

# Acceptable Level of Water Losses in Geneva

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## Introduction

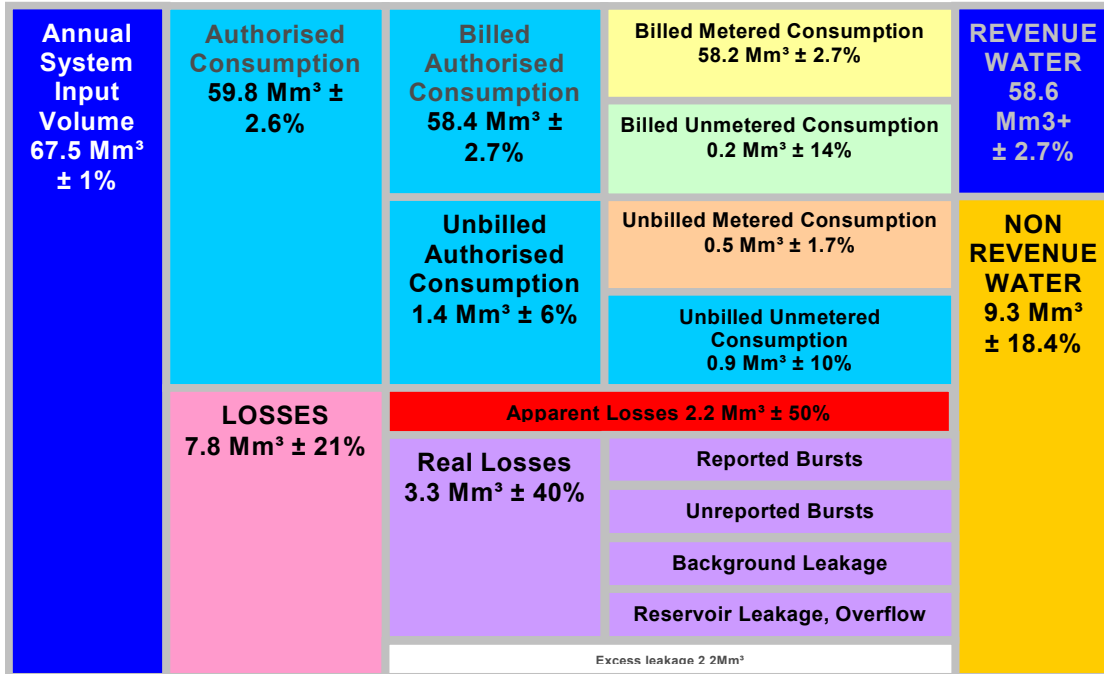
Geneva Water (SIG) is a public utility company which produces each year about 70 Mm<sup>3</sup> of drinking water for approximately 450'000 customers. In order to optimise the production process, Geneva Water has standardised the methodology to estimate the quantities of Non Revenue Water (NRW) produced and supplied to the network each year. This first step has been achieved in March 2006 using the methodology proposed by IWA (International Water Association).

This process highlighted that the previous estimations were under-evaluated, and that improvement of the whole process of water production and distribution was necessary.

The aim of this paper is to share the actions implemented and the first results obtained toward an acceptable level of Water Losses for Geneva.

## Water Balance calculation

Until 2004, there was no standard methodology to establish an accurate annual Water Balance at SIG. Estimation of water losses for year 2004 led to an increase of 1% and NRW exceeded the virtual level of 10%. This initiated the project for a standard and stable estimation of Non Revenue Water. During year 2005, an in-depth study of each component of IWA Water Balance model has been carried out, including a detailed calculation of the tolerances. This procedure is now followed every year and the results for year 2006 are presented in **Figure 2**.



**Figure 2:** IWA's Water Balance results for SIG – year 2004

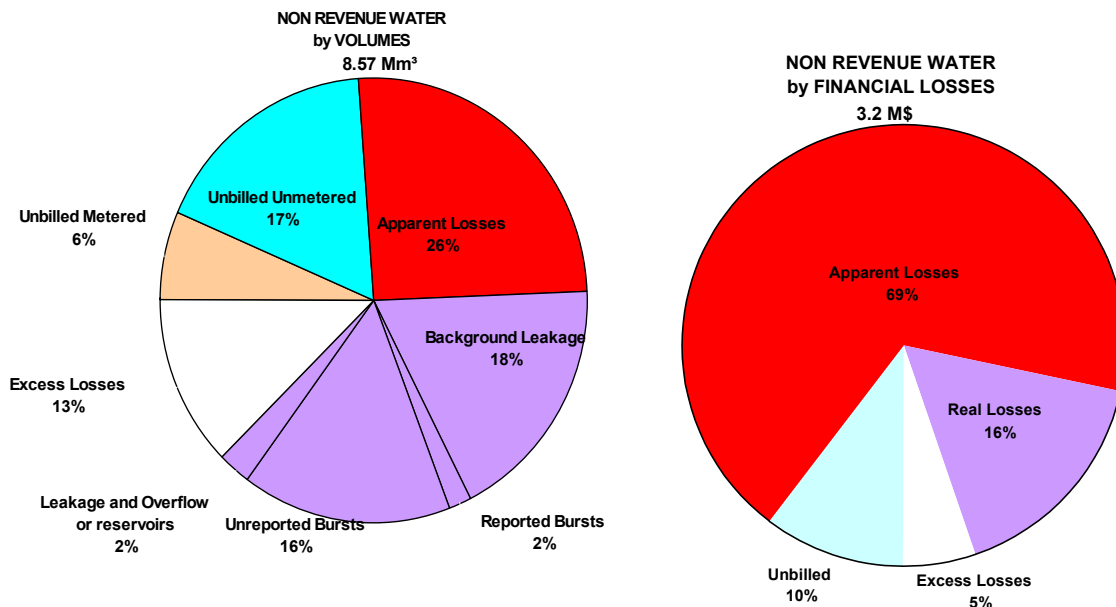
Table 5 highlights the evolution of the Non Revenue and the Real Losses for the last years.

Year	Non Revenue Water	
	Previous estimations	IWA's methodology
2002	9.30%	
2003	9.60%	
2004	10.40%	13.30%
2005		14.00%
2006		13.70%

*Table 5: evolution of the Non Revenue Water (% of water production)*

Not only the 10% level was passed in year 2004, but also an additional 3% resulted from use of the new methodology...

The detailed analysis of the Non Revenue Water on quantity and financial point of views is presented in **Figure 3** for year 2004.



**Figure 3:** Losses in 2004 with both volume and financial views

These significant results confirmed that improvement was achievable and led to the elaboration of a detailed action plan.

## Action plan

Some actions were immediately undertaken and did not need any further analysis: for example, the spilling of water during winter in order to prevent freezing of certain exposed pipes was drastically reduced with a better management, and pipe flushing is now limited to strict necessity. However, other actions need some more analysis to fix the target value of the loss reduction at an acceptable limit.

From the result of the Water Balance calculation, two types of actions have been planned and are currently implemented:

- **Improvement of the reliability of figures** (decrease tolerances)
  - Flow meters checking;
  - Customer meters sampling
  - Proposition of an improved method for integration of the consumption data (annual index).
- **Identification and reduction of the losses**
  - Optimisation of the customer meter's renewal program
  - Calculation of the ILI indicator (Infrastructure Leakage Index) to focus pertinent actions
  - Identification and implementation of pilot sectors for reducing the average pressure in the network

The aim of the first type of actions is to improve the Water Balance by increasing the accuracy of figures. Indeed, Water Losses being deducted from this calculation, the accuracy of the results is essential to focus on the correct actions for the reduction of losses. Concerning the second type of actions, the aim is to implement actions where

the potential of improvement has already been demonstrated, and in parallel to investigate complementary actions. In this way, SIG is able to directly enhance the efficiency of the water supply network toward an acceptable limit.

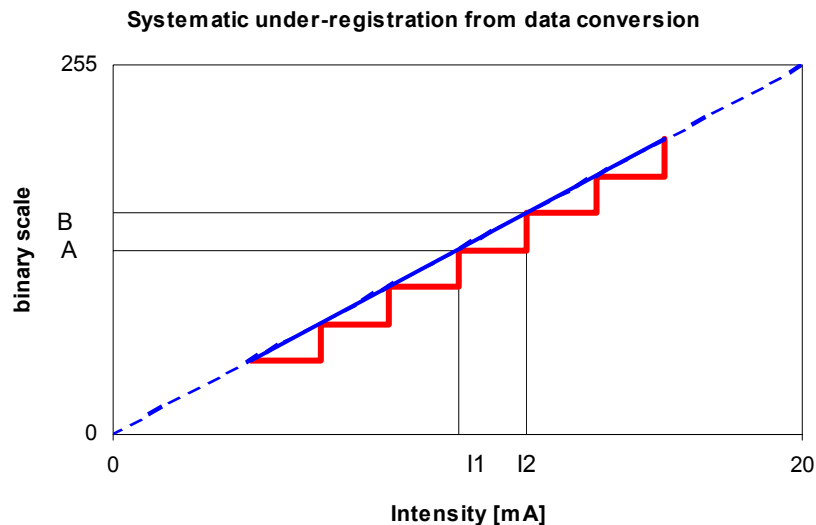
## Improvement of the reliability of figures

### *Flow meters checking*

The tolerance of the volume of water delivered into the network depends on the accuracy of the flow meters at the production units (treatment plants, pumping stations). It is essential to get the most accurate value for the total input volume of water as it affects the Non Revenue Water in the water balance. First estimations were based on figures from manufacturer (% of tolerance versus age of the flow meters for different models). This had to be confirmed on site and the verification of the accuracy of the flow meters at the production units has been initiated, as most of these flow meters, either ultrasonic or electromagnetic, are more than 10 years old and have never been checked.

Up to now, more than 15 flow meters have been checked (total of 28) measuring 70% of the total production volume. The results of the checks are very positive as none of these measurement instruments gave noticeably wrong data (deviation of more than 3% of the measured flow). Until now, it is not possible to deduct a tendency for the flow meters to over or under register the production volumes.

However, this process recently pointed out that the systematic errors in the transmissions of data from the site to the Control Centre, where figures are stored, was higher than previously estimated. Indeed, the 8-bits (256 steps) converters used in most of the equipments produce a systematic under registration of the volumes as illustrated on **Figure 4** hereafter.



**Figure 4:** systematic error during binary conversion

For intensity  $I$  from the flow meter between  $I1$  and  $I2$ , the binary conversion will always give the value  $A$  on the binary scale. To reach the binary value immediately above ( $B$ ), the intensity has to reach  $I2$ . The flow rates are therefore always under estimated to the Last Significant Bit (LSB).

The resulting error was initially estimated to 0.2% (average error with 255 step) However, considering that many flow meters are sized for maximum flow but are usually operating at less than 50 % of their capacity, the difference can be quite important for some flow meters. Considering the real operation of flow meters for the whole production units, the average under estimation of the production is above 0.5%, representing 3% of the NRW...

### **Customer Meter sampling**

The estimated tolerance of the apparent losses from customer meter under registration is high (50%, see Figure 2) as the figures are taken from literature and not specific to Geneva situation. A whole campaign of in-depth measurements of the accuracy of meters registration has therefore been started to assess the apparent losses for the meters' park in Geneva. Two different tasks are now ongoing:

- Construction of the water consumption pattern to determine the actual volumes measured through the meters at different flow rates;
- Assess the metrological performances of the meters at these different flow rates.

More than 200 meters have been selected in a sample representing the whole meters park of Geneva in terms of annual volumes, diameters, manufacturer, age, type of customer etc. Up to now more than 100 meters have been investigated. The intermediate results indicate that the type of meters (velocity meters) used in Geneva tends to under estimate the low flows (especially the old meters) but are accurate at high flow (Table 6). For the customer meters with a diameter of 30 [mm], the mean error represents 6% of the registered volume and for the 40 [mm]; the mean error is above 10% (Table 7). This high result if confirmed by further investigations will increase the apparent losses in the Water Balance.

Flow rates [l/h]	consumption pattern	meter error	registered volume
0 - 22	0.4%	-100%	0%
22 - 120	9%	-50%	4%
120 - 300	14%	-3.5%	13%
300 - 480	16%	0.3%	17%
480 - 3'240	60%	-0.5%	60%
3'240 - 6'000	0.5%	-0.9%	0.4%
6'000 - 12'000	0%	-0.4%	0%
<b>total</b>			94%
<b>weigthed error</b>			6%

**Table 6:** Error of the 30 [mm] customer meters – results of a sample of 25 meters

Flow rates [l/h]	consumption pattern	meter error	registered volume
0 - 45	0.4%	-100%	0.0%
45 - 200	11%	-76%	2.7%
200 - 500	20%	-5%	19%
500 - 800	22%	-1.7%	22%
800 - 5'400	46%	-1.2%	45%
5'400 - 10'000	0%	-1.2%	0%
10'000 - 20'000	0%	0.1%	0%
<b>total</b>			89%
<b>weigthed error</b>			11%

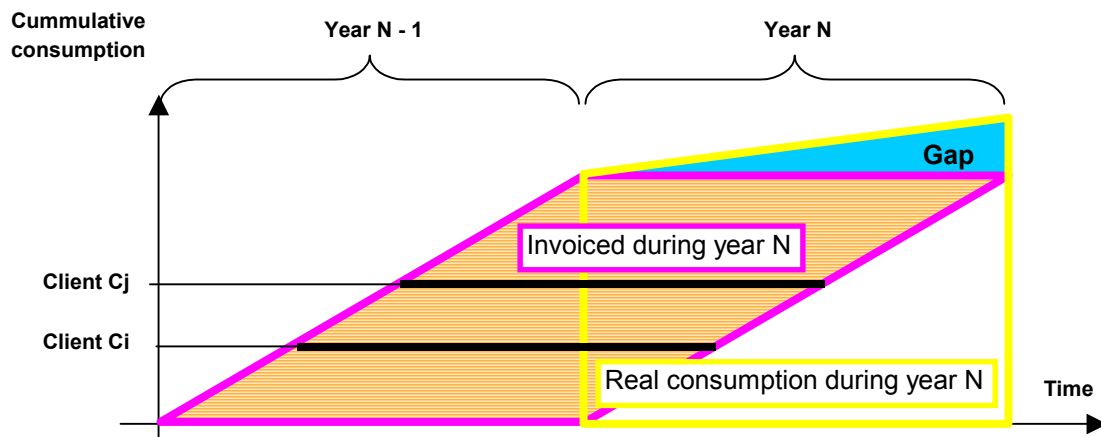
**Table 7:** Error of the 40 [mm] customer meters – results of a sample of 20 meters

These first results are still to be confirmed with the ongoing checking process, but they already highlight that the customer meters renewal (presently done every 12 years for domestic customers) will need a strong review.

### **Improvement of integration of the Billed Metered Consumption**

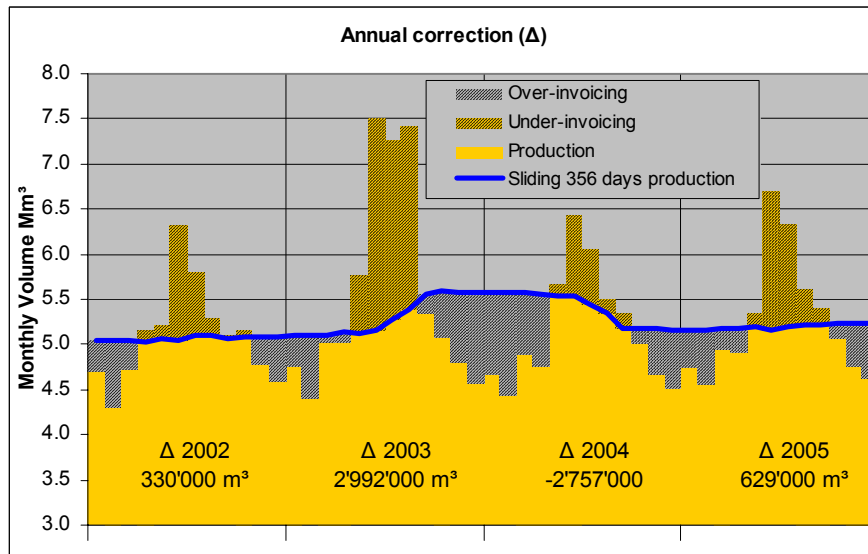
The Billed Metered Consumption represents more than 97% of the Authorised Consumption (Figure 2). Thus, 1% of deviation of this component of the Water Balance leads to a deviation of approximately 10% of Non Revenue Water...

In Geneva most of the indexes of the customer meters are read only once a year. It is therefore essential to correct the total volume invoiced during a year as the gap between two years with significant differences in the total annual production of water can be high (Figure 5).



**Figure 5:** gap between real consumption and billed consumption

The estimation of this gap is based on the calculation of the difference between the Annual Production and a « sliding » production average as shown of Figure 6 hereunder.



**Figure 6:** Billed Metered correction

The calculation is the following:

$$BMC = B + Gap = B + \sum_{n=1}^{365} \left( \frac{\sum_{i=1}^{365} P_{(n-i)}}{365} - P_{(n)} \right)$$

where: BMC = Annual Billed Metered Consumption  
B = Annual Billed Volume  
P = Net Daily Production (without estimated NRW part).

This formula will be slightly adapted to take into account that some of the customer's meters (mainly for industrial customers) are read every month (and are therefore not subject to annual deviation). This represents approximately 15% of the total consumption. A daily estimation of the volumes billed monthly will be deducted from the daily production in the above formula.

Considering a 1% tolerance on the monthly-billed volume (to take into account the time between readings and invoicing which affect the volume in beginning of January and end of December), the tolerance for Billed Metered Consumption can be reduced from 2.7% to 2%. Further investigations are still necessary, particularly on a possible shift of the annual period taken into account (April to March instead of January to December), to reduce the influence of the position of the peak consumption period.

A project is also under implementation for the installation, as a first step, of about 600 radio frequency remote read water meters in 2008. This will increase the percentage of monthly read volumes and increase the accuracy of the annual billed metered consumption.

## **Identification and reduction of the losses**

To actions for reducing the losses were started without any additional investigation: improve the leak detection by enhancing the frequency of the detection operation, and reduction of the winter spilling and pipe flushing. Results of leak detection new program have not yet been analysed, but spilling of water has been reduced by 98% during the winter 06-07 (this winter was not very cold), and flushing of pipes was reduced by 75% during the first 6 months of 2007, owing to a better management of compulsory pipe cleanings.

The following actions are also planned:

### ***Optimisation of the water meter's renewal program***

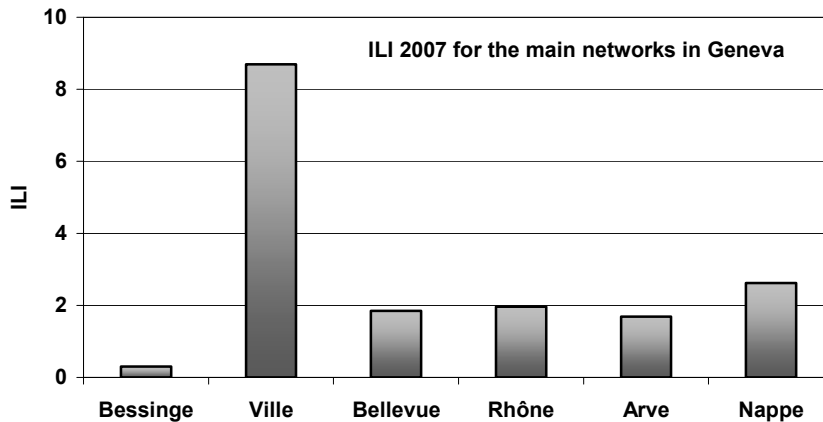
The renewal program for the water meters, aiming at reducing the virtual losses, depends on the final results of the sampling campaign for both metrological curves and consumption patterns. The questions to be answered concern the renewal frequency and also whether the current velocity meters are the best options in comparison with other technologies (for example the volumetric meters).

The renewal program will be analysed by the end of the year, and will probably propose a renewal frequency depending on the type and the diameter of the meters.

### ***Calculation of the indicator ILI (Infrastructure Leakage Index)***

The ILI for the whole Geneva Network is between 2.5 and 3 for years 2004 to 2006, calculated with CARL (Current Annual Real Losses) issued from the Water Balance.

There are however 6 main networks in Geneva and 10 smaller secondary and tertiary networks. An estimation of the ILI for the 6 main networks was completed, and the results are presented in **Figure 7** below. It was not possible to calculate the Water Balance for each network, as the Billed Volumes are not geographically plotted, and thus ILI was estimated taking into account the minimal night flow analysis. The result for the whole network computed with this methodology by aggregating the weighted ILI for each network is 2.8, in the range of the ILI calculated from Water Balance. However, **Figure 7** points out important discrepancies (mainly for primary networks of Bessinge and Ville), which will have to be elucidated with further investigations.



**Figure 7:** ILI for the main networks in Geneva

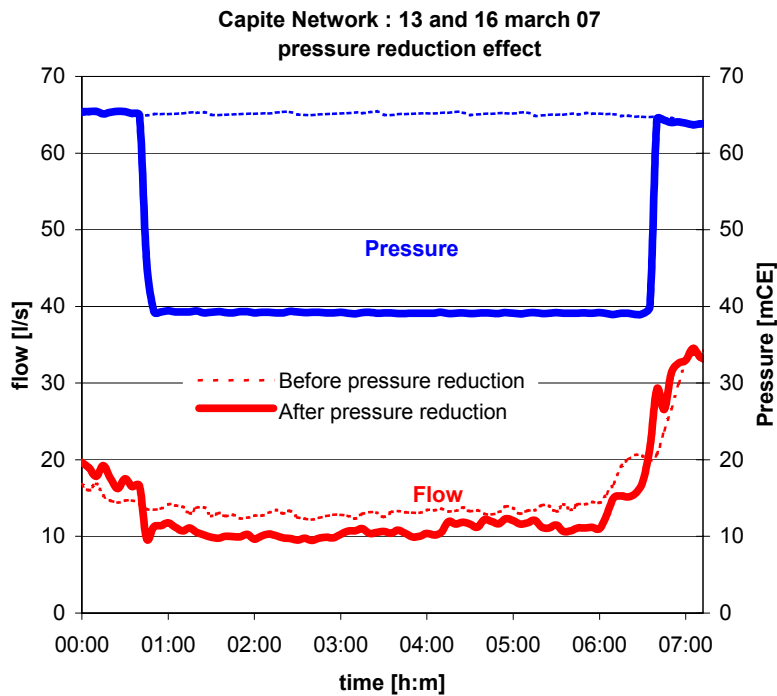
These results probably highlight the limit of the ILI calculation for small networks

### ***Pilot sectors for reducing the average pressure***

The average pressure in the Geneva Network is quite high (above 75 m), and there is some room for pressure management. However, the first step is to check the target; indeed, pressure management will request some important investments (pressure reducing valves, modification of networks), and the real benefit has to be confirmed beforehand. Therefore, the on-going project features pilot areas for pressure management.

Two different targets are pursued by a reduction of the average pressure in the network: the background leakages can be reduced and the frequency of bursts can also be dramatically lowered.

A first test has been completed in small sub-network in Geneva (Figure 8), which highlighted the effects of a reduction of pressure applied during a few nights.



**Figure 8:** Reduction of pressure and effects on background leakages

Two pilot areas are under definition: the total length of networks concerned is 31 and 37 km, and the possible pressure reduction will be between 3 and 3.5 bars (close to 50% reduction). As the equipment of the network with pressure reduction valves will be implemented during next winter only, results will be available at the time of the next congress...

## Conclusions

An in-depth evaluation of the Water Balance for Geneva, carried out when the previous calculation reached a Non Revenue Water percentage exceeding 10%, highlighted that the situation was not acceptable and that many improvements were necessary and possible. This work allowed for a better knowledge of all the components of the water balance and wide spread information of the staff involved. Necessary improvements concern both the reliability of the Water Balance figures and the reduction of losses.

The first steps of implementation of the action plan allowed to reduce easily some of operation losses, and the next step will fix the necessary targets for the two main points: optimisation of the Consumer Meters renewal program (important financial losses) and pressure management (important reduction of bursts are expected).

The main lesson learned from this project is that the situation remains acceptable until we really look at it...

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