18. Conservation of water in public and domestic supply systems

All water, even wastewater, has value and it should not be wasted. The conservation of clean water depends on minimizing wastage from leaks and reducing unnecessary or excessive consumption. Some wastage appears to be inevitable in every drinking-water supply system, and the term "waste prevention" is used here for measures intended to reduce losses to a minimum. In this context, the term "waste" refers to water that escapes from the system unused or unaccounted for, and not to human wastes or other forms of used or degraded water that are carried away by drains or sewers. There are cases where in the order of 60% of the distributed water is unaccounted for, and not billed, due to leaks or non-metering.

Wastage and leakage of water can occur from the public (mains) system or in the private systems owned by individual customers. In the public supply system, the best protection against wastage is the careful design and construction of the mains, combined with an active programme of supervision and preventive maintenance and leak detection. In the private system, the main strategies are the prompt correction of leaks, the use of technologies to reduce overuse, and public education on water conservation, as well as metering and use of rate structures that are a function of volume consumed versus block billing.

While leaks in the public mains system can be minimized by systematic inspection and maintenance by the authority concerned, it is more difficult to trace and remedy leaks on private property. A relatively small (3 millimetres) leak in a service pipe, or a dripping tap, under normal working pressure can waste 340 litres (90 US gallons, 75 UK gallons) per day, the amount required to supply the needs of a family of three. While leaks within private properties are charged to the property owner, a multiplicity of leaks can compromise the drinking-water supply system. Leakage and wastage on private property can be minimized by the use of quality materials and workmanship in the installation of plumbing systems, as well as promptly instituting repairs when needed.

Leakage into drains (infiltration) can lead to the overloading of sewers and sewage disposal works, with consequent additional expense to the sewerage authority. The infiltration of storm water into wastewater disposal systems may create health hazards. Measures must be taken to exclude materials that can choke sewers, or those of inflammable, explosive, corrosive or toxic nature that may be potentially dangerous to the public, or may interfere with the purification process at the disposal works.

Leaking pipes significantly increase the vulnerability of pipelines to contamination, especially where the supply is intermittent or the pressure fluctuation can lead to infiltration of contaminated water into the distribution system.

18.1 Special problems associated with public buildings and communal accommodation

Public health authorities have a particular interest in the plumbing of buildings used by large numbers of people, such as schools, lodging houses, hotels, public baths, hospitals and transport terminals. Unsafe or inadequate water and waste system plumbing in those establishments can lead to major outbreaks of infectious disease. For this reason, sanitary fittings must be appropriate for the high level of use and must be installed and maintained so as to minimize risks to health. Special precautions are necessary on premises where food and drink are processed, stored or served to the public.

The responsibility for ensuring that public plumbing systems conform to effective hygienic standards is primarily located with the drinking-water supply authority and the body responsible for sewage disposal. The health authority has the overall task of ensuring that these water and sewerage authorities take their responsibilities seriously. The day-to-day supervision of new plumbing installations is often the responsibility of a local agency, the building control inspector, whose prime duty is to ensure the stability of the particular premises in which the plumbing system is installed, and the safety of its occupants. Supervision of plumbing installations requires special knowledge and skill, so it is essential that well-trained and conscientious plumbing inspectors are serving in those critical functions.

18.2 Leakage and wastage in the public drinking-water supply system

No public supply is completely leakproof; not even the best-designed and carefully constructed system can remain absolutely watertight throughout its life. An efficient public drinking-water supply authority will therefore maintain a continuous programme of inspection and preventive maintenance to discover and stop leakage for both financial and health reasons. Unaccounted-for water represents a lost opportunity for the authority to earn income from the supply of water. Leaks that allow water to flow out of the system can also provide the means of entry for contaminants, which may in turn cause illness. A further reason to maintain a continuous programme of inspection and timely implementation of repairs to the public drinking-water supply mains is that it sets an example for the owners of private properties to maintain their own drinking-water supply systems so as to minimize waste.

Wastage below ground is difficult to detect and isolate and often expensive to remedy. The best strategy is therefore to ensure that the drinking-water supply systems are built to the highest possible standards. The selection of materials,

installation practices and workmanship in both public and private drinking-water supply systems should all contribute to reducing the incidence of unseen wastage. The usual procedure for tracing these leaks in the mains system is a combination of district metering and inspection of the mains and services with a leak detection system such as a listening device between midnight and dawn when supply demands are low. This can be followed by the investigation of suspect properties.

18.3 Leakage and wastage from private drinking-water supply systems

Leakage from piping systems within a building is usually self-evident because it threatens to damage the building structure and internal walls and fittings. It is in the interest of the owner of the property to have this remedied promptly, especially since a leak can become progressively worse as the escaping water increases the size of the orifice through which it emerges. In certain situations, especially where water charges are not based on metered volumes of water used, powers of enforcement may have to be used to compel those responsible to undertake repairs.

Another type of wastage is very difficult to control without the cooperation of the building's occupants, namely that due to leaking taps, valves or incorrectly adjusted fittings in fixtures such as washbasins or toilet cisterns. Because the wastewater is conveyed through the fixture to the drainage system or is discharged through an overflow, it may cause no obvious nuisance within the building, and therefore there is less incentive for the property owner to take action to fix the leak. In large buildings, factories or high-density housing estates, the total wastage due to this cause may be very considerable. The actual cost of replacing worn washers and adjusting leaking fittings is minor once the leaks have been identified. Because of this, some drinking-water supply authorities offer to carry out simple remedial works or repairs free of charge to consumers, thus encouraging them to report such faults at an early stage.

18.4 Use of meters to reduce wastage and excess consumption

Installation of individual water use meters in all properties is an important strategy to encourage consumers to repair leaks promptly and to avoid excessive use of water. Metering ensures that the cost of wasted water will be borne by the individual consumer rather than by the public authority. This strategy is effective in the case of large commercial and industrial premises and in large multiple dwellings where there are facilities for inspection and repair by maintenance staff. This strategy should also be applied to single dwellings, which usually constitute the greatest part of the total demand for a drinking-water supply in non-industrialized communities.

Meters are an essential tool in the proper management of a water distribution system. In many countries there is a trend towards private operation of water

supplies or the corporatization of publicly owned water suppliers, which in turn leads to full-cost accounting. Assistance to disadvantaged persons can then be provided from the public purse rather than a system of implicit subsidy by higher water users, such as hospitals, schools, sports grounds or industries.

The provision and installation of meters does not represent the final cost of their use. Meters have a limited life and are a continuously depreciating investment. Facilities for repair and calibration must be provided and a team of meter readers and supporting clerical personnel must be supported, although remote sensing systems have been developed that obviate the need for direct reading. In some cases the cost of installation of meters in all domestic premises in a supply area may be greater than the cost of supplying consumers with more water to compensate for the wastage than might have been prevented by metering. However, the latter presupposes that not only is there unlimited low-cost source water and the means to treat it, but also that there is adequate capacity for sewage treatment of waste flows if the wastage is going to drains. It also assumes that there is no risk of contamination if the leakage is from pipes. Many analysts conclude that the compensation for increased demand due to wastage by increasing supply is at best a short-term fix. In addition, reducing wastage with meter use may allow consumer demand to be met from the existing supply for a longer time, therefore reducing the overall cost of water.

If every connection to the main supply has its own meter, the meters can help reduce the cost of supplying water by assisting with the identification of unaccounted-for water, below ground leakage and excess usage. Underground leakage through the mains and branches can be detected by comparing the quantity of water entering a district or section of the mains system (through a recording meter inserted in the mains) with the sum of the quantities registered on the individual meters on outlets connected from that section of the mains during the same period. Similarly, when individual meter readings are higher than average, the property owner will become alerted and will be more likely to identify the cause and take corrective action.

18.5 Minimizing systematic excessive and wasteful use of water

In a new drinking-water supply area, the entire distribution system may be designed with the efficient use of the available water in mind, water pressures may be regulated and maximum flows and capacities of plumbing fixtures regulated by the plumbing code. In older systems there are a number of actions that can be taken, but the first and most important is to secure the cooperation of consumers through publicity, education and other forms of communication.

In some instances it could be economical to fund the retrofit of water-saving fixtures and flow controls in private connections so as to lower demand. These costs may be less than the expenditure on infrastructure to increase supply. Larger consumers may be persuaded to install devices to cut down water use if

free audits are provided to quantify and cost the potential savings. Use of flow control valves and efficient shower heads should be encouraged, and consumers should be made aware of the substantial additional savings in heating costs for hot water that can be achieved. In establishments such as large factories, industrial complexes, mining camps and hotels, where large numbers of people use showers and handwashing facilities, the savings on energy by reducing the demand on hot water generation will dramatically reduce the payback period for expenditures on flow control valves and efficient shower heads.

In domestic properties with flushing toilets the toilet may account for one third of the daily household consumption of water. Low flush toilets that utilize 5 or 6 litres (1.5 US gallons) versus about 20 litres (5 US gallons) per flush are now widely available. Washing, bathing and showering may account for an additional one third of water used within the home. By regulating toilet flushing volumes and the flow rates at washbasin taps and showers heads it is possible to conserve up to half of this water without loss of amenity to the householder.

Care is needed when regulating the flow rate of hot water taps and showers as some of the instantaneous types of water heaters are flow regulated at the unit and further flow reduction at the tap may be detrimental to the operation of the hot water heater. Shower heads also require careful consideration, as fitting a flow restrictor to a poorly designed shower head may reduce the amenity to the user to such an extent as to cause the consumer to remove the restrictor and return to higher flow rates. In multiple shower installations the risk of thermal shock or temperature spiking must be taken into account. These problems can often be traced to poorly balanced flow rates at various taps or shower heads.

A guide to the water use efficiency of showers, as determined by flow rates at the point of use under normal drinking-water supply conditions and pressures, is as follows:

- 6–8 litres per minute: Very good
- 8–12 litres per minute: Good
- 12–18 litres per minute: Reasonable
- 18–24 litres per minute: Fair
- > 24 litres per minute: Poor and very wasteful

18.6 Minimizing water usage in flushing cisterns

There are three main categories of flushing cisterns that are connected to toilet bowls – high level, intermediate level and close coupled. The application of the high-level cistern is normally restricted to a single flush operation, whereas the intermediate and close-coupled toilet cisterns are available in a variety of designs and materials incorporating a dual flush function. Typically, the full flush volume is 6 litres (1.6 US gallons or 1.4 UK gallons) and a half flush volume is 3 litres (0.75 US gallons or 0.66 UK gallons) or less. Plumbing codes must ensure that

only matching toilet bowls designed to operate with low flush volumes are used in conjunction with these dual flush or low flush cisterns. The volume of the larger flush in a dual flush system should not exceed 6 litres, and the lesser flush volume must not exceed two thirds of the larger flush volume. Urinals with flushing controls are also available. Sensors control their operation so that flushing does not occur when they are not in use. Waterless urinals are also available that can achieve significant savings if they are installed and maintained correctly.

Reduced toilet flushing volumes may cause problems if the drainage system does not have a substantial flow into the system upstream of the toilet. When water flows are too low, solids may be stranded in the drainage piping and may cause blockages. This and similar problems can be avoided if plumbing codes are regularly revised to incorporate new design practices.

Although the half flush is an important strategy for reducing water usage in cisterns, it may not be effective when toilet tissue paper is used with a half flush. The problem is that the tissue paper often becomes stranded at the outlet weir of the toilet bowl. This in turn results in the draining out of the water trap seal due to the inability of the reduced flush volume to carry the tissue paper clear of the water seal zone of the bowl. After one or two such events the user may resort to using the full flush every time and the potential benefits of the dual flush system are lost.

In areas of extreme water scarcity it may be necessary to install chemical or composting toilets instead of water closets. There are a number of types, but most are self-contained. Since they do not strictly come under the heading of plumbing fixtures, they will not be discussed here.

18.7 Minimizing water wastage in lawn and garden irrigation

When promoting a water use efficiency programme, steps should be taken to minimize the use of drinking-water on gardens and lawns. More than 40% of household water use can be external in households in dry areas that have fully established gardens and lawns. Advice on appropriate gardening practices, selection of plants suitable for the local climate and suitable irrigation watering schedules all help to reduce water use without loss of amenity. In localities with high daytime temperatures, lawn and garden watering and some other external high-volume uses should be banned during the hottest part of the day to reduce loss through evaporation. In some situations, more drastic restrictions or bans on lawn watering and other high-volume external uses may be required, at least seasonally.

18.8 Attempts to reduce water usage through intermittent supply

Water authorities adopt various expedients to reduce consumption by the public during periods of water shortage. One of the most unacceptable is to make

supplies intermittent. In this strategy mains supply to all or part of the system is shut down completely during certain hours of the day. One of the worst consequences is the development of negative pressures, which carries a risk of serious backflow contamination of mains water. In addition, deposits of rust, detritus and other sediments within the mains are stirred up and carried in suspension when the flow resumes. Air may be drawn into the system, causing airlocks or water hammer. Cessation of mains flow means that emergency calls for water for firefighting cannot be met without undue delay.

It is also doubtful whether significant savings result in the long run, since consumers fill bathtubs and containers in anticipation of shutdowns. During the shutdown period, consumers may turn on a water tap and, finding that the supply is unavailable, leave the tap in the open position; water is then wasted when supply is resumed. Although water is not available during the shutdown period, after the supply is returned to normal there may be considerable water wastage through open taps and the disposal of excess water that was stored in baths or sinks. These losses could easily cancel out any potential water savings.

A better strategy is to maintain adequate pressure in the distribution mains to eliminate low or negative pressures in hilly conditions or where tall buildings must be served. The flow to individual premises can be controlled by inserting pressure reduction or limiting valves adjacent to the water authority's stop valves for each service. Thus, the system can more easily be balanced to provide each branch with adequate flows at all times. Further balancing of flows and pressure is then possible in each private service feeding multiple dwellings or tall buildings so as to provide equal amenity to all consumers. It is important that all branches from the main distribution system are regulated, as any uncontrolled flows will have an adverse effect on a balanced system.

The plumbing of multiple latrines, bathhouses and laundries should comply with the general principles of the plumbing code with regard to cross-connection, backsiphonage and backflow. By providing each with its own storage tank, peak use flows are evened out and economies may be possible in the delivery mains and connections. In many arid areas, it is customary to provide storage at groups of standpipes for the same reason.

Above all, the maintenance of the installations will depend upon the cooperation of those using them. Efforts to build a sense of communal ownership and pride of possession are important so that cooperation is voluntarily given or assured by peer pressure, and enforcement is therefore unnecessary. In this way, communal sanitary facilities can be kept clean and working with the minimum need for supervision and inspection.