

**UNACCOUNTED-FOR WATER STUDY IN DISTRIBUTION  
NETWORK OF RASHT WATER & SEWERAGE CO.**

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**1- INTRODUCTION**

During 1998 and 1999 RASHT WATER & SEWERAGE CO (RWSC) conducted a study to more accurately define and understand the magnitude and nature of its UNACCOUNTED-FOR WATER (UFW) volume for the 1999 calendar year. UFW is generally defined as the difference between the measured volume of water received into the system and the measured volume through deliveries. To determine this exact difference, the study identified the factors contributing to the losses and the UFW volumes associated with each factor.

This paper provides the highlights of the comprehensive report issued after the study's completion. It provides as overview of why UFW is important, where RWSC looked for and found UFW, and how quantified UFW by assignment of of SHARGAN CONSULTING ENGINEERS.

**2- WHY PERFORM A UFW STUDY?**

Gaining a good understanding of UFW can be both complicated and expensive. However, considering the rate structure, the reasonableness of operations, and the environmental implications, ignoring UFW could be even more costly.

With increasing environmental concerns over Water-Leakage released into the environment and preventing Water shortages, in future, RWSC saw a need to better understand and quantify water leakage from its own distribution system.

**3- STUDY RESULTS SUMMARY**

The UFW study was able to examine in detail, all aspects of RWSC operation and identify the individual elements contributing to UFW. As shown in Figure 1, the study identified UFW volumes in four categories: *measurement, accounting, leakage, and illegal connections.*

In the past, RWSC has used its accounting data to estimate the volume of UFW. This estimating process used input from consumer departments to define the contributions to UFW.

#### **4- Definition Of UFW**

The definition of the UFW could we use:

$$\text{UFW} = A - B \quad (\text{Equation 1})$$

A = **Measured Volume of Receipts** (water purchases)

B = **Measured Volume of water Deliveries** (water sales)

When expressed as a percentage, UFW is described as a percentage of the system's throughput.

$$\text{UFW \%} = (\text{UFW} / \text{T}) \times 100\%$$

UFW % = The percentage UFW of the total system throughput.

UFW = UFW volume from Equation 1

T = System throughput for a given time period

Traditionally, RWSC has used its accounting records to calculate UFW. This estimated volume is referred to as *accounting* UFW.

From the study of the various elements that could contribute to UFW we approached a total UFW volume estimate called UFW-by-element.

A comparison of the UFW volume estimated by two separate approaches, yields some difference. The small difference supports the reliability of the calculated data and confirms that all major elements contributing to UFW have been addressed by the study.

In this study estimation is made based on element approach since no measurement equipment were available in the entry of network.

## **5- DESCRIPTION OF RWSCS' SYSTEM**

RWSC in pilot area serves approximately 14000 number of connection. Its distribution system consists of nearly 100000km of pipelines. RWSC distribution system consists of mains and of service pipe, with individual services. Figure 2 is a schematic of the RWSC system under review by the UFW project. Water enters the system at various interconnection points with intrastate pipelines and flows through the transmission and distribution system before delivery to customers. During a given period, several factors may cause differences between the actual volume flowing through the system and the recorded volume. All reported volumes are subject to the individual meters as well as factors such as pressure and ... which affect the water volume measurement. As the water flows through the pipeline, it may be lost due to 1) leaks in the pipe, 2) accidental damage to the pipe, 3) release to the environment during normal maintenance operations, or 4) illegal connection.

As indicated in the schematic, a boundary is established around the pilot area and a material balance study is conducted across this boundary.

## **6- RESULTS OF THE STUDY**

The analysis done in each of the four major study areas yielded a 1999 UFW-by-element volume estimated at 5477 M<sup>3</sup>/D. The breakdown of this volume is shown graphically in Figure 1 and is discussed in the next four sections.

### **i- MEASUREMENT ELEMENT RESULTS**

RWSC calibrates and maintains measurement equipment with the objective of keeping all metering errors within mandated tolerances. The UFW measurement study identified the extent to which the sum of all these errors did not equate to zero and, therefore, produced a measurement bias. The contributing elements in the measurement study area are the meter accuracy, of 657M<sup>3</sup>/D, even though these meters are built and maintained according to industry standards.

Accurate measurement of water volume is a function of the meter and the factors used to adjust the meter read. If the meter registers slow, the actual water volume passing through the meter will be more than the volume registered by the meter. If the meter registers fast, the volume of water metered will be greater than the actual volume delivered by the

meter. The volume of water registered by the meter may also be adjusted for pressure elevation. These factors are applied to the meter read to compensate for the effect of the meter's operational environment on the volume of Water. The measurement UFW volume is the difference between the volume of Water registered by the meter and the estimated volume of Water which actually flowed through the meter. The estimated UFW volume from all measurement elements resulted in an overall net under measurement of 1999 Water volume in the RWSC system of 657M<sup>3</sup>/D.

**ii- ACCOUNTING ELEMENT RESULTS**

In the accounting element, cycle billing adjustment (conversion of cycle read meter data to calendar month volumes) was found to be one of the largest contributor to UFW approximately 2596M<sup>3</sup>/D.

The UFW project identified the accounting components that bias the reported water (receipt) or delivery volumes and thus contribute to the operating UFW.

These elements include the cycle billing adjustments, and other activities where usage is not billed, broken meters, incorrect zero consumption, incorrect low consumption (less than 10) and ... observed both through checking/recalculating document and making comparison with field investigation. Overall, these factors contribute approximately 2596M<sup>3</sup>/D to the 1999 UFW volume.

**iii- LEAKAGE ELEMENT RESULTS**

The UFW study indicated that leakage from RWSC distribution system is 1547M<sup>3</sup>/D. Out of the this amount due to leakage (28 percent of total UFW), approximately 921M<sup>3</sup>/D is due to leaks on the distribution and connection system and the remainder, is from the pin leaks and flushing system. Prior to this study, the distribution leakage was supposed to be very much higher because of high corrosivity environment.

Leakage, defined in this study as "unintentional release of Water to the environment", is a term that applies to Water losses that are unplanned such as damage to pipe by outside forces or mechanical and material failures. Other released of Water to environment, such as pipeline blowdowns, are needed for company operations. Unplanned Water

releases to environment in RWSC'S Distribution operations were studied and estimated in two major areas. These areas contributed approximately 1166M<sup>3</sup>/D to the 1999 UFW volume and are discussed in the following sections.

**a- Pin Leaks**

Leakage from underground piping is caused by such factors as corrosion, material failure, threaded fittings, construction defects, mechanical fittings, and mechanical joints.

These area contributed approximately 291M<sup>3</sup>/D to the UFW volume.

**b- Leaks Caused by Damage**

A leak caused by damage is defined as the unintentional release of Water to the environment caused by an outside force. A damage, also known as a dig-in, typically occurs when a contractor accidentally ruptures a Water facility.

Nearly all damages were sustained by small diameter polyethylene (PE) piping. The UFW volume resulting from damages was calculated by first establishing an average Water loss per damage and then multiplying that average by the total number of damages for the year.

The majority of the leaks (over 76 percent) are occurred on ½" & ¾" dia piping system.

Overall, it is estimated that the volume of unaccounted-for Water in 1999 due to damages was approximately 925M<sup>3</sup>/D.

**IV- ILLEGAL CONNECTION RESULTS**

Due to major problem in many cities as well as in Rasht, from lack of supervision and maintenance of the distribution system over an extended period of years, the user client survey were carried out in the pilot area. Its main aim was to find the amount of nonphysical losses, verifying the metering system, legal and illegal connections and asses the extent of losses. In this respect a comprehensive census of consumers and thoroughly customer services connections were checked. To achieve a proper information, a standard survey form was designed and filled for each user, non user and households (covering houses, flats, offices, industries, shop, schools, Mosque, bungalows and others) by survey team.

This area of activity has been undertaken by student (survey team) during the summer of 1999 and the results are summarized accordingly. In this survey all broken or unreadable, non meters, unmetered authorized consumers, metered consumers who are not billed, incorrect billing or not done, illegal connections and water administrative anomalies were specified/reported.

The illegal connection study was based on a comprehensive RWSC study conducted in the beginning of the project to estimate the incidence and volume of illegal connection occurring among both residential and commercial customers. The results of this study, were analyzed using statistical methods. The analysis indicated that a conservatively high estimate of the illegal consumption contribution to UFW is approximately 3930M<sup>3</sup>/D.

## **7- RECOMMENDATIONS**

### **I- Measurement**

RWSC should have an active participant in the proceedings of standard-setting bodies such as meter manufacturers. RWSC currently has the ability to put meters in service with an accuracy setting that is suited to a given meter type. Refinement of this approach can reduce accuracy bias. RWSC should further refine the recently adopted use of ultrasonic meter accuracy settings. Furthermore, a better understanding of the causes of significant over delivery at low flow rates could be attained through more intensive studies and may reveal a solution for reducing this source of UFW.

RWSC should pursue more in-depth studies to quantify the pressure effect encountered when operating meters at higher pressures and, if possible, compensate for the effect.

### **II- Leakage**

Distribution Leakage: RWSC should continue and improve the current leak repair program.

The UFW study indicates that RWSCS' current leak repair program is not successful in reducing the number of leaks throughout the system. It is

speculated that the sensitive detection equipment purchased recently should be used properly to find leaks earlier in their development and, therefore, also reduces the average leakage rate. Applying further-improved leak detection techniques with undoubtedly continue to reduce future leakage rates.

RWSCS' process used to decide whether old pipe should be repaired or replaced can be refined with the knowledge gained from the study's underground leakage tests and network analysis calculation.

The low leakage observed from the distribution system should be factored into the economic analysis performed prior to pipeline replacements.

### **III- Consumer System**

RWSC should concentrate and continue on identifying illegal water use and modify the consumer services department According to results, customer management system should be improved, the existing consumer plumbing fixtures and their condition should be maintained as well as collecting all illegal connections.

It is noted however that some Client-User of Water were blamed in breaking meters and otherwise damaging the system by illegal means and would have to be aducated to a more operative behavior in the future.