MALTA: USE OF LEAKAGE CONTROL IN WATER MANAGEMENT STRATEGY CASE #22

The case study illustrates the importance of setting leakage control in the wider strategic management at corporate level, with significant implications for resource use in Malta.

ABSTRACT

Description

The Maltese islands, like other parts of the Mediterranean area is an area of acute water shortage. Leakage control has been developed to become a strategically important component for water resoruce management, and has been used to reach an optimum economic balance between water supply and water demand. An understanding of the economics of leakage control, the target setting of leakage goals, and the strategic management of leak control resources is vital. The study describes the major advances made in the fields of technology, training, HR skills and management techniques that collectively enabled the Water Supply Corporation to more than half its leakage within 5 years The reduction in National leakage from 2,800 cubic metres per hour to 1,200 cubic metres per hour over 5 years, as well as the achieving of an internationally recognized leakage target for Gozo, is the focus of this case study. This has been achieved despite the technical difficulties of a dense and complex water network.

Lessons learned

- Despite severe technical difficulties, leakage reduction has played a significant role in reducing dependence on (high cost) water supply from desalination.
- To be effective, leakage control should be seen as a major component of corporate strategy for water resource management, involving sophisticated management techniques as well as technical innovation.

Importance for IWRM

Malta faced shortages of water, and limited groundwater (due to illegal abstraction in the agricultural sector). Leakage management is an effective supply side action to increase efficiency in water use leading, and can be used as a strategic tool.

Tools used

C1.4 Developing water management indicators
C3.1 Improving efficiency of use

MAIN TEXT

1 Background and problems

The Maltese archipelago consists of 6 islands and islets, the main islands being Malta, Gozo and Comino. The total surface area is approximately 316 Km^2. The Islands have a population of approximately 376,000. Water is a scarce resource, particularly in view of the local hydroclimatological conditions, including the low rainfall and high evapotranspiration rate, relatively long dry season, small surface area, the irregular topographic relief and the characteristics of the local aquifers. International benchmarking through a comparison of indices reflects the difficult environmental constraints facing the country's water sector, (WSC Annual Report, 2000). Malta has the lowest water resources index (at 40 m^3/year/capita) and the highest water competition index (inhabitant/hm^3/year) in comparison with other countries Mediterranean basins.

Shortages in supply have partially been overcome by the use of reverse osmosis. To date six reverse osmosis plants have been built locally, supplying the Maltese Islands with 16.6 million cubic metres out of the total 33.7 million cubic metres consumed in the 12 month period between October 2000 and September 2001. However, the water is expensive at a cost of 20c[1] per cubic metre, *excluding* the capital cost, nearly three times that of groundwater extracted and treated. However, the level of exploitation of aquifer-based groundwater is high and largely uncontrolled, mainly illegal extraction irrigation purposes. Increased use of groundwater is therefore not an option for municipal water supply, since this would result in a further deterioration of the groundwater aquifers, already feeling the effects of over-exploitation as is being seen by a steady increase in chloride levels over the years.

Furthermore, per capita consumption of water in Malta is extremely low for a developed country, at around 250 litres per connection per day. This implies that there is little potential for reduction on the demand side.

Leakage management therefore became seen as an important contributor to balancing supply and demand, and the prime aims of reducing production costs, improving the economies of the water supply organisation, and postponing capital investments in water network renewal.
The challenge was considerable: the total length of water mains below ground, excluding consumer services, is around 2,000 Km and the total number of water services is at around 200,000. The average density of 100 services per Km of mains is one of the highest ratios to be found worldwide. As service connections are particularly prone to leakage, this high density of connections adds weight to the importance of adequate leakage control in a system that is both compact and complex.

There are other difficulties peculiar to Malta:

- The existence of numerous galvanized iron service connections which are highly leakage prone
- The hilly terrain means that substantial pressure variations exist throughout the network.
- Leak detection is difficult for a number of reasons (eg clay soils below the surface becoming water logged, delaying identification of leaks; the uneven road surface containing numerous potholes that are backfilled with materials of unequal density makes acoustic leak localization difficult)
- The density of the local network, at around 100 services per Km of main, means that numerous pipe junctions, fittings, valves, crossings, etc. exist in a network that can only be compared to that of a crowded metropolitan city.

[1] *1 Malta Lira equals 100 Malta Cents equals 2.4 US Dollars*

Other management difficulties which needed to be overcome were:

- A legacy of weak data management practice had resulted in the existence of network plans that are untrustworthy at best.
- Poorly qualified staff
- The drive towards transparency by the Corporation in the purchase of equipment via tender had the disadvantage of allowing for the inclusion of a range of often-incompatible systems and technologies. As of late, the Corporation has started to standardize upon systems and equipment.

Institutional context

The Water Services Corporation Act XXIII of 1991 serves as the legislative basis and includes all tools and instruments for water resources management issues in the Maltese Islands. The act regulates the whole water cycle (acquisition, production, distribution of drinking and second class water, disposal and reuse of sewage and wastewater and reuse of storm water runoff) as well as water trading rights between individuals. It sets up the WSC as the corporate body in charge of water management in Malta. In February 2001 the WSC handed over its regulatory responsibilities to the newly setup Malta Resources Authority (MRA), by means of the Malta Resources Authority Act XXV of 2000. This move allowed for a much-needed legal delineation between regulatory and operational responsibilities within the Maltese Islands

3 Actions taken

The Water Services Corporation has, from its setting-up in 1992, been aware of the importance of achieving and sustaining an economically viable leakage level.

Quantification of leakages

The initial step taken by the Corporation was directed at quantifying leakage. This major exercise included the zoning of the Maltese Islands into 8 master zones, over 200 hydraulically encapsulated zones, and the further sub-division of high leakage zones into segmented areas, which were amenable to step-testing. Continuous data logging of all zone inlets and metering of all service connections allowed computations of leakage to be made on:

- a ’bottom-up’ (using minimum night flows) basis and
- a ‘top-down’ (using annual water balance) basis, in accordance with recommended best practice from the International Water Association (IWA).

This two-pronged approach enabled assumptions to be crosschecked and uncertainties in calculation errors to be reduced.

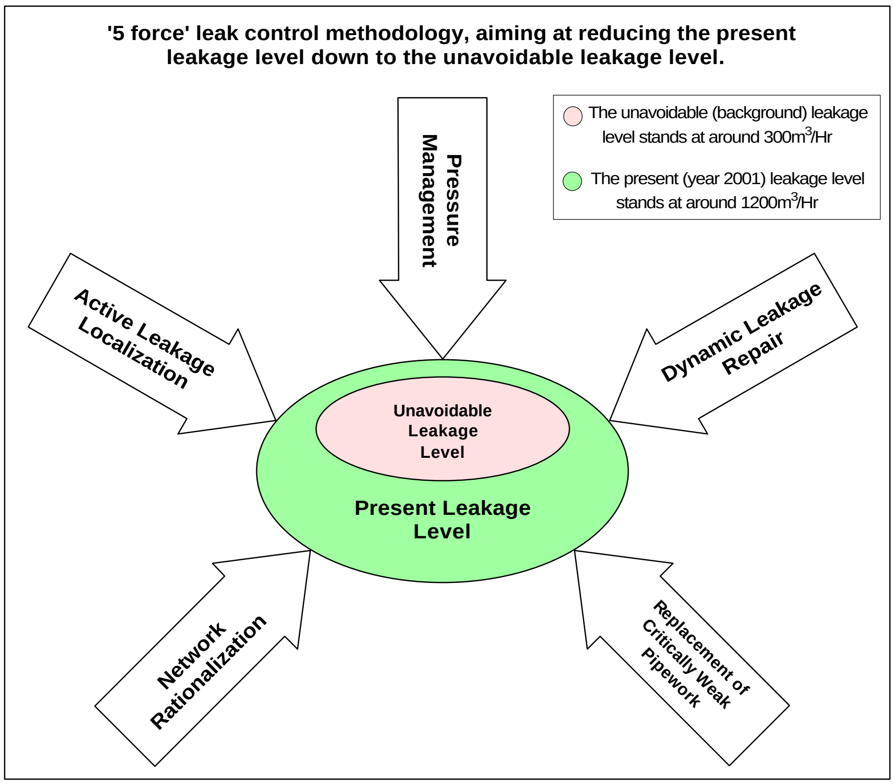
Management approach

Following initial leakage quantification based on sector night flows, the Corporation gradually implemented a leakage control programme based upon a delicate balance between five key components; pressure management, network rationalization, active leakage localization, dynamic leakage repair and replacement of critically weak pipework. This approach consists of achieving an equal balance between five activities, or “forces”. The methodology is illustrated in Figure 1 below. To understand this methodology one can imagine the five forces attempting to work equally to reduce the area of the outer ellipse (corresponding to the present day volume of leakage) down to the area of the inner ellipse (corresponding to the minimum technically achievable leakage level). If the five forces are not implemented with equal strength and consistency, the outer ellipse will not compress inwards, it will only shift towards the direction of the weaker force/s.

In brief, these five forces are described as follows:

Pressure management: at the zone entry point.
Active leakage localization: This involves a wide range of tasks and activities that enable the accurate pinpointing of leakage that is not visible from the road surface
Network Rationalization: This consists of numerous infrastructural works that will be carried out in line with the component above, aiming at creating a manageable and controllable water network.
Dynamic leak repair: Speed and quality of repair are the two main criteria. Any service connection found to be defective is replaced as a matter of policy.
Replacement of critically weak pipework: Leak repair data superimposed onto a G.I.S. platform are utilized for planning purposes to target and eliminate critically weak segments of the water network. This concept is a cost-effective alternative to network rehabilitation as only the genuinely defective portions of the water network are replaced.

Figure 1: The National Leakage Control Methodology (A.Rizzo (2001))



Initial programme in Gozo

As the implementation of a viable leakage control methodology in the whole of Malta would take a number of years, the Corporation initially targeted the smaller island of Gozo (18,700 service connections and 25,000 permanent residents) for comprehensive and integrated pilot leakage studies and trials. Over a six year period, a staged development took place:

By the end of 1993 a complete and verified set of pipework plans was compiled for the Gozo network.

- Master Plan for water supply in Gozo drafted in 1994, targeting the weaker parts of network for enhancement.
- In 1995 the Gozo workforce adequately staffed in terms of quantity and quality of its members, who were comprehensively trained in the required skills and techniques.
- Electronic database set up, helping to target critically weak water mains, and system gradually integrated into a geographic information system (GIS) in 1998.

- In 1995-96 Gozo zoned into around 45 hydraulically encapsulated zones and electronic data logging was immediately commenced. Leakage levels in each zone were computed and high leakage areas were targeted.
- By 1998 water balance developed to allow for weekly computation of the leakage spectrum in all zones, cluster-zones, reservoirs, transfer mains, etc. in Gozo.
- By 1999 the Gozo day repair teams had achieved a high level of teamwork with the leakage technicians in the excavation, assessment and repair of leakages pinpointed through night operations. Skills for delicate tasks such as automated pressure control, leak noise data logging, correlation and digital pipe location mastered. .

By 1999 Gozo annual system input volume had fallen to less than 70% of the 1995 figures and was actually lower than 1989 system input volume. Total leakage for the Island, calculated using the lowest night flow in each sector each week, was generally maintained at below 770 m^3/day (i.e. 33 Lt/service connection/day). This was less than a third of the initial leakage level calculated before on the same basis.

Lessons learned in this first programme were then replicated in Malta. Corresponding to earlier leakage reductions in Gozo, in 1995 the first effects of falling leakage levels were felt in Malta also.

Standard methodology and indicators

Throughout 1998 and 1999 the Corporation participated in an international leakage comparison exercise, as part of the IWA 'best practice' Task Force activities. This was coordinated by Mr. Allan Lambert of International Water Data Comparisons Ltd. (IWDC Ltd). The IWA Task Force broadly aimed at two objectives:

- Creation of an international standard approach for calculating annual leakage from an annual water balance.
- identifying the most rational performance indicators for performance comparisons of leakage levels between diverse international data sets.

The comparison exercise carried out by the IWDC on 27 supply systems in 20 countries showed Gozo as one of the system leaders, with an ILI of close to 1.5, based on the initial calculations of leakage based on minimum night flows.

Ongoing developments

The ongoing major developments for both Gozo and Malta are, at present, as follows:

- A study into the quantification and control of apparent water losses, through the introduction of an Off-Site Meter Reading Scheme. Apparent water losses, as opposed to real water losses (i.e. leakage), do not relate to a physical loss of water but are a loss of revenue, induced through three primary factors; meter under-registration, water theft and billing deficiencies. The off-site meter reading project aims at eliminating the component 'billing deficiencies' and in providing data that can assist in controlling the other two components of apparent losses. The system comprises of hand held computers utilized by meter readers for the capturing of both consumption and consumer data.

- The completion of an innovative *economic leakage intervention model* (described in further detail on page 15) that is being developed.

- The development of an *Integrated Water Management System*, or IWMS. This is, in essence, an information system that utilizes a corporate data model and a geographical information system (or GIS) to integrate the various functional modules within the Corporation's sphere of operation. Data relating to leakage control and water accounting form one specialized module within the IWMS. Other modules are a distribution module, a water production module, a water quality module, an asset management module and a billing/revenue module. The objective of the IWMS is primarily as a mid to high-level decision making – decision assisting tool. An example of the potential use of this tool may be made with reference to a decision as to whether or not to replace a segment of water main. The decision maker may wish to assess the leakage history of that layer, water quality characteristics within the segment, consumer complaints and metering issues, the age and type of water main, the elevation, pressure criteria and network design criteria of the area, etc. All the information that may help in making a decision of this financial nature would be mapped out in an easily digestible manner onto the IWMS. The Corporation is in the process of completing the first major module for this tool.

3 Outcomes

Overall, the leakage control programme has been successful and has led to substantial reductions. More importantly, the approach has been integrated into the corporate strategy within the WSC. Elements illustrating the strategic aspects of leakage management are described below.

Use of performance indicators

The Water Services Corporation has adopted the Infrastructure Leakage Index (ILI) as the official corporate performance indicator for leakage. The ILI is a relatively new measure that is being advocated by the International Water Association as the most accurate benchmarking tool or performance indicator for comparing performance in the management of leakage. The ILI is the ratio of the current actual leakage (litres/service connection/day) to the calculated 'Unavoidable Annual Real Losses' (UARL), where the UARL calculation allows for 3 key system-specific factors – density of connections/km of mains, location of customer meters on service connections, and average operating pressure. An ILI value close to 1 indicates that the actual leakage is close to its minimum technically achievable level for the system, which can only be achieved for infrastructure in good condition and management of all aspects of leakage management to the highest standard.

The Corporation has set the achieving of an ILI of close to 1 within 10 years as a strategic target. This will mean a further reduction of the present leakage level of 1,200 m^3/Hour (giving an ILI of 4) down to a very low value of 300 m^3/Hour (giving an ILI of 1).

Economically efficient Leakage Management

To solve this issue the Water Services Corporation has developed an innovative "*economic leakage intervention model*", used in a practical fashion to plan for leakage control. This model is designed to act as a tactical planning tool focused towards daily resource utilization and tactical planning decisions with one objective: guiding the leakage practitioner towards reaching the long-range goals and targets of the Corporation as quickly and economically as possible.

Continuous Research and Development

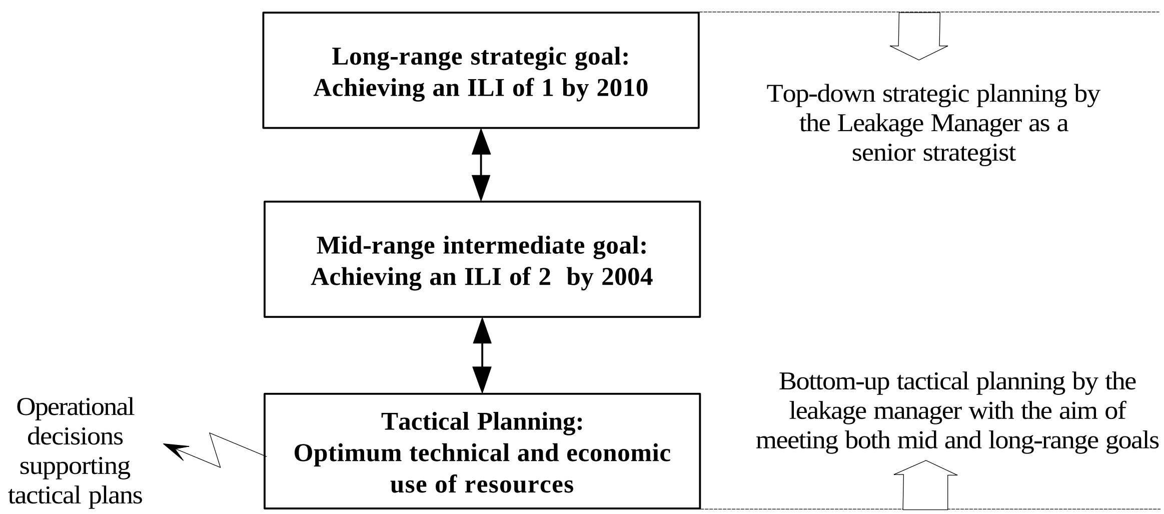
The Corporation is fully aware that, in order to keep abreast of technology in the field of leakage control, it must constantly research into innovative techniques and technologies. For this reason a partnership was set up with the Department of Power and Control, Faculty of Engineering, University of Malta with the objective of joint research into network control and leakage detection techniques.

At the centre of this setup is a customs-designed leak simulation test rig that allows for the creation and study of water leakage under a variation of conditions. Once studies are concluded on this rig, portable test equipment is designed to allow for more intensive field-testing.

4 *Lessons Learned*

Leakage control in the Maltese Islands is more than just capital investment into modern technology; it is an exercise in proper strategic management at a corporate level. The role of management is central. The strategic leakage manager must function at two levels (Figure 2). On a lower, tactical level he/she must ensure that the five-force methodology (described earlier) is being properly implemented on each and every zone within the water network within his or her responsibility. On a higher, integrative level he/she must ensure that all the components that make up the strategy are being followed on a corporate level. Failure on any one of these two levels will most certainly result in a weakened leakage control incentive.

Figure 2 Top-Down and Bottom-Up Strategic Planning



Interaction with other institution is important – and includes the University of Malta, the International Water Association and the Malta Institute of Water Technology.

Accountability, Leadership and Teamwork: For a job as intangible as leakage control, the performance of the staff is critical to success. Leakage teams have been developed into self-directed work teams, setting their own zone leakage targets in line with more broad master-zone targets set out by leakage engineers. This teamwork approach has been found to be most effective although it has taken time to build capacity. Leakage engineers themselves are held fully accountable for results obtained and the achieving of targets.

Use of the ILI as a leakage indicator as opposed to simple percentages: The adoption of the ILI now means that more meaningful performance comparisons can now be used, giving a much clearer picture of true performance in leakage management.

Strategic planning for leakage control: Leakage management is an exercise in planning itself. Long-range targets have been set out such as the achieving of an ILI of 1 by the year 2010. Mid-range targets have also been set, such as the achieving of an ILI of 2 by 2004. Short-range tactical planning is effected through the use of the Corporation's economic leakage intervention model. Resources used for leakage management are regularly adapted in line with the outputs of this, within the constraints of human resources within the Corporation.

Whilst it is difficult to compute the true savings that a leakage reduction brings about, an audited accounting exercise was carried out in 2001 by the Corporation, with the aim of establishing the Net Present Value (NPV) that would result when considering leakage control as a project with a finite 20-year time span. An assumption was made that the target ILI of 1 would indeed be reached by 2010. The accumulated marginal cost of water saved was compared to the various expenditures such as labour costs, contractor expenses, equipment, training, materials, overheads, etc. The NPV was computed to be in excess of Lm 16 Million over the 20-year period. The computation was a conservative one, as it did not disregard sunk costs such as corporate labour costs, and did not consider deferred capital within the equation.

Customer Impact: The prime outcomes of effective leakage management are often seen as reduced production costs, in the improving of the economies of the organization, and in postponing capital investments in both water network renewal and new production plant capacity. Whilst the customer often has very little involvement in the activities and issues relating to active leakage control, the same customer will benefit in several ways from a successful leak control campaign.

However, consumers may sometimes feel an unfortunate negative impact relating to leakage management when zoning is implemented on a water network that was not initially designed to be hydraulically encapsulated. The carrying out of zoning works, namely end caps to create new zone boundaries, sometimes results in areas of low flow or water stagnation within the network. Accumulation of deposits may occur and will result in a reduced water quality at the peripheries of the newly created zone. A short-term solution to this problem is often found in the regular use of washouts at the zone boundaries, although the real solution lies in the re-designing of the reticulation of the network in question.

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