15 438 000**

SURPLUS / DEFICIT	**Budget July 2012 / June 2013**	**Actual July 2012 / June 2013**	**Budget July 2013 / June 2014**
	-2 732 299,00	**-5 313 078,11**	**1 607 000**

APPENDIX 2: BIGGEST CONSUMERS IN KEETMANSHOOP

	Place	Metered consumption (m^3/year) 2010/2011	2011/2012	2012/2013
1	Hospital	0	7747	76002
2	P.S.K. School	13742	23856	34249
3	Suiderlig School	34944	11646	28977
	Suiderlig School Hostel	9823	5929	4958
4	P.K. De Villiers Boys Hostel	18538	13657	17915
	P.K. De Villiers Girls Hostel	8016	9332	10287
	P.K. De Villiers School	4131	3022	2012
5	J.A.Nel School	4522	1884	13296
6	NIMT (Institute of mining tech.)	9571	8815	11936
7	Prison	12910	11664	11325
8	Police station	11010	10145	9418
9	Daan Viljoen Klinic	5283	9459	9335
10	St. Mathias PS	5494	7789	7460
11	Canyon Hotel	5616	6150	-
12	Transnamib Station building	5407	8655	5635
13	Maritz Country Lodge	1623	3862	4708
14	Ons Tuiste Old age home	6746	5966	4567
15	Jaselra Properties (Badmintons)	4616	4145	4215
16	Karma Properties (Central Lodge)	1990	1411	3466
17	Stalls in Kroenlain	-	-	3138
18	Construction Namibia Ltd	-	-	2911
19	Min. of Fin. Inland&Rev.	7672	3901	2773
20	Judith Maria (J.J. Supermarket)	1737	1775	2660
21	Oosthuizen Jacobus (O.K. Shop)	3252	3139	2359
22	Nuwe Welkom (Spar)	1796	1975	2239
23	Rural Water (Ministry, office)	3334	2252	2182
24	Keetmanshoop Privaatskool	1059	1363	2151
25	Multipurpose Youth Center	6811	5208	2009
26	Military base	-	-	1694
27	Bird's Nest	-	-	1671
28	La Rochelle (Bed&Breakfast)	1404	1634	1669
29	Police Barracks (Tseiblaagte)	1584	1848	1645
30	Sundown selfcatering acc.	-	-	1282
31	Keetmanshoop health center	-	-	1045
32	Wholesale shop	-	-	977
33	IGL PTY LTD t/a Afrox	1156	1320	979
34	Retief Maria Guest House	-	-	511
35	Nampol Police (Tseiblaagte)	933	760	446
36	Schutzenhaus CC	-	-	253
37	D+K Builders (constructions)	-	-	234

APPENDIX 3: MUNICIPALITYS OWN WATER USE [m³] 2013

September 19th, 2013

X = the meter has been broken

	Place	January	February	March	April	May	June	July	August	TOTAL 8 months	AVERAGE Monthly	ESTIMATE Annually
1	Municipality street (opp. P.K De Villers Sch. gate)	11	33	14	4	17	19	47	12	157	20	236
2	Opposite Ministry of finance	19	35	36	23	36	45	64	52	310	39	465
3	Opposite Main office	20	28	23	17	19	20	18	20	165	21	248
4	Opposite mun. water services office	7	10	12	9	9	8	3	9	67	8	101
5	Opposite the book shop	4	8	15	12	7	8	6	7	67	8	101
6	Opposite FNB	6	16	19	17	10	10	16	8	102	13	153
7	22nd avenue island No.1	19	35	145	60	7	39	18	38	361	45	542
8	22rd avenue island No.2	31	29	67	33	3	10	25	18	216	27	324
9	22th avenue island No.3	19	134	59	167	7	21	37	28	472	59	708
10	22th avenue island No.4	5	16	X	X	X	X	X	X	21	11	126
11	Riool damme	1	5	8	2	1	2	3	7	29	4	44
12	Carvan park No.1	7	17	6	5	6	5	2	6	54	7	81
13	Carvan park No.2	115	67	87	92	55	43	22	31	512	64	768
14	Caravan park No.3	1	11	7	8	12	11	15	5	70	9	105
15	Cemetry No.2 (in town)	5	8	4	3	19	6	34	19	98	12	147
16	Cemetry No.3 (in town)	26	60	50	41	25	37	30	18	287	36	431
17	Horse stall at stadium No.1	X	32	25	84	35	77	103	57	413	59	708
18	Horse stall at stadium No.2	X	40	43	70	46	58	23	25	305	44	523
19	Wesdene Horse stall	X	X	X	X	X	X	X	X	-	-	-
20	Kronline cemetry	76	66	94	81	96	18	110	76	617	77	926
21	Kronline stadium house	9	33	31	18	25	7	13	11	147	18	221
22	Kronline park	X	12	23	X	X	X	X	removed	35	18	210
23	New warehouse care taker house	18	21	11	15	13	9	10	7	104	13	156
24	New warehouse	405	72	X	235	207	173	185	263	1540	220	2640
25	Old warehouse	X	X	28	38	23	52	50	27	218	36	436
26	Old warehouse care takers house	105	109	73	82	53	69	X	X	491	82	982
27	Park in Westdene No.1	20	9	5	9	0	6	1	4	54	7	81
28	Park in Westdene No.2	X	15	24	11	X	X	X	X	50	17	200
29	Swimming pool	255	470	352	334	271	349	354	246	2631	329	3947

30 Swimming pool house	X	X	X	6	12	16	15	16	65	13	156
31 Keetmanshoop stadium	X	341	1328	1114	918	795	809	699	6004	858	10293
32 Keetmanshoop care taker house	20	7	7	8	7	6	8	6	69	9	104
33 Keetmanshoop stadium house	39	5	8	7	7	6	12	8	92	12	138
34 Jackson Witbooi's stall room	1	0	1	1	2	0	0	removed	5	1	9
35 Threecorner park in Wesdene, opp. Stadion 1	769	53	170	266	165	134	200	252	2009	251	3014
36 Threecorner park in Wesdene, opp. Stadion 2	86	27	68	190	159	125	114	294	1063	133	1595
37 J.Stephanus stadium	102	136	53	118	83	52	126	165	835	104	1253
38 J.Stephanus stadium, care taker house	10	1	21	12	14	12	19	12	101	13	152
39 W.K. Rover hall in Tseiblaagte	62	166	24	46	18	31	114	12	473	59	710
40 Municipality in Tseiblaagte	161	169	119	154	76	69	92	51	891	111	1337
41 Community toilet in Ileni	X	10	55	77	X	X	X	removed	142	47	568
42 Cemetry in Tseiblaagte	X	X	X	X	X	X	X	X	-	-	-
43 Traffic office	101	139	77	70	57	52	53	48	597	75	896
44 Natis (Driver's License registration building)	74	71	52	28	31	10	23	30	319	40	479
45 Swakara monument	28	15	3	4	2	4	5	4	65	8	98
46 Municipality workshop	37	31	24	34	10	12	21	22	191	24	287
47 Behind Rcc. Mission church	X	X	X	X	X	189	213	15	417	139	1668
48 Municipality water services office	X	X	X	10	11	11	32	10	74	15	178
49 Noordhoek park	12	85	29	25	X	58	20	X	229	38	458
50 Museum	47	80	1079	164	76	115	53	52	1666	208	2499
51 Show hall	56	275	92	113	67	91	65	73	832	104	1248
52 Central park	163	294	336	331	248	277	48	X	1697	242	2909
53 Monument garden	79	81	136	103	86	96	110	79	770	96	1155
54 Municipality head office	429	571	544	491	284	281	505	321	3426	428	5139
55 Month hall	228	19	66	43	129	31	183	114	813	102	1220
										4430	**53161**

APPENDIX 4: MAP OF KEETMANSHOOP WATER NETWORK

NOTES

All measurements, locations and sizes given are approximate

KEETMANSHOOP

LEGEND

- Municipal pipeline
- End Cap
- Shutvalve Confirmed
- Shutvalve Estimated
- Fire hydrant confirmed
- Fire hydrant estimated
- Borehole
- Borehole pipeline

Date	Description	Initials
18.8.2013	Corrections to valves and pipelines. Connections at Donkie Draai updated.	MT & GH
July2012	Fieldwork with 'Jackals'. Corrections to valves and pipes. New lines added.	MAa & JH
8.8.2010	Shut valves confirmed, adjustments of pipes	AL& NH
29.7.09	New shut valves added, corrections of some mistakes	MS
25.8.08	Borehole water pipeline added, reservoir areas checked	RS
29.7.08	Adjustments, newly developed area included in Krönlein	AA

Drawn and Prepared by:

PLDDSI–PROJECT

DATE:

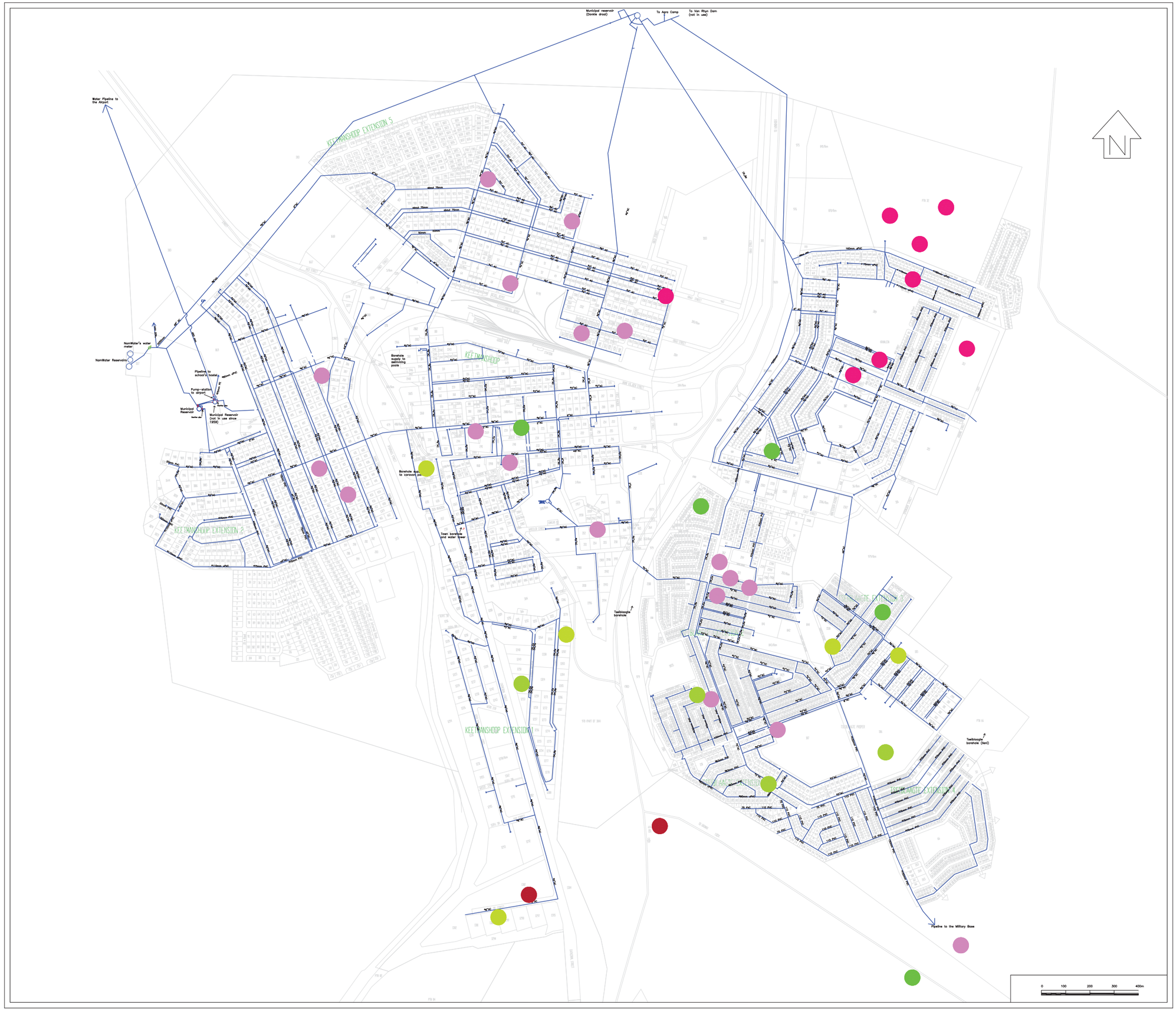
18.8.2013

KEETMANSHOOP Water Reticulation

APPENDIX 5: PRESSURE MEASUREMENTS IN KEETMANSHOOP

Number	Date	Time	Area	Place	Pressure [kPa]
1	August 8th	11:30	Town center	Our own office	350
2	August 8th	11:55	Industrial area	Municipality store house	600
3	August 8th	14:00	Westdene	Park	320
4	August 8th	14:10	Westdene	House	390
5	August 8th	14:30	Westdene	Rugby stadium	390
6	August 8th	14:40	Nordhoek	Municipality garage	320
7	August 8th	14:50	Nordhoek	Nordhoek park	340
8	August 8th	15:00	Nordhoek	Nordhoek erf 856	310
9	August 8th	15:45	Town center	Municipality head office	420
10	August 8th	16:00	Town center	Caravan park	540
11	August 9th	9:05	Kroenlain	Hospital (tap no. 1)	220
12	August 9th	9:10	Kroenlain	Hospital (tap no. 2)	230
13	August 9th	9:12	Kroenlain	Hospital (tap no. 3)	230
14	August 9th	9:25	Kroenlain	Suiderling school hostel	240
15	August 9th	10:00	Tseibglaate	J.A.Nel SSS hostel	640
16	August 9th	10:20	Tseibglaate	Municipality office, Erf 570	310
17	August 9th	10:30	Tseibglaate	House, Erf 2004	350
18	August 9th	10:45	South	Military base	370
19	August 9th	11:25	South	Engen petrol station	420
20	August 12th	14:00	Tseibglaate	Evangelish luterian chuch, Erf 256	600
21	August 12th	14:10	Tseibglaate	House, Erf 662	340
22	August 12th	14:20	Tseibglaate	House, Erf 1998	650
23	August 12th	14:30	Tseibglaate	House next to stadium	320
24	August 12th	14:45	Tseibglaate	House, Erf 483 (Kopieslachte)	460
25	August 12th	14:55	Tseibglaate	House next to graveyard (Soweto)	540
26	August 12th	15:05	Tseibglaate	House, Erf 911 (Sun up)	550
27	August 12th	15:20	Kroenlain	House, Erf 587 (Smarties)	320
28	August 13th	10:25	Kroenlain	St. Nicholas church	400
29	August 13th	10:38	Kroenlain	St. Matthias Primary School (opp. erf 289)	240
30	August 13th	11:05	Kroenlain	House, Erf next to 643	340
31	August 13th	11:20	Kroenlain	Disability center, Erf 1586	400
32	August 13th	11:30	Kroenlain	NAMCOL, Gordon street	260
33	August 13th	11:45	Kroenlain	House, Erf 834	280
34	August 13th	14:20	Industrial area	Roads construction company	740
35	August 13th	14:35	Industrial area	Supersand company	570
36	August 13th	14:50	South	Customs	700
37	August 13th	15:03	Industrial area	Pro-Edge Auto	590
38	August 13th	15:12	Town center	Karas regional council	360
39	August 13th	15:25	Town center	Puma service station	320
40	August 14th	9:45	Nordhoek	House, erf 1498	250
41	August 14th	9:53	Nordhoek	House, erf 1552	300
42	August 14th	10:03	Nordhoek	House on 1st street	300
43	August 9th	14:20	North	Airport tap 1 (own pumping station)	140
44	August 9th	14:25	North	Airport tap 2 (own pumping station)	150

APPENDIX 6: WATER DISTRIBUTION NETWORK PRESSURES IN KEETMANSHOOP



KEETMANSHOOP

Municipal pipeline

- 200 – 290 kPa
- 300 – 390 kPa
- 400 – 490 kPa
- 500 – 590 kPa
- 600 – 690 kPa
- 700 – 790 kPa

KEETMANSHOOP
Water
Reticulation

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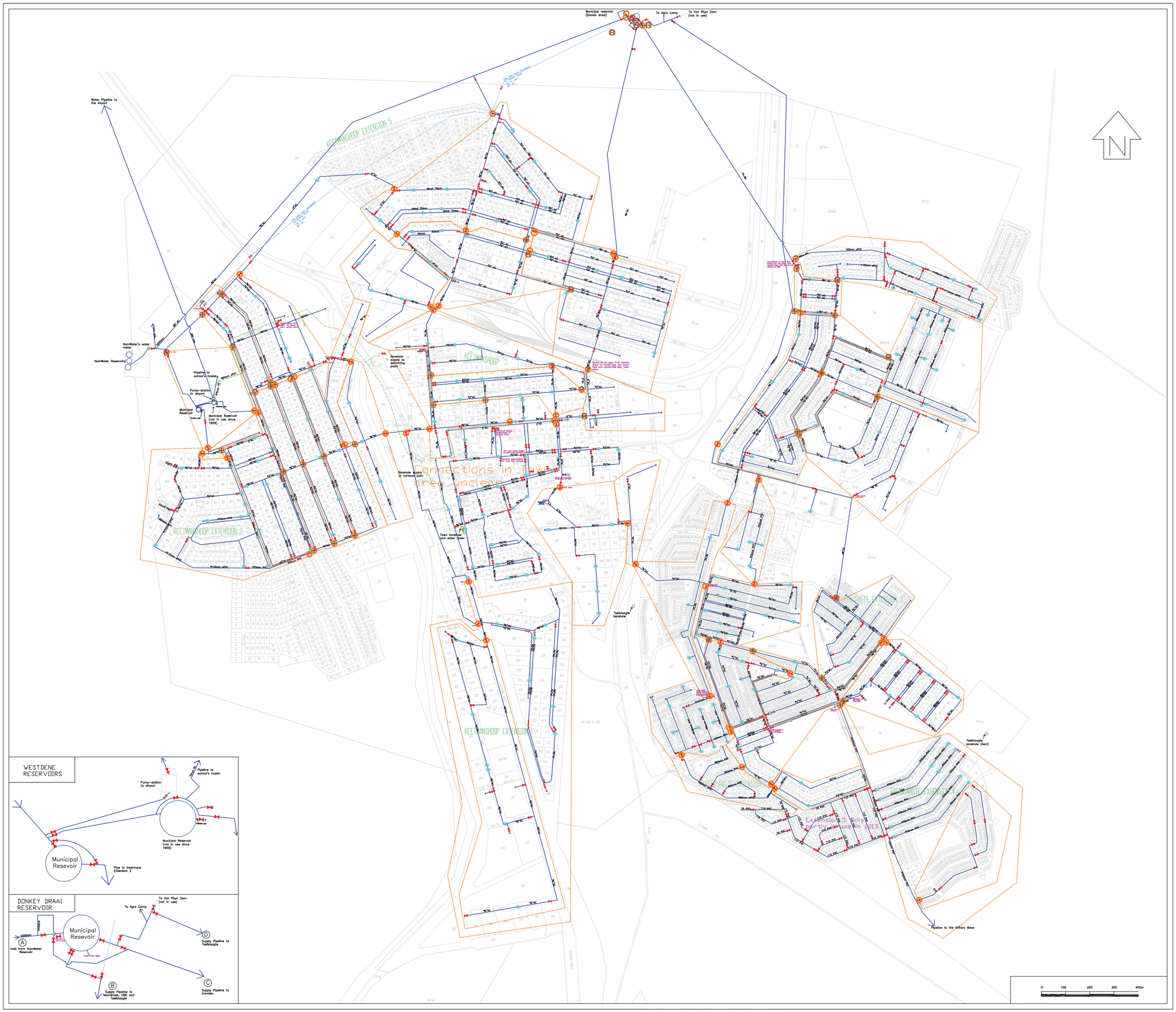
APPENDIX 7: PLAN TO DIVIDE KEETMANSHOOP WATER DISTRIBUTION NETWORK IN SECTORS

(Aalto)



NOTES

All measurements, locations and sizes given are approximate

KEETMANSHOOP

LEGEND

- Municipal pipeline
- End Cap
- Shutvalve Confirmed
- Shutvalve Estimated
- Fire hydrant confirmed
- Fire hydrant estimated
- Borehole
- Borehole pipeline
- An important valve, works
- Add a valve
- Replace the valve
- An important valve, don't know about working

Date	Description	Initials
18.8.2013	Corrections to valves and pipelines. Connections at Donkie Draai updated.	MT & GH
July2012	Fieldwork with 'Jackals'. Corrections to valves and pipes. New lines added.	MAa & JH
8.8.2010	Shut valves confirmed, adjustments of pipes	AL& NH
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DATE:

18.8.2013

KEETMANSHOOP Water Reticulation

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APPENDIX 8: ORGANIZATION CHART OF KEETMANSHOOP MUNICIPALITY