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INTERNATIONAL REFINANCE CORPORATION  
FOR LOCAL CURRENCY WATER SUPPLY AND  
SEWERAGE (IRCL)

# Reduction of unaccounted for water

*The job can be done!*

Guillermo Yepes



ESD

Water and Sanitation Division

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The Water and Sanitation Division of the Transportation, Water, and Urban Development Department is addressing the sectoral challenges articulated in the World Bank's Water Resources Management Policy Paper and in the World Development Reports of 1992 and 1994. These challenges involve implementing key management principles:

- Water should be treated as both a social and economic good.
- Water should be managed within a comprehensive framework, taking into account cross-sectoral considerations.
- Water should be managed at the lowest appropriate level, employing a demand-based approach and facilitating participation of all stakeholders.
- Institutional and policy reforms should be linked to incentives influencing decision making.

The Division's work program is therefore selectively focused on three distinct themes: water resources management, performance of water and sanitation utilities, and service provision through non-formal institutions.

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TWUWS

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## **Introduction**

Programs to reduce Unaccounted for Water (UFW) have been frustrating experiences in many Bank-supported operations. Lack of accountability and managerial incentives to deal with the problem have been offered as the main factor to explain this experience (Infrastructure Note No. WS-15. Private Sector Participation in the Reduction of Unaccounted-For Water. Penelope Brook-Cowen ) and will not be discussed further. Nonetheless, a lack of clear understanding of the causes of UFW and of the costs and benefits that can derive from UFW reduction also contributes to unsuccessful water reduction programs. The purpose of this note is to document these causes and potential payoffs from UFW reduction in the light of two successful experiences (Murcia, Spain and Singapore) and to draw some lessons from them.

***UFW is defined as the difference between water delivered to the distribution system and***

***water sold.*** Therefore, the reliability of UFW estimates hinges on both production and consumption being fully and reliably metered. Metering is a major deficiency in most utilities in developing countries.

UFW includes two basic components: physical and commercial losses. **Physical losses** include water lost from pipe leaks in distribution systems, in house connections, and from overflows in distribution tanks. **Commercial losses** represent water used but not paid for. They stem from the unauthorized use of water (illegal connections), from faulty meters that inaccurately register consumption, and from tampering with the often inadequate controls of the commercial system (meter reading and maintenance, billing and collection); this results in fewer consumers and less consumption acknowledged as well as less water sold.



The above definition of UFW is often not adopted, and many utilities have their own, but seldom explicit, definition. Undesirable operating practices to account for both water produced and consumed are also common. These practices and lack of agreement with the definition of UFW often clouds the analysis of the causes and severity of UFW, and in the process create a very confusing picture of the situation. This leads to misguided remedial actions. Among these practices are:

1. Many utilities do not fully meter water production and consumption. In particular, estimates of the volumes of water provided free of charge for fire-fighting or to religious and public institutions can be highly unreliable. In some cases, none of the water produced and consumed is metered. In such a case it is difficult to reach a meaningful understanding of the causes of UFW.
2. Water losses that occur beyond the consumer meter—

water lost but paid for—as well as consumption considered as wasteful are often grouped with estimates of physical losses in the distribution system. Water beyond the consumer's meter is water used and "paid" for; it is not part of UFW. While wasteful consumption should be discouraged, as it has little or no benefits, the best way to reduce it is through adequate pricing which requires metering, rather than arbitrary definitions of what is wasteful.

3. Water used in the operation of water treatment plants (filter back-washing and other operations), from the definition of UFW, is not water delivered to the distribution system and therefore should not be part of UFW. Water losses in the treatment process should be taken into account in the design and monitoring of raw water and treatment water production facilities. These losses, of course, should be kept at a minimum.



Many Bank studies have documented that commercial losses often constitute a major portion of total UFW. Recent studies in Sao Paulo, Brazil; Santafe de Bogota, Colombia; and San Jose, Costa Rica, for instance, have demonstrated conclusively that commercial losses account for 50-65 percent of total UFW. Experiences in utilities in industrialized countries also confirm these findings (Table 1). However, a common denominator in many UFW reduction programs is the assumption that most or all water losses are of a physical nature. Utility managers are very often reluctant to admit to problems in the commercial system or the existence of extensive unauthorized users.

Low levels of UFW benefit both the utility and the consumer in many ways:

1. A reduction of physical losses translates into less water to be produced, treated and pumped. This results in the postponement of expansion of capacity, which eases the

**TABLE 1. COMPOSITION OF UFW (%)**

| UTILITY           | Year | Physical | Commercial | Total |
|-------------------|------|----------|------------|-------|
| Singapore         | 1989 | 4        | 7          | 11    |
| Santafe de Bogota | 1988 | 14       | 26         | 40    |
| Barcelona, Spain  | 1991 | 11       | 12         | 23    |
| San Jose, C.R.    | 1990 | 21       | 25         | 46    |

Source: Yepes, Guillermo. *Performance Indicators. Water and Sanitation Utilities. Set one: Operational Indicators. TWUWS, August, 1993.*

financial pressure to finance new works. Less water produced also translates immediately into cost savings in operations, due mainly to savings in energy and treatment costs (chemicals). All of these savings could be passed on to the consumer.

2. A reduction of commercial losses results in more water being billed, and in additional revenues for the utility. It has also been shown that water metering and adequate rates reduce wasteful consumption. Therefore, total consumption is likely to decrease and will yield lower production and corresponding cost savings.



3. Adequate understanding of consumption patterns will permit the utility to optimize the operation of the distribution system.

4. A better knowledge of real consumption, not masked by high levels of UFW, is an important pre-requisite for a more reliable demand projection, which is key to the definition of capacity expansion programs and financial planning.

5. A reduction in water consumption also reduces sewage flows and therefore associated costs. In addition, such a reduction has a positive environmental impact as less waste water reaches the receiving waters.

All these benefits (economic and financial), in the form of costs forgone, deferred investments, or additional revenues and less pollution depend heavily on the use of adequate pricing of water resources and services (from raw water extraction to wastewater discharge). Subsidi-

aries for water extraction, discharge of wastewater, and for capital investment and operations of water supply systems, lower the cost of water perceived by the utility and thus the incentives to reduce physical losses. Low water rates to consumers or group of consumers reduce the utility's incentives to meter their water consumption and to detect and deter unauthorized water uses. They also reduce the incentives to consumers to deal with leaks and wastage beyond their meters.

A reduction in UFW requires, foremost, a commitment by the management of a water utility to provide an excellent service at the lowest cost. However, a reduction of UFW entails costs (capital and operational) to the water utility which need to be balanced against the benefits to arrive at an optimum level. These costs and benefits will be discussed in the context of the Singapore case.



## **The Murcia Case**

The city of Murcia (population 350,000) was experiencing difficulties in providing 24 hours of continuous service to its residents. A mixed-capital company (municipal and private sector with the latter in charge of operations), Aguas de Murcia (AdeM), was created to manage the provision of water and sewerage services. When AdeM began operations in early 1989, it was confronted with an UFW level of 44 percent. By 1994 UFW had been reduced to 23 percent, an enviable achievement (Table 2).

The main actions taken by AdeM to accomplish this reduction in UFW were:

1. Implementation of a new

commercial system for better accounting of all water uses and users. Reliability of the new commercial system is high and billing errors and complaints have been drastically reduced. The lead times between meter reading, billing, and collection have also been drastically reduced, thus improving the cash flow of the utility. For instance, the lead time between meter reading and billing has been reduced from 90 days in 1989 to 9 days in 1994.<sup>1</sup>

2. Intensive searches for unauthorized users and rapid incorporation of these users into the commercial system.

**TABLE 2. MURCIA, OPERATIONAL INDICATORS**

| <b>INDICATOR</b>                               | <b>1988</b> | <b>1989</b> | <b>1990</b> | <b>1991</b> | <b>1992</b> | <b>1994</b> |
|--|-------------|-------------|-------------|-------------|-------------|-------------|
| <b>UFW (%)</b>                                 | 44          | 44          | 38          | 31          | 25          | 23          |
| <b>Water Production mM3/yr</b>                 | 36          | 38          | 38          | 34          | 32          | 30          |
| <b>Connections (000)</b>                       | 72          | 73          | 76          | 80          | 85          | 92          |
| <b>Water Consumption mM3/yr</b>                | 20          | 22          | 24          | 23          | 24          | 23          |
| <b>Meters Read (%)</b>                         | 36          | 84          | 90          | 91          | 92          | 96          |
| <b>Profit (loss) before taxes \$US million</b> | (3.4)       | (1.5)       | 1.7         | 2.2         | 2.6         | n.a.        |

Source: *El Proceso de Modernización de una Empresa de Aguas*. Jose Luis Hervás. AdeM. Mayo, 1993.





3. Replacement of faulty meters and extension of metering to all users.

4. Metering of all production sources and installation of meters at key points in the distribution system. Development and implementation of a computer cost-optimization model for the operation of the distribution system.

5. Improved maintenance of both production and consumption meters to ensure reliability of flow measurements.

6. Pressure zoning of the distribution system to avoid extreme low and high pressures.

7. Leak detection survey and intensive repair of pipe leaks including replacement of old pipes in bad condition.

Actions 1, 2, and 3, all aim to the reduction of commercial losses, resulted in a rapid increase in revenues from \$US 14.2 million in 1989 to \$US 24.4 million in 1992 (current terms), mainly the result of increasing the number of con-

nections and improving metering. These actions also helped to reduce wasteful consumption which led to a reduction in water production (Table 2). Metered consumption increased from 22 to 24 million m<sup>3</sup>/year while average consumption per connection decreased by 17 percent from 301 m<sup>3</sup>/year to 250 m<sup>3</sup>/year from 1989 to 1994. Actions 4 and 5 have provided the utility with better information and tools to operate the distribution system which have also translated into cost savings and better service. Action 6, a more traditional one, has also contributed to a reduction of pipe leaks and to a further reduction of water production and operating costs.

Service users have benefited as well by this program. Service by house connection has been extended to 100 percent of the population, water pressure is adequate and water service is reliable and available 24 hours a day. Last but not least, water rates in real terms have been reduced by 4 percent between 1989 and 1992.



## The Singapore Case

Singapore is a small but vibrant city state with a population of about 2.8 million. Water resources are scarce, and about half of the water supply is imported from neighboring countries. Water services are provided by the Public Utilities Board (PUB), a public statutory agency. Sewerage services are operated by the Sewerage Department under the Ministry

of the Environment, but sewerage rates are collected by PUB on behalf of this department. PUB also provides electricity and gas.<sup>2</sup> PUB is a model public company; accountability is high, and it has a highly trained, motivated and lean staff force (2.2 staff per thousand water connections). The quality of services provided is outstanding. The vision of PUB is to provide the best service to

**TABLE 3. SINGAPORE. VOLUMES SOLD AND REVENUES, 1994**

| Consumer                | Percent of Volume                | Percent of Sales               | Relative Tariff                       |
|-------------------------|----------------------------------|--------------------------------|---------------------------------------|
| Residential             | 47.3                             | 40.3                           | 0.85                                  |
| Commercial & Industrial | 32.0                             | 47.1                           | 1.47                                  |
| Government              | 19.9                             | 10.6                           | 0.53                                  |
| Shipping                | 0.8                              | 2.0                            | 2.50                                  |
| <b>Total</b>            | <b>100% = 456 Mm<sup>3</sup></b> | <b>100% = \$US 237 million</b> | <b>1.00 = \$US 0.52/m<sup>3</sup></b> |

Source: PUB

**FIG. 4. SINGAPORE. EVOLUTION OF UFW**

| YEAR    | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 |
|---------|------|------|------|------|------|------|
| UFW (%) | 10.6 | 9.5  | 7.7  | 6.7  | 6.4  | 6.0  |

Source: Chan Yoon Kum & Hew Kit San, *Singapore's Water Supply and Sewerage Services*. World Bank, Water Conference. Landsowne, VA. December, 1994.



all the population of Singapore at the lowest cost and to be the best utility in the world. They receive the highest marks on both objectives.

Water rates in Singapore vary according to the user, being the highest for shipping and industrial consumers. The average 1994 rate was \$SD 0.80 per m<sup>3</sup>.<sup>3</sup>

PUB's enviable and long-sustained track record (Table 4) of very low levels of UFW has been attained by a consistent program that includes the following actions:

1. All water produced and service connections are metered and users are accounted for.

a) Meter accuracy is very high:

i. Production meters are all of the magnetic type and calibrated once a month.

ii. Domestic meters are replaced every seven years and large meters (industrial and commercial) every four years.

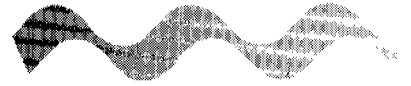
b) The volume of water used

for fire-fighting is either measured or estimated, and the fire department is billed for this use. All water users have to pay.

2. The commercial system is highly reliable and controls are in place to prevent tampering. Billing complaints, when they occur, are dealt with promptly. Low and high consumption patterns are identified and consumers are alerted to high consumption. Inconsistent readings are promptly reconciled and faulty meters are immediately replaced. Meters are read every two months but bills are issued monthly. Services are discontinued for non-payment (bad debts are less than 0.3 percent of billings). Average water rates are close to the incremental cost of water.

3. Leakage of pipes and water connections is under tight control:

a) The whole distribution sys-



tem is surveyed for leaks once every 11 months. On-the-surface transmission pipelines are surveyed three times annually. Troublesome spots or districts can be hydraulically isolated and are rechecked twice a year (on the twelfth month).

b) Water districts can be fully isolated to monitor for leaks (water into the district can be measured and water connections can be shut off).

c) Pipes in the distribution system are concrete-lined to reduce corrosion problems. Pipes are replaced if the number of breaks exceeds three per kilometer per year.

d) House connections are made of stainless steel or copper.

e) In-house repairs and installations are done by certified plumbers.

The goal of a utility is not to have zero UFW but rather to reduce it to a point where bene-

fits equal costs. At first glance, the PUB program to maintain UFW at such low levels may appear not to be cost effective.

Let's explore this argument:


1. The cost of magnetic production flow meters is about the same as more conventional water meters (velocity or pressure differential). However, they are more accurate, reliable, and easier to maintain.

2. The cost of replacing residential consumption meters on a seven-year cycle is higher when compared to the conventional practice of meter

**TABLE 5. SINGAPORE. METER ACCURACY**

| Age of Meters<br>Years | Percent of Meters<br>with accuracy within +/-3% |
|------------------------|---|
| 6                      | 87  |
| 7                      | 88  |
| 8                      | 87  |
| 9                      | 50  |
| 10                     | 32  |

Source: PUB, *Water Supply in Singapore. International Conference on Water & Development, January, 1992.*



replacement every 10 to 15 years. However, longer replacement cycles reduce meter accuracy and therefore increase commercial losses.

PUB 7-year meter replacement practice versus a 10-year one implies additional costs of about \$SD 1.70 per connection/year (based on a discount rate of 10 percent and an installed meter cost of \$SD 40). On the other hand, and based on PUB tests, a 10-year cycle will add a loss of at least two percentage points to UFW (Table 5), which would imply a corresponding loss in revenue of \$SD 9.65 per domestic connection per year. Similar calculations for industrial and commercial consumers, which pay higher rates, also indicate that PUB strict replacement metering policy is cost-effective.

3. The amount spent on leak

control is about \$S 1.03 million per year (1994), of which about 95 percent represents manpower costs<sup>4</sup> and the rest maintenance and depreciation costs of the leak control equipment. An increase of one percentage point in physical losses would require the purchase of an additional water supply of about 4.5 million cubic meters per year at a cost of \$SD 1.3 million.

4. From 1983 to 1993 an intensive pipe and house connection replacement program was implemented. Under this program some 76,000 connections (10 percent of connections) and 182 kms. of pipes (4 percent of the distribution system) were replaced at a cost of \$SD 26.8 million and \$SD 28.2 million respectively.

The use of mortar-lined pipes and of high quality house connections materials has other benefits. For instance, recur-



rent problems with water decoloration (red water) have been reduced substantially as well as the number of pipes breaks (from about 12 breaks/100kms/yr in 1985 to less than 4 breaks/100 kms/yr in 1992) since the pipe replacement was started.

The annualized cost of these investments over a 30-year period is \$SD 5.8 million. The attributed reduction of physical losses to this replacement program is hard to estimate. However, reduction of 1.4 percentage points in physical losses (which were much higher when the program started), not an unrealistic trade-off, would fully justify this replacement program on UFW grounds alone.

In conclusion, PUB's existing program of strict controls and consistent actions to maintain UFW at such low levels appears well justified.



## ***What are the lessons?***

The approaches followed by these two utilities to successfully reduce UFW are similar and provide many lessons:

1. First and foremost, accountability at all levels is high in both institutions. Accountability is probably the most important factor that will induce management of an utility to take the necessary actions and for them to fall into place in the right sequence.

2. Water services are adequately priced to provide the right signal to both the utility and the users to act promptly in keeping UFW at the lowest cost-effective level.

3. Reduction of commercial losses is very important because it helps improve the revenue stream almost immediately. Hence, both utilities give the highest priority to the commercial systems (accounting for all users, universal metering and maintenance,

billing, and collection) which are tightly controlled operations. A well operated and maintained commercial system is the life-blood of both utilities, as they do not rely on subsidies for their operations.

4. Reliable information on water production and consumption and their evolution over time are critical to a reliable assessment and monitoring of UFW and identification of the correct actions to keep it under control. This information is also critical for the optimal operation of the distribution system.

5. Reduction of physical losses has a lesser impact on net revenues, at least in the short run (variable production costs are often not significant). However, in the medium and long term, such reduction postpones the need for additional capacity and eases the pressure of financing new works. In



addition, broken pipes that remain unrepaired project a bad image of the utility among consumers.

6. Reduction of both physical and commercial losses are undertaken concurrently. As a high level PUB official pointed out, "UFW is the result of a combination of factors, not the result of a single one." Therefore, the components of an UFW reduction program and their costs and benefits should be carefully determined to arrive at a cost-effective strategy.

7. Last but not least, UFW programs have become routine and institutionalized operational programs and not sporadic exercises to be undertaken only when financing by loans or grants is available.

### **References**

1. A uniform tariff is applied to all consumers. This tariff covers operational costs, debt service and contribution to investments.
2. Power and gas services are being privatized.
3. 1\$US = 1.53 \$SD (1994)
4. A staff force of 58 persons is assigned to this task. This staff is also responsible for the operation of large valves in the transmission and distribution system.



