JIMMA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

JIMMA INSTITUTE OF TECHNOLOGY

FACULTY OF CIVIL AND ENVIRONMENTAL ENGINEERING

HYDRAULIC ENGINEERING MASTER SCIENCE PROGRAM

WATER SUPPLY COVERAGE AND WATER LOSS IN WATER DISTRIBUTION SYSTEM:-THE CASE OF CHANCHO TOWN, OROMIA, ETHIOPIA

By: HENOK GIRMA

A THESIS SUBMITTED TO SCHOOL OF GRADUATE STUDIES OF JIMMA UNIVERSITY IN PARTIAL FULFILLEMENT OF THE REQUIREMENTS FOR DEGREE OF MASTERS OF SCIENCE IN HYDRAULIC ENGINEERING

Feb, 2018

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BY: HENOK GIRMA

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JIMMA, ETHIOPIA

Declaration

This thesis entitled with Water Supply Coverage and Loss in Water distribution system, a case study of Chancho Town; has been approved by the following advisors, department head, and coordinator and Director of Graduate studies in partial fulfillment of the requirement of the degree of Master of Science in Hydraulic Engineering.

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Abstract

Problems in provision of adequate water supply to the rapidly growing urban population in developing countries are increasing dramatically. Losses could be caused by various factors and be considered as the amount of potable water loss from a supply source in transmission and distribution system. The need to manage water loss in pipe networks of most municipalities became urgent in recent years due to water shortages. The main objective of this study was to evaluate the water supply coverage and explore water loss in the distribution system of Chancho Town. Surveys, unstructured interviews, focus group discussion, and observation was used to triangulate the findings of the quantitative survey. Software such as WaterCAD6.5 and GIS map10 to be used for analysis. The study was carried out in Chancho Town and the population is 26,745 and the study would identify and analysis the water supply coverage and total water loss in distribution system in Chancho Town. The finding of this study showed that water supply coverage and water loss in Chancho town are 56% and 22.16% respectively. The coverage of the town water supply declines as time goes on from 2011-2015G.C. However, floating population who shares from the daily water proceed, for hospitals, hotels and health centers contributed to the water shortage of the town. In 2013 and 2015 water supply coverage was higher comparing with 2012. Drilling two different boreholes in each year to be utilized the coverage. The water loss trend of the town was fluctuating from year to year. This could be due to road, and hotels construction in Chancho Town and breakage of pipes was occurred, and this maximized water loss. Water loss was increases in 2014 comparing with 2015 because expansion of construction started. This study found out average per capita consumption was much lower as compared with some water supply standards. Uneven distribution of water and the spatial distribution of the pipe network system do not satisfy the demand of the public. The water loss in Chancho Town was intermediate and loss was increase and decrease, depending on time of construction.

Keyword*:-Consumption: Water loss: Water production: Water Supply Coverage*

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Acronyms

CSA	Central Statistics Agency of Ethiopia
DMA	District Metering Area
DCI	Ducktail Cast Iron
EC	Ethiopian Calendar
EPA	Environmental Protection Authority
ETB	Ethiopian Birr
GIS	Geographical Information System
GPS	Global Position System
HGL	High Gradient Level
IWA	International Water Associations
NRW	Non Revenue Water
NFPA	National Fire Protection Association
UFW	Unaccounted for Water
USEPA	United State Environmental Protection Agency
WHO	World Health Organization

1 Introduction

1.1Back Ground

Sufficient potable water supply was one of the basic urban service, which highly affects the economic progress of towns and the health of their people. However, many urban centers around the world were facing serious problem of water supply. The problem in most of the third world countries, including Ethiopia, was particularly worst and multidimensional (Assefa, 2006)

Problems in providing satisfactory water supply to the rapidly growing population especially that of the developing countries is increasing from time to time. Water supply system in urban areas are often unable to meet existing demands and are not available to everyone rather some consumers take disproportionate amounts of water and the poor is the first victim to the problem (Bereket,2006). Access to adequate quantity of safe water is a fundamental human need. However, according to the Global Water Supply and Sanitation assessment Report, (2000) the percentage of people served with some form of improved water rose from 79% (4.1billion) in 1990 to 82% (4.9billion) in 2000. At the beginning of 2000, one sixth (1.1 billion people) of the world population was without access to improved water supply. The majority of these people live in Asia and Africa, where two out of five African's lack of improved water supply. The 2000 (G/C) coverage of water supply for the urban population of Africa and Ethiopia was 85% and 77% respectively. According to the millennium goal targets, the African urban areas will be accessed for improved water with 15 years from the year 2000. On the other hand, in Africa largest cities, only 43% inhabitants have house connection water supply services.

Unaccounted for water include water losses due to leakage in the water supply system, illegal connections, legitimate unmetered for flushing, over flow from reservoirs, improper metering and others for which bills are not paid. It is very crucial to estimate this quantity as it usually varies from 15 to 50% depending on the age of pipelines in the system and the size and complexity.

Limited institutional capacity is also one of the bottlenecks that hinder cities of developing countries for managing their infrastructure asset in general and water supply in particular. Besides to low coverage, water losses (physical loss) in urban water supply is accounted to more than 50% of the supplies that mainly arise from leakage of pipes, on joints and valves, over flowing service reservoir and waste of water through illegal connection and non-metered house connections..

Although leakage is one of the major causes for loss of water in networks distribution system, the loss of water through illegal connections and non-functioning meters is also contributing a lot; that needs a proper management and monitoring system. While developed towns have started using on-line continues operation and monitoring service, the developing towns have grate difficult even to collect information on their previously performed operation and maintenance activities that could help them developing a strategy for the future. Many developed countries use water audit procedures to determine the efficiency of the system and to identify the location and magnitude of water losses (Wolde, 2005).

Water CAD was adjusted to allow for modeling pressure dependent demand, for dealing with low pressure and “dry pipe" situations. A configurable tool was developed for incorporating roof tanks into the water supply analysis and for better formulation and schematization of the system hydraulics. Cases studies, water distribution model of Chancho Town are used to illustrate the practical use of this approach.

In more recent years, the ability to model water utility and water age has been added to hydraulic models (Clark and Grayman, 1998). There are many commercial models that offer a wide range of capabilities in distribution system modeling EPANET and WATER CAD are an open-structured, public domain hydraulic and water quality model developed by USEPA and is used worldwide (Rossman, 2000).In order to facilitate the examination of required pipe sizes, the standard Water CAD model was modified for use in the study project of simulating large distribution systems (Walski, et al, 2001).

The rapid increase in population, economic development and awareness of health benefits of improved water and sanitation have been proven by WWDSE (2010) to cause rise in water demand, necessity of improved system infrastructure management and strategies to deliver clean and safe drinking water to customers. Even though distributing the available water and water loss from a utility’s distribution system is a growing management problem in Ethiopia, there are few studies conducted on the existing water utilities in the country related to waterloss and coverage. Although the Chancho town water utility distribution system components were built decades ago and are currently in need of attention, issues related to the overall coverage of water supply and water loss from the utility are not investigated yet. Therefore, assessing the water supply coverage and water loss using statistical and water audit methods in order to develop strategies for the future is more urgent than ever. For that reason this study mainly deals with water supply coverage and loss assessment and developing strategies for the water loss reduction in Chancho town water utility

Problem in provision of adequate water supply to the rapidly growing urban population are increasing dramatically. Water demand in the domestic sector of developing town including Chancho increases through time that as a result demand for additional water sources and infrastructure. Financial and technical constrain is one of the major factors for the low water coverage of the water supply but poor management of the existing water supply also has a great impact for the low coverage. Beside to the overall low supply coverage, supply disparity existing among different localities. Therefore evaluating the town distribution of the water supply is important in order to identify the problematic areas and intervene accordingly.

1.2 Statement of the problem

A high level of real or physical loss reduces the amount of precious water reaching customers, increases the operating costs of the utility and makes capital investments in new resource schemes larger. A high level of apparent or commercial losses reduces the principal revenue stream to the utility. Components of water loss or Non-Revenue Water (NRW) are real losses or Physical losses. Real (physical) losses are: reported and unreported bursts on pipes, background Leakage on pipes and fittings, and Leakage and overflows from service reservoirs. Apparent (commercial) losses are errors on source and production meters, Errors on customer's meters, unauthorized use i.e. illegal connections and theft.

Adequate and safe water supply was one of the basic urban service, which highly influence economic progress of the city and the health of the people. The water resource availability was linked to economic and social progress, which suggests that the development was strongly influenced by water resource availability and management (Sullivan, 2002).

Chancho Town pipe lines leakage is often a large source of unaccounted for water and is a result of either lack of maintenance or failure to renew ageing systems. Leakage may also be caused from poor management of pressure zones, which result in pipe or pipe joint failure. Although some leakage may go unnoticed for a long time, detection of visible leakage also requires good reporting which includes some level of public participation.

Water loss occurs on all the systems, it is only the volume that varies and it reflects the ability of a utility to manage its network.

To understand the reasons why, how and where water is being lost managers have to carry out an appraisal of the physical characteristics of the network and the current operational practice. In many instances the problem of water loss is caused by poor infrastructure, bad management practice, network characteristics, operational practice, technologies, skills and social and cultural influences.

Water shortage and frequent service interruption is not only a consequence of the shortfall between demand and supply but also as result of unidentified leakage and complicated network systems. Depending on the context of the existing system both or one of the factors may be found as a root cause for the shortfall between demand and supply. As a cause of limited resources that as a result lead to poor maintenance and management of the water supply lines, leakage is observed as one of the main problems of the water supply service office.

Chancho Town has passed through various social and economic progress. However, increasing population, growing urbanization and socio-economic change of the people, have pushed up the demand for water extremely high in terms of quantity and quality. This clearly calls for the expansion and improvement of basic water supply service to give proper and timely response to the town water demand

1.3Objective

1.3.1 Main Objective

To evaluate the water supply coverage and explore the water loss in water supply distribution of Chancho Town.

1.3.2 Specific Objectives

The specific objectives of this study are:

- To evaluate water supply coverage of the town
- To identify components of nonrevenue water (NRW) in water supply
- To test and evaluate loss reduction strategies on a system
- To update existing network and propose new pipe size

1.4 Research Questions

- How much was the per capita demand of Chancho town?
- Which Component is nonrevenue water in water supply?
- How much water was lost in the entire town and what were possible causes and consequences of water losses?
- What is the existing pipe of the town and which part of the pipe can need update?

1.5 Expected outcomes

A municipality would benefit through reduced water loss and reduced costs to the utility. The importance of prioritizing active leak control practices and procedures in the identification of water loss and the corresponding strategies to reduce leakage cannot be understated. The municipality would also benefit through the extension of sustainable water supplies, reduce operating costs, improved system hydraulics and utility efficiency and this methodology would allow more rational performance measures to be calculated for systems, and utilities for realistic national and international performance comparisons of water loss management.

1.6 Scope

The first objective of this study was to provide municipalities with a basic common method of accounting for the water used and loss in their water distribution system. The intent was to use standard terms that were recognized internationally, allowing municipality to communicate readily and understand each other. By accounting for the water, municipalities can made operations, maintenance, and capital improvement decisions in the best interests of their local Administrative and the community they serve. This best practice would help municipalities prioritize their capital and operating decisions and better safeguard their system from water loss.

Two leading organizations represent municipalities, water utilities, individuals and other organization, in matters relates to this guide.

This, in turn, would allow their knowledge and expertise to be disseminated by these organizations for the benefit of municipalities and potable water suppliers everywhere. The scope of this study wereto evaluate of the water supply coverage of Chancho Town and total water loss in distribution system.

1.7 Significant of the study

The significance of the research is to now the water supply coverage of the Chancho Town and to save some amount of unaccounted for water. This study was expected to increase the understanding and provide up to date information of the town water supply size and its undesirable impacts on the urban community due to shortage of water supply. It would also serve as a working document to decision makers in the water sector and the non-governmental organizations. Moreover, the findings would further serve as reference material for any further investigation in the area.

1.8 Limitations

The limitations of data collection completely depend on the municipality and Chancho Water Supply and Sewerage Enterprise. There were some sorts of limitation while this document was prepared. Shortage of relevant data for the compilation of literature review, data would not organized in computerized system. A municipality must consider how it would collect, store and evaluate the data to allow it to make the most informed decisions.

2 Literature Review

2.1 Urban water demand and coverage

2.1.1 Urban water coverage

Water supply coverage provides a picture of the water supply situation of one specific country or city and helps to compare one country with other and inter and intra city distribution with in specific country. The percentage of population with or without piped water connection is relevant indicator to compare the coverage of water supply in urban areas. Although the water supply coverage is better in urban areas while compared to rural areas, the actual water supply coverage in cities of developing countries in general and African cities in particular is very low while compared to the demand.

A household is considered to have access to improved drinking water if it has sufficient amount of water (20liters/person/day) for family use, at an affordable price (less than 10% of the total household income), available to household members without being subject to extreme effort (less than one hour) a day for the minimum sufficient quantity, especially to women and children (UN-Habitat, 2003).

On the other hand a minimum quantity of 25 liters of potable water per person per day provided at a minimum flow rate of not less than 10 liters per minute with the sources being available within 200 meters from a household and the supply not interrupted for more than seven days per year (i.e. water should be available 98%of the time) is considered as a basic service for southern African cities' domestic water supply (Welday, 2005)

2.1.2 Water Demand management

Water demand is defined as the volume of water requested by users to satisfy their needs. In a simplified way it is often considered equal to water consumption, although conceptually the two terms do not have the same meaning (Wallingford, 2003)

Water demand management refers to any socially beneficial action that reduces average or peak water withdrawals or consumption from either surface or ground water, consistent with the protection or enhancement of water quality (Tate, 2002). According to Rothert and Macy (2002), water demand management is the adaptation and implementation of a strategy by a water institution to influence the water demand and usage in order to meet any of the following objectives: economic efficiency, social development, social equity (Mwenderaetal.., 2003)

Urban water demand is classified in to different category that domestic water demand that includes in house use and out of house is among the others. In house use includes demands for drinking, cooking, sanitation, house cleaning, laundry and car washing while out of house use includes like garden watering, swimming pools, public stand pipes for public uses and fountains, etc. urban water demand is usually quoted in terms of liter per capita per day (l/cap/day)

2.2 Water loss and leakage

Regardless of the magnitude that greatly varies from town to town or from one area to another, water loss is a problem experienced in all water distribution system. The first and for most cause of water loss is leakage. Water put to inappropriate or excessive uses may also be considered as loss. Water that is unaccounted for because of measurement errors, including inaccurate meters, forgotten users and unmeasured uses are also some of the causes for water losses.

2.2.1 Comparing water losses

The amount of water loss differs from country to country, town to town and even from network to network in the same town. Different countries uses different indicators to evaluate their states in comparison with others and to compare the distribution of water loss from one location to other distribution system in order to take action based on the level of loss. As stated above competition using Unaccounted for water (UFW) expressed as percentage has limitation when used for comparison as it highly depends with the volume of water produced. The traditional performance indicators of water losses are frequently expressed as a percentage of input volume. However, this indicator fails to take account of any of main local influences. Consequently it cannot be an appropriate performance indicator (PI) for comparison (WHO, 2001).

Deplaned upon the consumption per service connection, the same volume of real losses/service connection/day, in percentage terms, is anything from 5% to 30%. Thus developing countries with relatively low consumption, can appear to have high losses when expressed in percentage terms, percentage loses for urban areas in developed countries with high consumption can be equally misleading (Farley and Trow, 2003).

To avoid the wide diversity of format and definitions related to water loss, many practitioners have identified an urgent need for a common international terminology that among them task forces from the international water association (IWA) recently produced a standard approach for water balance calculation with a definition of all terms.

Table 2.1 IWA Standard international terminologies (Source, Farley and Stuart 2003)

System input volume	Authorized consumption	Billed Authorized consumption	Billed metered consumption	Revenue Water
			Billed unmetered consumption	
		Un Billed Authorized consumption	Unbilled consumption	Non-Revenue Water
			Unbilled unmetered consumption	
	Water Loss	Apparent Loss	Unauthorized consumption	
			Metering Inaccuracies	
		Real Loss	Leakage from water main	
			Leakage from storage tank	
			Leakage from service cup to revenue meter	

According to IWA the above terminologies are defined as below:

1 System input volume is the annual volume input to the part of the water supply distribution system

2 Authorized consumption is the annual volume of metered and/or non-metered water take by registered customers, the water supplier and other who are implicitly or explicitly authorized to do so. It includes water exported, and leak and overflows after the point of customer metering.

3 Non-Revenue Water (NRW) is the difference between system input volumes and billed authorized consumption.

4 Water losses are the difference between system input volume and authorized consumption, and consist of apparent losses and real losses.

5 Apparent losses consist of unauthorized consumption and all types of metering inaccuracies.

6 Real losses are the annual volumes lost through all types of leaks, bursts and overflows on mains, service reservoir and service connections, up to the point of customer metering.

2.2.2 Causes of water losses

Leakage is usually the major component of water loss in developing countries, but this is not always the case in developing or partially developed countries, where illegal connections, meter error, or an accenting error are often more significant (Farly and Trow, 2003). The other component of total water loss are non-physical losses, e.g. Meter under registration, illegal connections and illegal and unknown use (WHO, 2001)

2.2.3 Pressure and Leakage

In many water network systems, even though the total demand and the total loss of water can be known rather easily, information about the possible influence of local pressure upon demand is sadly lacking that as a result creates difficultly to assess and compare the demand and loss of water in its spatial distribution. Pressure distribution system on the one hand contributes to the shortage of water that as a result causes for unequal distribution of water among residents. To alleviate such problems, some water authorities develop a zoning scheme whereby the complete water distribution network is broken down in to manageable segments that can be easily metered and monitored and analyzed.

The leakage from water distribution system has been shown to be directly proportional to the square root of the distribution system pressure as indicated by the relationship below (Wallingford HR, 2003).Leak detection techniques that are in use in the water industry involve two major steps. There are estimation of leakage rate and location of leak.

2.2.4 Pressure Management through Distribution Systems

Pressure management can be defined as the practice to manage system pressures to an optimum level of service ensuring sufficient and efficient supply to legal uses and consumers, while eliminating or reducing pressure transients and variations, faulty level controls and reducing unnecessary pressures, all of which cause the distribution system to leak and break unnecessarily. There are many different tools that can be used when implementing pressure management, including pump controls, altitude controls and sustaining valves [Lambert et al., 2006]. It was reported that many water utilities introduced pressure management to their water distribution systems. In the most cases, large reductions in a new break frequency can be achieved over a wide range of pressures. In Australia, Canada, German and Italy, ongoing monitoring shows that the reductions in break frequency have been sustained for over five years to date by implementing pressure management procedure (Lamber et al., 2006). On the other hand, the rapid reduction in new break frequency following pressure management is immediately evident for water loss management. Some of the pressure management benefits reported by many different utilities include reduction in annual repair costs, reduction of the repair backlog, shorter run times for bursts, fewer emergency repairs more planned work, reduced inconvenience to customers.

Calculations of the economic benefit of pressure management have been based on the predicted reduction in flow rates of existing leaks and the value of the water thus saved. If management of excess pressure can also regularly achieved reduction in numbers of breaks of between 28% and 80% per year (Lamber et al., 2006), the annual savings in repair costs will usually be far greater than the value of the water saved.

Replacement of mains and services, the most expensive aspect of water distribution system management, is normally initiated by break frequencies that are considered to be excessive. Most water utilities consider break frequency to be a factor outside their control, and something that can only be remedied by expensive replacement of mains and services. However, if pressure management can reduce break frequencies and extend the working life of parts of the distribution infrastructure by even a few years, the economic benefits would generally be even greater than the short term reduction in repair costs.

A flow measuring system in a water distribution system should include not only measurement of total flows from source or treatment plants, but also zone and district flows. This allows the engineer to understand and operate the distribution system in smaller areas, and allows more precise demand prediction, leakage management and control to take place. The measurement system must therefore be hierarchical at a number of levels, beginning at production measurement, via zone and district measurement and ending at the customer’s meter.

The technique of leakage monitoring is considered to be the major contributor to cost-effective and efficient leakage management. It is a methodology which can be applied to all distribution networks. Even in systems with supply deficiencies leakage monitoring zones can be introduced gradually. One zone at a time is created and leaks detected and repaired, before moving on to create the next zone. This systematic approach gradually improves the hydraulic characteristics of the network and improves supply.

Leakage monitoring requires the installation of flow meters at strategic points throughout the distribution system, each meter recording flows into a discrete district which has a defined and permanent boundary. Such a district is called a district meter area and the concept of design and operation of DMA has been detailed in elsewhere in Farley and Trow, (2003).

The design of a leakage monitoring system has two aims:

1. To divide the distribution network into a number of zones or DMAs, each with a defined and permanent boundary, so that night flows into each district can be regularly monitored, enabling the presence of unreported bursts and leakage to be identified and located.
2. To manage pressure in each district or group of districts so that the network is operated at the optimum level of pressure.

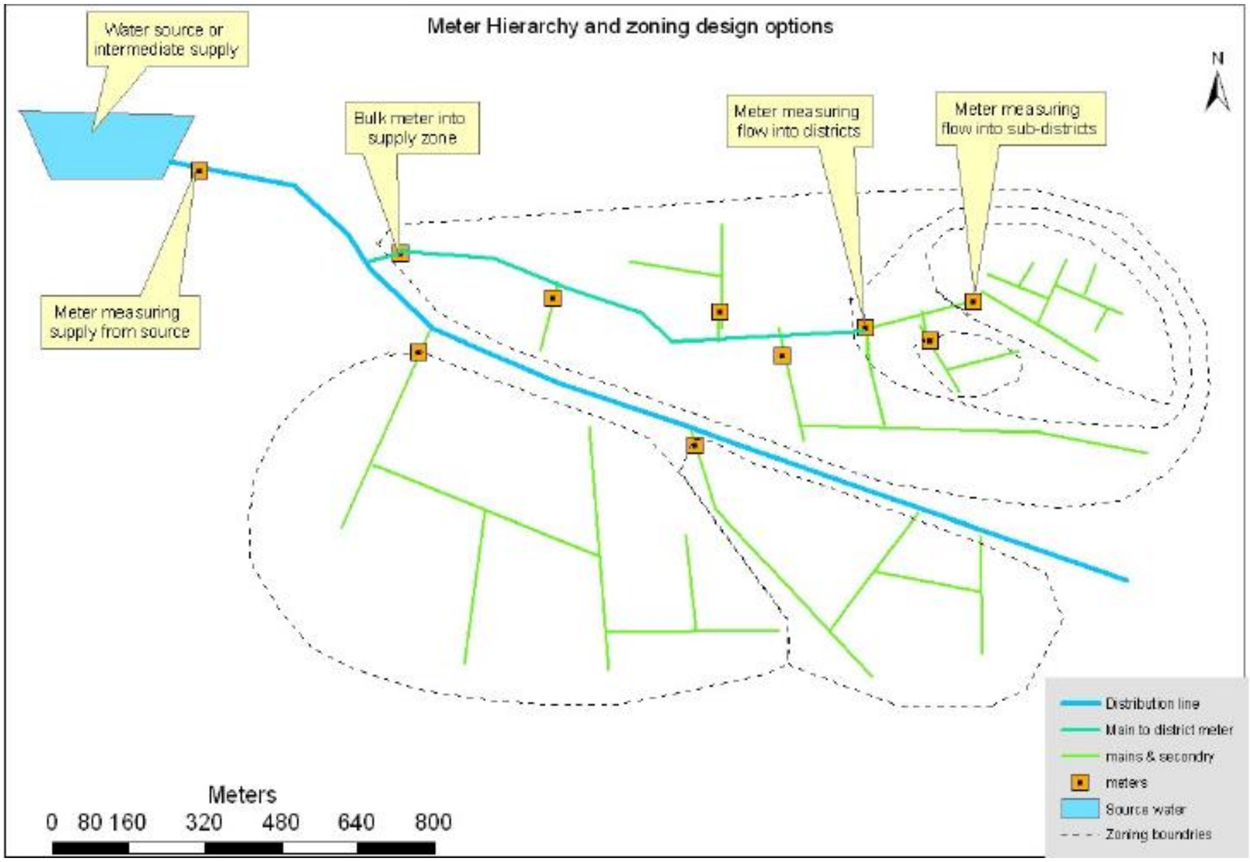


Figure 2.1 Metering Hierarchy and DMA design options (Farley and Stuart, 2003)

It therefore follows that a leakage monitoring system will comprise a number of districts where flow is measured by permanently installed flow meters. In some cases the flow meter installation will incorporate a pressure reducing valve.

2.2.5 Water Audits

Unaccounted-for water accounts for authorized unmetered use and under-registering metered use in addition to water lost as leakage (Smith et al., 2000). An overall survey of leaks is done as a part of water audit since, leakage is considered as a major component of unaccounted-for water.
A water audit involves comprehensive accounting of the total water pumped at a service station and water utilized at the consumer end. The water supplied at a utility is measured while being pumped into the network, and water consumed is obtained from billing records. Water lost as leakage is estimated from simple mass balance principle which can be stated as the difference between the amount of water produced at the utility and amount of water purchased by consumers.

Flow measurements taken in the distribution network give more precise estimates of leakage rates. A portion of the network is isolated using valves and measurements of flows entering the isolated portion of the network are taken for at least a period of 24 hours. Mass conservation principle is applied to that part of the network to estimate the average amount of leakage rate. However; such methods give only an approximate estimate of leakage rates.

2.2.6 Leak Location

The leakage control involves location of leaks across the distribution network. Acoustic equipment combined with correlation methods are generally used to locate leaks. Acoustic methods are based on changes in sound of the escaping water (Smith et al., 2000). Acoustic sound transducers are placed in contact with ground surface to listen to any abnormalities in the underlying pipes. In acoustic equipment accompanied by noise correlates, the acoustic signals from transducers are transmitted to a receiving unit, where the signals are processed automatically. Other leak detection methods employed are infrared thermograph, tracer gas methods, and mechanical drilling of soil.

2.2.7Water losses in distribution system

Water losses occurs on all the system and it reflects the ability of utility to manage the networks. The water losses consist of real and apparent losses. To understand the reason, why, how and where water was being lost, the managers have to carry out an appraisal of the physical characteristics of the networks and the current operational practice. The condition of the infrastructure and the renewal or rehabilitation perhaps one of the main reasons for the variation in leakage across the world. This problem was more pronounced in the developing countries with the ageing infrastructure (Liemberger and Marin, 2006). A high level of real loss reduces the amount of precious water reaching customers, increase the operating costs of the utility and makes capital investments in new resources schemes larger. Reducing water losses was a special concern of every water supply utility.

2.2.8Water loss management

Water encompasses a set of different values in different contexts (ecological, economical, and social). Water users depend upon a steady supply of enough hygienically safe water to be used for drinking, cooking washing. In urban areas, normally a water service provider has the responsibility to cater for these needs. Water loss management thus entails all the efforts a water service provider make in order to account for all the water that was being invested in it through production and distribution. The ultimate goal of this effort was to make sure that water losses were kept at a minimum. There would always be certain amount of leakage to varying degrees in any distribution system, but the key point was to try to get as much as possible of the water supplied to reach its intended users (Mathias, 2011). In order to make the water distribution system more efficient, utmost importance must be placed on water loss management. Independent of the type of method being used for performing a water audit, there would always be an uncertainty while calculating non-revenue water, apparent losses, and real losses. There were four methods of managing real losses: Those are improve maintenance replacement and rehabilitation, pressure management, improve response time for leak repairs and active leakage control.

Putting a focus on these four management methods could reduce real losses, but at a given average system operating pressure, the total real losses cannot be economically reduced any further than the value of unavoidable real losses. There were four methods for managing apparent losses: Those are unauthorized consumption (theft and illegal use), analysis errors between archived data and data for billing or water balance, meter accuracy error and transfer error between meter reading and archived data.

Depending upon the amount of attention given to each component related to apparent losses would increase or decrease. A primary purpose of the utility was to keep real and apparent losses at minimum to minimize use of water resources and maximize revenue.

2.2.9 Pressure and leakage management in water distribution system

Despite operational improvements over the last 10-15 years, water utilities still lose a significant amount of potable water from their networks through leakage. The most effective way to combat leakage was on one hand to locate and physically repair bursts and on the other hand to introduce pressure control to reduce background leakage from connection and joints. Reduction of leakage has two positive impacts on the environment and it minimize clean water losses and energy used for pumping and treatment of water (Hossam, 2011).

Water companies have tried many management strategies, which were general pipe rehabilitation, direct detection, and repair of existing leaks and operational pressure management. Direct detection and repair of existing bursts was one of the most powerful policies that was used to prevent the high-level leakage from bursts. Detecting and reducing burst was an attractive solution, and many algorithms have been developed to predict and detect the location and quantify the leakage in water distribution (Hossam, 2011). Operational pressure management was a cost-effective method for leakage reduction over entire DMAs, and for minimizing the risk of the further leaks by smoothing pressure variations. Many researchers have presented, developed, and implemented various methods and algorithms to optimize the operational pressure, and the results showed that, the leakage could be reduced by up to 60%. Hossam (2011), analyzed the effect of employing pressure management techniques on the operating costs of water distribution systems, which increases the savings by a 20-55% (Girard and Stewart, 2007) described implementation of the pressure. Leakage management strategies on the Gold Coast, Australia, and the results revealed a good opportunity to achieve significant water savings (Hossam, 2011) implemented a pressure management as a leakage reduction, in Zimbabwe. The results showed that an operating pressure reduction from 77m to 50m result in 25% reduction in the total leakage.

2.2.10 Water loss reduction practices

In order to ensure that the utilization was made of the assets and the water supply itself, it was essential that the water flows were measured within the supply network. The design of the water supply system and construction, management, operation and maintenance must be understood and optimized. This issue would vary for each unique water supply system. There were a series of connected techniques, procedure, and methods to be applied to get a better managed.

A diagnostic approach, followed by the practical by implementation of achievable solutions could be applied to any water company, anywhere in the world, to develop water loss management strategy (Trow and Farley, 2006).

2.2.11Leakage monitoring and control

Leakage management could be classified into two groups including passive leakage control and active leakage control. Passive leakage control was reactive to report bursts or a drop in passive, usually report by customer or notes by the company's own staff while carrying out duties other than leaks detection. This method could apply in areas with low cost supplies.

Active leakage control (ALC) was when customer deployed company staff to find leaks, which have no reports. The main ALC methods were regular survey and leakage monitoring.

Leakage monitoring was flow monitoring into zones to measure leakage and to prioritize leaks detection activities. This has now become one of the most cost effective activities for leakage management programs. The most appropriate leakage control policy would mainly dictate by the characteristics of the networks and local condition, which may include financial constraints on equipment and other resources.

2.2.12Activities to reduce water losses

Effective and pro-active infrastructure management could prevent most water losses. The following infrastructure management activities would help to reduce real losses: Those are distribution system operation and maintenance to prevent breakdowns in equipment and the associate leakage, material and construction standards to assure quality of future infrastructure installation, maintain prober inventory to repair all sizes of main breaks or leaks, GIS mapping of system components to order quickly find valves to isolates main breaks, increased surveillance in areas with aging infrastructure or reported leaks, periodically checking proper operation and control of pumps used to fill storage tanks, leak detection surveys or studies and leak repair, water main rehabilitation and replacement, Pressure management.

The following activities would help reduce apparent water losses:

1) Metering of all source inputs, water experts or sales and customer accounts (includes billed, authorized use and non-billed authorized)

2) If not going to meter hydrants usage, accurately estimate and record the water used for firefighting or flushing.

3) Accounting and record keeping practice to improve reliable and accuracy of the water balance; more easily pinpoint areas with water losses (EPD, 2007).

2.2.13Acceptable water loss

It is a compromise between the cost of reducing water loss and maintenance of distribution system and the cost of water saved. AWWA leak detection and accountability committee (1996) recommended 10% as a benchmark for UFW.

Table2.2 UFW levels and action needed (Sarjo, 2008)

< 10%	Acceptable Monitoring and control
10-25%	Intermediate could be reduced
> 25%	Matter of concern, reduction

2.3 System Evaluation and Design

The designing and evaluating of community water supply distribution systems has to consider the amount of water for the commercial interests, governmental property, educational facilities, and all classifications of residential property as presented above in a general relationship to average and maximum daily consumption demand. At any time of the day, the day of the week, or the week of a given year, a structure fire or other fire emergency such as transportation vehicle fires or, in some cases, natural cover fires may erupt. Water is the primary agent of choice to confine, control, and extinguish structural fires. Some new development in fire extinguishing agents may be used for rapid knockdown of a fire, but a well-developed structure fire still requires established needed fire flows from fire hydrants to control and extinguish developing fires. Each community needs to evaluate and design or modify the design of the community water system to meet present-day needs to address future demands based on growth of the built area and population increases, along with the need to meet EPA criteria for water quality,. This will be an ever-increasing demand and challenge for every community water distribution system. Some specific guidelines on consumer consumption requirements and needed fire flows are established by the ISO, which represents in excess of 130 property and casualty underwriters in the United States in developing advisory insurance rates. The following topics address some fundamental information on understanding 1) water system demands, 2) determining design flow, and the very important topic of 3) water storage on a community water system. This should provide community leaders, municipal officials, fire department officials, water supply superintendents, and consulting engineers on water systems, a common knowledge base so that they all can sit at the same table and have a meaningful dialog about the present and future state of a specific water system and even how it may relate to adjacent water supplies in nearby community water systems.

2.3.1 Water system demands

Water demands need to be assessed on the basis of the following considerations:

a. The year and date the water supply system was commissioned or started supplying water through the distribution system. Hopefully, there is a water supply system map that will detail where pipes were laid, the size of the pipes, the pipe material, the location of the valves, the location, size and type of fire hydrants along with the lateral size and valve arrangements.

b. These water maps need to show all extension and changes to the water system covering the same topics as above.

A clear and accurate knowledge of the water system in place is needed before discussing changes to be made to existing systems. If this is to be a new community water system, all of these details should be laid out on a proposed street map for evaluation. If an Engineering Firm uses different criteria, it should conform to the most current publications of the National Fire Protection Association (NFPA), the ISO, the Civil Engineering Handbook, and any special State or county regulations.

There should be no oversight in considering both short-term and long-term goals. The primary objective is to make sure that the community is being serviced adequately. If there are deficiencies in meeting current or future goals because of economic constraints, this needs to be identified for the areas of the community where there may be inadequate flows to meet consumer consumption during peak water demand, so that constraints such as watering lawns and washing cars, can be placed on water usage. If available fire flows do not meet needed fire flows in specific districts of the community, the fire department needs to know these conditions on virtually a real-time basis. The local fire department may need to plan on relaying water from larger supply mains to fire sites using large- diameter hose or the existing water supply may need to be augmented by an alternative water supply using mobile takers from adjacent fire departments under automatic-aid and mutual-aid arrangements. Another alternative is to provide retention ponds in the community to capture runoff. Retention ponds may be outfitted with dry hydrants as a supplementary water supply for fire protection.

2.3.2 Planning water demand changes

Special planning is needed when new water demands will be placed on a specific community water system. This point cannot be overstressed. The amount of construction performed and the amount of construction that realistically can be accomplished to provide adequate service are dependent on when the construction will be needed. Ultimately, final development should be consistent with the utility's ability to provide consumer consumption and fire protection at the same time. Fire protection must not lag behind supplying domestic taps, as often occurs in new residential areas of communities. The planning and installation phase should assure that water supply for fire protection is never interrupted. There have been too many large-loss structure fires because the water system was shut down in the vicinity of the fire site.

The ideal way to develop a water distribution system would be to construct a distribution network of pipe that would adequately serve the short-range and long-range development of the service area. Individual construction projects, developments, subdivisions, and industrial complexes then could be developed without checking for adjustments to ensure that the original design plans remain adequate for all projected consumer consumption and fire protection demand. However, in reality, the best of plans needs to be adaptable to change measures where growth, moves, and demand may decline in older portions of a community. Therefore, the design for the source, through the treatment plant to the distribution system, must provide for growth and change in the delivery demand points. The best water system is the one that is designed with a vision for the future. Existing water systems have to evaluated and redesigned with a future perspective that includes a rehabilitation and/or replacement of existing system components due to the age factor. The maintenance of old infrastructures may be more expensive than the replacement with a better designed system that will meet both the future needs of water quality and distribution system demand.

The bottom line is that a water supply system cannot remain constant. It is the responsibility of elected officials, water supply superintendents and their staff, hydrologist, geologists, professional civil engineers, rural and urban planners as appropriate, fire officials and fire protection engineers, and representatives from the insurance industry to sit at the table and plan water systems for the future with due consideration to all of the regulations and requirements that are being placed on water systems at this time and in the future, especially as programmed by the

EPA. The cost to do this is not going to be any small thing, so the financial planning is just as important as the physical planning.

It is now recommended that every 3 to 5 years, as a minimum, existing water distribution systems be evaluated thoroughly for requirements that would be placed on it by development and reconstruction for a 20-year period into the future. A plan then should be developed for meeting those needs. In this way, individual improvements and projects can be evaluated and made to conform, generally, to long-term development and contingency plans for such events as serious system interruptions caused by natural disasters and terrorism attacks without undue additional expense to either the developer or the utility.

A water distribution system is a pipe network which delivers water from single or multiple supply sources to consumers. Typical water supply sources include reservoirs, storage tanks, and external water supply at junction nodes such as groundwater wells. Consumers include both municipal and industrial users. The pipe network consists of pipes, nodes, pumps, control valves, storage tanks, and reservoirs. Figure 2.1 illustrates a node-link representation of a simple water distribution network.

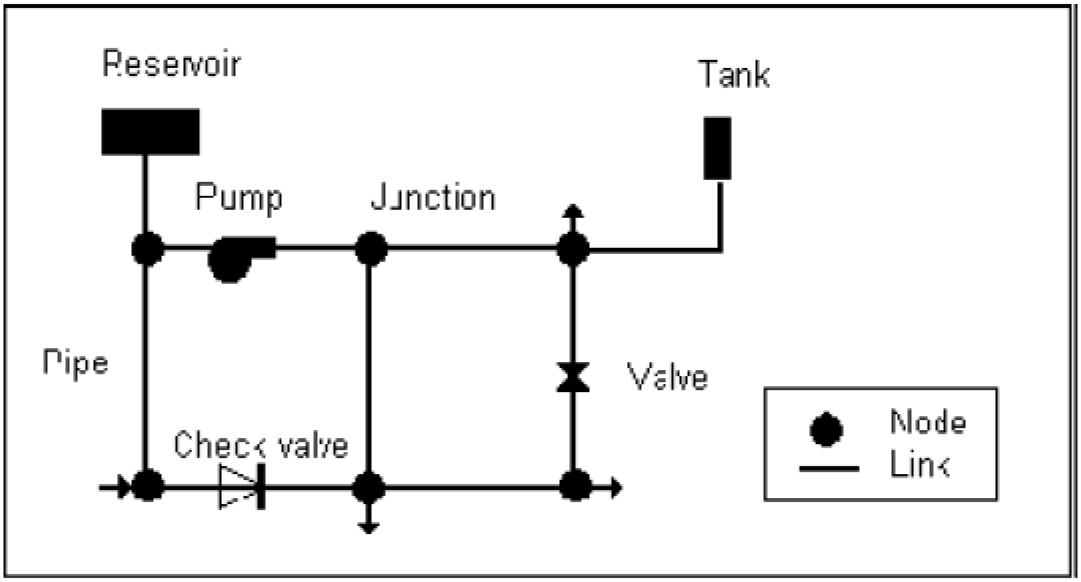


Figure 2.2 Node-link representation of a water distribution network

How the Water CAD program models the hydraulic behavior of each of these components is described in the following sections. All flow rates in this discussion will be assumed as liters per second (l/s).

Pipes

Every pipe is connected to two junction sat its ends. In a pipe network system, pipes are the channels used to convey water from one location to another. The physical characteristics of a pipe include the length, inside diameter, roughness coefficient, and minor loss coefficient. The pipe roughness coefficient is associated with the pipe material and age. The minor loss coefficient is due to the fittings along the pipe.

When water is conveyed through the pipe, hydraulic energy is lost due to the friction between the moving water and the stationary pipe surface. This friction loss is a major energy loss in pipe flow and is a function of flow rate, pipe length, diameter, and roughness coefficient.

The head lost to friction associated with flow through a pipe can be expressed in a general fashion as:

$$hL = aqb \tag{1}$$

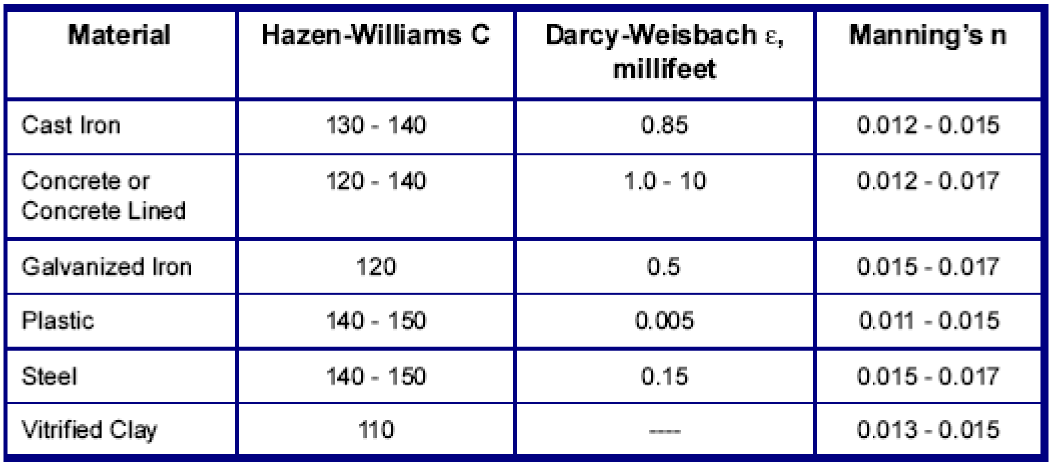
Where, hL is head loss in m, q is flow in l/s, a is a resistance coefficient, b is flow exponent.

Water CAD can use any one of three popular forms of the head loss formula shown in Equation (1) the Hazen-Williams formula, the Darcy-Weisbach formula, or the Chezy-Manning formula. MIKE NET allows the user to choose the formulation to use.

The Hazen-Williams formula is probably the most popular head loss equation for water distribution systems, the Darcy-Weisbach formula is more applicable to laminar flow and to fluids other than water, and the Chezy-Manning formula is more commonly used for open channel flow. Note that each formula uses a different pipe roughness coefficient, which must be determined empirically. Table 2.3 lists general ranges of these coefficients for different types of new pipe materials. Be aware that a pipe's roughness coefficient can change considerably with age.

While the Darcy-Weisbach relationship for closed-conduit flows is generally recognized as a more accurate mathematical formulation over a wider range of flow than the Hazen-Williams formulation, the field data on E values (required for the Darcy-Weisbach formulation) are not as readily available as are the C values for the pipe wall roughness coefficient (used in the Hazen-Williams formulation).

Table 2.3 Roughness coefficients for new pipe



Material	Hazen-Williams C	Darcy-Weisbach ε, millifeet	Manning's n
Cast Iron	130 - 140	0.85	0.012 - 0.015
Concrete or Concrete Lined	120 - 140	1.0 - 10	0.012 - 0.017
Galvanized Iron	120	0.5	0.015 - 0.017
Plastic	140 - 150	0.005	0.011 - 0.015
Steel	140 - 150	0.15	0.015 - 0.017
Vitrified Clay	110	----	0.013 - 0.015

Valves

Aside from the valves in pipes that are either fully opened or closed (such as check valves), WATERCAD can also represent valves that control either the pressure or flow at specific points in a network. Such valves are considered as links of negligible length with specified upstream and downstream junction nodes. The types of valves that can be modeled are described below.

Pressure reducing valves (PRV) limit the pressure on their downstream end to not exceed a pre-set value when the upstream pressure is above the setting. If the upstream pressure is below the setting, then flow through the valve is unrestricted. Should the pressure on the downstream end exceed that on the upstream end, the valve closes to prevent reversal of flow.

Pressure sustaining valves (PSV) try to maintain a minimum pressure on their upstream end when the downstream pressure is below that value. If the downstream pressure is above the setting, then flow through the valve is unrestricted. Should the downstream pressure exceed the upstream pressure then the valve closes to prevent reverse flow.

Pressure breaker valves (PBV) force a specified pressure loss to occur across the valve. Flow can be in either direction through the valve.

Flow control valves (FCV) limit the flow through a valve to a specified amount. The program produces a warning message if this flow cannot be maintained without having to add additional head at the valve.

Throttle control valves (TCV) simulate a partially closed valve by adjusting the minor head loss coefficient of the valve. A relationship between the degree to which the valve is closed and the resulting head loss coefficient is usually available from the valve manufacturer.

Node

Nodes are the locations where pipes connect. Two types of nodes exist in a pipe network system, (1) fixed nodes and (2) junction nodes. Fixed nodes are nodes whose HGL are defined. For example, reservoirs and storage tanks are considered fixed nodes, because their HGL are initially defined. Junction nodes are nodes whose HGL are not yet determined and must be computed in the pipe network analysis. Degree of freedom, elevation, and water demand are the three important input parameters for a node. A node's degree of freedom is the number of pipes that connect to that node. In Water CAD, a junction node may be connected to more than one pipe, but a fixed node (reservoir) must be connected to exactly one pipe. Therefore, a fixed node's degree of freedom is always one, and a junction node's degree of freedom may be greater than one. The elevation of a node can sometimes be obtained from system maps or drawings. More often, it is approximated using topographic maps. Water demand at a junction node is the summation of all water drawn from or added to the system at that node.

All nodes should have their elevation specified above sea level (i.e., greater than zero) so that the contribution to hydraulic head due to elevation can be computed. Any water consumption or supply rates at nodes that are not storage nodes must be known for the duration of time the network is being analyzed. Storage nodes (i.e., tanks and reservoirs) are special types of nodes where a free water surface exists and the hydraulic head is simply the elevation of water above sea level.

2.3.3 Water Distribution Network Building

The approach to building the model is to first sketch out the system practically on existing topographic maps. The concept of a network is fundamental to a water distribution model. The network contains all of the various components of the system, and defines how those elements are interconnected. Networks are comprised of nodes, which represent features at specific locations within the system, and links, which define relationships between nodes. Water distribution models have many types of nodal elements, including junction nodes where pipes connect, storage tank and reservoir nodes, pump nodes, and control valve nodes. Models use link elements to describe the pipes connecting these nodes. In addition, elements such as valves and pumps are sometimes classified as links rather than nodes. Intelligent use of element labeling can make it much easier for users to query tabular displays of model data with filtering and sorting commands. Rather than starting pipe labeling at a random node, it is best to start from the water source and number outward along each pipeline. In addition, just as pipe elements were not laid randomly, a pipe-labeling scheme should be developed to reflect that.

2.3.3.1 Principles of Network Hydraulics

In networks of interconnected hydraulic elements, every element is influenced by each of its neighbors; the entire system is interrelated in such a way that the condition of one element must be consistent with the condition of all other elements. Two basic equations that govern in Water CAD modeling network of these interconnections (Bentley Water CAD/GEMs, 2008). There are conservation of mass or continuity principle and conservation of energy or energy principle.

2.4.4 Water Distribution Modeling

2.4.4.1 Water CAD

Water CAD is a powerful, easy-to-use, which is: a water distribution modeling software; used in the modeling and analysis of water distribution systems and used for firefighting flow and constituent concentration analyses, energy consumption and capita cost management and popular for water supply design.

Water CAD provides sensitive access tool needed to model complex hydraulic situations. Some of the key features allow us to: perform steady state and extended period simulation. such that analyze multiple time-variable demands at any junction node, quickly identify operating inefficiencies in the system and Perform hydraulically equivalent network skeletonization including data scrubbing, branch trimming, and series and parallel pipe removal and efficiently manage large datasets and different “what if” situations with database query and edit tools.

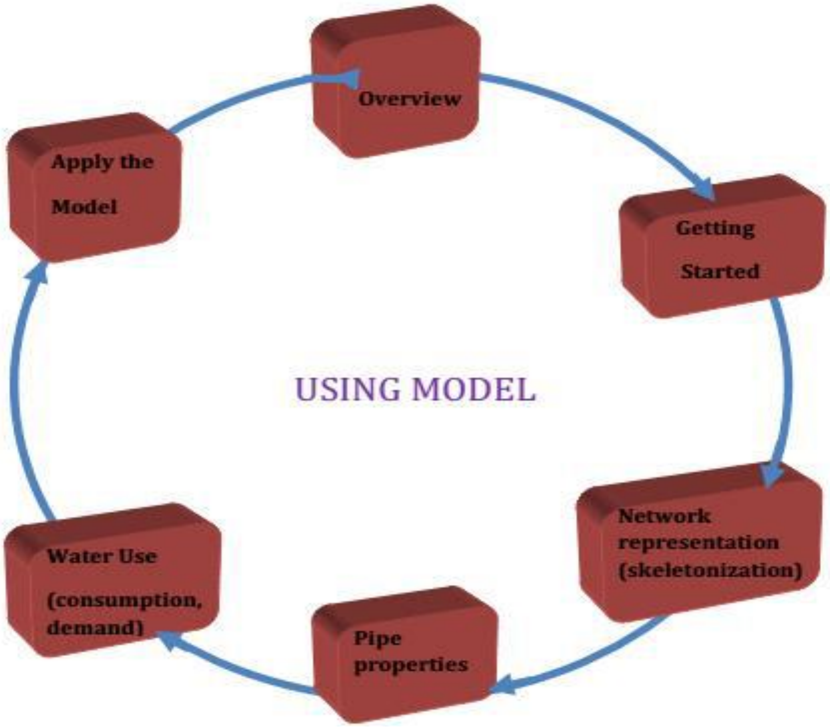


Figure 2.3: Diagrammatical representation modeling process
Source (Bentley Water CAD/GEMs, 2008)

3 Materials and Methods

The research method applied in this study was a non-theoretical approach using unstructured interview that were developed by discussion and input from the local water supply experts and local community. The survey was designed to gather data about customers‟ perceptions on water and sewerage service in Chancho town and the degree of satisfaction of customers.

3.1 Study Area

Location: Chancho Town, one of the towns of special zone surrounding Finfinne, is located in Northern Oromia National Regional state of Addis Ababa city at a distance 40km.The town stretches between 9 18' 29" to 9 12' 40" N latitude and 38 45' 15" to 38 23' 20’’E longitude and it has an elevation of 2,400 meters above sea level.

Area: According to the newly revised master plan by Chancho Town covers 776hectares the area of the town currently classified into administrative areas, residential areas, commercial areas, storage, playgrounds, infrastructure, market, religious, cemetery, recreation areas, mixed use, social services, manufacturing and other types of development purposes. Average Annual temperature is 18.5ºC; Mean Annual Rainfall is 1,380 mm and the existing wind direction is from north to south. The Chancho Town water supply and sewerage service is a public institution in the town that is responsible for supplying of portable water and collection, treatment and disposal of water and sludge for town, yet the disposal of sludge at present is being done by the municipality.

Population: According to CSA (2007), and population of the town was 20,295 and average annual growth rate of 2.9 % .The town is administratively divided into four administrative units (like locally named as kebeles). Demographically, Chancho was the most rapidly growing Town both in terms of population and in terms of physical areas in the region starting from the outside of its establishment. The impacts of population pressure that has placed pressure on public service and tremendous pressure on the town administration as the town population has swelled and become obstacle to improve welfare of the population in the town. The natural growths of the town in terms of the physical expansion and the increasing number of population have brought about the increasing demand for different infrastructure developments.

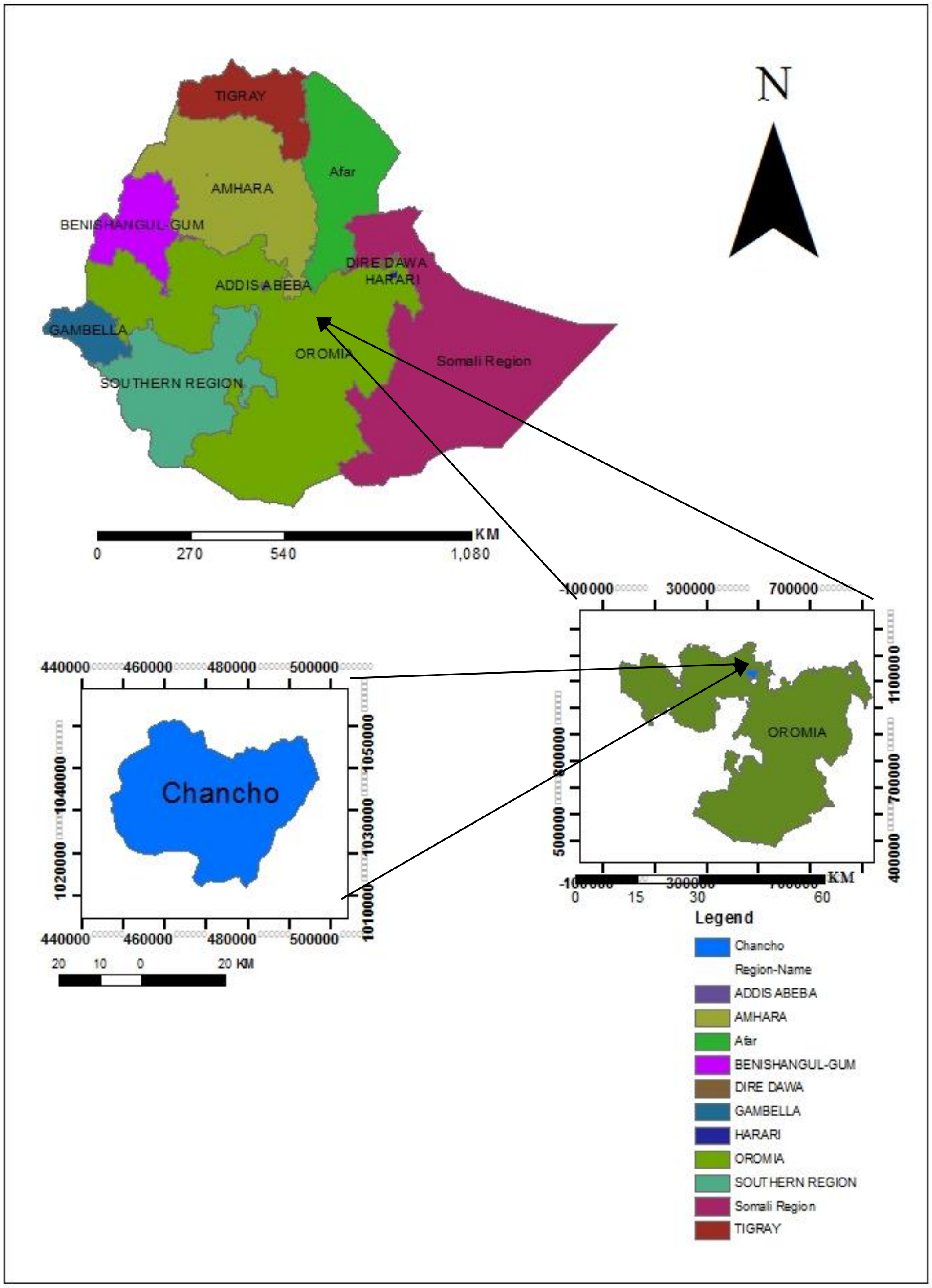


Figure 3.1 Location map of Study area

3.2 Existing Water Supply system

The existing Water Supply System was examined in close co-operation with the representatives of Chancho town water supply service regarding the fields of water production, treatment, transmission, and storage and water distribution network.

According to data from the Chancho Water Supply and sewerage Enterprise, the majority of households in Chancho are partially supplied with water from the town's water supply system. The available water supply source is borehole in Chancho Town, which was dug in 1969 E.C and in addition to this in 1998 and 2000 additional two wells have been drilled and connected to the system and now the old well not functional due to low yield and maintenance. There are 23 public fountains of which 17 are operational and the remaining abandoned due to different reasons, like detoreriation of structure. Householders collect part of their total water needs from the town's water supply system fed directly through private connections or public taps. However, there is insufficient water to meet all demands and the deficit is made up from other sources including wells and water vendors. The source of water supply for the town is ground water. These functional boreholes are working for 20 hours per day. Description and available data on the boreholes are presented in the Table 3.1.

Table3.1 Description of existing boreholes in chancho

No.	Source Name	Location		Elevation	Yield (l/s)
		x	y		
1	BH1	473945	1035862	2635	2.5
2	BH3	474645	1027862	2627.0	3.0
3	BH4	471306	1027758	2551.0	1.5
4	BH5	473729	1031701	2590.0	3.0

3.3Study design

Observation and Exploratory survey design was used in this study.

Interview

To secure additional information, unstructured interview question were conducted.

Observation

In order to make the research actual on site observation technique were carried out. Site observation would be conducted data on the causes of leakage on distribution system.

3.4Study variables

The study variables asses in this research were both independent and dependent variables.

Independent variables: independent variables were more related with specific objectives. However, each specific objective was affecting one another. Different problems occurs before and during water supply and distribution stages under construction. Those are joints of pipe and sizes of pipe.

Dependent variable: dependent variables, which observed and measured to determine the effective of the independent variables, which was directly, related to the general objectives. Those are per capita demand and water loss.

3.5Data collection process

The data collection processes exercised in this study were personal observation, measurement on study site, unstructured interview, and reviewing of archived secondary.. The interviews type would be unstructured where necessary and data were obtained in the form of face-to-face interview or through telephone.

3.5.1 Primary data collection

Primary data were collected through field survey, face-to-face interview with local administrative (Chancho Water Supply and Enterprise) and field observations.

3.5.2 Secondary data collection

Secondary data were collected from reviewing of documents from archives of Chancho Town Water Supply and Sewerage Enterprise, journals, reports, and internet.

3.6Data processing and analysis

Based on the research objective and the questions stated in the introduction part the method how the research was carried out is discussed in this part. Generally the research is divided in to major parts, analyzing the water supply coverage and the water loss analysis. The yearly water production and consumption data was used to evaluate the water loss. After evaluation the water loss the causes for the loss was tried to be identified using the different factors that have an impact to the water loss like pipe age, the ground elevation and customer meter records etc.

For locating and delineating the study area, Arc GIS map 10 was utilized. The quantitative data would collect from Chancho Water Supply and Sewerage Enterprise would be coded and processed using Microsoft excel 2013. The survey data for distribution system were evaluated using Water CAD6.5, which is used to analysis the quantitative data. The qualitative data would collect through the key informant interviews; Focus group discussion and field observation were used to triangulate the findings of the quantitative survey.

Average daily per capita consumption

The volume of water consumed for domestic purpose has been aggregated to all kebeles of the town so to analyses the distribution of the water supply coverage among different localities. The annual consumption data has been converted to average daily per capita consumption using the number of population. The average daily per capital consumption of the town was derived using the following expressions:-

$$Per\ capita\ consumpion(l\ preson\ day) = \frac{Annual\ consumption(m^3)*1000l/m^3}{Population\ number\ of\ each\ kebele*365days} \qquad (2)$$

Level of connection per family

In order to compare the distribution of the water connection among the different kebeles, the total numbers of connections per kebele are converted to connection per family using the population data of each kebele by the following expression:-

$$Connection\ per\ family = \frac{Totalnumberofconnectionofthetown}{Numberofpopulationofthetown/_{Averagefamilysize}} \qquad (3)$$

Water loss analysis

In order to identify the total loss of water in the town, the total volume of water supplied to the network distribution system was compared with the actual water consumption. The total annual water produced and distributed to the distribution system and the water billed that was aggregated from the individual customer meter readings were used to quantify the total water loss for the town.

$$Totalwaterloss(\%) = \frac{(Totalwaterproduced - Totalwaterbilled)}{Totalwaterproduced} * 100 \qquad (4)$$

3.6.1Water distribution system network

A water distribution system is a pipe network that delivers water from single or multiple supply source to consumers. There is a general belief arising out of negligence on behalf of service providers, that water supply networks can be expanded indefinitely. Many water supply providers, in a drive to provide wide water supply coverage increase the number of customer connection through a massive network expansion. Because of rapid population growth and high water losses from the distribution network, the total water demand of the system in Chancho Town exceeds available production capacity.

The flow and pressure distributions across a network are affected by the arrangement and sizes of the pipes and the distribution of the demand flows. Since a change of diameter in one pipe length will affect the flow and pressure distribution everywhere, network simulation is not an explicit process. Pipe network analysis involves the determination of the pipe flows and pressure heads that satisfy the continuity and energy conservation equations. According to this study, Hazen-Williams equation was commonly used in the design, modeling of water distribution network and water distribution systems because of its simple form, and analyzing an entire network in steady state flow.

Table 3.2 Pipe head loss formulas for full flow (Rossman, 2000)

Formula	Resistance coefficient (A)	Flow Exponent (B)
Hazen Williams	$4.727C^{-1.852}d^{-4.871}L$	1.852
Darcy Weisbach	$0.0252f(\ ,d, q)\ d^{-5}\ L$	2
Chezy Manning	$4.66\ n^{2}\ d^{-5.33}\ L$	2

Where: C is Hazen williams roughness coefficient; e is Darcy Weisbach roughness coefficient (ft); f is friction factor (dependent on e, d and q); n is manning roughness coefficient; d is pipe diameter (ft); L is pipe length (ft); q is flow rate (cfs).

3.6.2 Initial setup

Throughout the process, International System Unit (SI) has been used. To request the use of these units in WaterCAD6.5, the user chooses SI flow unit under the hydraulics option. In this study, it was selected liters per second for flow in this model, which also defines all other units using the SI system. Hence, lengths, pressure, head, elevations are taken in meters, and diameters of pipes are defined as millimeters. The network element are Reservoir, Pipes, Nodes and pumps.

3.6.3 WaterCAD6.5

WaterCAD6.5 is a powerful, easy-to-use program that helps hydraulic engineers design and analyzes water distribution systems. WaterCAD6.5 provides intuitive access to the tools you need to model complex hydraulic situations. It can be used for many different kinds of applications in distribution system analysis. In this study, it was used to carry out the hydraulic analysis of the distribution networks in the study area.

WaterCAD6.5 can be analyze complex distribution systems under a variety of conditions for a typical WaterCAD6.5 project, it may be interested in determining system pressure, velocity and flow rates under average loading conditions, head loss or under fire flow conditions. Those are perform stead state and water quality simulation and analyze multiple time variable demands at any junction node.

A Modeling of the network was carried out using the Water CAD6.5. Water CAD6.5 views the water distribution system as a network containing nodes and links, where the nodes are connected by links. Data using for WaterCAD6.5 are X-Y coordinate, Elevation, Junction/ node and Demand.

3.6.4 Reservoir

Reservoirs are a type of storage node. A storage node is a special type of node where a free water surface exists, and the hydraulic head is the elevation of the water surface above sea level. The water surface elevation of a reservoir does not change as water flows into or out of it during an extended period simulation.

3.6.5 Pipes

Every pipe is connected to two nodes at its ends. In a pipe network system, pipes are the channels used to convey water from one location to another. The physical characteristics of a pipe include the length, inside diameter, roughness coefficient, and miner loss coefficient. The pipe roughness coefficient was associated with the pipe material and age. The miner loss coefficient is due to the fitting along the pipe. Pipe length and diameters are then inputted as well as roughness.

3.6.6Nodes

Nodes are the locations where pipe connected. Two types of nodes exist in a pipe networks system. All nodes should have their elevation specified above sea level. Nodes, besides representing the connection point between pipes, can represent the following components in a network: Those are points of water consumption (demand nodes), points of water input (source nodes) and location of tanks or reservoirs (storage nodes).

4 Results and Discussions

4.1 Water supply coverage and Demand

4.1.1 Coverage

Problem in provision of adequate water supply to the rapidly growing urban population are increasing dramatically. Water demand in Chancho Town increases through time that as a result demand for additional water sources and infrastructure increases. Chancho Town has significant problem on the shortage of water supply. In Chancho both household and industry consumption were provided by Chancho Town water and sewerage enterprise which was responsible for water treatment and distribution in the Town. The total drinking water demand that required in the town in the year 2015 was around 587 m^3/d.

As described above from the distributed 587 m3/d of water supply was provided for animal fattening and garden watering consumes 115 m3/d amount of water from the total production, so it contributes for the shortage happened in the town. As information gathered from Chancho town water supply and sewerage office over all coverage of water service in Chancho was 56%. Still shortage of water is not minimize in the case of floating people to the town and more people use public water point.

Changing the previous water supply system and increase water distribution system program and a bottleneck to any type of development project for the town. Since all require clean water in one way or the other, that forced the requirement of conducting detailed assessment of the current system capacity, recommend interim and long-term solution for the available of clean and adequate systems.

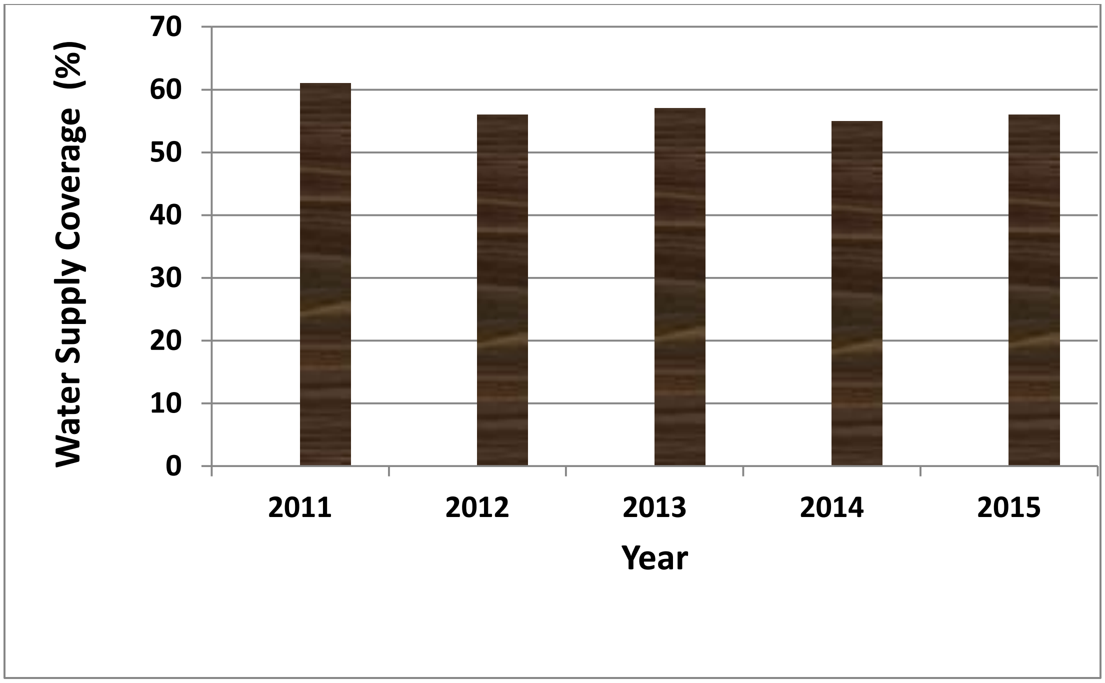


Figure 4.1 Water supply coverage trends in Chancho Town

The coverage of the Town water supply declines as time goes on from 2011-2015, however floating population who shares from the daily water proceed, additional number of hospitals and health centers, gusts and visitors as a result of conference, establishment of hotels all contributed to the water shortage of the town. In 2013 and 2015 water supply coverage were increases comparing with 2014, because drilling two different boreholes in each of years to be utilized the coverage.

4.1.1 Average Daily per Capita Consumption

The level of water consumed for domestic purpose has been aggregated to all kebele of the town so as to analysis the distribution of the water coverage among different localities. Statistical analysis was used to evaluate the distribution of the supply coverage in all kebele of the town while a supply coverage. Evaluating the domestic water supply coverage using volume of consumption may not allow realizing the distribution comparison among the kebeles. For this reason the annual consumption data has been converted to average daily per capital consumption using the number of population. The average daily per capita consumption of each kebeles for the year 2015 was computed as shown in the Table below.

Table 4. 1 Average daily consumption of Kebele of Chancho Town from bill of 2015

Kebeles	Population by kebele	Annual Consumption by kebele (m^3)	Per capita consumption (l/person/day)
01	7951	37,451	12.90
02	8653	45,675	14.46
Guto Elemo	5789	33,864	16.03
Chancho Buba	4352	25,247	15.89

As Table 4.1, observed that, the distribution of the water consumption varies among each Kebele. More or less the variation is observed in all Kebele; particularly Guto Elemo kebele has relatively best average consumption while compared to the others.

Taking the mean consumption as shown in Table 4.1, the average domestic water coverage of the town was found as 14.82 l/p/d. According to WHO (2008), the minimum quantity of domestic water required in developing countries in urban areas was taken as 20 l/c/d within a radius of 0.5km. Domestic water supply is categorized as basic level of service, which is higher than the average domestic consumption of chancho Town.

4.1.2 Level of connection per family

Level of water connection was an important element for evaluating the level of coverage. In order to compare the distribution of the water connection among different Kebele of Chancho Town, the total numbers of connection per Kebele were converted to connection per family using the population data of some Kebele. According to the 2014 and the town administrative finance and economic development, Average family size 2.9 was used for calculating the average number of connection per family

Table 4. 2 Level of connection per family of Chancho Town for the year 2015

Kebele	Number of population by kebele	Average family size	Total number of connection by kebele	Level of connection
01	7951	2.9	1524	0.56
02	8653	2.9	1756	0.59
GutoElemo	5789	2.9	984	0.49
ChanchoBuba	4352	2.9	786	0.52

As can be seen from the Table 4.2, some of the Kebele are found to be having higher level of connection per family while compared with Kebele02 have higher value of connection per family as compared to other Kebele. Taking the average connection per family for the entire town was found 0.54. This implies that almost at an average of nine persons are sharing one connection or water tap.

4.1.3 Evaluating distribution system of water supply coverage

As clarified Table 4.1 and 4.2, the water supply coverage of the town in terms of Per capita consumption is very low and relatively good in level of connection. In areas where water supply coverage is sufficient, volume of domestic water consumption is expected to be linearly related to the level connection. Areas having better level of connection are expected to consume more water as they can easily get it within their building or compound. A detailed demand study in Africa found that average water carried was about 22 l/d per capita over a long distance rising to about 30 l/d per capita where water was obtained from the consumer own stand pipe. Of course, distance is not a big problem in urban areas as compared to rural areas (ADB, 1993). Some areas may have better level of connection that consuming more volume of water, as the possibility of getting the water does not depend only on the location (Kebele02 has connection per family of 0.59 but has only a per capita consumption of 14.46 l/c/d, which is very far from the value of 20 l/c/d).

4 .2 Water loss Analysis

Globally, water demand was increasing while the recourses were diminishing. Water loss from water distribution systems (WDSs) has long been a feature of the WDS operations management. Water loss occurs in all WDSs, only the quantity of loss varies and depends on the physical characteristics of the pipe network, operating factors and parameters, and the level of technology and expertise applied to control this loss.

Reducing and controlling water loss was becoming very important issue in this age of rapidly growing demand and relative abundance to one of relative scarcity of the water resource, and climate changes that bring droughts to many locations over the world (Hossam, 2011). The water resources were subjected to the fluctuations of the nature and were therefore largely beyond the human control. In order to preserve valuable water resources, many water utilities have been developing new strategies to minimize losses to an economic and acceptable level.

Residential, commercial, industrial, public water use, and unaccounted system loss and leakage constitute the overall water demand. While all components create revenue to the water utility, the unaccounted system loss and leakage were not associated with total cost revenues, and are a source of wasted production costs. With today's high water production, treatment and transmitted costs and rates, the expense of detecting and reducing the unaccounted for water and leakage was an attractive solution for minimizing operating expenditures.

4.2.1 Chancho town water loss analysis

The total annual water produced and distributed to the distribution system and the water billed that was aggregated from the individual customer meter readings were used to quantify the total water loss for the town.

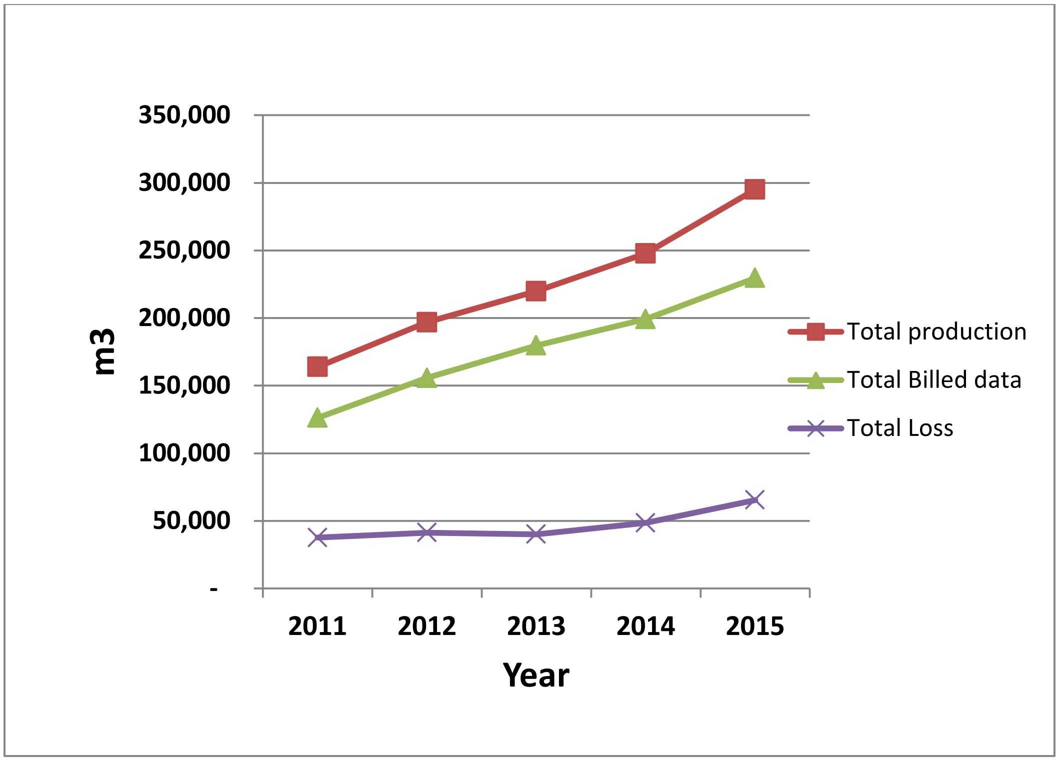


Figure 4. 2 Annual water production, consumption and loss trends

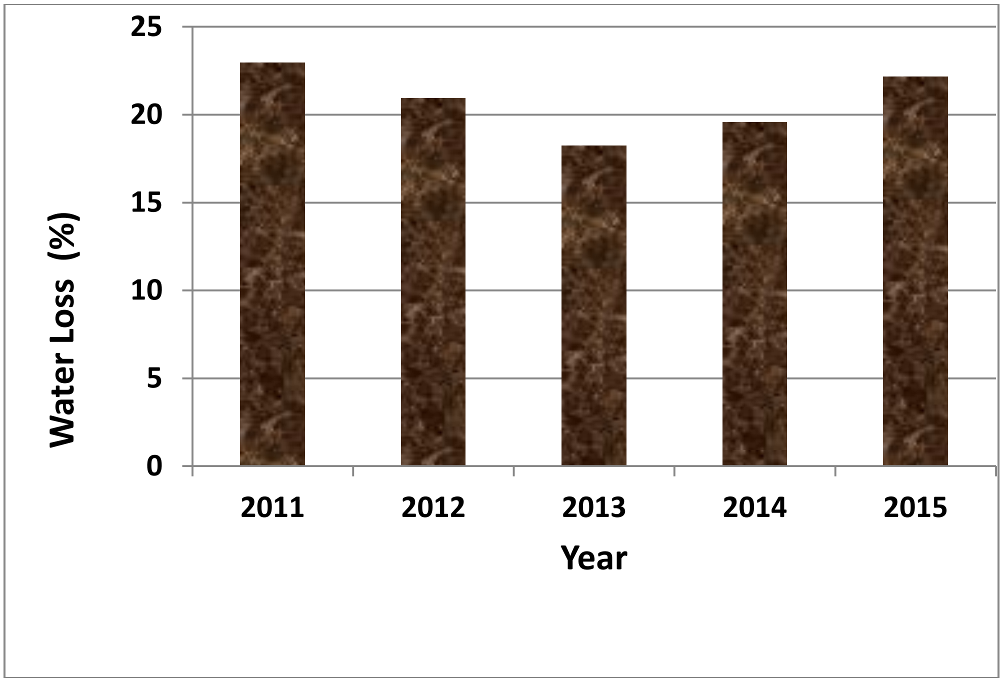


Figure 4. 3 Total water loss trends in Chancho town

The water loss trend of the town showing that loss was fluctuated from year to year. This could be due to road construction some infrastructure in Chancho town and breakage of pipes was occurred, and this maximized water loss. The total annual water loss of the town is vary from year to year at the end of the year 2015 the annual water produced and distributed to the system within specified year was 295082 cubic meters and annual water loss as derived using the above expression was 65395cubic meters which account to 22.16% of the total production. Water loss was increases in 2015 comparing with 2014 because additional construction (road and drainage) restarted. It is a compromise between the cost of reducing water loss and maintenance of distribution system and the cost of water saved. AWWA leak detection and accountability committee (1996) recommended 10% as a benchmark for UFW. Saroj (2008) gives classification and descriptions of UFW as acceptable, which could be monitored and controlled, when the loss is < 10%, as intermediate, which could be control when the loss is 10-25% and as a matter of concern that reduces the water supply when the loss is > 25%. According to this study, water loss in Chancho town was 22.16% in the year 2015, showing that the loss in the town was intermediate, according to the description given by Saroj (2008). Thus, the loss could be controlled and monitored.

4.2.2 Water loss as per number of connection

Water loss expressed as a percentage could be an appropriate means to show the extent of the loss within a given environment, but it is not a good indicator for comparing the loss from one area to another. According to some literature comparison of water loss between different areas is recommended to be done using the water loss per service connection per day. Taking the total number of connection in the town as 2654 the water loss per connection for the similar duration was derived as,

Water loss= 67.51 liter/connection/day. This figure shows as litters per service connection per day increase water losses also increases.

4.2.3 Water Loss Expressed as per Length of pipes

Water loss expressed as per kilometer length of main pipes is also used as indicator to compare water loss. This indicator is usually recommended for non-densely populated areas. The total length of pipes of greater or equal to 50mm diameter have been used to evaluate total water loss of the entire town is 19.54km. Using total pipe length of the entire town, the water loss per kilometer length of main pipes was 11.53m3/km/day. This figure shows that as length of the pipe increased the amount of water losses per day increases.

4.2.4 Major Factors Contributing to High Level of Water Loss in Chancho town

There are several reasons for the high level of water loss in Chancho. These factors are given below, and some advisory solutions were briefly proposed in next sections.

4.2.4.1 Age of pipe network

Pipe age is one of the factors that affects the magnitude of the loss specially that of physical loss. Aged pipes are more likely having more water loss through leakage than newly installed pipes. It is estimated that nearly more than 65 % of the pipe network in the town was laid over 30 years ago. The main duties which made more than half a month is checking of each customer (door to door water connection) by sounding rod .In this time get so many invisible & visible leakages both on the private connection & also on the main line.

These lines are including DCI (ducktail cast iron), polyvinyl carbon steel pipes. The aged pipe is especially in the central part of the town and in densely population areas. All these materials suffer from degradation over time due to operational measures, environmental conditions and general wear and tear result in increased leakage in the network. It is therefore necessary to replace older mains so that less leakage occurs.

4.2.4.2 Poor maintenance of networks

In some places like expansion areas water supply enterprise has performed a maintenance program for distribution system, and in recent years approximately more than 15% of network system was replaced in the expansion areas. In some parts of the town, poor maintenance of network and poor man power management for maintenance, it is so difficult to find financial support to renew the water distribution system. Thus, the lack of finance to buy proper materials and poor construction resulted in increased leakage in the system.

Figure 4.4 Photo taken during field observation showing poor maintenance of network

4.2.4.3 Water scheduling

The problem of water scheduling caused by an intermittent supply results in leakage, with a cyclic pressure situation created due to having the supply turned on and off in the corner of the town, increased levels of leakage are experienced due to stress being inflicted on the pipes causing them to rupture. There is clear paradox in this situation as the problem of water scheduling is caused by water shortages. Due to high levels of water loss, a continuous supply is not available resulting in water schedules.

4.2.4.4 Illegal connections

There are a significant number of illegal users of water within distribution system in Chancho town especially in the expansion areas or construction areas. The number of households who do not pay water rates but receive water from its distribution system is not known by chancho town water supply and sewerage enterprise. As a consequence, they contribute significantly to apparent losses and revenue loss to the water Enterprise. These connections are often poorly laid just a few inches below the surface and will break easily resulting in real losses taking placed in the form of leakage. Illegal connections are therefore of significant concern of water utilities.

4.2.5 Economical Dimension of Water Loss

The total annual water produced and distributed to the system within the specified year has been 295,082 cubic meters and the annual total loss as derived using the above expression was 65,395 cubic meter that accounts to 22.16% of the total water production. Taking the average tariff of water in the town as 5.04 birr/m3, the water loss is estimated to be 329,590.8 birr every year. However, the real loss is beyond this as the water tariffs like other developing countries are usually subsidized. The marginal cost producing one additional unit volume of water as the level of leakage is reduced the cost of water saved is first benefit. Redaction in leakage will produce a similar redaction in future projection of water supply requirements.

4.3 Remedial measures to reduce water loss and leakage

Knowing the magnitude and the spatial distribution of the loss greatly helps to intervene giving priority to those area with higher magnitude of loss with regard to the leakage index usually fixed based on local condition. Nevertheless identification is not by itself an end in reducing the water loss. Identifying the causes of the losses might help where to focus with probably limited resources that the town is having. This study somehow gave an indication that the predominant causes of the water loss in the town is leakage and losses due to meter errors. ones the spatial distribution and the characteristics of the loss are identified: it is possible to see alternative solutions to reduce the water loss. Therefore, an appropriate long and short term strategy is necessary.

Due to time limitation all the strategy issue are not addressed, rather some of the remedial measures to be taken are discussed in this section. The following may be considered to be remedial actions to be taken to reduce water loss and leakage in a distribution system but not limited.

4.3.1 Establishing pressure management

Pressure management is related to the establishment of zoning and district meter areas. In the previous sections, this has been discussed in detail with the perspective of identifying and quantifying losses. While establishing zoning and district meter areas, the scope for pressure management should be evaluated in all cases.

4.3.2 Proper maintenance and renewal

One of the major causes for the increase of water loss in the usage of poor quality materials and poor workmanship. in spite of the many pipe networks in the town seem to younger ages, the loss found from the analysis is high. The main reason for this might be the usage of poor quality of material and poor workmanship. Therefore care should be taken while maintaining existing networks and installation of new ones. While rehabilitation of any mains is planned, due attention should be given to maintain as well the service connections fed from the mains.

Replacing an old water main with a new installation will undoubtedly reduce on the main . Most leakage occurs on service connection and unless the service connections are also renewed the benefit may not be a great as the first estimated(Farley and Trow , 2003)

4.3.3 Regular inspection of the water network

Ones the locations of highly suspected leaking networks are identified due attention should be given to inspect for these areas and any leaks should be well recorded as it will be good base for further maintenance or replacement. Regular inspection supports to find the problematic areas and take action immediately before much water is wasted. Regular inspection should not be limited only to the network systems and supply meters but also to the customer meters.

4.3.4 Calibration and replacement of customer meters

One of main causes for the water loss is the under recording of customer meters. The usage of poor material quality also holds true for the customer meters. unless meters are regularly calibrated and those not functioning well are either maintained or replaced the water loss reduction programmer will not be effective. Until recently, the water authority was checking the customer meters only if it is requested by the themselves, but this night only help the customer not to pay more as such requests are usually for over registration. Therefore systematic check up of the customer meters is important not only to identify the magnitude of the loss but also to maintain and replace when necessary.

4.4 Distribution System Modeling of the Town

4.4.1 Model Representation

Frequently system maps are draw as combination of various system components in water distribution system. It is common to include; Reservoirs, Tanks, Pipes, Pumps and Valves as much as possible and the resulting sketch fairly represent the actual water net work. With little difference the real water distribution system represented as combination of nodes and links. Junction, reservoirs and tanks are usually referred as nodes. Pipes pump and valves are categorized as links. Figure 4.4 below illustrates layout of Chancho town distribution system. The sketch was taken from town water distribution system map and represented in the model according to available drawing options.

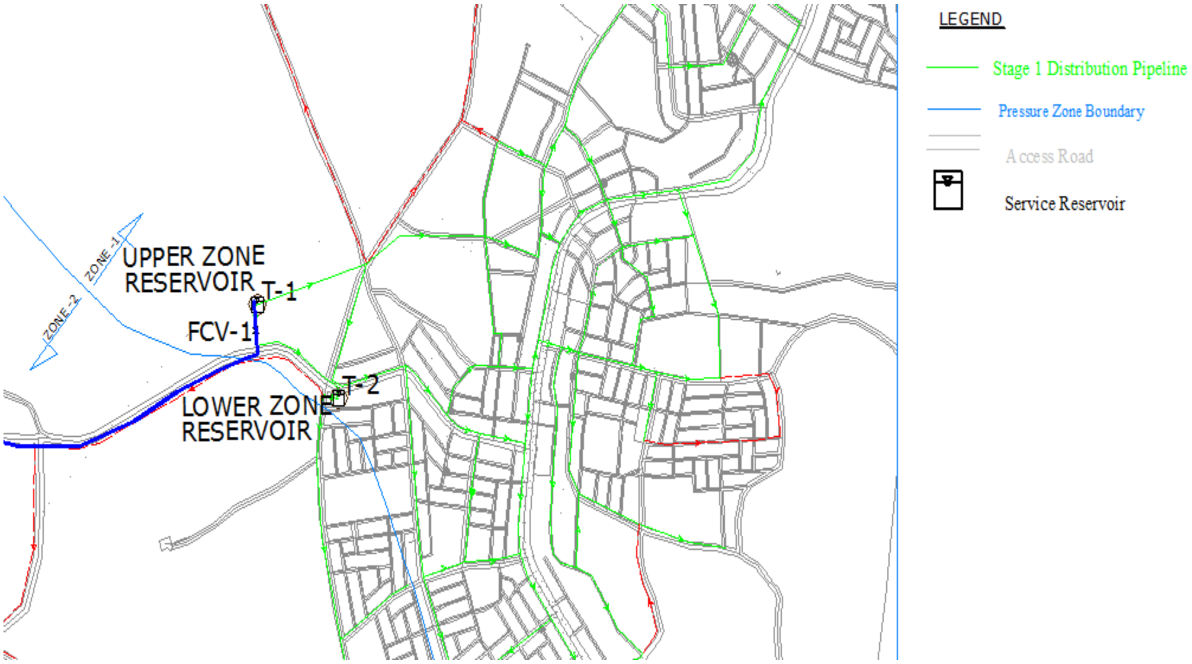


Figure 4.4 Modeling of the system

Analysis of water distribution network provides the basis for the design of new systems, the extensions, and control of existing systems. The flow and pressure distributions across a network are affected by the arrangement and sizes of the pipes and the distribution of the demand flows. The objective of this modeling was not to predict the exact time at which different users get water, but to develop a simplified model, node demand is dependent on the pressure at the junction nodes to reduce the water loss and maximize the flow rate at the tap.

WaterCAD6.5 could show pressure, demand, and hydraulic grade in different nodes as well as flows, velocities, head-loss gradient and head-loss in different pipes throughout the distribution system.

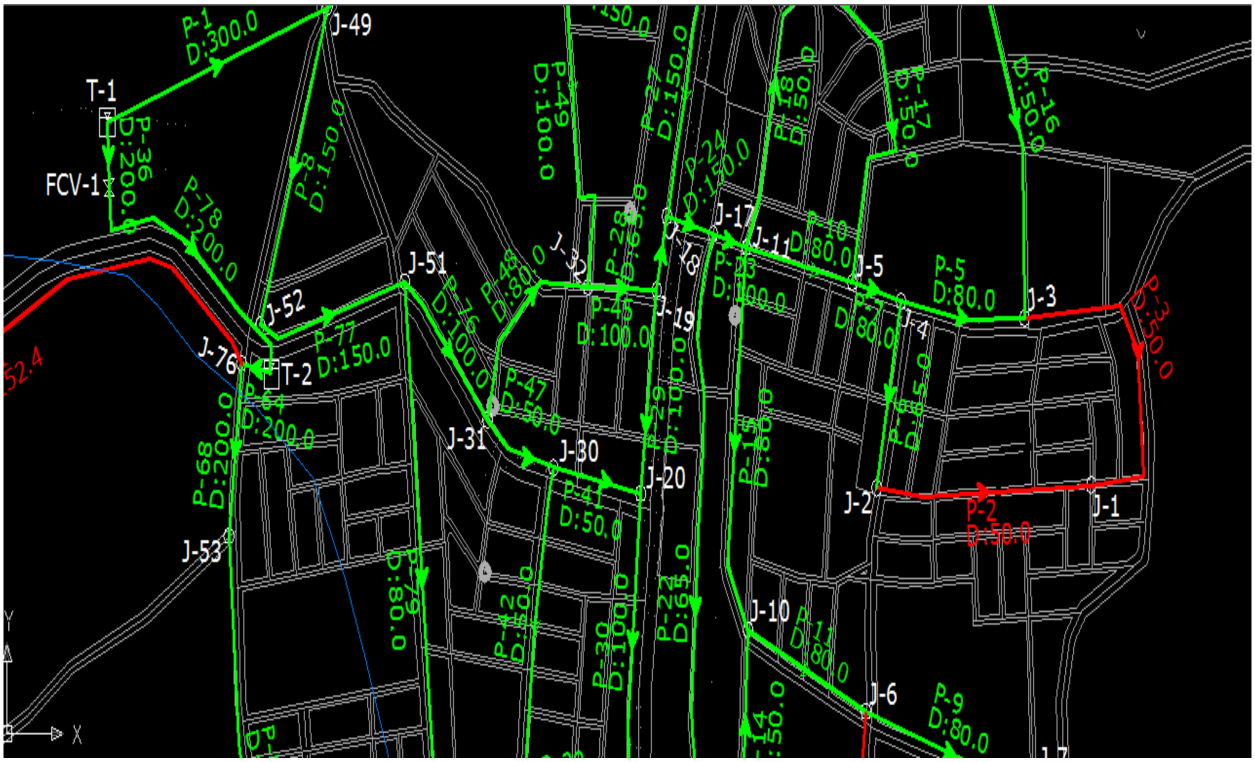


Figure 4.5 Water distribution network analysis of pressure zone

4.4.2 Pressure

There are extremes of low and high pressure throughout the system mainly due to topography of area and the elevation of the distribution reservoirs. kebele 02 Reservoirs are marked by high elevation. As a result, water was distributed to the system by gravity system.

The pressure in water distribution system is at a minimum when the flow and subsequent head losses in the pipes are at peak demand. On the other hand, the pressure is a maximum when the flow is at minimum, normally at night time while most consumers sleep and institutions were shut down. The low-pressure nodes were normally those nodes, which are located relatively at high elevations and far from the supply points.

Ethiopian guideline criteria for the minimum and maximum operating pressure value in the distribution network were 15m to 70m respectively (MoWR, 2006). Maximum pressure limitation are required to reduce the additional cost of the pipe, strengthening necessary due to the high pressure.

For town of Chancho water supply service is using an operating pressure which ranges from 15m to 80m. However, there was no defined maximum and minimum pressure ranges set by the office. Therefore, literature based recommendation for optimum operating pressure was used to assess system hydraulic performance.

With regard to current result for pressure at peak flow is summarized in table 4.4 and detailed in appendix D.

Table 4.4 Distribution of pressure at peak hour flow

Pressure (m)	Node/Count	Count %
15-20	5	5.68
21-30	15	17.04
31-40	22	25
41-50	16	18.18
51-60	13	14.77
61-70	14	15.91
>70	3	3.41

As shown in table 4.4, 3.41 % of nodes exceed maximum allowable pressure of 70 meter. While 90.9% of nodes are in the permissible pressure range of minimum 15m and maximum 60m.

Table 4.5 Pressure distribution during low flow

Pressure (m)	Node/ Count	Count %
21-30	5	5.68
31-40	13	14.77
41-50	11	12.5
51-60	14	15.91
61-70	15	17.05
71-80	13	14.77
>80	17	19.32

During low flow typically at mid-night when most of the customers are sleep and not using water distribution system of case study is marked by excessive pressure. As shown in table 4.5 and detailed in appendix E, 19.32 % of nodes are liable to extremely high pressure. Minimum pressures are also observed at the morning time which accounts only 5.68% of nodes.

The guideline further states that water velocity shall be maintained at 0.6 to 2m/s. Maximum and minimum velocity limitation was necessary because: Velocity is not be lower than 0.6m/s to prevent sedimentation and Velocity is not be more than 2m/s to prevent high head loss

According to this study, velocity was below and above as compared to the standard at some pipe. As Table 4.6 shows, velocity ranges which count below, above and fill the criteria of Ethiopian guideline.

Table 4. 6 Velocity range from WaterCAD6.5 analysis

Velocity range (m/s)	Count	Count (%)	Effect
0. - 0.6	21	19.81	Sedimentation occur
0.6 - 2	83	78.30	Acceptable
> 2	2	1.88	Head loss occur

4.4.3 Flow

The flow arrow symbol on the pipe in the plan view always indicates the direction of flow, and the “Start node” and “Stop node” fields in the pipe properties indicate the orientation of the pipe itself. If water is flowing from the “start node” to the “stop node”, the flow arrow will point that way and the flow result value will be positive. If water is flowing from the “stop node” to the “start node”, the flow arrow will point that way and the flow result value will be negative. A negative flow indicates orientation of flow with regard to the orientation of the pipe itself. The reason why this behavior occur is because in some system (mainly water distribution), flow can often reverse direction over the course of a day. Showing the negative sign in front of the calculated flow value is one way for the user to distinguish the current direction of flow.

5 Conclusions and Recommendations

5.1Conclusions

The findings of the study lead to the following conclusions:

Both the average domestic water supply coverage and distribution were evaluated based on the daily per capita consumption and level of connection using the population data of the Chancho Town for the year 2015. The average water supply coverage of the town is 14.82 l/p/d. This average per capita consumption was much lower as compared with some water supply standards set by WHO (2008), the minimum quantity of domestic water required in developing countries urban areas a basic need 20 l/c/d within a radius of 0.5 km. In this regard, the town domestic water supply satisfies about 56% of the standard value. Although the distribution of water supply coverage within the town (among each Kebele) has variation, the amount of each Kebele average per capita water consumption is still below the standard. The existing pipes of the distribution system do not cover all areas of the town. Uneven distribution of water and the spatial distribution of the pipe network system do not satisfy the demand of the public. In addition, some part of the town that are located at higher elevation and those areas located closer to the reservoir site do not the minimum required water pressure.

Despite the low water coverage of the town, the total water loss is found to be high, the total water loss was computed by subtracting the consumption (bill data) from the water supplied is 65395 m^3 that means 22.16% of the production water in 2015 at the town.

The total water loss was computed by subtracting the consumption from the water supplied. Three approaches were used to compute the loss among the system are the uncounted for water expressed as a percentage, water loss per connection and loss per length of pipes, comparison using the percentage has reversed the result of the comparison using the loss per length of mains and loss per number of connection.

Therefore, even through the total water loss expressed as percentage is an important tool to know the extent of the loss within a given environment, comparison of losses from one location to another using the percentage has limitations as the percentage of loss highly depends on the amount of water produced. This is also the experience of many international comparisons as explained by the international water association (IWA) task forces. Depending on the hierarchy of the network system, both water loss per connection (liter, connection/day) and loss per kilometers length of main pipes (m3/km/day) may be appropriate to measure the loss in the Chancho town context.

The approaches unaccounted for water expressed as a percentage and loss as per connection. The total water loss express as percentage is an important tool than water loss as per number of connection. In the town the loss of water as per number of connection, taking the total number of connection in the town as 2654 the water loss per connection for the similar duration was derived as; Water loss is 67.51 l/connection/day.

The main reason was the under-capacity of operation and maintenance, the team did not have necessary materials and equipment to make proper repairs, and due to large area coverage did not maintain at time.

The other issue addressed in the analysis was the major factor contributing to high levels of water loss in Chancho town are age of pipe network, poor maintenance of networks, water scheduling and illegal connection.

The other issue addressed in the analysis was that of the impact of pipe age on water loss. On the one hand the loss was found to be higher in the system where pipes of relatively older age are located. On the other hand despite the fact that overall pipe network seems to be of a young age, the total water loss is higher. This signifies that besides to the loss caused as a result of leakage, other non-physical losses may also be expected to be higher. To this effect, as illegal connection is not noticed as major problem when compared to the other factors.

This paper has attempted to put forward the current situation of water loss in Chancho town. Besides, it proposes appropriate solutions for the reduction and control of water loss. It is hoped that it will be a catalyst for increased and enhanced awareness and implementation of water loss solutions in the town.

5.2Recommendations

Based on the results of the study the following recommendation are forwarded:

The first and actual information will be collect and assess the problem. Therefore, this study work specifically investigated the potable water supply and demand, the existing water supply quantity, reducing water loss; the gap associated with water scarcity and suggested possible measurer.

While the higher magnitude of the loss is evaluated in conjunctions with the amount of water which is extremely low, the magnitude of the loss is expected to be much higher had there been enough water supply and pressure in all area. Therefore due to attention should be given while additional water sources are planned for the future that a proper management of the existing in infrastructure in general and the water network in particular is paramount.

The predominant approach towards meeting increasing water demand of the town is towards supply augmentation schemes. This includes developing new sources or expanding existing sources. In addition, adoption of water management strategy will help to reduce the per capita demand for water. Therefore, the town water supply enterprise have to look seriously into water demand management. To satisfy continuous rising of water demand several measures will be take. Such that construct additional borehole in order to increase water supply coverage, awareness creation to the community, operation and maintenance strategy in order to decrease leakage, Proper sized pipes during the implementation of the project, Increase reservoir, Updating existing network data, measuring and evaluating water loss.

One of the major limitation of this study was the quality of the consumption data especially the customer meter readings. The contract number of the customer meters which is supposed to be the unique identifier has been found to be repeated for some of the contacts. As the data set is very large it may even difficult to know which contracts are active at present. The other problem observed was, as each of the twelve months data of the customer meters are not linked together it will be very difficult to compare for any significant reading differences among consecutive period's meter readings. Therefore for better management of the billing system in general and better evaluation of water losses comparing with the billed water consumption.

The available quantity of water from all sources of supply will be distribute to all people on equitable and fair distribution system. Therefore, a planned and scheduled rationing system as well as additional reservoir can be implement to supply water to higher elevated area.

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Appendix

Check List for Discussion with Local Experts

- What are the main sources of water in the town? Are there any water sources that are not included to the distribution system? Where and how much?

- Is there any seasonal different amount of water supplied particularly in the rainy season and dry season?

- How do you identify leakage or breakage of water pipes? How do the communities support in reporting leakage or breakage of pipes?

- From your experience, does leakage and breakage of pipes have significant relation with age of pipe?

- Do you have a plan to replace aged pipe and water meters? What major criteria do you use for prioritization of replacement?

- Do you have a plan regarding operation and management in general and leakage reduction in particular? If so what are the main components?

Appendix B

In put parameter for water CAD 6.5

Junction	Easting	Northing	Elevation
J1	473595.70	1028300.72	2649.00
J2	473190.53	1028294.37	2646.00
J3	473467.41	1028497.59	2634.50
J4	473233.71	1028514.10	2639.46
J5	473143.53	1028539.50	2640.43
J6	473170.21	1028033.99	2645.00
J7	473492.82	1027955.25	2650.00
J8	473181.64	1027618.67	2600.00
J9	472936.50	1027895.55	2620.00
J10	472947.93	1028130.52	2640.00
J11	472941.58	1028578.88	2635.62
J12	473107.97	1028914.19	2620.00
J13	473374.69	1028948.48	2620.00
J14	473317.54	1029092.00	2608.12
J15	473047.00	1029065.33	2614.20
J16	472878.08	1028925.62	2612.17
J17	472880.62	1028594.12	2627.16
J18	472792.98	1028615.71	2624.77
J19	472722.66	1028529.34	2625.80
J20	472740.91	1028289.29	2619.90
J21	472727.93	1027938.13	2598.29
J22	472843.03	1027728.13	2598.29
J23	472981.95	1027533.65	2600.00
J24	472916.46	1027263.75	2583.85
J25	473470.15	1026972.02	2580.00
J26	472940.27	1026874.77	2570.00
J27	472556.29	1027542.63	2575.32
J28	472520.73	1027913.51	2583.32
J29	472369.33	1027866.77	2580.00
J30	472578.89	1028320.26	2612.90
J31	472454.94	1028377.15	2618.78
J32	472643.91	1028532.60	2630.02
J33	472803.66	1028960.42	2610.70
J34	472593.31	1028950.50	2612.70
J35	472593.31	1029170.76	2611.00
J36	472894.94	1029295.78	2610.00
J37	472644.91	1029248.15	2600.00
J38	473158.16	1029729.65	2604.00

J39	473624.49	1029717.74	2611.18
J40	473285.16	1029928.09	2607.10
J41	473678.07	1029951.90	2608.00
J42	472949.81	1030418.23	2605.00
J43	472838.68	1030199.95	2605.00
J44	472752.82	1030076.68	2603.00
J45	472636.27	1030068.98	2600.00
J46	472392.20	1030475.78	2590.00
J47	473858.65	1029868.56	2616.20
J48	472505.31	1029314.92	2600.00
J49	472150.10	1028860.49	2613.65
J50	471697.66	1029844.74	2600.00
J51	472296.43	1028539.79	2604.70
J52	472024.57	1028486.22	2584.50
J53	471965.04	1028242.14	2580.00
J54	472056.32	1027660.72	2555.00
J55	472123.79	1027361.07	2560.00
J56	472207.13	1027053.50	2550.00
J57	470913.32	1028275.87	2555.00
J58	471978.93	1027434.50	2555.00
J59	471159.38	1027523.79	2549.00
J60	470746.63	1027672.62	2544.00
J61	471967.03	1027029.68	2555.00
J62	471193.12	1026928.48	2545.00
J63	470613.68	1026841.17	2541.00
J64	472294.45	1025823.18	2555.00
J65	472969.13	1026331.18	2550.00
J66	473336.24	1025339.00	2540.00
J67	473082.24	1025297.32	2540.00
J68	471965.04	1025614.82	2545.00
J69	472810.38	1025025.47	2535.00
J70	473497.57	1024869.38	2540.00
J71	472939.96	1024678.88	2535.00
J72	474051.15	1024384.70	2541.00
J73	472307.30	1027478.59	2575.00
J74	472356.20	1027498.56	2571.00
J75	472470.02	1027478.59	2575.00
J76	471989.80	1028444.98	2581.00
FCV-1	471739.36	1028650.21	2670.00

Appendix C

SIMULATION DESCRIPTION: Peak Hour

Water Supply Mains – Chancho Town

PIPELINE RESULTS

Pipe Name	Node Names		Length	Dia	HWC (l/s)	Flow rate	Velocity	HL /1000	Head loss	Remark
	Node 1	Node 2	(m)	(mm)		(l/s)	(m/s)	(m/m)	(m)	V -check
P-1	T-1	J-49	437.39	300	120	38.65	0.55	1.11	0.48	ok
P-2	J-1	J-2	406.3	50	125	-0.66	0.34	3.65	1.48	ok
P-3	J-1	J-3	493.78	50	125	-0.6	0.3	3.03	1.5	ok
P-4	J-49	J-34	473.66	250	120	24.31	0.5	1.14	0.54	ok
P-5	J-3	J-4	234.7	80	120	-2.03	0.4	2.95	0.69	ok
P-6	J-2	J-4	224.33	65	120	-1.22	0.37	3.15	0.71	ok
P-7	J-4	J-5	108.51	80	120	-3.79	0.75	9.38	1.02	ok
P-8	J-49	J-52	395.63	150	120	6.57	0.37	1.22	0.48	ok
P-9	J-7	J-6	332.54	80	120	-2.79	0.56	5.31	1.77	ok
P-10	J-5	J-11	190.8	80	120	-3.74	0.74	9.15	1.75	ok
P-11	J-6	J-10	242.62	80	120	-2.62	0.52	4.72	1.15	ok
P-12	J-6	J-8	447.45	50	120	-0.42	0.22	1.6	0.72	low V
P-13	J-8	J-9	395.63	50	120	-0.55	0.28	2.62	1.04	ok
P-14	J-9	J-10	228.9	50	120	0.56	0.28	2.66	0.61	ok
P-15	J-10	J-11	459.64	80	120	-2.69	0.54	4.97	2.28	ok
P-16	J-3	J-13	468.78	50	120	-0.67	0.34	3.76	1.76	ok
P-17	J-5	J-12	466.95	50	120	-0.55	0.28	2.63	1.23	ok
P-18	J-11	J-12	398.07	50	120	0.38	0.19	1.3	0.52	low V
P-19	J-12	J-15	155.14	65	120	-1.29	0.39	3.5	0.54	ok
P-20	J-13	J-12	264.26	50	120	-0.74	0.38	4.45	1.18	ok
P-21	J-13	J-14	156.67	50	120	-0.44	0.22	1.72	0.27	low V
P-22	J-9	J-17	740.36	65	120	-1.22	0.37	3.15	2.33	ok
P-23	J-11	J-17	64.01	100	120	-7.17	0.91	10.29	0.66	ok
P-24	J-17	J-18	90.53	150	120	-8.53	0.48	1.97	0.18	ok
P-25	J-14	J-15	285.6	100	120	-4.9	0.62	5.08	1.45	ok
P-26	J-15	J-16	230.73	100	120	-5.2	0.66	5.67	1.31	ok
P-27	J-16	J-18	326.75	150	120	7.42	0.42	1.52	0.5	ok
P-28	J-18	J-19	88.7	65	120	-1.44	0.43	4.3	0.38	ok
P-29	J-19	J-20	241.4	100	120	2.75	0.35	1.75	0.42	ok
P-30	J-20	J-21	345.03	100	120	2.85	0.36	1.86	0.64	ok
P-31	J-21	J-22	247.19	100	120	3.05	0.39	2.12	0.52	ok
P-32	J-22	J-23	238.96	80	120	2.27	0.45	3.63	0.87	ok
P-33	J-8	J-23	213.97	50	120	-0.93	0.48	6.89	1.48	ok
P-34	J-23	J-24	288.04	65	120	1.07	0.32	2.47	0.71	ok
P-35	J-24	J-25	730.91	50	125	0.58	0.29	2.82	2.06	ok
P-36	T-1	FCV-1	75.9	200	120	20	0.64	2.35	0.18	ok

P-38	J-22	J-27	344.12	50	120	0.57	0.29	2.74	0.94	ok
P-39	J-21	J-28	211.84	50	120	-0.46	0.23	1.85	0.39	low V
P-40	J-24	J-27	462.99	50	120	-0.39	0.2	1.37	0.63	low V
P-41	J-20	J-30	113.69	50	120	-0.35	0.18	1.1	0.13	low V
P-42	J-30	J-28	465.43	50	120	0.29	0.15	0.81	0.38	low V
P-43	J-28	J-29	147.52	50	120	-0.4	0.2	1.44	0.21	low V
P-44	J-27	J-29	387.1	50	120	-0.81	0.41	5.35	2.07	ok
P-45	J-19	J-32	129.84	100	120	-4.37	0.56	4.12	0.53	ok
P-47	J-30	J-31	194.46	50	120	-0.93	0.47	6.82	1.33	ok
P-48	J-32	J-31	288.34	80	120	-1.52	0.3	1.72	0.5	ok
P-49	J-32	J-34	451.71	100	120	-3.2	0.41	2.31	1.04	ok
P-50	J-16	J-33	78.03	150	120	-12.76	0.72	4.15	0.32	ok
P-51	J-33	J-34	287.12	150	120	-12.44	0.7	3.96	1.14	ok
P-52	J-33	J-35	211.84	50	120	-0.44	0.23	1.75	0.37	low V
P-53	J-15	J-36	287.73	65	120	-1.3	0.39	3.53	1.02	ok
P-54	J-36	J-35	149.05	100	120	-5.64	0.72	6.61	0.98	ok
P-55	J-35	J-37	196.9	150	120	-6.27	0.35	1.11	0.22	ok
P-56	J-37	J-34	306.02	150	120	-8.1	0.46	1.79	0.55	ok
P-57	J-14	J-39	928.42	100	120	2.96	0.38	2	1.86	ok
P-58	J-36	J-38	515.72	100	120	4.11	0.52	3.68	1.9	ok
P-59	J-38	J-39	772.67	50	120	0.61	0.31	3.14	2.43	ok
P-60	J-38	J-40	244.45	50	120	1.54	0.78	17.34	4.24	ok
P-61	J-40	J-39	396.54	50	120	-0.75	0.38	4.57	1.81	ok
P-62	J-39	J-41	247.19	80	125	1.94	0.39	2.72	0.67	ok
P-63	J-38	J-44	586.13	50	120	0.92	0.47	6.78	3.97	ok
P-64	T-2	J-76	59.13	200	125	36.65	1.17	7.22	0.43	ok
P-65	J-40	J-43	540.41	50	120	0.34	0.17	1.05	0.57	low V
P-66	J-44	J-45	99.67	50	125	-1.11	0.56	9.48	0.95	ok
P-67	J-45	J-46	485.85	50	125	1.25	0.64	11.9	5.78	ok
P-68	J-76	J-53	204.52	200	120	30.3	0.96	5.07	1.04	ok
P-69	J-42	J-46	701.95	50	125	0.25	0.13	0.59	0.41	low V
P-70	J-41	J-47	205.74	65	125	1.13	0.34	2.76	0.57	ok
P-71	J-37	J-48	151.18	65	125	1.42	0.43	4.18	0.63	ok
P-72	J-48	J-45	791.26	80	125	3.22	0.64	6.95	5.5	ok
P-73	J-48	J-49	577.9	80	125	-2.04	0.41	2.97	1.72	ok
P-74	J-46	J-50	942.14	50	125	-0.64	0.33	3.45	3.25	ok
P-75	J-49	J-50	1,086.00	80	125	3.7	0.74	8.97	9.74	ok
P-76	J-31	J-51	215.19	100	120	-2.68	0.34	1.66	0.36	ok
P-77	J-51	J-52	314.55	150	120	-5.19	0.29	0.78	0.25	ok
P-78	FCV-1	T-2	432.82	200	120	20	0.64	2.35	1.02	ok
P-79	J-29	J-51	662.94	80	120	-1.97	0.39	2.79	1.85	ok
P-80	J-26	J-65	546.81	150	120	14.33	0.81	5.15	2.81	ok
P-81	J-74	J-65	740.05	50	120	-0.18	0.09	0.33	0.24	low V
P-82	J-55	J-54	311.81	200	120	-28.32	0.9	4.48	1.4	ok
P-83	J-54	J-53	583.39	200	120	-29.53	0.94	4.84	2.82	ok
P-85	J-26	J-56	758.04	150	120	-16.26	0.92	6.5	4.93	ok
P-86	J-56	J-55	319.13	200	120	-21.48	0.68	2.68	0.86	ok
P-87	J-55	J-58	162.76	100	120	6.55	0.83	8.7	1.42	ok
P-88	J-58	J-59	860.76	80	125	3.93	0.78	10.03	8.63	ok
P-89	J-59	J-60	455.68	80	125	2.02	0.4	2.93	1.33	ok

P-90	J-65	J-64	926.9	80	125	4.08	0.81	10.73	9.94	ok
P-91	J-76	J-57	1,218.90	150	125	6.35	0.35	1.05	1.29	ok
P-92	J-57	J-60	701.65	50	125	1.74	0.89	21.88	15.35	ok
P-93	J-65	J-66	1,107.03	100	120	6.4	0.81	8.34	9.23	ok
P-94	J-56	J-61	243.84	80	125	4.29	0.85	11.79	2.87	ok
P-95	J-58	J-61	404.77	65	125	1.68	0.51	5.72	2.31	ok
P-96	J-61	J-62	781.2	80	125	4.21	0.84	11.37	8.88	ok
P-97	J-59	J-62	596.19	50	125	0.72	0.37	4.3	2.56	ok
P-98	J-62	J-63	585.52	80	125	2.82	0.56	5.43	3.18	ok
P-99	J-60	J-63	943.36	50	125	0.76	0.39	4.67	4.41	ok
P-100	J-63	J-64	2,147.62	50	125	0.38	0.19	1.28	2.75	low V
P-101	J-64	J-67	953.72	50	125	-0.1	0.05	0.11	0.11	low V
P-102	J-64	J-68	396.85	80	125	2.9	0.58	5.7	2.26	ok
P-103	J-66	J-67	271.88	100	120	3.14	0.4	2.23	0.61	ok
P-104	J-67	J-69	385.88	80	120	2.01	0.4	2.91	1.12	ok
P-105	J-66	J-70	486.16	80	120	2.38	0.47	3.95	1.92	ok
P-106	J-69	J-71	381.61	50	120	0.52	0.27	2.34	0.89	low V
P-107	J-70	J-71	589.79	50	120	0.36	0.18	1.19	0.7	low V
P-108	J-70	J-72	733.35	50	120	1.04	0.53	8.49	6.23	ok
P-109	J-43	J-44	150.57	65	120	-1.65	0.5	5.55	0.84	Ok
P-110	J-42	J-43	234.39	50	125	-1.43	0.73	15.3	3.59	Ok

Appendix: D

Simulation Result :- END NODE RESULTS

Water Supply Mains – Chancho Town

Peak Hour

Node Name	Node Title	External Demand	Node Elevation	Hydraulic Grade	Pressure Head	Pressure check
		(l/s)	(m)	(m)	(m)	
J-1	-	2,649.00	1.26	2,667.00	17.96	Ok!
J-2	-	2,646.00	0.56	2,668.48	22.44	Ok!
J-3	-	2,634.50	2.11	2,668.50	33.93	Ok!
J-4	-	2,639.46	0.54	2,669.19	29.67	Ok!
J-5	-	2,640.43	0.5	2,670.21	29.72	Ok!
J-6	-	2,645.00	0.25	2,668.52	23.48	Ok!
J-7	-	2,650.00	2.79	2,666.76	16.72	Ok!
J-8	-	2,600.00	1.06	2,669.24	69.10	Ok!
J-9	-	2,620.00	0.11	2,670.28	50.18	Ok!
J-10	-	2,640.00	0.63	2,669.67	29.61	Ok!
J-11	-	2,635.62	0.36	2,671.95	36.26	Ok!
J-12	-	2,620.00	0.38	2,671.44	51.33	Ok!
J-13	-	2,620.00	0.5	2,670.26	50.16	Ok!
J-14	-	2,608.12	1.49	2,670.53	62.28	Ok!
J-15	-	2,614.20	0.31	2,671.98	57.66	Ok!
J-16	-	2,612.17	0.14	2,673.29	60.99	Ok!
J-17	-	2,627.16	0.14	2,672.61	45.36	Ok!
J-18	-	2,624.77	0.32	2,672.79	47.92	Ok!
J-19	-	2,625.80	0.18	2,673.17	47.28	Ok!
J-20	-	2,619.90	0.25	2,672.75	52.74	Ok!
J-21	-	2,603.34	0.25	2,672.11	68.63	Ok!
J-22	-	2,598.29	0.22	2,671.58	73.15	Ok!
J-23	-	2,594.07	0.27	2,670.72	76.49	Ok!
J-24	-	2,583.85	0.88	2,670.01	85.98	Ok!
J-25	-	2,580.00	0.58	2,667.94	87.77	Ok!
J-26	-	2,570.00	1.93	2,577.34	7.33	Low P
J-27	-	2,575.32	0.99	2,670.64	95.13	Ok!
J-28	-	2,583.32	0.23	2,672.50	89.00	Ok!
J-29	-	2,580.00	0.76	2,672.71	92.52	Ok!
J-30	-	2,612.90	0.29	2,672.87	59.85	Ok!
J-31	-	2,618.78	0.23	2,674.20	55.31	Ok!
J-32	-	2,630.02	0.34	2,673.71	43.60	Ok!
J-33	-	2,610.70	0.13	2,673.61	62.78	Ok!
J-34	-	2,612.70	0.58	2,674.75	61.92	Ok!
J-35	-	2,611.00	0.18	2,673.98	62.85	Ok!
J-36	-	2,610.00	0.23	2,673.00	62.87	Ok!

J-37	-	2,600.00	0.41	2,674.20	74.05	Ok!
J-38	-	2,604.00	1.04	2,671.10	66.96	Ok!
J-39	-	2,611.18	0.88	2,668.67	57.37	Ok!
J-40	-	2,607.10	1.94	2,666.86	59.64	Ok!
J-41	-	2,608.00	0.81	2,668.00	59.88	Ok!
J-42	-	2,605.00	1.19	2,662.70	57.59	Ok!
J-43	-	2,605.00	0.56	2,666.29	61.17	Ok!
J-44	-	2,603.00	0.38	2,667.13	64.00	Ok!
J-45	-	2,600.00	0.86	2,668.07	67.93	Ok!
J-46	-	2,590.00	2.14	2,662.29	72.14	Ok!
J-47	-	2,616.20	1.13	2,667.43	51.13	Ok!
J-48	-	2,600.00	0.23	2,673.57	73.42	Ok!
J-49	-	2,613.65	2.02	2,675.29	61.51	Ok!
J-50	-	2,600.00	3.06	2,665.54	65.41	Ok!
J-51	-	2,604.70	0.54	2,674.56	69.72	Ok!
J-52	-	2,584.50	1.39	2,674.81	90.12	Ok!
J-53	-	2,580.00	0.77	2,587.35	7.33	Low P
J-54	-	2,555.00	1.21	2,584.53	29.47	Ok!
J-55	-	2,560.00	0.29	2,583.13	23.08	Ok!
J-56	-	2,550.00	0.94	2,582.27	32.21	Ok!
J-57	-	2,555.00	4.61	2,587.10	32.03	Ok!
J-58	-	2,555.00	0.94	2,581.71	26.66	Ok!
J-59	-	2,549.00	1.19	2,573.08	24.03	Ok!
J-60	-	2,544.00	3.01	2,571.75	27.69	Ok!
J-61	-	2,555.00	1.76	2,579.40	24.35	Ok!
J-62	-	2,545.00	2.11	2,570.52	25.47	Ok!
J-63	-	2,541.00	3.2	2,567.34	26.28	Ok!
J-64	-	2,555.00	1.66	2,564.59	9.57	Low P
J-65	-	2,550.00	3.67	2,574.53	24.48	Ok!
J-66	-	2,540.00	0.88	2,565.30	25.25	Ok!
J-67	-	2,540.00	1.03	2,564.69	24.64	Ok!
J-68	-	2,545.00	2.9	2,562.32	17.29	Ok!
J-69	-	2,535.00	1.49	2,563.57	28.51	Ok!
J-70	-	2,540.00	0.97	2,563.38	23.33	Ok!
J-71	-	2,535.00	0.88	2,562.68	27.62	Ok!
J-72	-	2,541.00	1.04	2,557.15	16.12	Ok!
J-73	-	2,575.00	0	2,584.53	9.51	Low P
J-74	-	2,575.00	0.18	2,574.29	-0.71	Low P
J-75	-	2,575.00	0	2,583.13	8.11	Low P
J-76	-	2,581.00	0	2,588.38	7.37	Low P

Appendix E

Simulation Result (minimum consumption)

Water Supply Mains – Chancho Town

END NODE RESULTS **Night Flow**

Node Name	Node Title	Node Elevation	External Demand	Hydraulic Grade	Pressure Head	Node Pressure
		(m)	(l/s)	(m)	(m)	(kpa)
J-1	-	2,649.00	0.21	2,674.05	25.001	Ok!
J-2	-	2,646.00	0.09	2,674.11	28.049	Ok!
J-3	-	2,634.50	0.35	2,674.11	39.526	Ok!
J-4	-	2,639.46	0.09	2,674.13	34.601	Ok!
J-5	-	2,640.43	0.08	2,674.17	33.67	Ok!
J-6	-	2,645.00	0.04	2,674.11	29.049	Ok!
J-7	-	2,650.00	0.47	2,674.04	23.995	Ok!
J-8	-	2,600.00	0.18	2,674.13	73.984	Ok!
J-9	-	2,620.00	0.02	2,674.17	54.061	Ok!
J-10	-	2,640.00	0.11	2,674.15	34.08	Ok!
J-11	-	2,635.62	0.06	2,674.23	38.534	Ok!
J-12	-	2,620.00	0.06	2,674.21	54.103	Ok!
J-13	-	2,620.00	0.08	2,674.17	54.061	Ok!
J-14	-	2,608.12	0.25	2,674.18	65.926	Ok!
J-15	-	2,614.20	0.05	2,674.23	59.911	Ok!
J-16	-	2,612.17	0.02	2,674.28	61.984	Ok!
J-17	-	2,627.16	0.02	2,674.26	47	Ok!
J-18	-	2,624.77	0.05	2,674.26	49.392	Ok!
J-19	-	2,625.80	0.03	2,674.28	48.378	Ok!
J-20	-	2,619.90	0.04	2,674.26	54.25	Ok!
J-21	-	2,603.34	0.04	2,674.24	70.754	Ok!
J-22	-	2,598.29	0.04	2,674.22	75.775	Ok!
J-23	-	2,594.07	0.05	2,674.19	79.955	Ok!
J-24	-	2,583.85	0.15	2,674.16	90.129	Ok!
J-25	-	2,580.00	0.1	2,674.09	93.896	Ok!
J-26	-	2,570.00	0.32	2,587.25	17.216	Ok!
J-27	-	2,575.32	0.16	2,674.18	98.664	Ok!
J-28	-	2,583.32	0.04	2,674.25	90.748	Ok!
J-29	-	2,580.00	0.13	2,674.26	94.068	Ok!
J-30	-	2,612.90	0.05	2,674.26	61.241	Ok!
J-31	-	2,618.78	0.04	2,674.31	55.421	Ok!
J-32	-	2,630.02	0.06	2,674.29	44.185	Ok!
J-33	-	2,610.70	0.02	2,674.29	63.463	Ok!
J-34	-	2,612.70	0.1	2,674.33	61.508	Ok!
J-35	-	2,611.00	0.03	2,674.30	63.177	Ok!
J-36	-	2,610.00	0.04	2,674.27	64.139	Ok!
J-37	-	2,600.00	0.07	2,674.31	74.163	Ok!
J-38	-	2,604.00	0.17	2,674.20	70.059	Ok!

J-39	-	2,611.18	0.15	2,674.11	62.805	Ok!
J-40	-	2,607.10	0.32	2,674.05	66.812	Ok!
J-41	-	2,608.00	0.14	2,674.09	65.954	Ok!
J-42	-	2,605.00	0.2	2,673.90	68.757	Ok!
J-43	-	2,605.00	0.09	2,674.03	68.887	Ok!
J-44	-	2,603.00	0.06	2,674.06	70.913	Ok!
J-45	-	2,600.00	0.14	2,674.09	73.941	Ok!
J-46	-	2,590.00	0.36	2,673.88	83.712	Ok!
J-47	-	2,616.20	0.19	2,674.07	57.751	Ok!
J-48	-	2,600.00	0.04	2,674.29	74.14	Ok!
J-49	-	2,613.65	0.34	2,674.35	60.58	Ok!
J-50	-	2,600.00	0.51	2,674.00	73.85	Ok!
J-51	-	2,604.70	0.09	2,674.33	69.485	Ok!
J-52	-	2,584.50	0.23	2,674.33	89.653	Ok!
J-53	-	2,580.00	0.13	2,587.61	7.597	Low P
J-54	-	2,555.00	0.2	2,587.51	32.445	Ok!
J-55	-	2,560.00	0.05	2,587.46	27.405	Ok!+-
J-56	-	2,550.00	0.16	2,587.43	37.354	Ok!
J-57	-	2,555.00	0.77	2,587.60	32.538	Ok!
J-58	-	2,555.00	0.16	2,587.41	32.343	Ok!
J-59	-	2,549.00	0.2	2,587.10	38.019	Ok!
J-60	-	2,544.00	0.5	2,587.05	42.961	Ok!
J-61	-	2,555.00	0.29	2,587.32	32.26	Ok!
J-62	-	2,545.00	0.35	2,587.00	41.919	Ok!
J-63	-	2,541.00	0.53	2,586.89	45.796	Ok!
J-64	-	2,555.00	0.28	2,586.79	31.724	Ok!
J-65	-	2,550.00	0.61	2,587.15	37.074	Ok!
J-66	-	2,540.00	0.15	2,586.81	46.72	Ok!
J-67	-	2,540.00	0.17	2,586.79	46.698	Ok!
J-68	-	2,545.00	0.48	2,586.71	41.623	Ok!
J-69	-	2,535.00	0.25	2,586.75	51.648	Ok!
J-70	-	2,540.00	0.16	2,586.74	46.651	Ok!
J-71	-	2,535.00	0.15	2,586.72	51.615	Ok!
J-72	-	2,541.00	0.17	2,586.52	45.428	Ok!
J-73	-	2,575.00	0	2,587.51	12.485	Ok!
J-74	-	2,575.00	0.03	2,587.14	12.115	Ok!
J-75	-	2,575.00	0	2,587.46	12.435	Ok!
J-76	-	2,581.00	0	2,587.65	6.637	Low P