Republic of Iraq

Ministry of Water Resources

General Directorate for Water Resources Management

Strategy for Water and Land Resources in Iraq

Guidance Note Series

Demand Management for Municipal Supplies

GN 07

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This document is one of a series of occasional guidance notes published by the Ministry of Water Resources addressing issues relevant to strategic planning for the sustainable use of the water and land resources of Iraq.

The guidance note presents guidelines for managing the demand for municipal and rural potable water supplies.

Report Issue and Revision Record

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1 INTRODUCTION

1.1.1 The Guidance Note presents guidelines for managing the demand for municipal and rural potable water supplies. Although it may be seen merely as an attempt to persuade people to use less water, the wider aims of demand management are to:

- Prevent wasteful use of water, limiting consumption and hence minimising investments needs;
- Ensure an equitable distribution of potable water supplies to all customers;
- Ensure water supply systems are sustainable, providing customers with the level of service they want at a price they can afford while covering the total costs of providing water.
- Ensure an efficient and equitable distribution of available water resources between municipal water supplies, industry, agriculture and the environment.

1.1.2 This Guidance Note focuses on long term demand management, to limit the growth of demand in the long term in order to minimise investment. It can, however, also be applied to overcome short term problems caused by droughts or loss of supply capacity.

2 METHODS OF MANAGING DEMAND

2.1 Tariff Increases

2.1.1 Raising the marginal tariffs to the level of the marginal cost of supply is the theoretical level required to achieve efficiency in the allocation of resources. There is considerable evidence from around the world that heavily subsidised water supplies lead to excessive and wasteful consumption by those who have access to water and shortages for people at high points or at the end of the distribution network, as investment in new resources fails to keep up with demand. Metering consumers, charging by the amount of water consumed and setting tariffs to meet the full cost of the supply is a key component of any demand management programme. Any significant subsidy sends the consumer a message that water has a low intrinsic value and wastage of water is not important. The charges for water should as far as possible cover the full cost of the service provided, which makes the system sustainable since the water company will be able to expand its system to meet rising demand from its own revenues. The full cost includes:

- Operating and maintenance costs, including personnel, energy, chemicals, spare parts, consumables and all other overhead costs;
- Depreciation of existing assets;
- The cost of financing investments in new works.

2.1.2 It has to be accepted that in many countries, especially low income countries, it is difficult for everybody to pay the full of the service. One method of ensuring that poorer people can receive an affordable basic level of service is to structure the tariff in a way that allows those households using low volumes of water to pay the lowest cost. This is achieved by the following means:

- Metering supplies so that customers pay according to the volume of water that they consume.
- Having a low fixed element of the charge. There is usually a fixed monthly charge, not related to the volume of water consumed, to cover the water company's fixed costs. It may be desirable to reduce this and put more on the variable charge, which minimises bills for low water users.
- Different tariffs for different categories of consumer. By charging them higher tariffs, industrial, commercial and institutional customers can subsidise household customers.
- A progressive tariff with a low rate for the first 10 m^3 per month (or whatever quantity may be deemed appropriate in specific circumstances) and a much higher tariff for consumption above this figure. Poorer customers can limit their consumption to levels that meet basic needs and pay less per unit volume of water than richer households which use well over the 10 m^3 per month limit for the lowest tariff band.
- In rural areas where people may have limited internal plumbing in their houses and want only a yard tap, neighbouring households can be encouraged to share a connection, which reduces the connection charges and fixed charges for each household.

2.2 Building Regulations and Restrictions on Water Using Devices in the Home

2.2.1 Most water is used in the home for:

- Toilet flushing
- Bathing and showers
- Clothes washing
- Dish washing

2.2.2 Water consumption for all the above uses may be reduced by regulating the design, manufacture, installation and marketing of water using devices.

2.2.3 **Toilet flushing** is one of the largest single uses of water in the home. Old cisterns contain 9.0 litres of water, whereas a modern well designed toilet operates with 6.0 litres. Building regulations may be easily changed to require the use of 6.0 litre cisterns in all new houses or whenever cisterns are replaced. Further saving may be effected by requiring dual flush toilets to be installed. These have a small flush to remove liquid and a larger flush for solids. The full effect of such regulations is of course only felt over time as more new houses are built and more people have their bathrooms and toilets refurbished. However, this is an effective and economic means of reducing water consumption.

2.2.4 A more rapid impact can be gained by inserting solid objects in existing large toilet cisterns to reduce the volume of water. Such objects are best specially made as if any objects that interfere with the flushing mechanism are inserted they may prevent closure of the valves, which causes leaks and hence the devices are counterproductive.

2.2.5 For **washing machines and dishwashers**, it is also possible to limit water consumption by imposing standards on water use. This is already done in some countries and manufacturers of washing machines and dish washers are responding by designing new environmentally friendly low water using machines.

2.3 Education and Public Campaigns

2.3.1 Education and publicity are two key components of a demand management policy. Education is often conducted with school children, who are effective at taking the message of the importance of saving water home to their parents. However, it is also important to explain to adults why it is necessary to save water, how they can contribute to savings and how using water carefully can help reduce their water and wastewater bills. This is effective when combined with increases in tariffs and the imposition of new tariff structures.

2.3.2 Education campaigns can cover:

- The importance of not wasting water, including replacing washers on leaking taps, not leaving taps running, not washing up under running taps, etc.;
- Advice on purchasing water saving washing machines, dishwashers, toilets, etc.
- Advice on plants with a low water consumption for the garden.
- The implications of excessive water use for the environment and levels of service that can be provided to all customers.

2.3.3 Campaigns can be effective in restricting use in a severe drought. Experience in some areas which can suffer from droughts, e.g. mid-western USA and Australia has shown people respond well to appeals to save water provided they are kept well informed of the situation and appreciate the need to conserve water. However, such appeals must be used for limited periods (a few months at most) and water companies must be open and honest with their customers.

2.3.4 Persuading people to invest in devices for the home that use less water will have a long term beneficial effect. The tariff is also an important influence here as if people are paying the full cost of water, they will be more likely to recoup the cost of their investments in water saving devices from reductions in their water bills.

2.4 Restrictions on Use

2.4.1 This is generally applicable to drought periods and restrictions stay in force for a few months. Common restrictions may include:

- Banning the use of hosepipes to water the garden and other outside activities
- Closing down car washes
- Restricting watering of parks, sports fields, etc.

2.4.2 All these actions are short term measures to overcome shortages created by extreme droughts or major unanticipated failure in the supply system.

2.5 Reducing Unaccounted for Water

2.5.1 All the above measures are aimed at reducing water consumption by the customer. It is also important the water service provider takes action to minimise the loss of water from his own distribution system and other water that is not charged for. The term non-revenue water (NRW) is now preferred to unaccounted for water (UfW) and is the difference between the volume of water put into the distribution system and that which is charged for. NRW comprises:

2.5.2 Physical losses from leakage in the distribution system and the consumer connection pipework up to the meter or property boundary, including the supply pipe from the property boundary to the meter, where it is installed inside the house.

2.5.3 Commercial losses, which comprise:

- Unregistered consumption through illegal connections and bypasses to consumer meters;
- Connections that are not recorded and billed due to deficiencies in the water authorities billing system;
- Under registration by consumer meters;
- Legitimate unbilled consumption for fire fighting, mains flushing, etc.

2.5.4 Taking action to minimise UfW directly reduces the demand through the reduction in leakage and indirectly by ensuring that all customers are properly billed and charged for water used, which discourages wasteful use.

2.5.5 Further details of how to control UfW are given in Appendix A.

3 POTENTIAL IMPACTS OF DEMAND MANAGEMENT

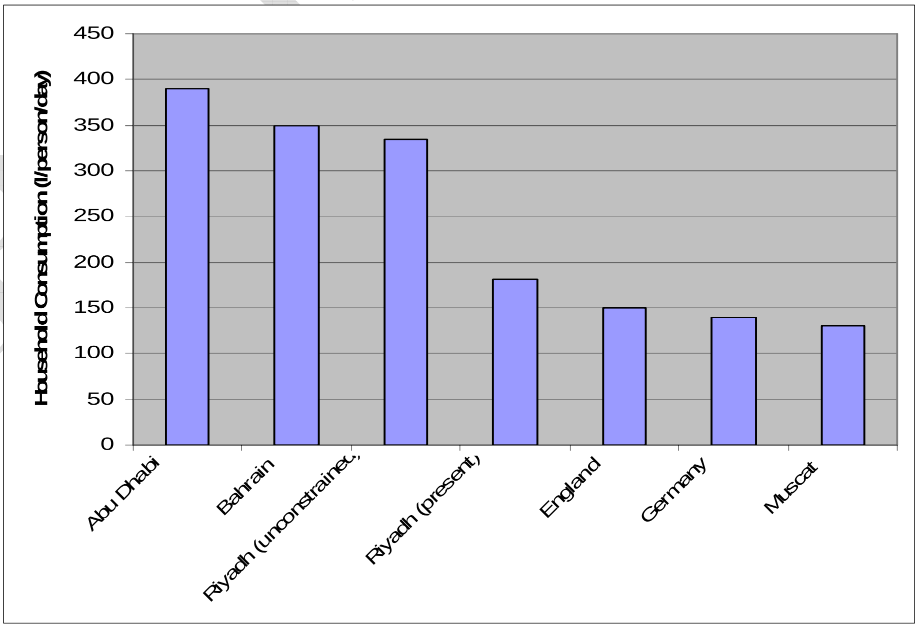
3.1 International Experience

3.1.1 The impacts of demand management measures will vary according to the particular circumstances in the country, or even the district, where they are applied. They will depend on the income levels of customers, local customs, attitudes to conservation and present water consumption practices.

3.1.2 There is little doubt that the tariff is a key element of demand management. Figure 3-1 below shows a comparison of per capita consumption levels in various countries in the Middle East and Europe.

3.1.3 The demand is very high in Abu Dhabi and Bahrain, which are characterised by a hot arid climate (similar to Oman) and low tariffs. In the early 1990s, the consumption in Riyadh was similarly high, but has reduced dramatically in recent years due to supply constraints. Demand in England and Germany, which are characterised by a temperate climate and tariffs meeting the full cost of supply, consumption is much lower. In Muscat, where tariffs cover over 50% of the supply costs, the present consumption is actually less than that in England and Germany, and less than half of that in the neighbouring countries, where tariffs are much lower. This is an indicator of the possible magnitude of reductions in demand that might be expected in the Middle East from metering of supplies and increased tariffs combined with other demand management measures.

Figure 3-1 : Household Water Consumption in Selected Locations



3.1.4 The impacts of more widespread metering and higher tariffs in Eastern Europe have also had a dramatic impact on water consumption, which has fallen by over 50% where individual flats have been metered and tariffs raised to cover some new investment costs as well as operating and maintenance expenses.

3.1.5 In England, on the other hand, the introduction of metering for household supplies has had a relatively small impact on demand. Prior to 1990, very few household customers in UK were metered. Trials were introduced to assess the impact of metering in the early 1990s. The outcome of these trials indicated that there would be an immediate fall in demand of about 20% on the introduction of metering and charging for water by volume. However, over a period of about year there was also a recovery in the level of demand, so the long term savings appear to be about 10%.

3.2 Likely Impacts in Iraq

3.2.1 It is very difficult to assess the impact of demand management in Iraq, but given the apparently high present levels of consumption, where it is not constrained by supply, we would anticipate that it would be significant. We believe that if an intensive demand management programme accompanied by full metering of household supplies and increases in tariffs can be implemented, then winter demands should be brought down to the levels currently seen in Europe and Oman.

3.2.2 The demand in summer will be increased due the extreme heat experienced in any areas. Apart from the increase in water used for washing and bathing in the summer, an important factor in Iraq is the use of air coolers, which consume a significant volume of water.

3.2.3 The likely impacts of demand management are reflected in the guidance note on demand forecasting.

Appendix A Approach to NRW Control

A.1 Terminology and Definition of Non Revenue Water

The term 'non revenue water' (NRW) is now generally preferred to 'unaccounted for water' (UFW) to describe that water which is put into the distribution system but not delivered to registered consumers paying for a supply. NRW comprises:

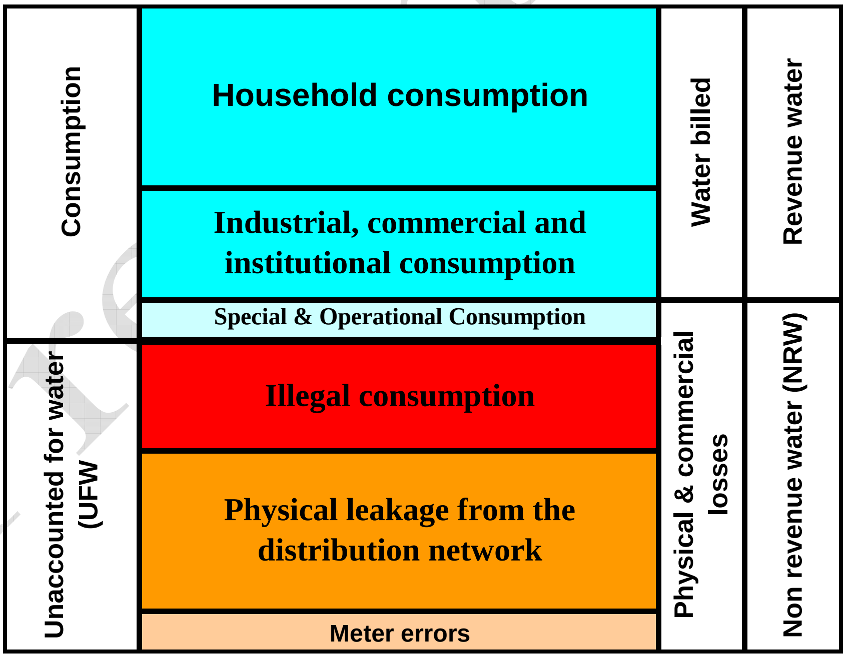
- Physical losses from leakage in the distribution system and consumer connection pipework up to the meter, or property boundary.

Commercial losses, which comprise:

- Unregistered consumption through illegal connections and bypasses to consumer meters;
- Connections that are not recorded and billed due to deficiencies in the water authorities billing system;
- Under registration by consumer meters;
- Legitimate unbilled consumption for fire fighting, mains flushing, etc.

It should be noted that 'water accounted for' normally includes authorised water consumed but not billed, such as that for fire fighting, whilst 'revenue water' only includes water actually billed. The definition of NRW and UFW is presented diagrammatically in the figure below.

Figure A-1 : Diagrammatic Representation of UFW and NRW



UFW is slightly less than NRW. Legitimate unrecorded use is usually a very small component of NRW, so the difference is not significant. NRW sometimes includes allowance for unpaid bills, but in this report we have considered this separately under the heading of collection efficiency.

A.2 Identifying the Components of NRW

As noted above, legitimate unbilled consumption is normally very small and may be ignored.

Meter Under-registration

Under-registration of meters should also be small, at least while meters are typically not more than five years old and provided the water put into supply is of potable quality. The under registration may be expected to increase as the meters age and it will be important to have a programme for checking and replacement or repair of meters when errors reach uneconomic levels, i.e. when the cost of meter repair or replacement is exceeded by the loss of revenue from under recording of consumption.

The accuracy of meters also depends on the class of meter used. Class A meters have the lowest accuracy and Class D meters are the most accurate. It is recommended that Class B or C meters are used. The savings obtained from using Class A meters are usually rapidly offset by losses in revenue, whilst the extra cost of Class D meters is less likely to be justified by gains in revenue. Furthermore, Class D meters are more susceptible to clogging by any particles in the water and therefore likely to need more frequent replacement. This will be an important consideration in Iraq until water treatment facilities and water quality control are enhanced.

Physical leakage

In residential areas, physical leakage may be estimated by measurement of minimum night flows. The minimum flow is usually determined by measurements between 2.00 a.m. and 4.00 a.m. Leakage is then estimated as the minimum flow during this period less an allowance for legitimate use, which in the absence of actual data may be taken as 2.0 l/hour/connection in a residential area. If the area into which flow is measured contains any industrial connections or other non-household customers that may use significant volumes of water over night, these must be allowed for separately.

Illegal consumption

Once physical leakage has been estimated, illegal consumption may be calculated as NRW less physical losses less an allowance for consumer meter under registration.

A.3 Measurement of Flows

The key to identifying the different components of NRW is the ability to measure night flows accurately. Mechanical meters without a low flow bypass will not measure low flows accurately. Therefore, to measure minimum night flows, it is recommended that full-bore electromagnetic flow meters are used. These meters have the flow range capable of measuring peak flows and minimum night flows required for determination of leakage levels. The full-bore flow sensor is installed in the main without the need for a chamber, with the measuring display unit housed in an above ground cabinet. The flow meters can be mains powered or battery powered using lithium batteries, which have a life of around three years.

A.4 Reducing Illegal Consumption

Reducing illegal consumption depends on a combination of good billing records, which can be related to mapping of the system, and inspections of properties where there appear to be inconsistencies between the billed water consumption and the facilities in the building. It can be further influenced by relations between the service provider and the customer, and the policy on dealing with non-payment of bills. The following actions may be considered to address the problem of water theft and assist in its reduction.

- Establish a Commercial Losses Section: This section would have a continual programme of checking the status of every connection, but focusing on inactive connections, to identify instances of water theft. NRW and its reduction must be a priority for all water operating organisations and we believe the formation of a Commercial Losses Section with dedicated staff is essential in areas where illegal consumption is a serious problem to allow the required focus and attention to be given to this important task.
- Public Awareness Programme: A public awareness programme should be initiated informing the public that water theft will, without exception, result in action being taken against the offender. An amnesty period should be allowed for current offenders to stop taking water or register their connection. The programme should send the key message that theft of water is an anti-social activity which has an adverse impact on registered customers by keeping the tariffs higher than they would be otherwise. The programme should inform customers of the penalties for theft of water.
- Avoiding Disconnections: Customers should be disconnected as a last resort as this encourages theft of water. There are various ways of minimising the number of disconnections, including not allowing arrears to accumulate to the point at which they are unmanageable, extending repayment terms for arrears and reviewing debt collection procedures to improve revenue collection performance. This might involve the use of debt collection agencies or court action to collect arrears rather than disconnecting the customer.
- Prosecution: If all other actions to attempt to persuade a defaulting customer to come to an arrangement to pay his outstanding bills fail but, he should be prosecuted and a court order obtained to recover debts by distraint on his property. When necessary, prosecution should be implemented impartially against any customer, whatever his status and should be free from political interference.

A.5 Reducing Physical Leakage

A.5.1 General

There are various ways of reducing leakage. The decision on whether and how these should be implemented will depend on the relative costs of the measures and the potential benefits to be obtained. The intensity of leakage control activities should be increased until the marginal cost of leakage control exceeds the marginal value of water saved. The means of reducing system leakage are broadly the following:

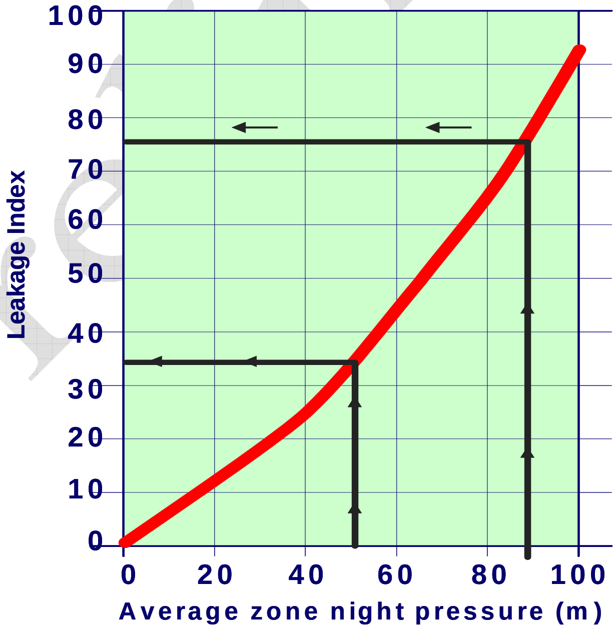
- Pressure management.
- District metering, followed by active leak detection and repair.
- Replacement of old pipework that is in poor condition.

These are likely to be in order of increasing cost, so pressure management, where appropriate will offer the greatest benefit cost ratio. Large scale replacement of distribution pipes will be an expensive solution, and only adopted where large sections of pipe are in poor structural condition or badly laid resulting in a high rate of leak repairs.

A.5.2 Pressure Management

Research undertaken by the UK water industry has determined the impact of pressure on leakage levels and this is presented below.

Figure A-2 : Pressure Management – Leakage Index



From Figure A-2, it can be seen that a knowledge of existing and proposed night pressures allows the leakage index to be determined from which the impact on leakage level from a reduction in system pressure can be calculated. The figure indicates that reducing the average zone night pressure from 90 m to 50 m would reduce leakage to 44% (=35/75) of its present value. The actual impact will vary from system to system, but where night time pressures are high, reducing the pressure could provide a substantial reduction in leakage at a low cost. This is most likely to be applicable to the mountainous districts on Northern Iraq.

A.5.3 District Metering

District metering requires the installation of flow meters at strategic points in the distribution system, each meter recording flows into and, where appropriate, out of a discrete district that has a defined and permanent boundary. Such a district is called a District Meter Area (DMA).

The DMA design process comprises:

- Preliminary design
- Detailed site survey and data collection
- Network modelling.

A DMA normally contains about 1,000 to 3,500 customer connections.

Surveys of the distribution system should be undertaken to confirm the location and nature of the mains and valves within the DMAs as a prerequisite to constructing the DMA network models. It is essential to ensure that adequate supplies are maintained to all customers in the DMA once it has been established. This can be confirmed by network analysis and field measurement.

Data loggers may be used to capture flow and pressure data recorded by insertion flowmeters and pressure transducers deployed at key points on the system. In conjunction with demand data determined from meter records, the flow and pressure data allow construction of network models for each DMA. Comparison of the model's simulated pressures and actual field pressures assist in identifying anomalies such as shut valves (when they should be open), cross connections (where none recorded) or dead ends, as well as variances in expected flow regimes. Network modelling also identifies pressures that need to be maintained at critical points to ensure adequate levels of service to all consumers.

If the model indicates deficiencies in the level of service the appropriate works, such as installation of a cross-connection or a new augmentation main, can be designed and implemented.

Appropriate valves for use as boundary valves and step valves are also identified from the models and, where appropriate, locations for new valves identified.

The process for establishing the DMA is as follows.

Proving of DMA boundary valves: The boundary valves need to be checked to confirm that they are drop tight.

Isolation test: The DMA is isolated from the adjoining system by closing the boundary valves and the district meter valve. DMA pressures should fall to zero thus indicating that the DMA is hydraulically separate from the adjoining system.

District meter installation: The district meters should be full-bore electromagnetic flow meters, which have the flow range capable of measuring peak flows and minimum night flows required for determination of leakage levels. The full-bore flow sensor is installed in the main, without the need for a chamber, with the measuring display unit housed in an above ground cabinet. The flow meters can be mains powered or battery powered using lithium batteries with a life of around three years.

Proving of step valves: Step valves allow sections of the DMA to be progressively shutdown. By measuring the effect of progressive shut downs on flow through the district meter, the sections exhibiting the highest leakage can be identified, thus allowing the leak detection effort to be directed to best effect.

After establishing the DMA, the minimum night flow is measured and the net night flow (the minimum night flow less an allowance for legitimate use) is determined to give an estimate of physical leakage. Where leakage is above the target level, a programme of leak detection and repair is undertaken to bring it down below the target level. The night flows are then monitored and when the leakage level rises again, a further programme of leak detection and repair is undertaken. The process continues indefinitely.

Research suggests that up to 65% leakage reduction can be achieved through district metering compared with a passive leakage control policy. However, in practice the reduction achieved will depend on a variety of factors including:

- The existing level of leakage in the distribution system.
- The pressures in the system.
- The type of pipe in the system. It is more difficult to detect leaks on non-metallic mains than on metallic mains.

The costs of establishing DMAs will depend on the need for new boundary valves and pipework to reconfigure systems and ensure service levels are maintained. Indicative costs for the materials and equipment for 12 DMAs and one leak detection team, which would cover the 12 DMAs are given below.

Table A-1 : Indicative Costs of DMAs and Leak Detection Teams

Item	Cost (US$)
Establish 12 DMAs - Design of DMA - Install meters, incl. isolating valves & above ground flow recorders - Install boundary valves and additional pipework	 25,000 180,000 Depends on requirements
Equipping leak detection team: - Leak detection equipment for one team - Purchase of vehicle	 40,000 30,000

A.5.4 Mains Replacement

Mains replacement is a last resort to reduce leakage and should always be targeted at pipe which is in a poor structural condition or where the number of leak repairs is such that it is more economic to replace large sections of pipework. Pipe replacement may be the preferred option in the following cases:

- Where leaks occur on GI service pipes, the full service pipe from the main to the water meter should be replaced as the whole length of pipe is likely to be severely corroded and in poor condition. The ferrule connection to the main should also be replaced if the existing connection is suspect. For plastic service pipes, the burst section only may be replaced by inserting a new piece of pipe if this is considered more economic than complete replacement. This may be the case where there is a very long service connection.
- Where frequent leaks occur on the barrels of pipes, this indicates a poor structural condition and it is likely that pipe of a particularly material or in a particular area should be replaced.

The pipe to be replaced should be carefully targeted and clearly this requires good information on the condition of the pipe and the nature of repairs being made. This in turn requires good records to be kept by the water authority.

A.5.5 Supply Pipe Replacement

Where water resources are heavily used and the shortage of resources is one of the main drivers for controlling leakage, companies will also need to address losses from the supply pipe, which is the pipe from the boundary valve or meter to the inside of the property. Whilst this pipe is normally the consumer’s responsibility, many water companies offer to repair or replace it free of charge as it is often a major source of leakage to reduce demand and the need for investment in new sources of supply.