Workshop on Water Demand Management

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Power and Water Institute of Technology, Tehran

In-house Water Saving Technologies

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OVERVIEW

- Why to adopt water saving technologies?
- Water use by micro-components
- Technologies
- Water savings achieved
- Potential for further savings
- References

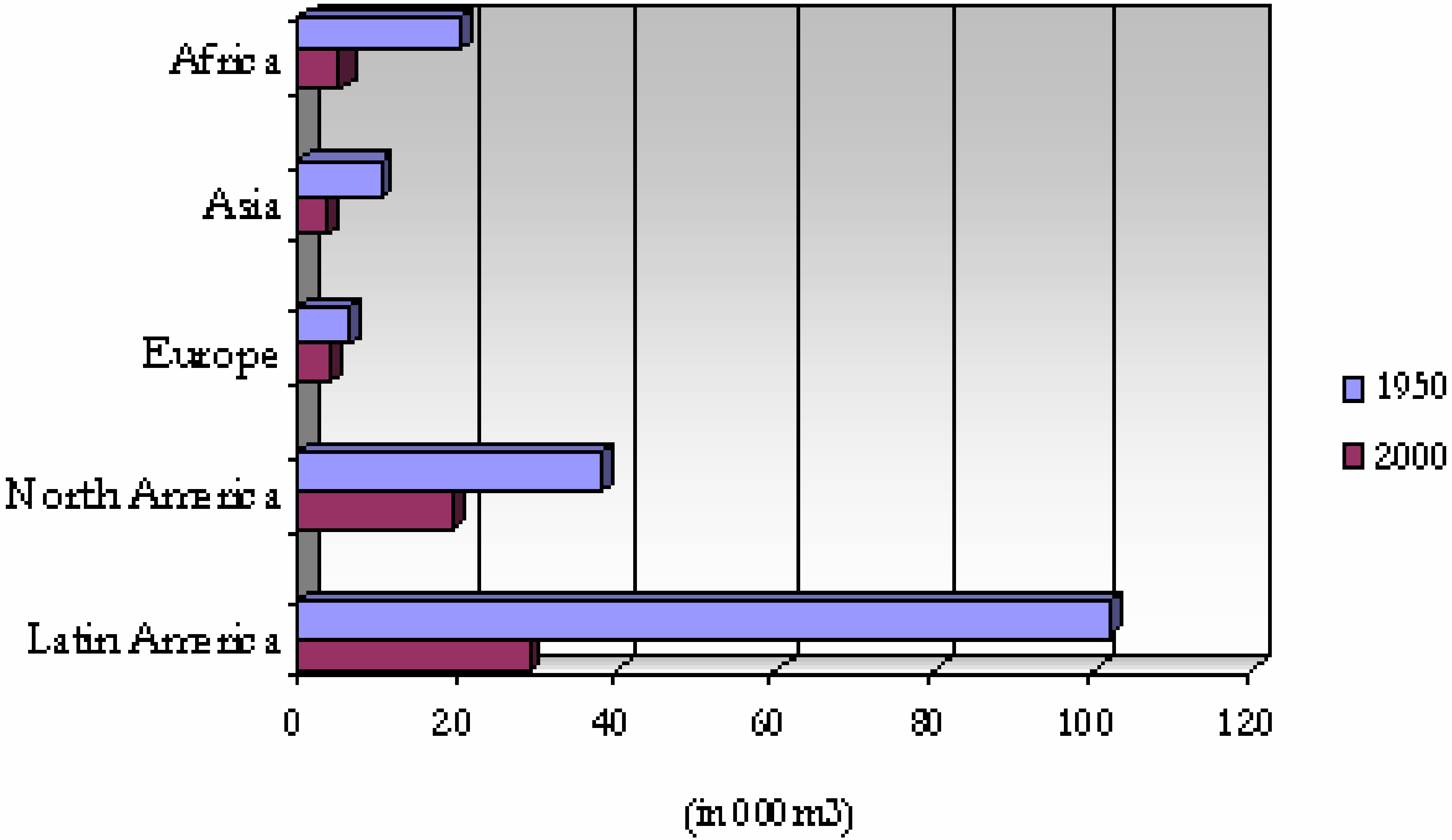
OVERVIEW

- Technologies
  - Taps and tap controls
  - Low flush/ no flush toilets
  - Urinals and urinal controls
  - White goods
    - washing machines
    - dishwashers
  - Flow Restrictors

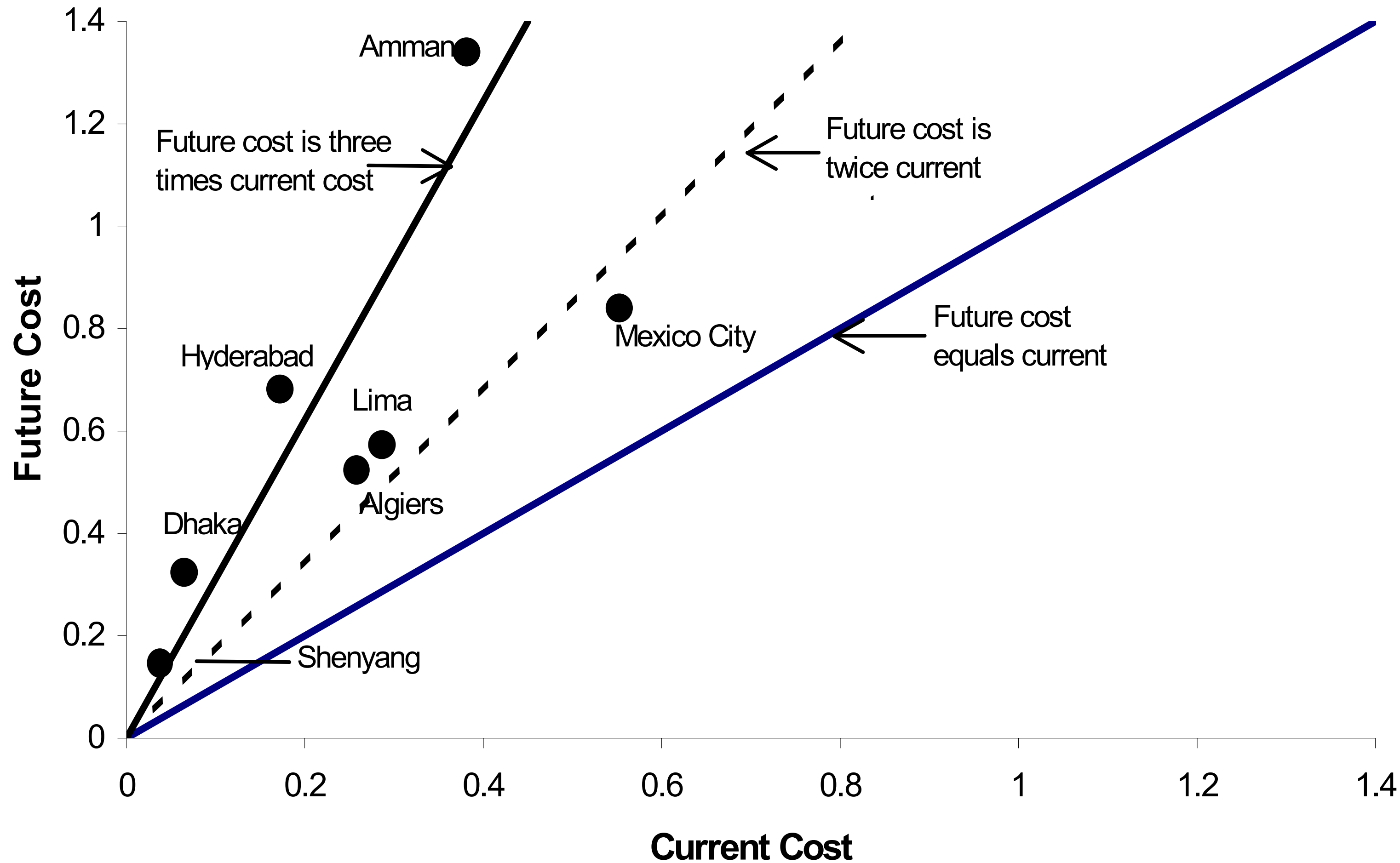
How they work?
Cost/benefit
General acceptability

WHY
Water saving technologies

1. Owing to climate change and rapid population growth, the ever increasing demand is difficult to meet because of
   - limited fresh water resources
   - high resource development cost



Availability of freshwater by region



Current and predicted cost of water supply in urban areas

(Serageldin, 1995)

WHY
Water saving technologies

2 . Campaigns aimed at educating people to reduce consumption have often failed to achieve significant change in consumers behavior

WHY
Water saving technologies

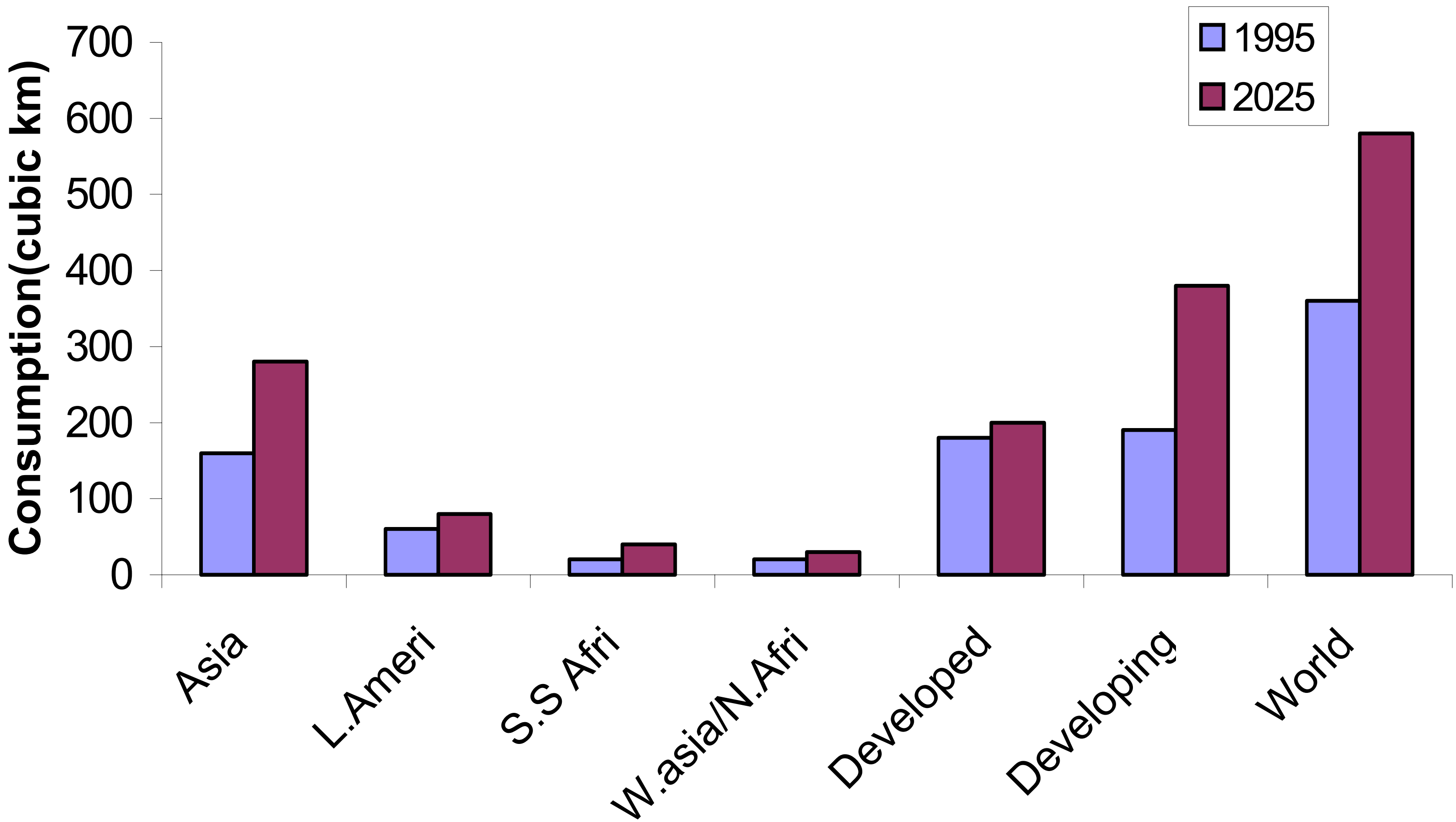
A public awareness campaign, costing about US $ 120,000, lunched for 8000 houses in south-east region in the UK concluded:

"*Persuasion by advertising can have little effect while there is no general public recognition of the importance of water resources.*"

McCann (2003)

WHY
Water saving technologies

3 . Long term water resources development planing needs to be based on concrete (safe) assumptions rather than relying on ‘high expectation’ that consumer habits will change and consumption will decline….

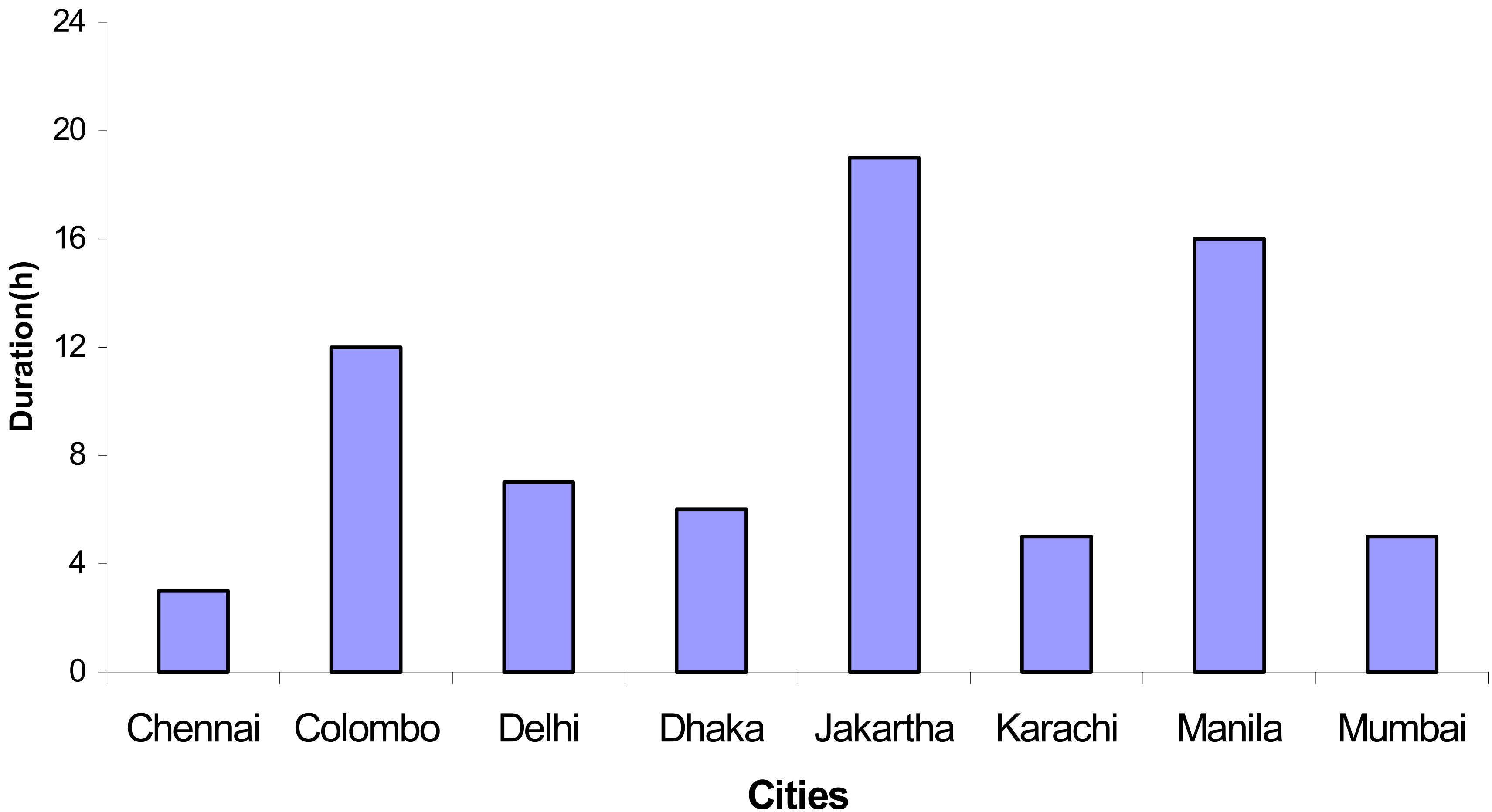


Non-irrigation water consumption by region

(Rosegrant *et al.*, 2002)

WHY
Water saving technologies

4 . Meeting the demand without reducing the level of service should be the first priority..But sadly, most of the urban areas in developing countries rely on intermittent supply



Duration of public water supply in urban areas

(ADB, 1993)

WHY
Water saving technologies

4 . Other demand management measures such as greywater recycling have implications such as

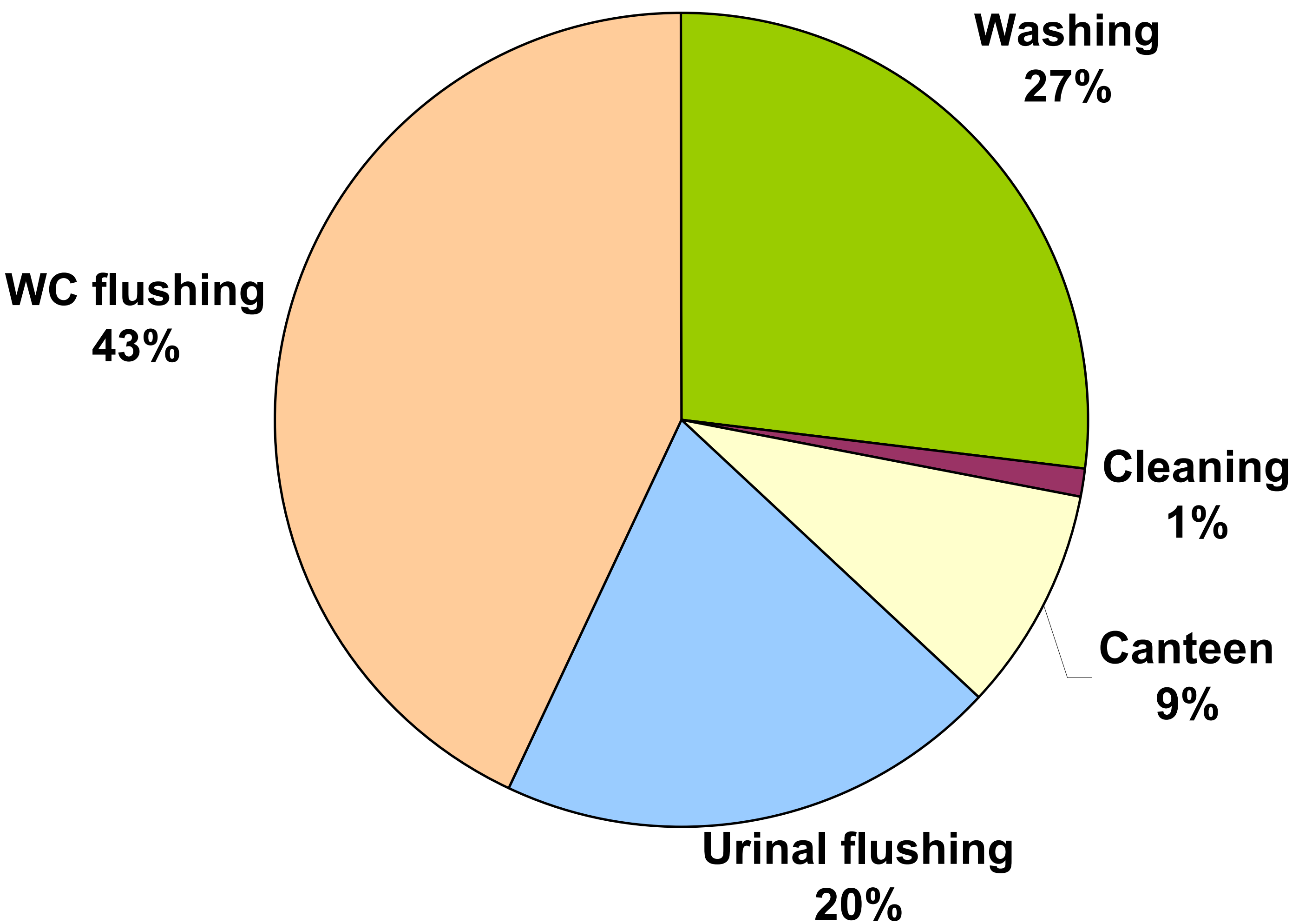
- Health risk
- public perception
- Costs

WHY
Water saving technologies

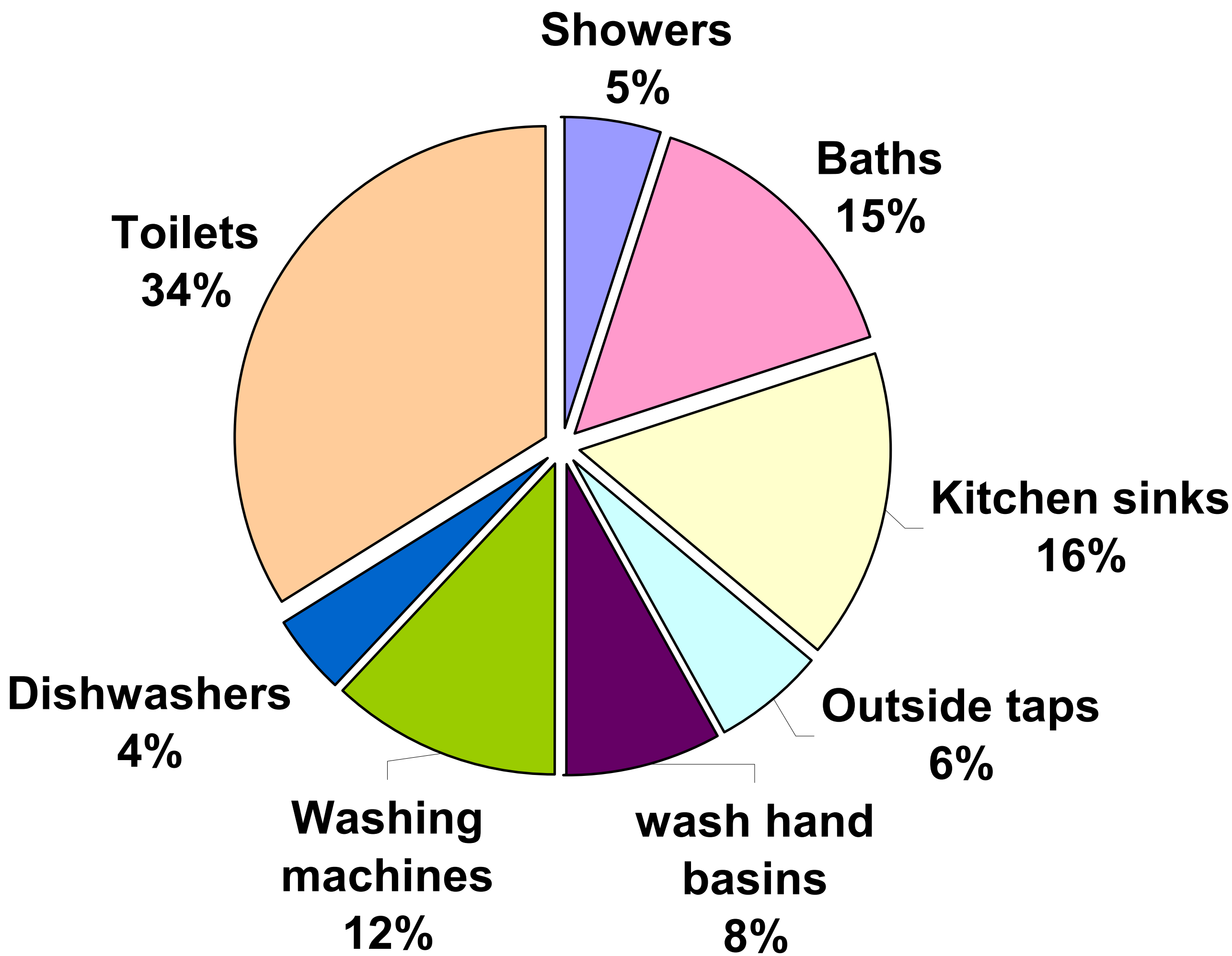
4 . Water saving technologies are probably the most effective solution as they offer:

- reduction in consumption at source
- relatively better payback period
- improved service to users
- relatively easy installation
- minimal maintenance

Water use by micro-components (Public places)



Water use by micro-components (Households)



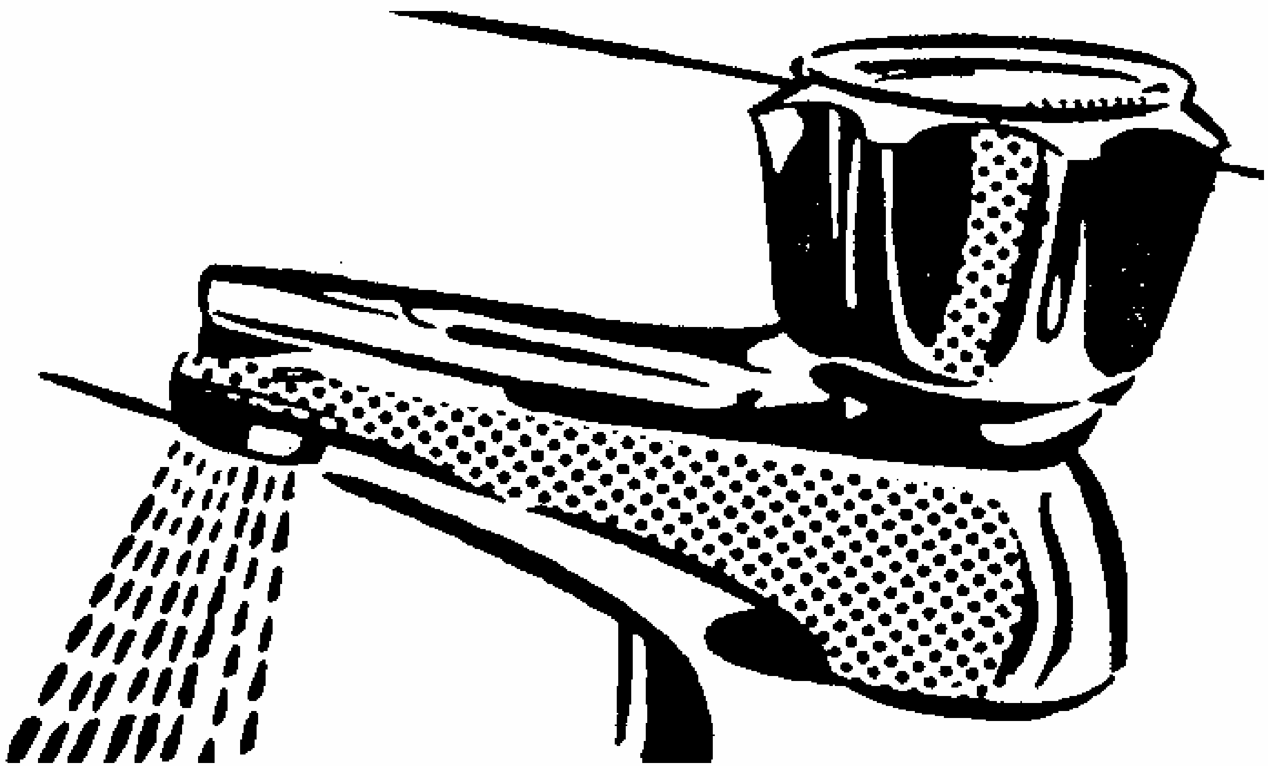
Taps

- In large commercial/public buildings about **30 %** water use is through taps
- At domestic level it is about **8 %**
- A conventional tap running continuously for one hour discharge about **1000** liters of water per hour
- A dripping tap looses **25-50 l/d** of water
  - Costing **£40** per year for single tap

Taps and tap controls

- Types
  - Spray taps
  - Battery operated taps
  - Infra-red taps
  - Push top taps
  - Single lever mixer taps
  - Tapmagic insert

Spray Taps



Spray Taps

- They contain small holes near mouth which forces water come out in mist or spray form
- Good for communal buildings
- Water savings about 60-70%
- But require some maintenance for efficient performance

Spray Taps: (Potential problems)

- Small holes may become blocked due to:
  - Soap and grease deposition
  - Scaling (in hard water areas)
- *Legionella* grwoth (bug thriving at 20-45 ^{o}C)
- Low flow hot water taps may induce wastage if water heater is far from the tap (ideally less than 1m)
- Solution: Regular maintenance and good practice

Battery Operated Taps

- These have small solenoid valve fitted in (hot /cold) pipes going to taps.
- The valve operates with battery and water flows by pressing the button to open valve (not tap)
- The duration of flow can be adjusted using the valve by user
- So the tap left open will switch off automatically (helps in wastage reduction)

Battery Operated Taps

- Taps with valves adjusted for very short duration of flow will lead to further tap use (hence may increase wastage)
- Battery in the valve lasts for about 2 years (hence minimal operating cost)
- Valves may be cleaned after 2 years

Infra-red Taps

- These are touch free taps
- Initially invented for hospitals to avoid cross contamination
- Contain infra-red sensor which switches on/off the tap automatically
- Duration of flow is pre-determined
- Some models have option to set the flow temperature
- Expensive

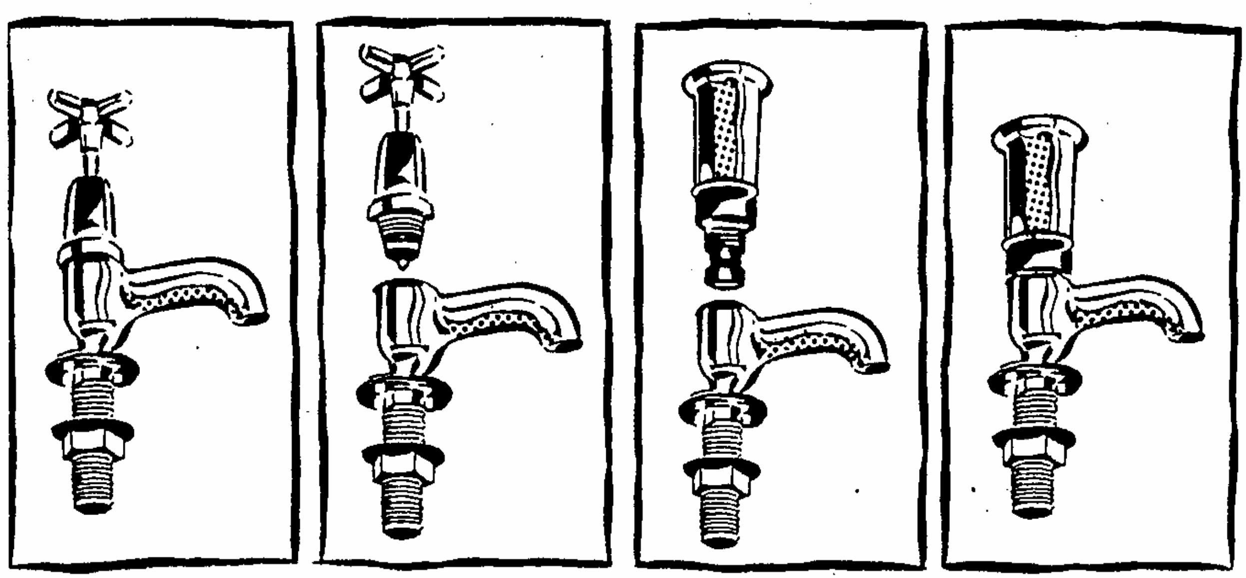
Push Top Taps

- These operate by creating pressure inside the tap (by pressing the tap top downwards)
- Once pressed down the tap top starts moving upwards
- Flow stops when the pressure is fully released
- Duration of flow can be adjusted at the time of installation (1 to 20 seconds)

Push Top Taps

- Hygienic in a sense, since they don't require retouching the tap to stop
- May cause significant water loss if stuck in 'ON' position
- May be retrofitted

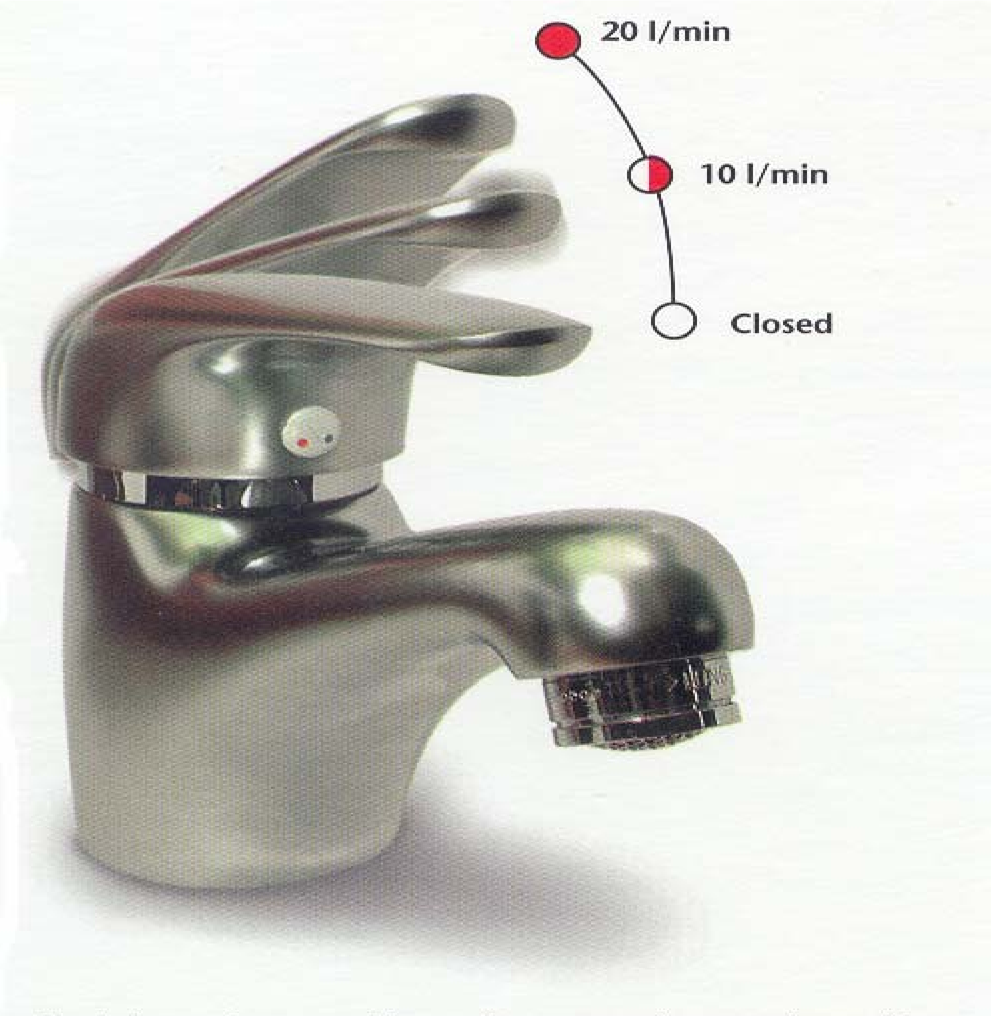
Push Top Taps
(retrofitting)



Single Lever Mixer Tap

- Flow rate increases when lever is lifted up
- When the lever is half way up, resistance is felt. This is due to ceramic cartridge (sitting in tap)
- Flow can be increased beyond this point to full flow by lifting the lever up with additional force

Single Lever Mixer Tap

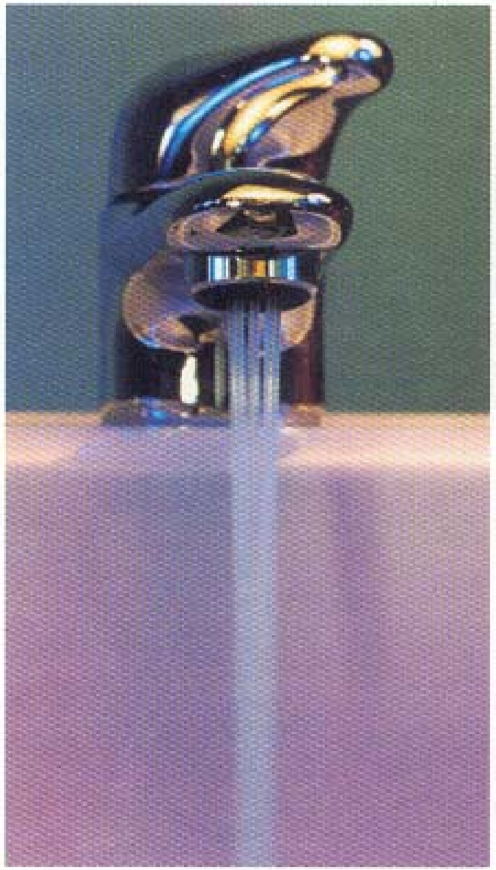


Single-lever mixer tap with retrofit water-saving ceramic cartridge (RST, Germany, Rodin Group UK).

Tapmagic inserts

- These are small inserts that can be fitted on taps with round mouth
- At low flow they work as spray taps
- At high flow the insert opens fully
- These are suitable for domestic use

Tapmagic inserts



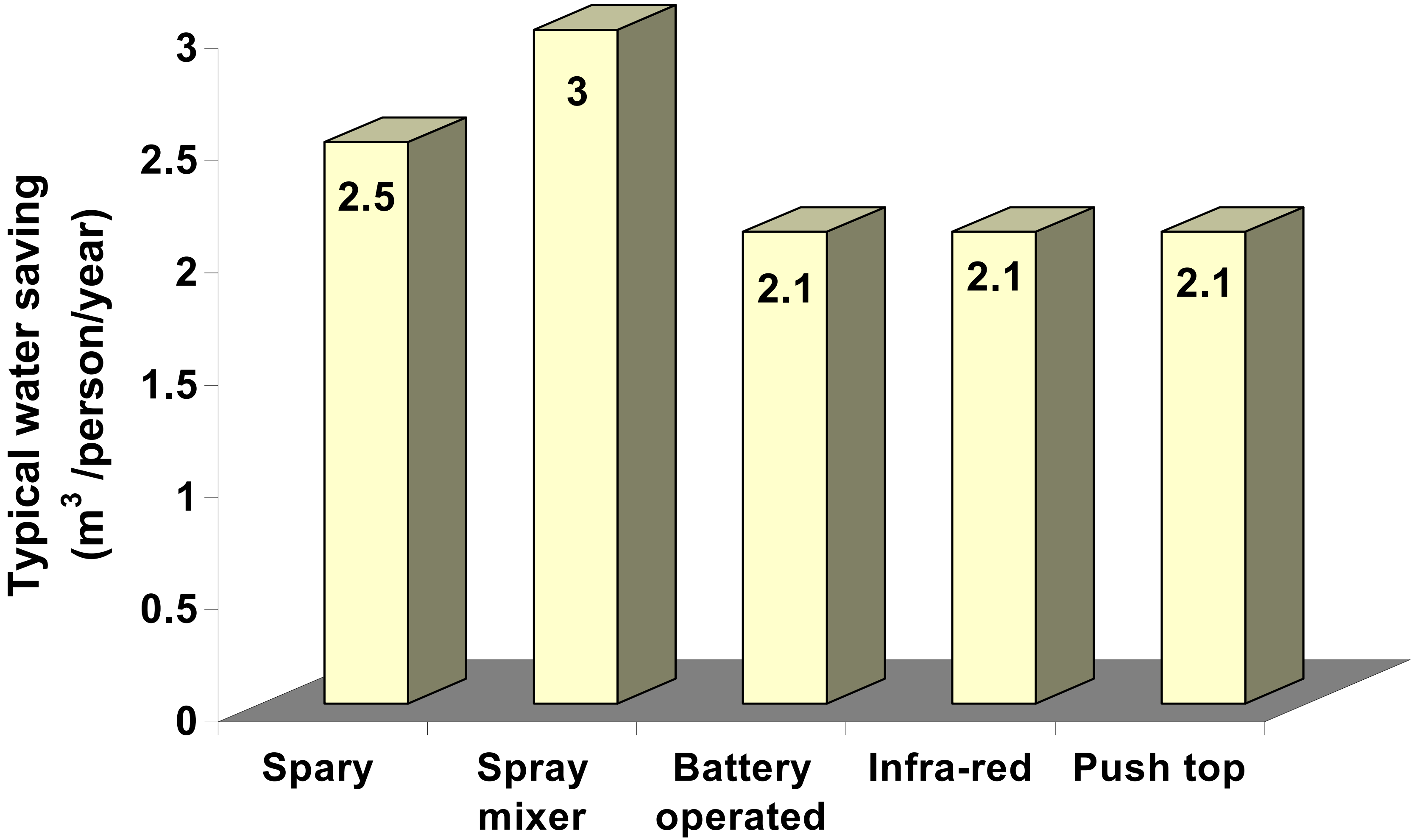
spray

full flow

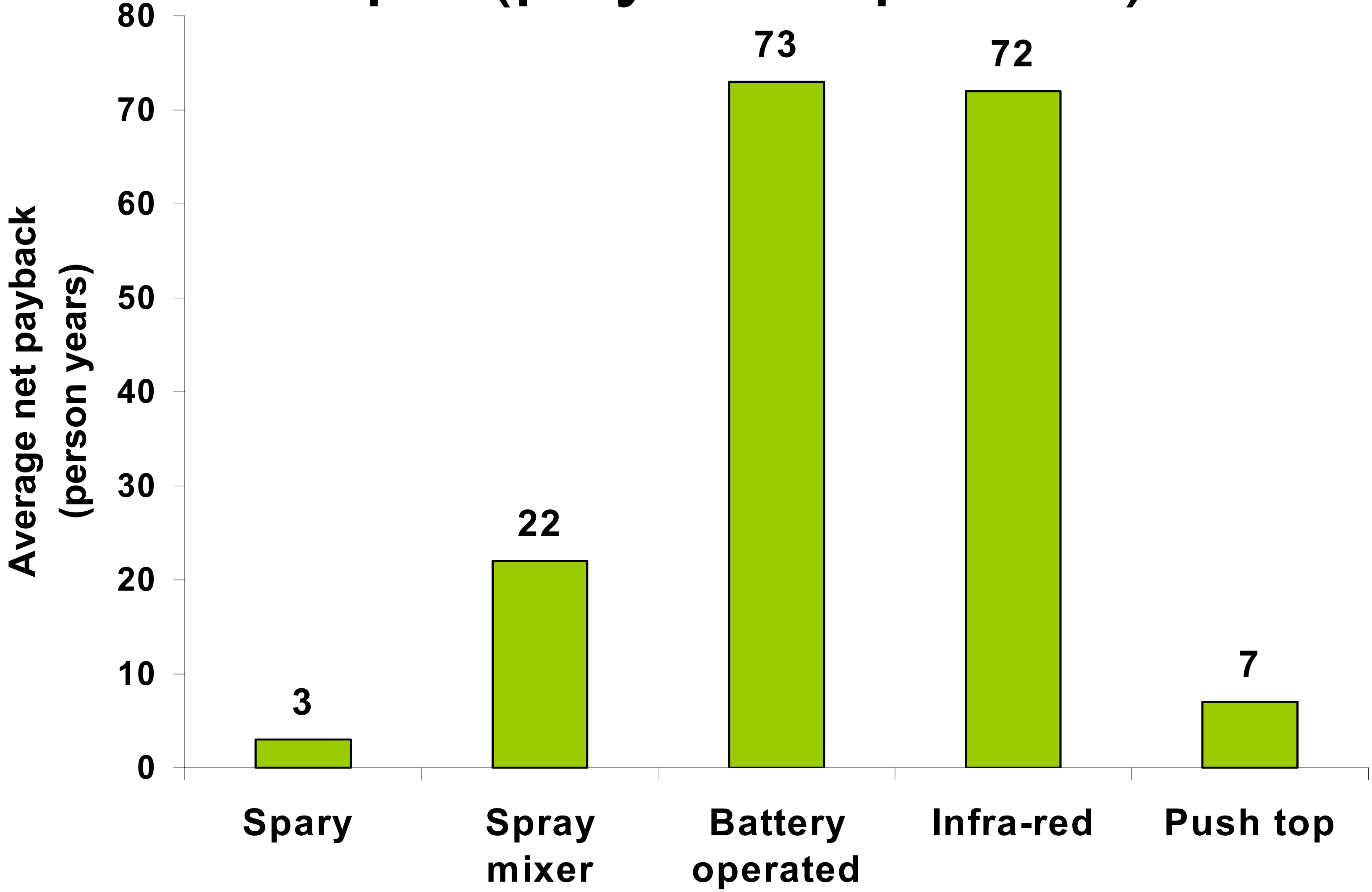
Taps: General Acceptability

- The options discussed are suitable for areas where
  - Frequency of use is high
  - Duration of use is low
- Typically at public places such as
  - Service stations/airports/train sations
  - Shopping centers/theatres/
  - Offices/hospitals/halls of residence

Taps (water savings)



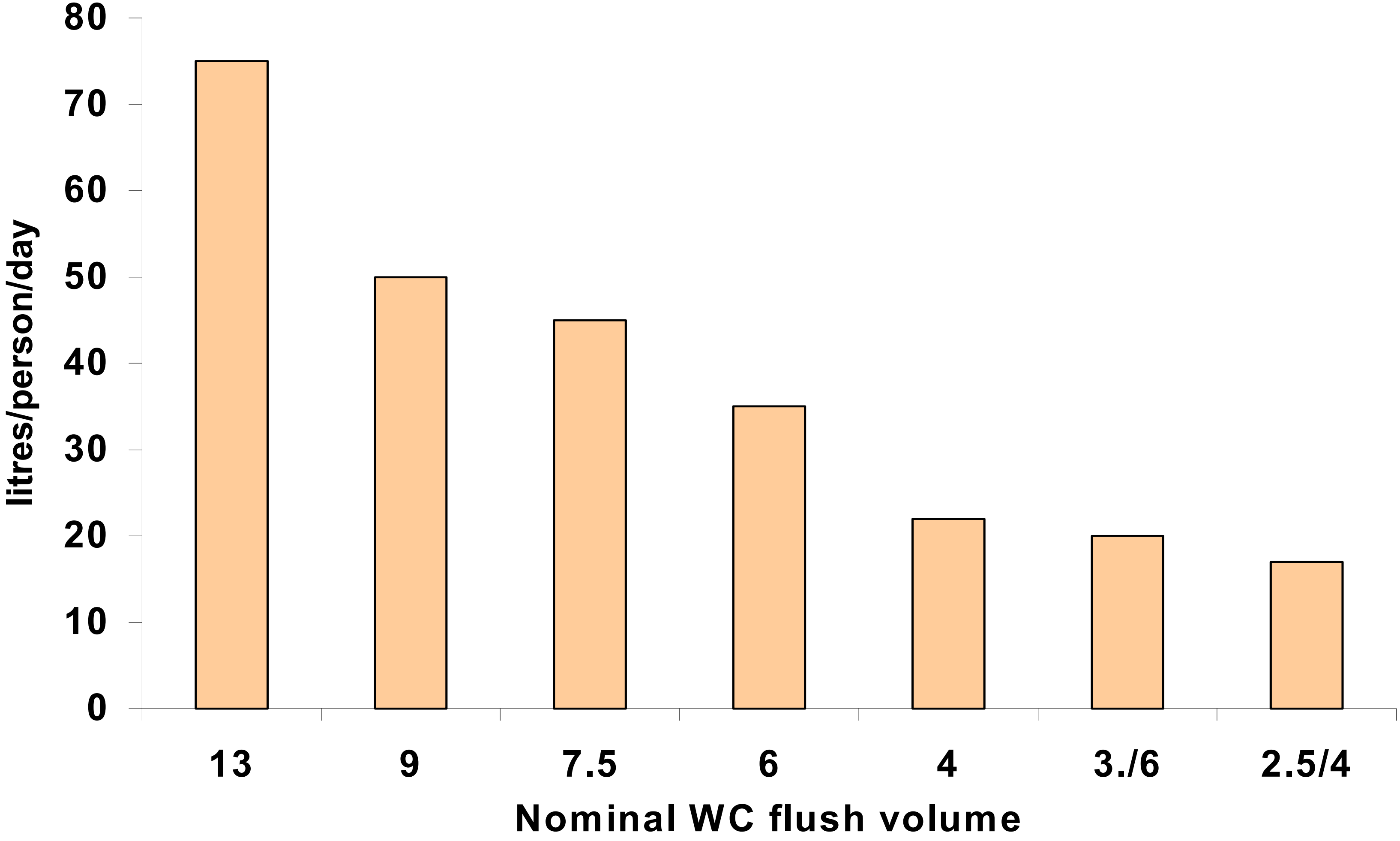
Taps (payback period)



Toilets (WCs) : components

- Mainly two components
  - Flush tank
  - Bowl
- Mainly efforts have been focused on reducing **flush volumes** and optimise the bowl size

Toilet flushing (water consumption (liters person/day)



Toilets (WCs): Options

- Displacement devices
- Flush tanks with siphon mechanism
- Flush tanks with valves
- Dual flush toilets
- Compressed air or vacuum toilets
- Waterless toilets

WC Cistern Dams

- This probably is the easiest and effective way (if installed correctly) to save water in WC flush tank.
- A solid object or water retaining container is placed in the tank to achieve water savings equal to volume of water displaced in the tank

WC Cistern Dams

- **Types**
  – DIY method (e.g. putting a brick..!!)
  – Proprietary products
    - Metallic bags
    - Hippos

Advantages

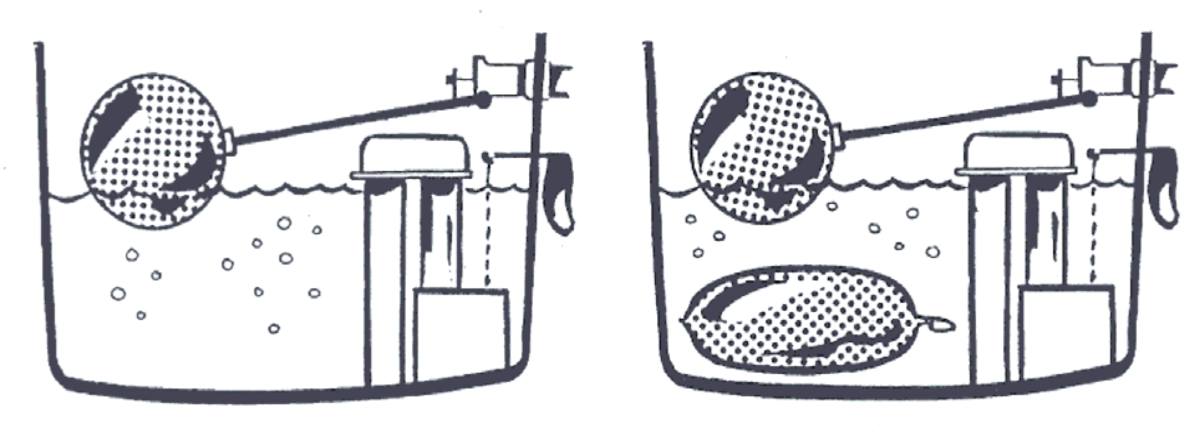
– No operating cost

– very short payback period

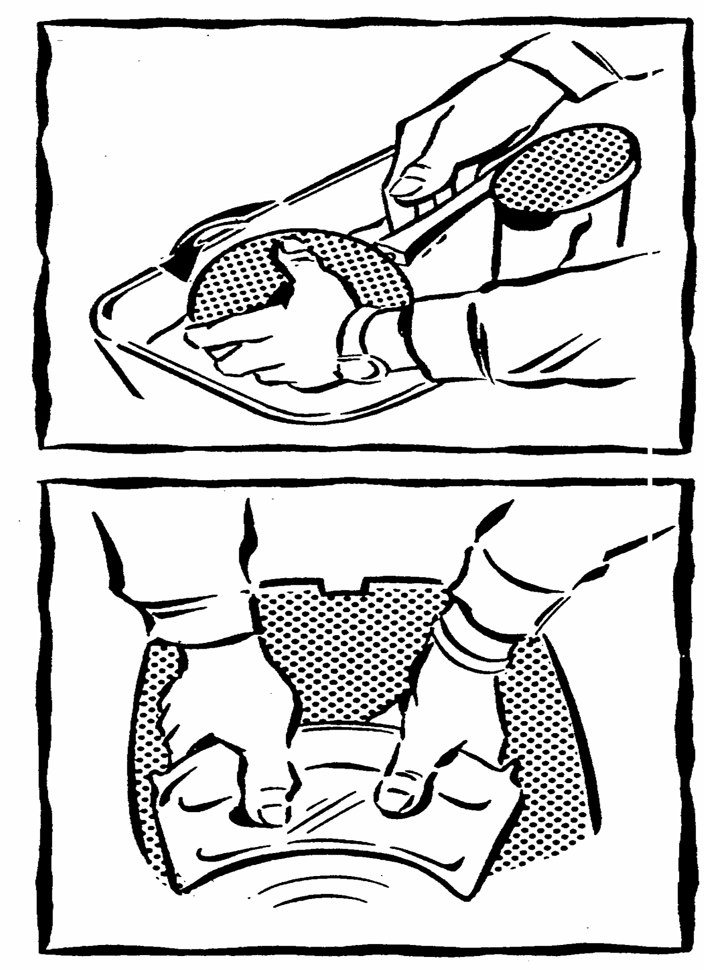
Disadvantage

– Incorrect installation could lead to double flushing

WC Cistern Dams



WC Cistern Dams



WC Cistern Dams General Acceptability

- These are suitable for household where user frequency is low and any malfunctioning can be spotted and corrected easily
- Not suitable for communal buildings where repeated flushing (in case of malfunction) will result in wastage

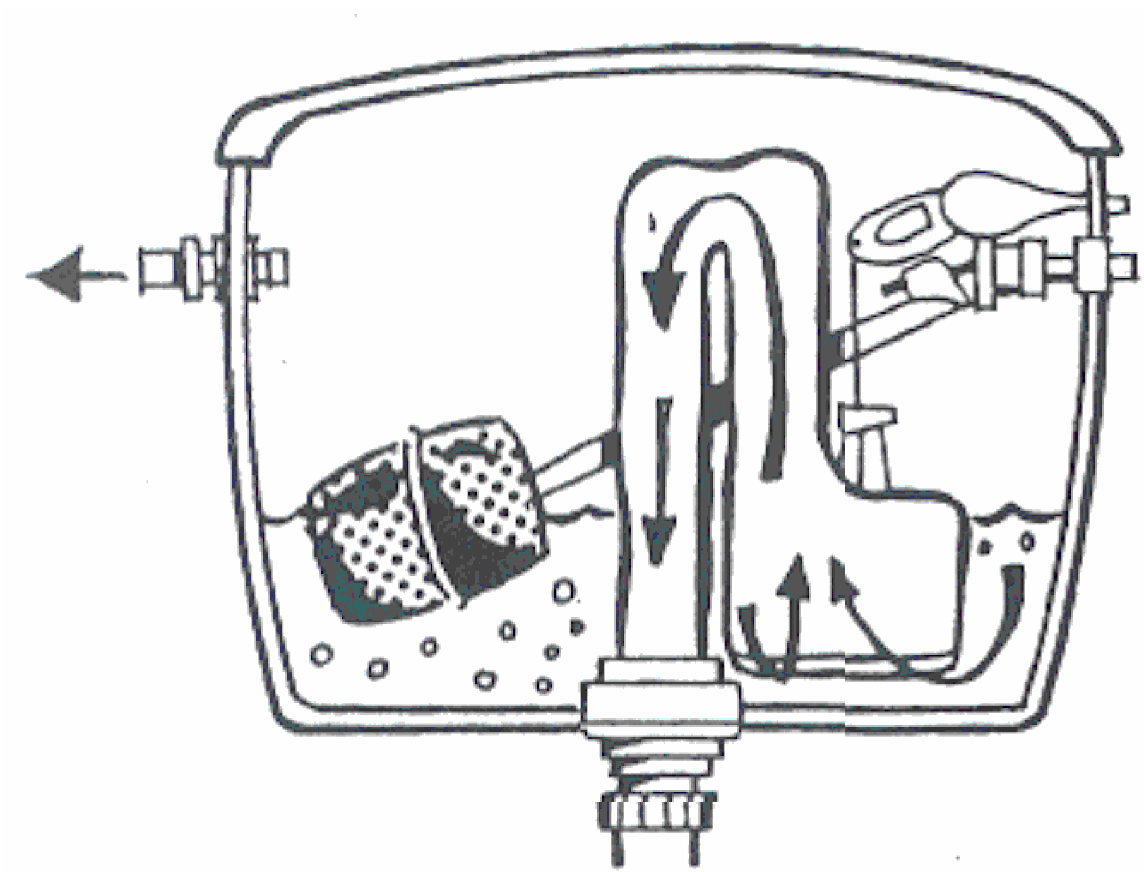
WC Cistern Dams Cost/Benefit

Product Description	Water saving	Unit cost (£)	Maximum net payback time
Metalised bag filled with sand or water	1.5 liters/flush	1.95	04-0.9 person years
Flexible cistern partition	40 % of normal flush	5.00	0.4-1.0 person years
Heavy gauge polythene bag (Hippo)	19.4 l/house/day	0.57	0.1-0.2 person years

Toilets: Flush tanks with siphon

- They have good reputation for being leak free
- Widely used in the UK with average volume of 9 litres/flush
- From January 2001, in the UK, all new toilets must not flush with water in excess of 6 liters
- The siphonic tanks with external overflow were made mandatory to reduce wastage

Toilets (WCs)
Flush tanks with siphon



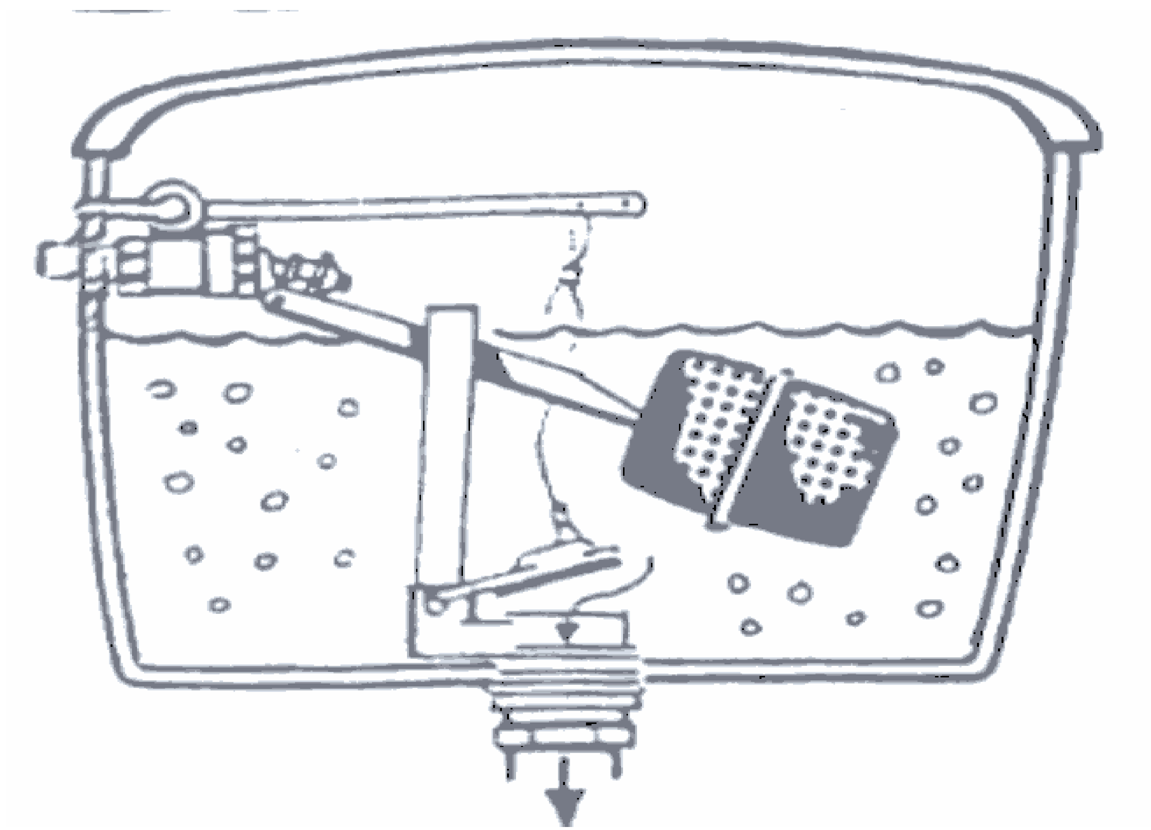
Toilets: Flush tanks with valves

- These operate on mains water or pressurized water supply
- They discharge the flushing water at higher rate than normal toilets
- Suitable for public places where frequency of use is high and not enough chance to refill cistern quickly
- Water fill volume can be adjusted

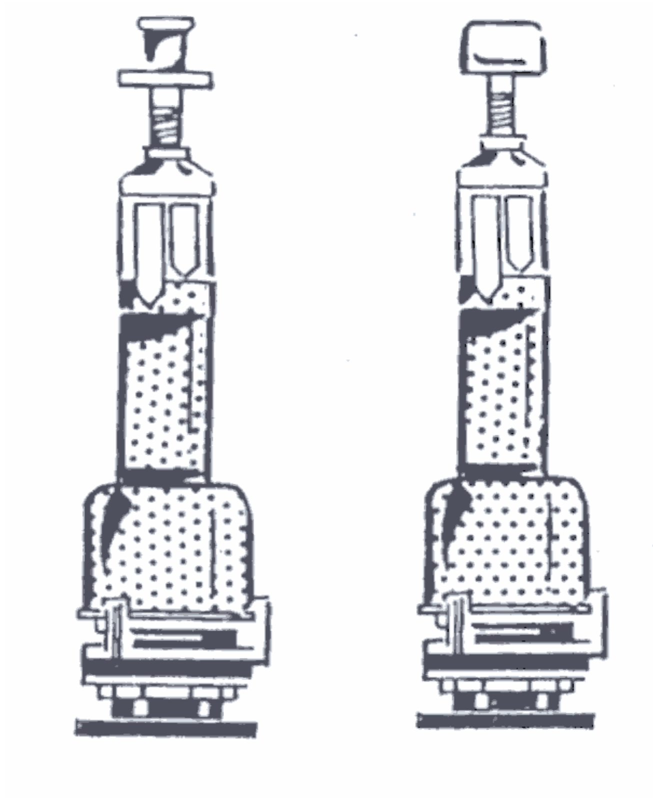
Toilets: Flush tanks with valves

- Not suitable for households because
  - high inflow rate required
  - High flushing rate requires bigger size of waste drain
- Eventually leak
- Types
  - flap valve (commonly used in the USA)
  - Drop valve (widely used in Europe, Australia, New Zealand)

Toilets (WCs)
Flush tanks with flab valve



Toilets (WCs)
Drop valves

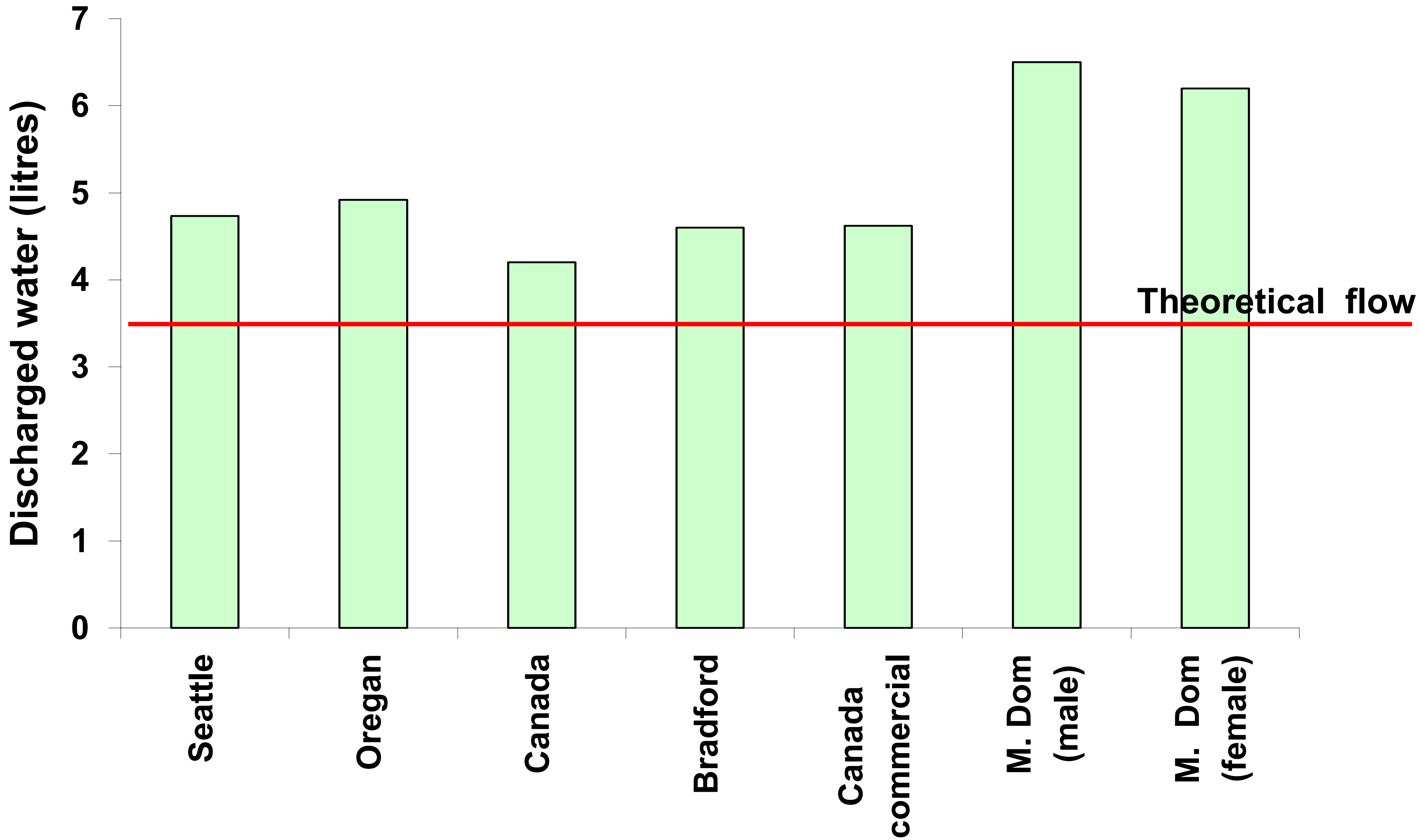


Toilets : Dual Flush

- They are designed to release water depending on the nature of use:
  - less water (half flush) for liquids
  - more water (full flush) for solids
- These were not permitted in the UK until 2001
  - more water use due to wrong operation
  - lack of clear instruction
  - curiosity

Toilets (WCs): Dual Flush

- These are permitted now provided
  - clear instructions are provided for users
  - the small flush should not be less than 2/3 of the full flush.
- There are marked differences between the theoretical and measured discharge from WCs
  - Theoretical discharge= (4p+f)/5



Measured flows from 3/6 dual flush toilets of 3.6 litres theoretical flow (EA, 2003)

Toilets: Vacuum or compressed air

- Often seen in aeroplanes/trains/ships
- Consists of a pan with two chambers separated by a FLAP
- Waste is dropped in top chamber
- When toilet is flushed the flap opens
- The opening of the flap cause water to flow and waste is transferred to the second chamber
- Flap is then closed. This causes release of compressed air, which sucks out the waste under vacuum to septic tank

Toilets: Vacuum or compressed air

- **Positive points**
  - minimum water quantity (1.2 liters /flush)
  - small bore pipe
  - extensive sludge de-watering not required
  - Small storage area
  - Good for places where flow of sewage under gravity is not possible (basements)

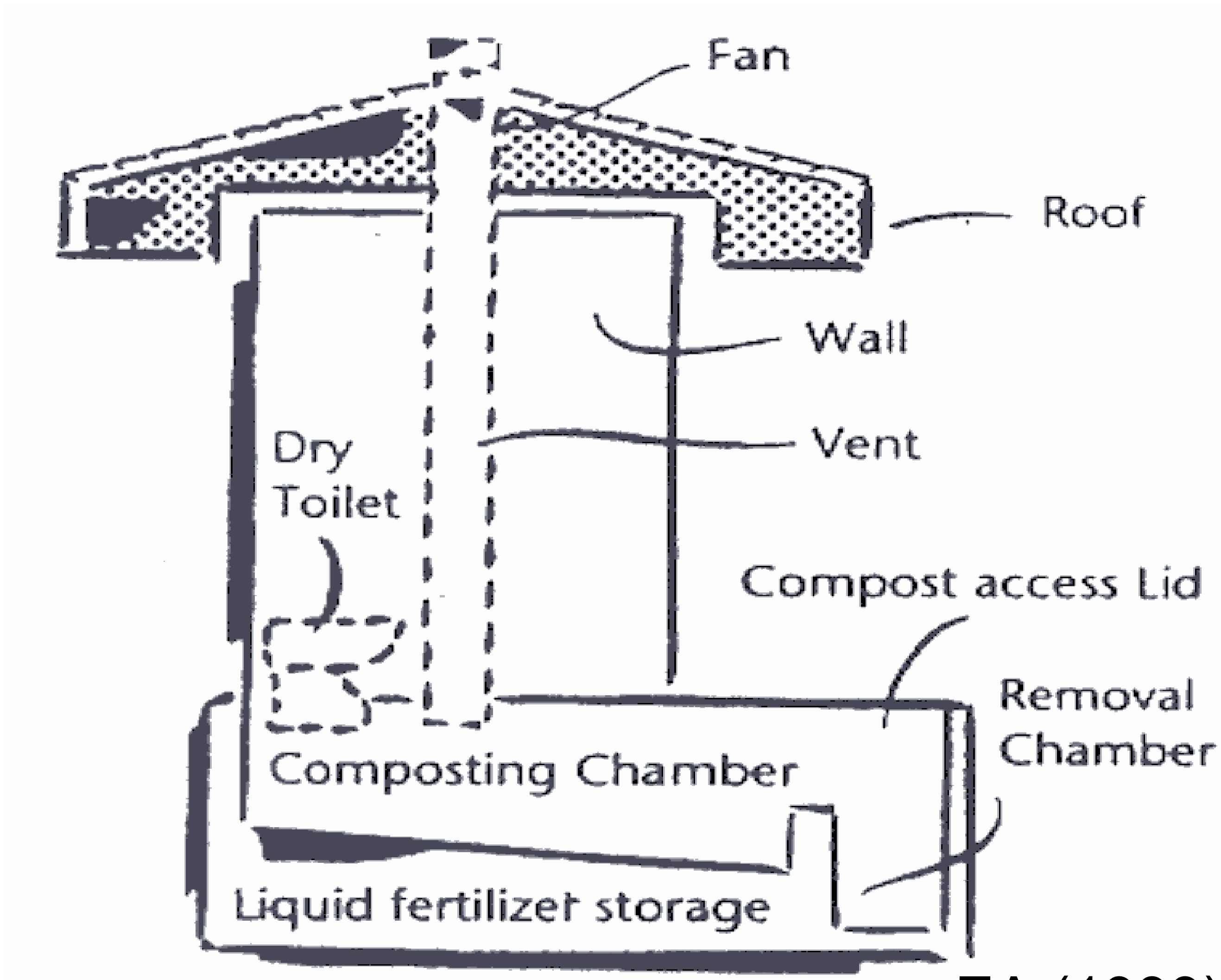
Toilets: Vacuum or compressed air

- **Negative points**
  - High capital cost
  - 60 liters of air per flush
  - High operational cost (energy requirements)
  - requires additional accessories like compressed air plant, pumps and tank on site
  - The system may be economically viable if installed in large numbers (> 20 units)

Composting toilets

- No water use (can save up to 35 % water)
- Waste is dropped in tank where it is biodegraded by aerobic bacteria
- The composted waste can be used as fertiliser
- Good for areas with no access to foul sewer
- Require large tank area or frequent emptying
- Two types
  - Unheated composting toilets
  - Heated composting toilets

Composting toilets



EA (1999)

Composting toilets:Unheated

- Rate of bio-degradation is low in winter
- Up to 90 % of liquid waste is evaporated through vent
- The residuals could be used as fertilizer after dilution with water (1:10)
- Also requires 2 kg of wood shaving added each week to facilitate aerobic activity at producing bulk compost.
- Can treat up to 22000 uses per year

Composting toilets:Heated

- Rate of bio-degradation is high
- Up to 100 % of liquid waste is evaporated through vent
- Mass of end product (compost) is reduced
- Less frequent emptying
- Suitable in areas with mains power supply
- Operational cost is high

Incinerating Toilets

- The waste is incinerated using heating and cooling cycles
- The end product is small amount of ash which can and can be disposed of with domestic rubbish
- Can be retrofitted
- Guaranteed water savings but very high operational cost

Waterless Toilets (Cost /benefit)

Product Description	Unit cost (£)	Operating cost (£)	Maximum net payback time*
Unheated composting toilet	1400	minimal	32-80 person years
Heated composting toilets	735	12.5	24-145 person years
Incinerating toilets	1212	64-78	Operating cost > Water savings

*** based on 35 % water saving (50 l/person/day)**

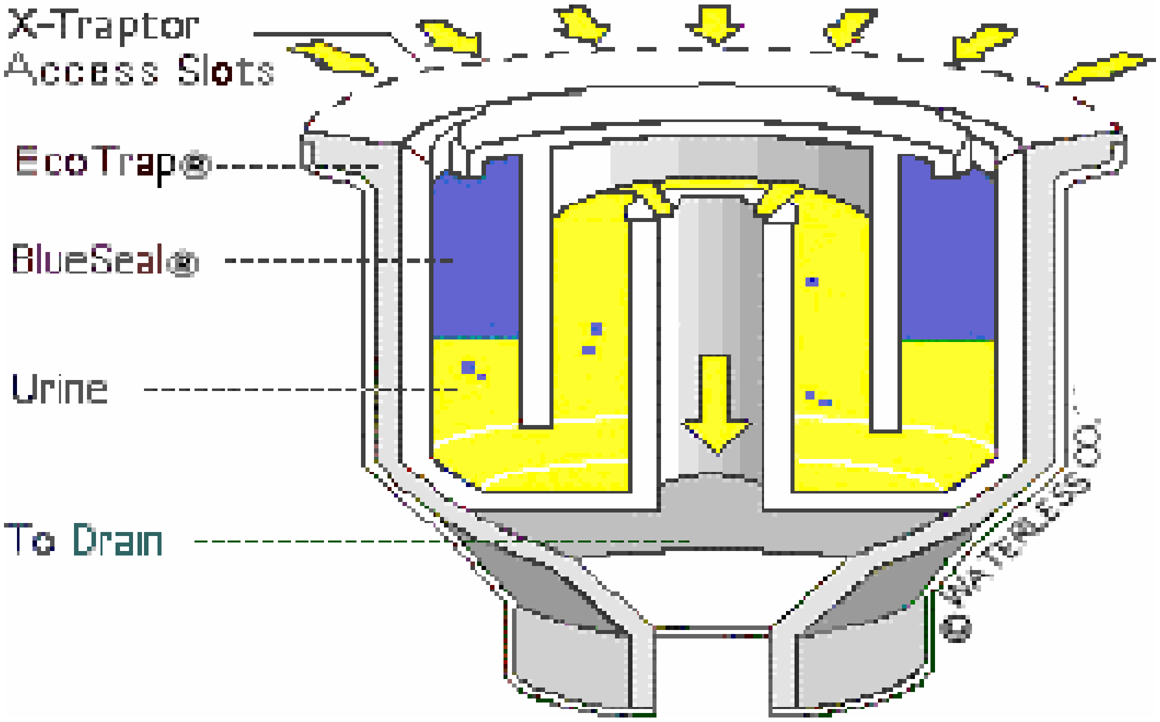
Waterless Urinals

- **20 %** of drinking water produced through out the world is used for urinal flushing
- A single waterless urinal saves up to **60 m^3** of water per year
- Water consumption by urinals alone in the USA is equal to volume required to meet water demand from **1.9 million** people (or half million homes)

Waterless Urinals: Types

- **Urinals with deodorizing pads**
  - These have wide outlet to accommodate pads
  - The pads contain chemical designed to escape foul gases from the urinal
- **Urinals with siphonic trap**
  - They contain a siphon and trap liquid (special chemical) seal
  - Urine passes through the liquid seal without draining the chemical itself
  - both systems can be retrofitted and require regular change of chemical/pad

Waterless Urinals



Waterless Urinals: Cost/benefit

Product Description	Unit cost (£)	Operating cost (£)	Maximum net payback time*
Urinals with deodorizing pads	78	£ 26 /year for pads	19-65 person years
Siphonic trap urinal with barrier fluid	322	£ 15 /urinal every 120 days	92-671 person years
Siphonic trap with barrier fluid	89	£ 19 for 1 years barrier fluid	20-62 person years

EA (1999)

Urinal Controls

- **Generally urinals are flushed at regular intervals**
  - **during day and night**
  - **independent of actual urinal use**
- **This contributes to considerable wastage**
- **Some forms of controls are required**

Urinal Controls

- **Infra-red sensors**
- **Water sensing**
- **Magnetic door switch**
- **infra-red door beams**
- **Temperature sensitive urinal controls**

Urinal Controls
Infra-red sensors

- These are mounted very near to urinals (on wall or ceiling)
- They detect the movement and trigger a time delayed flush
- If urinal remains unused for (12 to 24 hrs), a hygiene flush is activated
- They reflect the real use and offer use dependent savings

Urinal Controls
Water sensors

- These are fitted in the feed pipe to hand wash basin and detect flow to tap.
- When someone uses washbasin, the sensor assumes that urinal has also been used and a time-delayed flush is triggered.
- Potential problems are
  - water wastage
  - lime scale deposition (maintenance)

Urinal Controls
Magnetic door switch

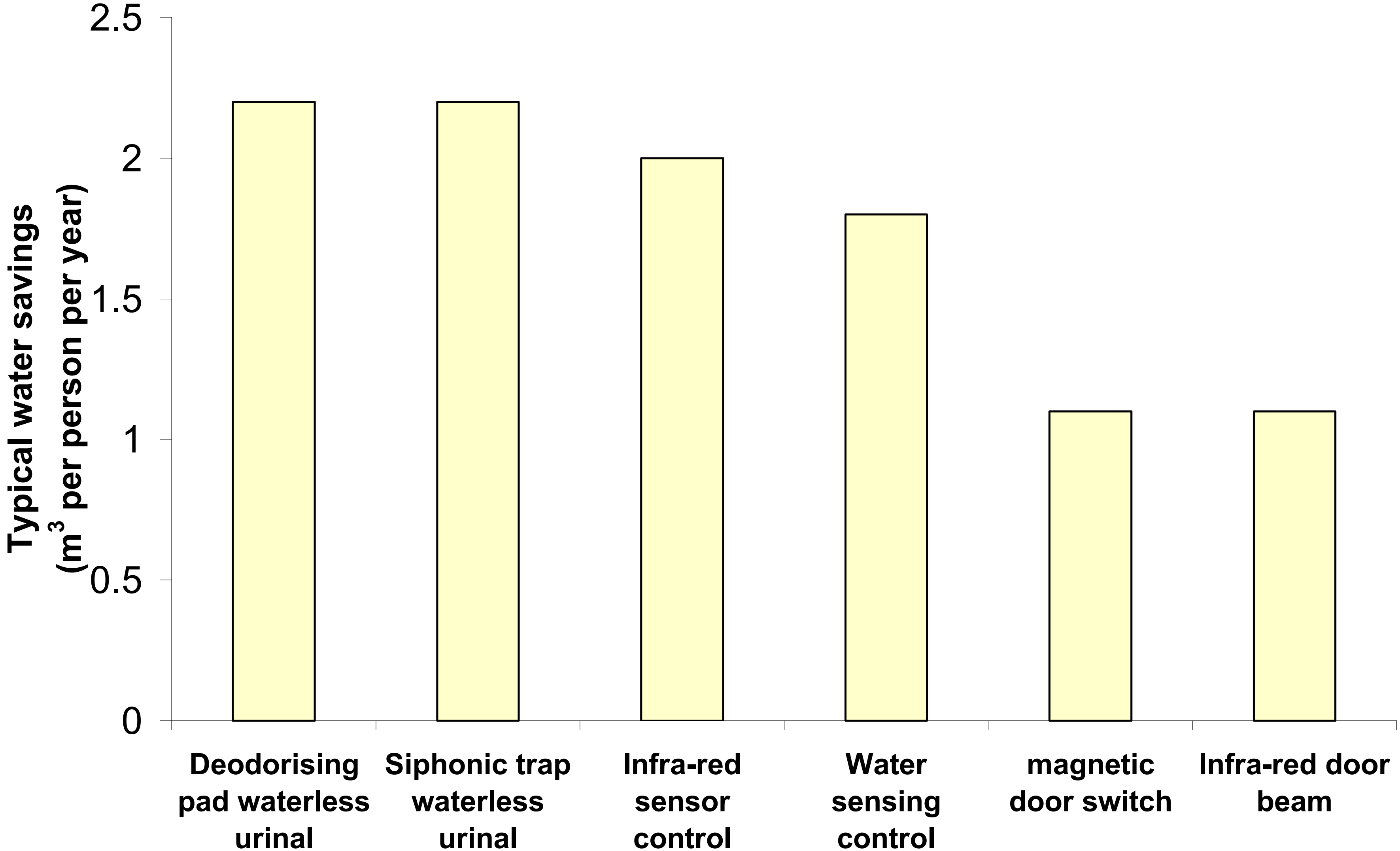
- These are fitted in automatic doors
- A time delayed flush (after 20 minutes) is triggered when the door is open
- Door can be opened several times but there will be only one flush in 20 minutes
- They assume that anyone entering the washroom will use urinal
- The door has to be closed fully first time, otherwise sensor switch will not work

Urinal Controls
Infra-red door beams

- These are located near washroom doors
- Operate under the same working principle as magnetic switches except infra-red beams are used to detect motion

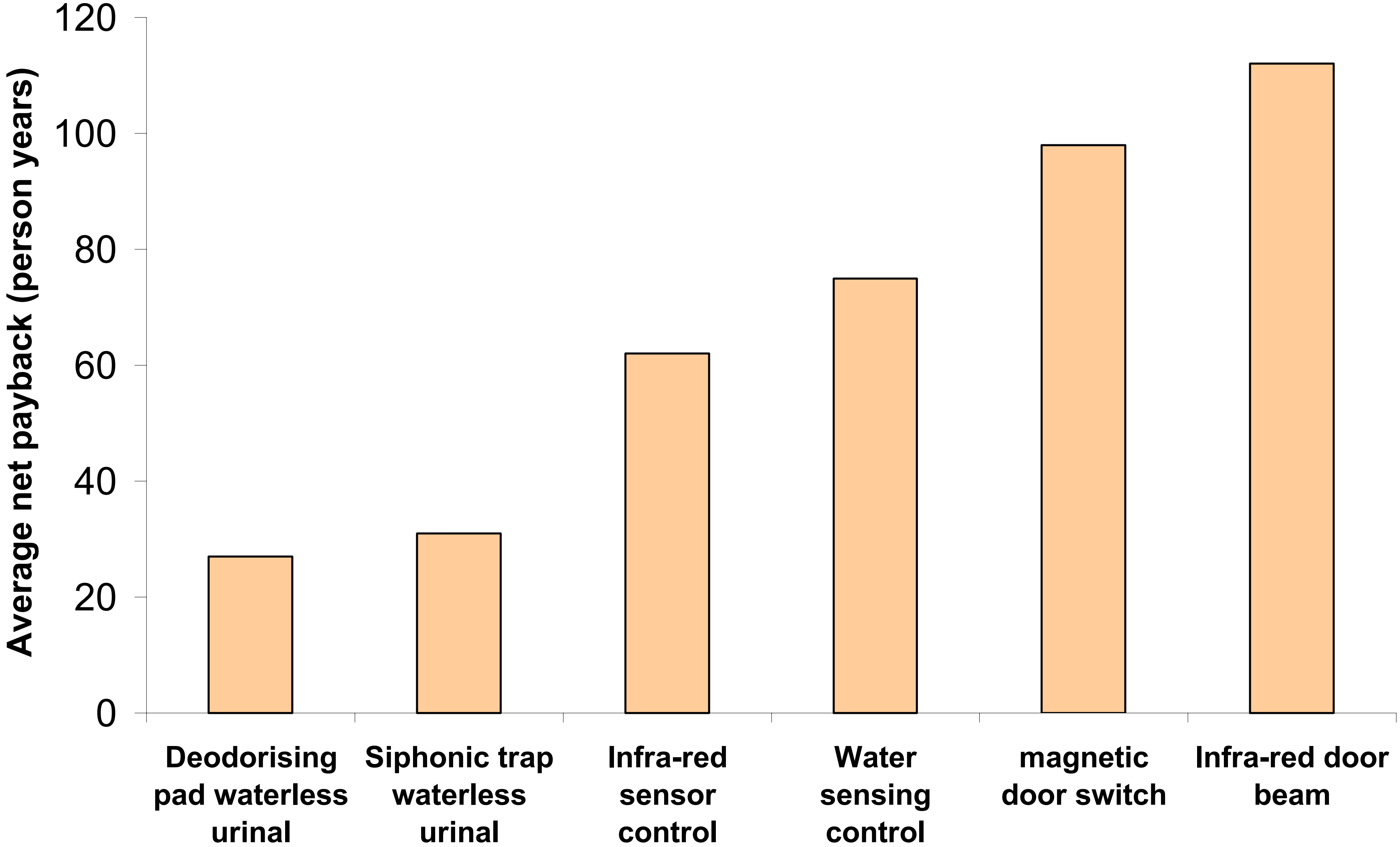
Urinal Controls
Temperature sensitive controls

- Thermal sensitive sensors are fitted in waste pipe draining the urinal
- They sense temperature increase due to urinal use and trigger immediate or time-delayed flush
- They reflect real use and minimse wastage
- Lime scale deposition on sensor surface can reduce its effectiveness



Typical water savings from urinals and controls

EA (1999)

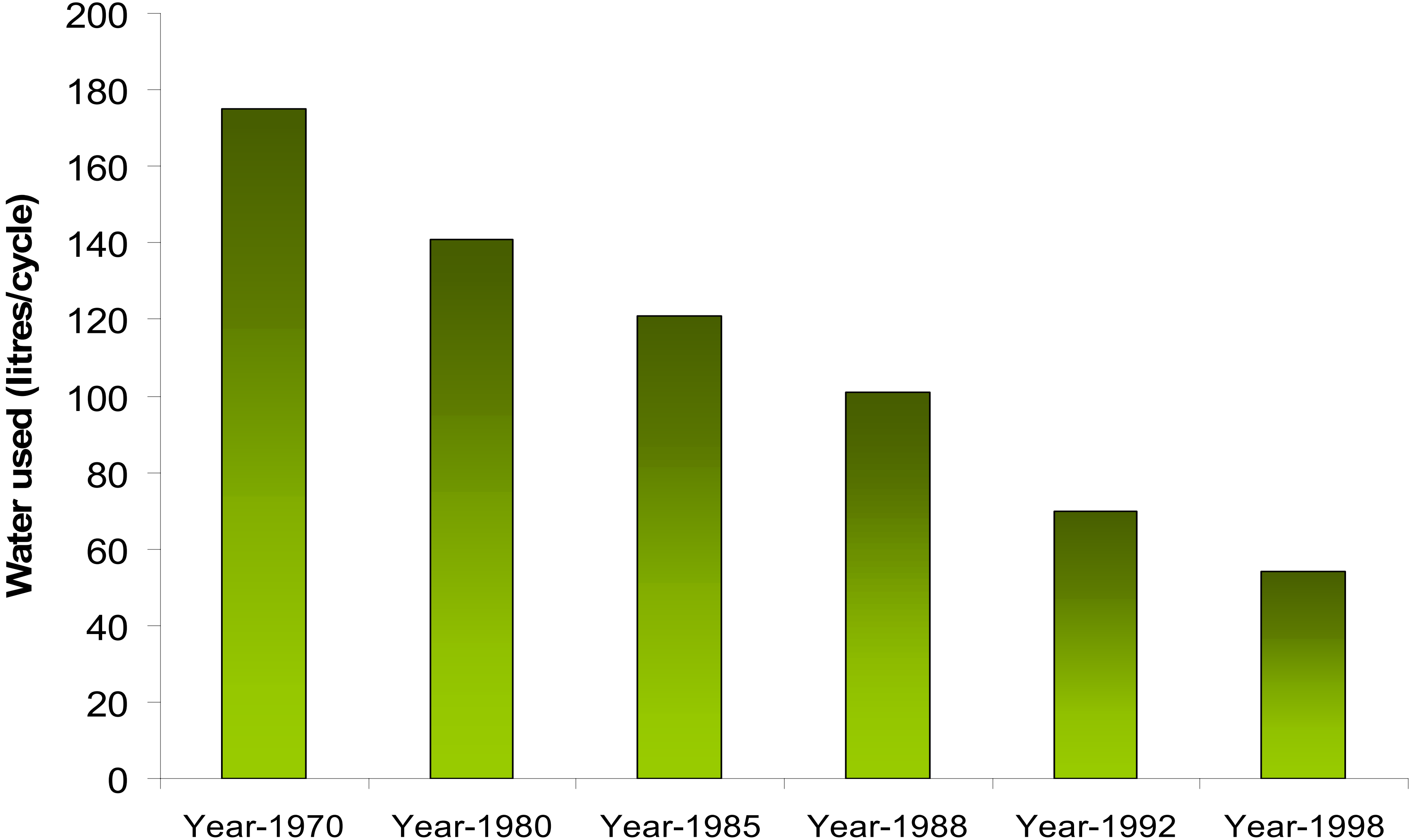


Average net payback for urinals and controls

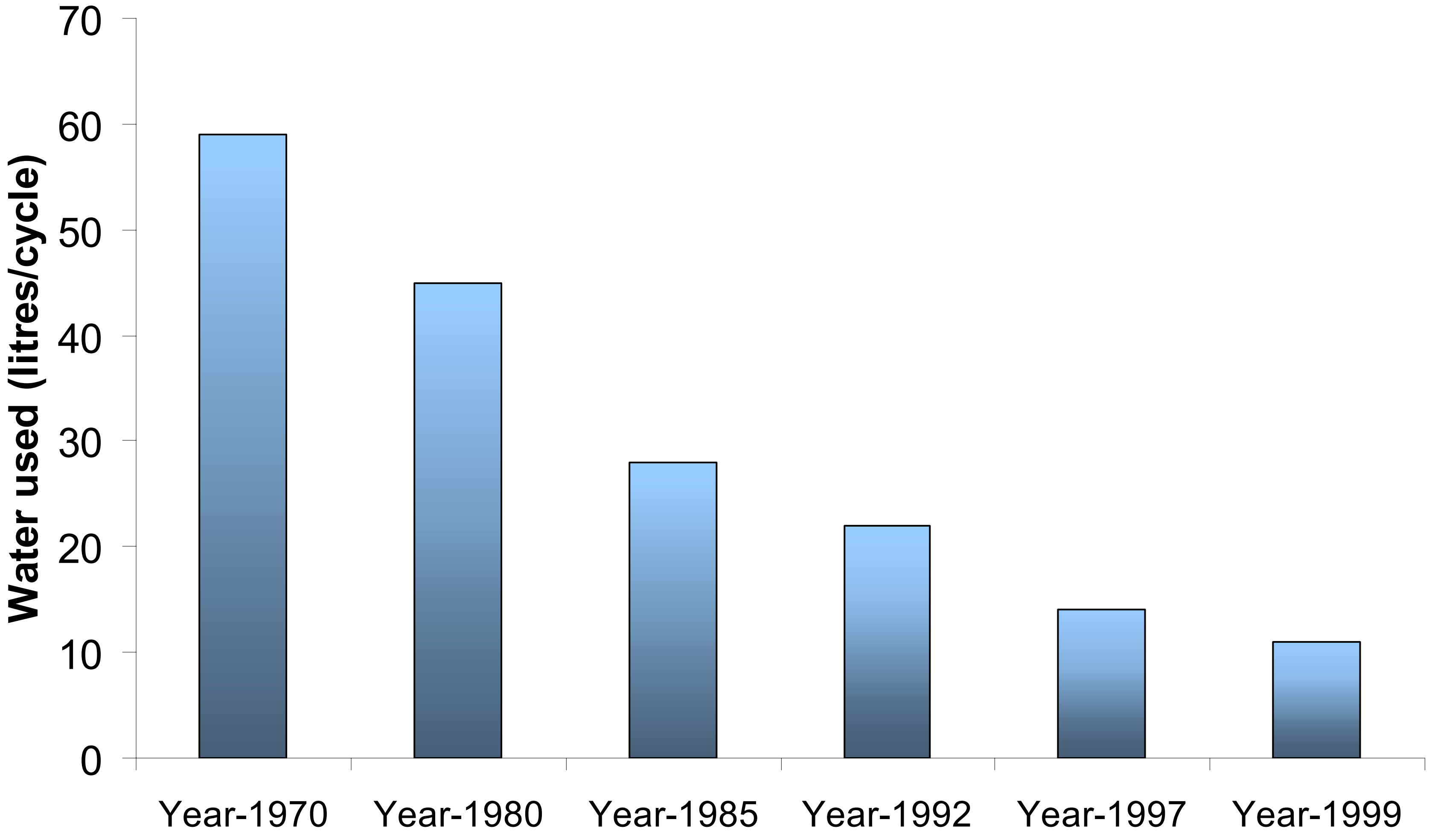
EA (1999)

Domestic Appliances
Washing Machines & Dishwashers

- Water consumption in washing machines is about **14 %** of domestic consumption
- Dishwashers account for about **7 %** of consumption
- Washing machine ownership about 77 %
- Dishwasher ownership increasing
  - (6 % in 1985 and 25 % in 2001)
- Consumption has decreased in last 30 years



Reduction in water consumption by washing machines



Reduction in water consumption by dishwashers

Washing Machines & Dishwashers Water Regulations

- Maximum water limit is
  - 27 liters per kg of load for washing machines
  - 48 liters per kg of load for washer dryers
  - 4.5 liters per place setting for dishwashers
- Most of the dishwashers and washing machines are consuming much less water than these thresholds

Washing Machines & Dishwashers Technologies

- Fuzzy logic based electronic controls
- Ultrasonic agitation
- Reuse of rinse water
- Further water savings would be possible
  - by inventing new detergents
  - by reducing/optimising consumption when machines are partly loaded

Washing Machines & Dishwashers Cost/benefit

	Washing machines		Dishwashers	
	old	**new**	**old**	**new**
Liters per wash (full load)	100	50	25	16
Annual water use (m^3)	36.4	18.2	9.1	5.8
Annual water cost (£)	54.6	27.3	13.6	8.7

EA (2001)

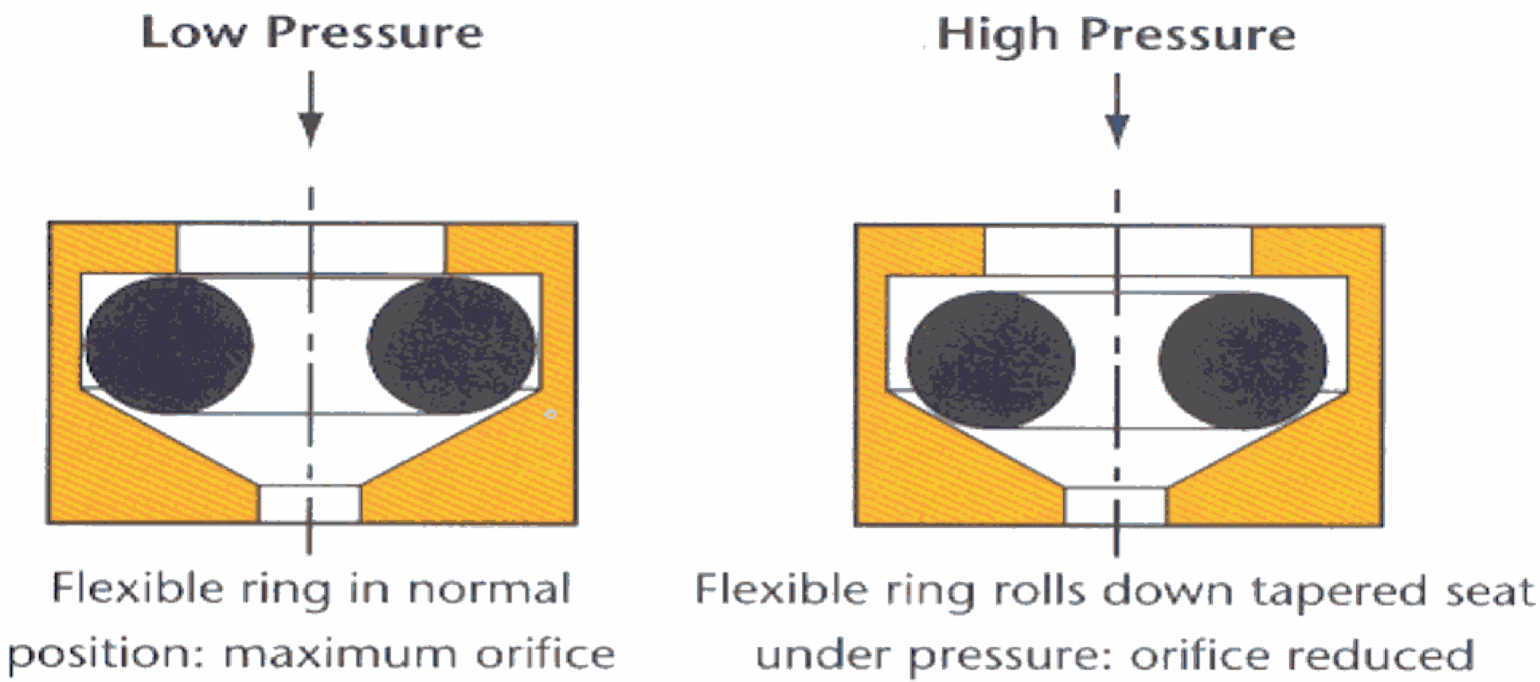
Washing Machines & Dishwashers Cost/benefit

- There are marginal savings with new models
- Appliances are replaced normally after every 8 years
- Changing the washing machine with a new model is less attractive in terms of financial gains (disposal costs)
- Local technological solutions and full load operation could improve the benefit side

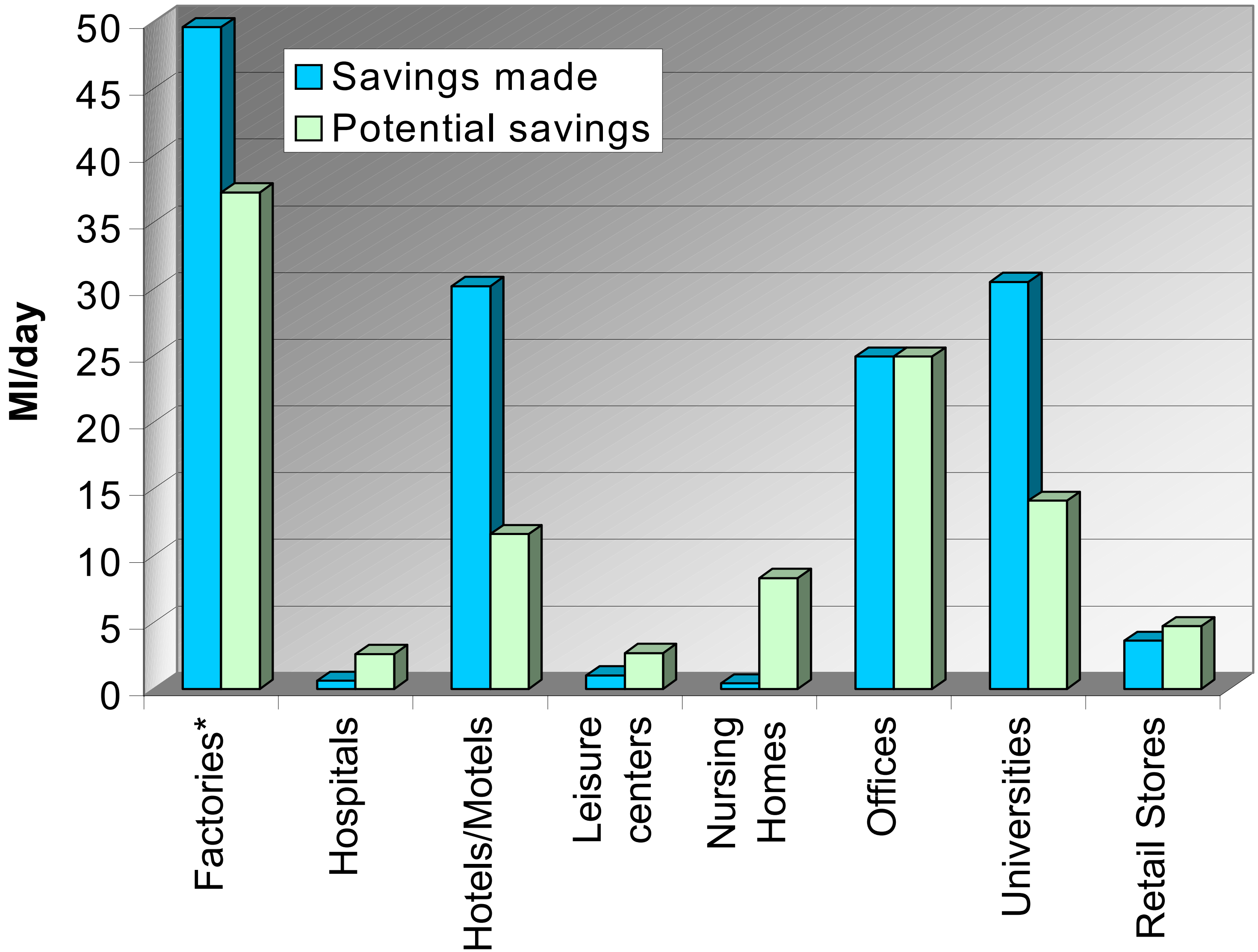
Flow Restrictors

- These are valves fitted upstream of the consumption point (tap/shower) in supply pipe
- They reduce the flow by means of reducing the orifice size when incoming water has high flow.
- They should not be installed in conjunction with spray taps etc..
- They can offer considerable water saving

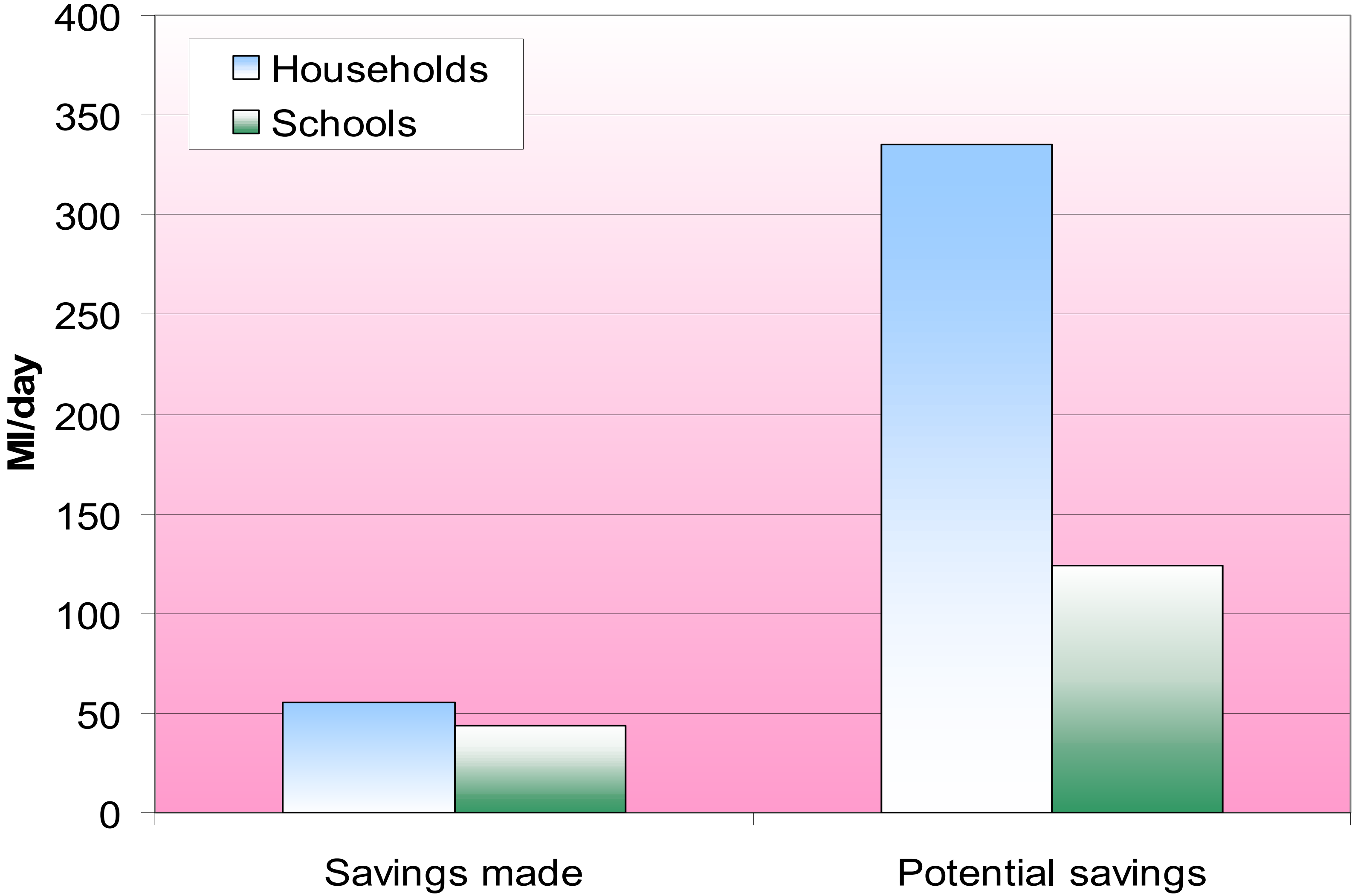
Flow Restrictors



EA (2001)



Estimated water savings with water saving technologies in the UK (BSRIA, 1998)



Estimated water savings with water saving technologies in the UK (BSRIA, 1998)

Conclusions / suggestions

- Considerable water savings
- Preference to simple technologies
- Higher chance of success in middle and high income groups
- Involvement of local appliance manufacturers is must
- May require incentives and subsidies

References

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Part-II

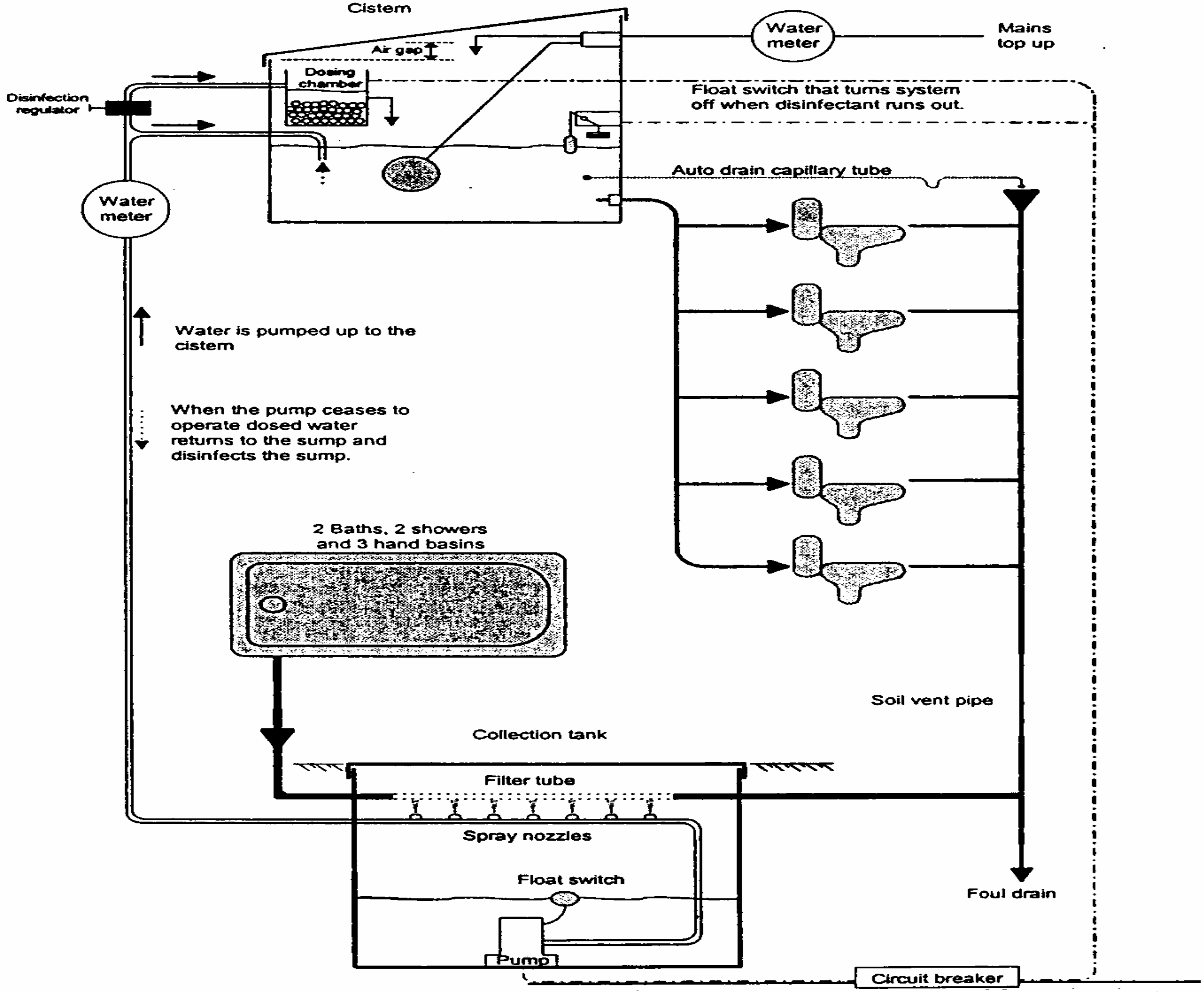
Examples of Water Conservation / Recycling Projects

Introduction

- Three case studies
  - Small scale domestic site
  - medium scale students hostel
  - Millennium Dome
- System description
- Problems identified
- Water savings achieved

Project -1: (Description)

- **A new 5 bedroom house**
- **Occupancy**
  - 3 adults, 3 children and 3 *dogs*
- **Water collected from**
  - 2 baths, 2 showers and 3 hand basins is recycled
- **System components**
  - Collection tank, filters, disinfection, cistern storage
- **Effective monitoring**
  - 2 months



Cistem
Air gap
Dosing chamber
Water meter
Mains top up
Disinfection regulator
Float switch that turns system off when disinfectant runs out.
Auto drain capillary tube
Water meter
Water is pumped up to the cistem
When the pump ceases to operate dosed water returns to the sump and disinfects the sump.
2 Baths, 2 showers and 3 hand basins
Soil vent pipe
Collection tank
Filter tube
Spray nozzles
Float switch
Foul drain
Pump
Circuit breaker

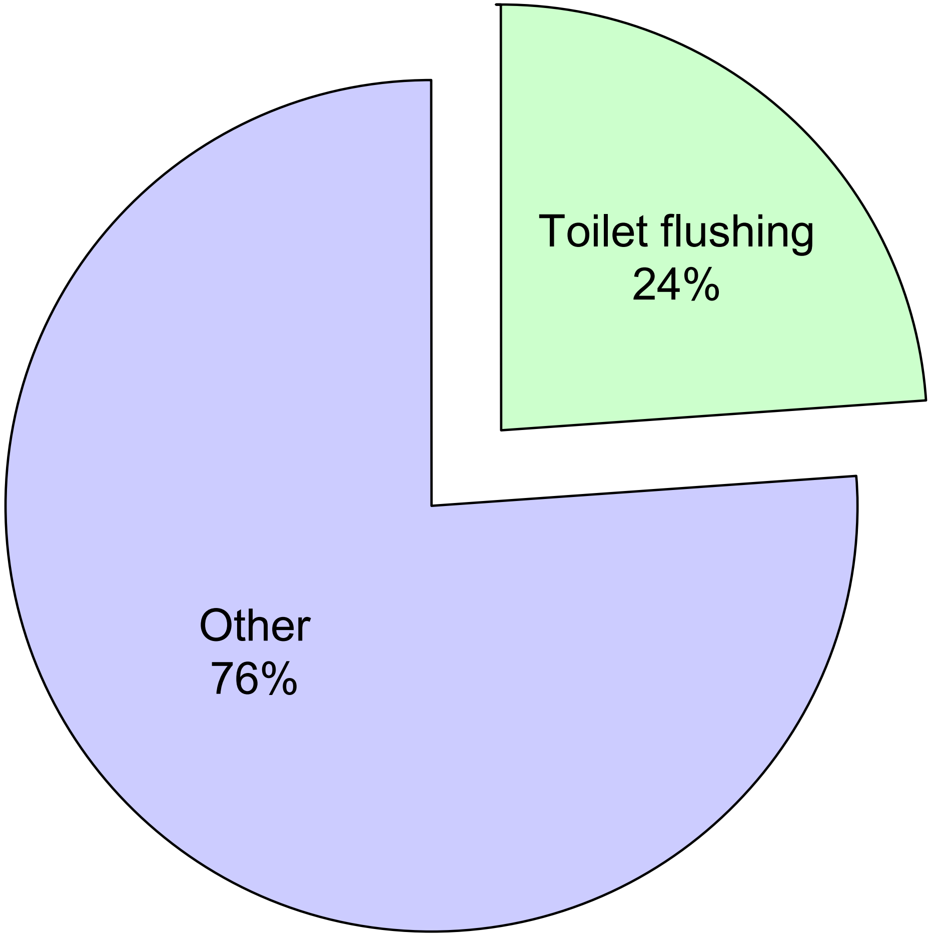
Project -1: (Problems)

- Backflow from sewer to collection tank during flooding
- Pollutants entry to tank due to ingress of rainwater
- No system failure **indicator** installed
- System remained inoperative most of the time because of
  - frequent trapping of pump circuit breaker
  - System users were not fully aware of system components and safety procedures

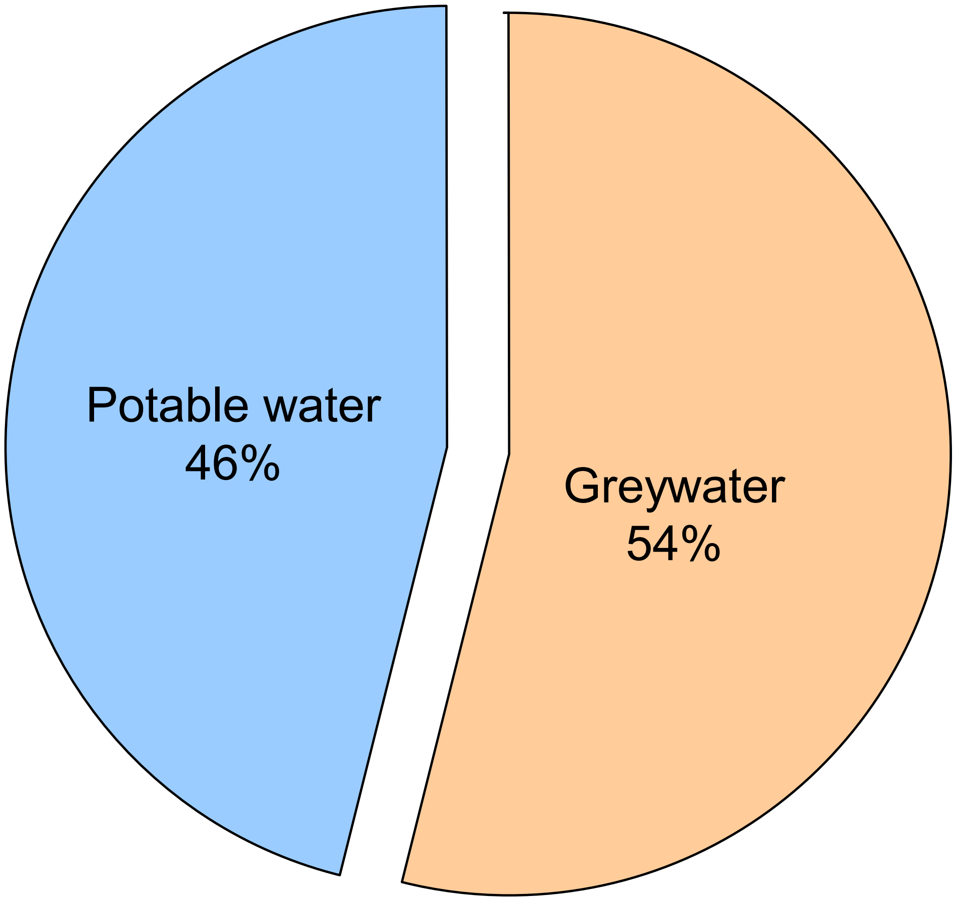
Project -1: (Solutions)

- Always provide backflow prevention valves
- Always provide strong tank cover and reliable tight seal
- Always provide user friendly system manual
- Some form of mechanism must be installed at **obvious** (?) location to alarm system failure.
- Instruction on '**steps to follow'** in case of system failure must also be provided

Project-1:
(Water use in building)



Project -1
(Water savings)

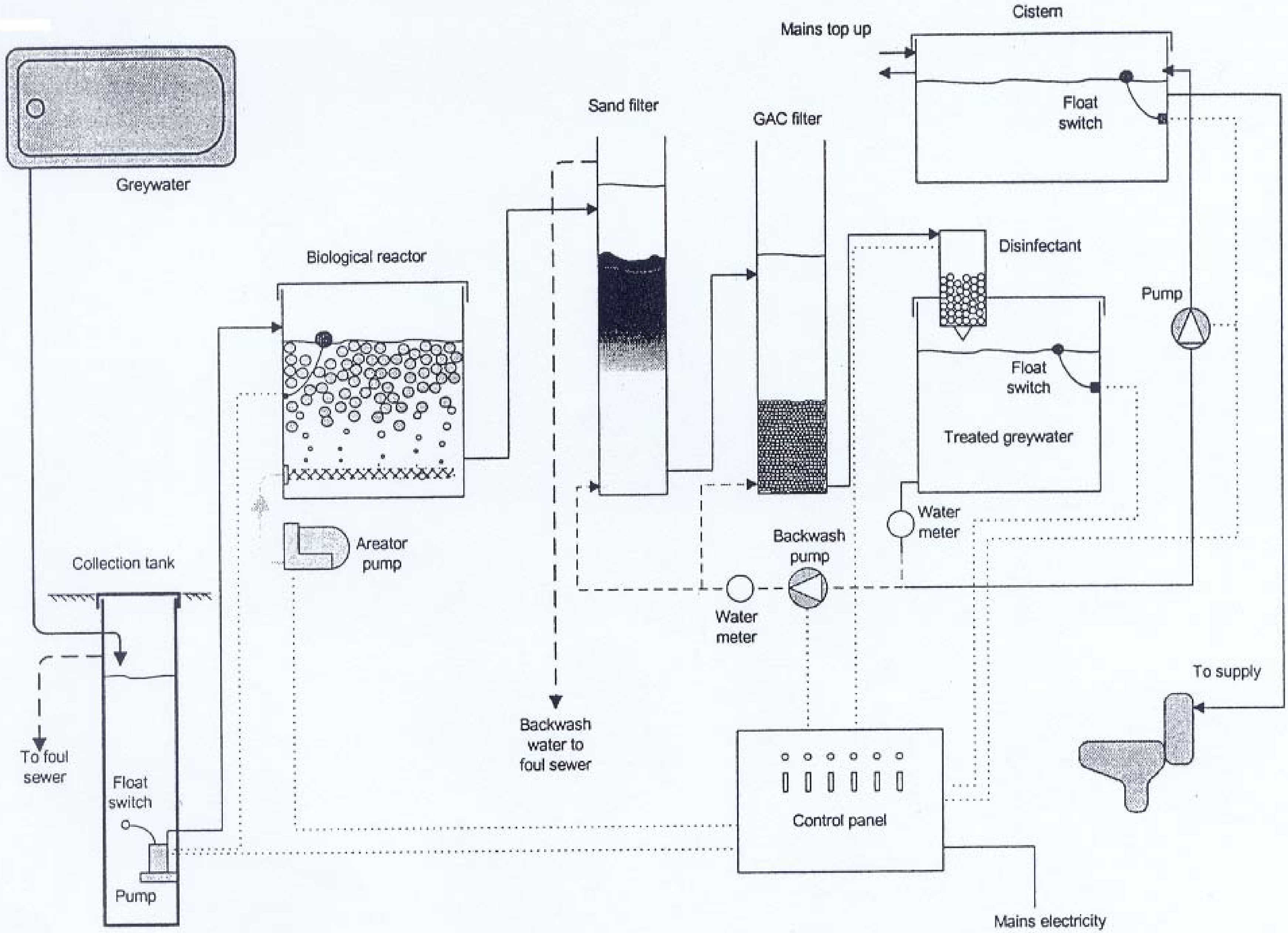


Project -2: (Description)

- A hall of residence in Oxford
  - Accommodation for 23 students
- Initially the system was designed to take
  - rainwater
  - greywater (including kitchen wastewater)
- System failed due to clogging of sand filters and membranes due to
  - heavy suspended solids loads and
  - microbial growth on membrane

Project -2: (Description)

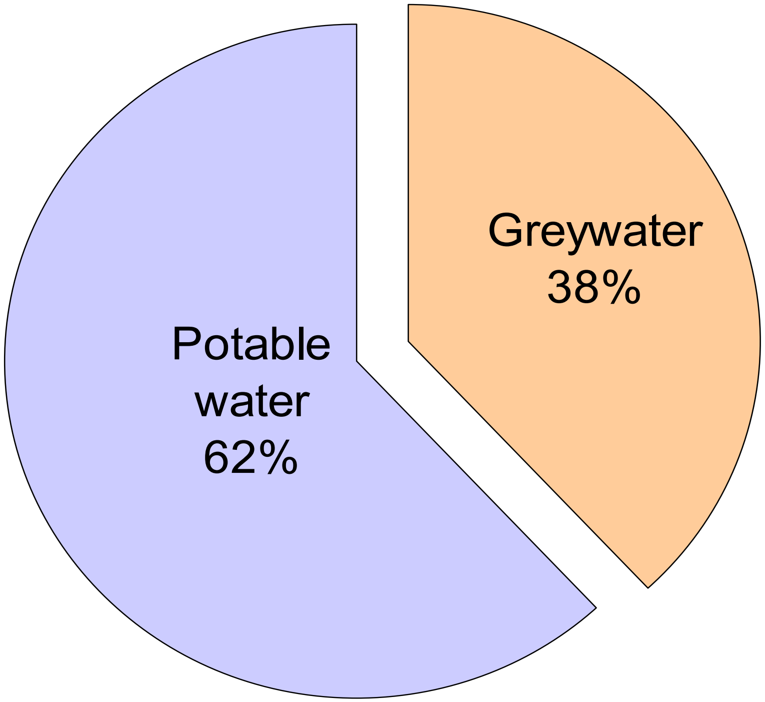
- System re-designed to only take water from
  - baths
  - washbasins
  - showers
  - **Laundry**
- The new systems includes
  - biological treatment
  - filtration and
  - disinfection


Greywater
Collection tank
To foul sewer
Float switch
Pump
Biological reactor
Areator pump
Sand filter
Backwash water to foul sewer
GAC filter
Water meter
Backwash pump
Control panel
Mains electricity
Disinfectant
Float switch
Treated greywater
Water meter
Cistern
Mains top up
Float switch
Pump
To supply

Project -2: (Problems)

- High operational cost *(mainly energy)*
  - oversized aerator
- High maintenance cost
  - requires monitoring by trained staff
- No information on how much water was lost as overflow to sewer because of inadequate collection tank size

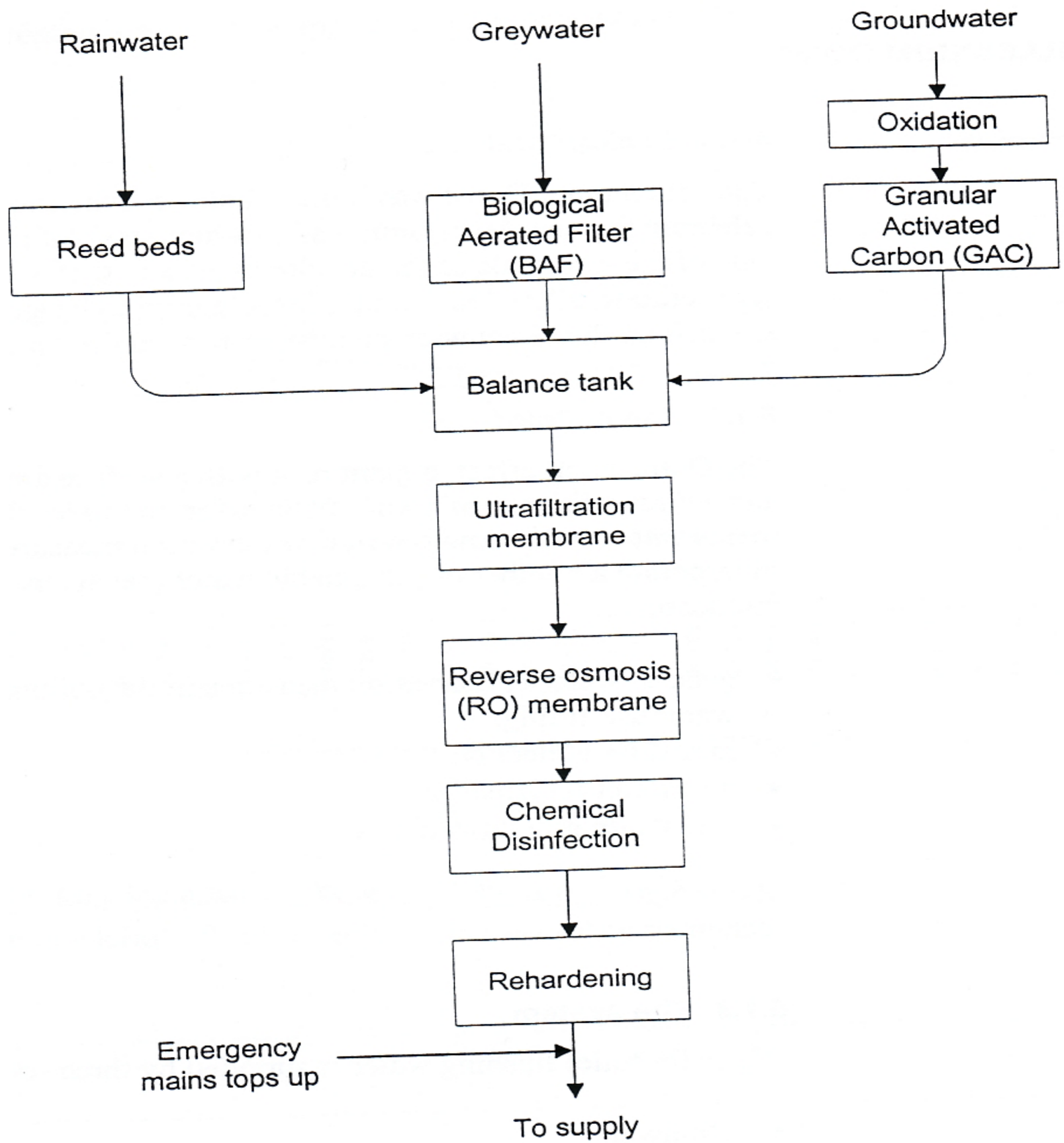
Project -2
(Water savings)



Water use for toilet flushing

Project -3
Millenium Dome

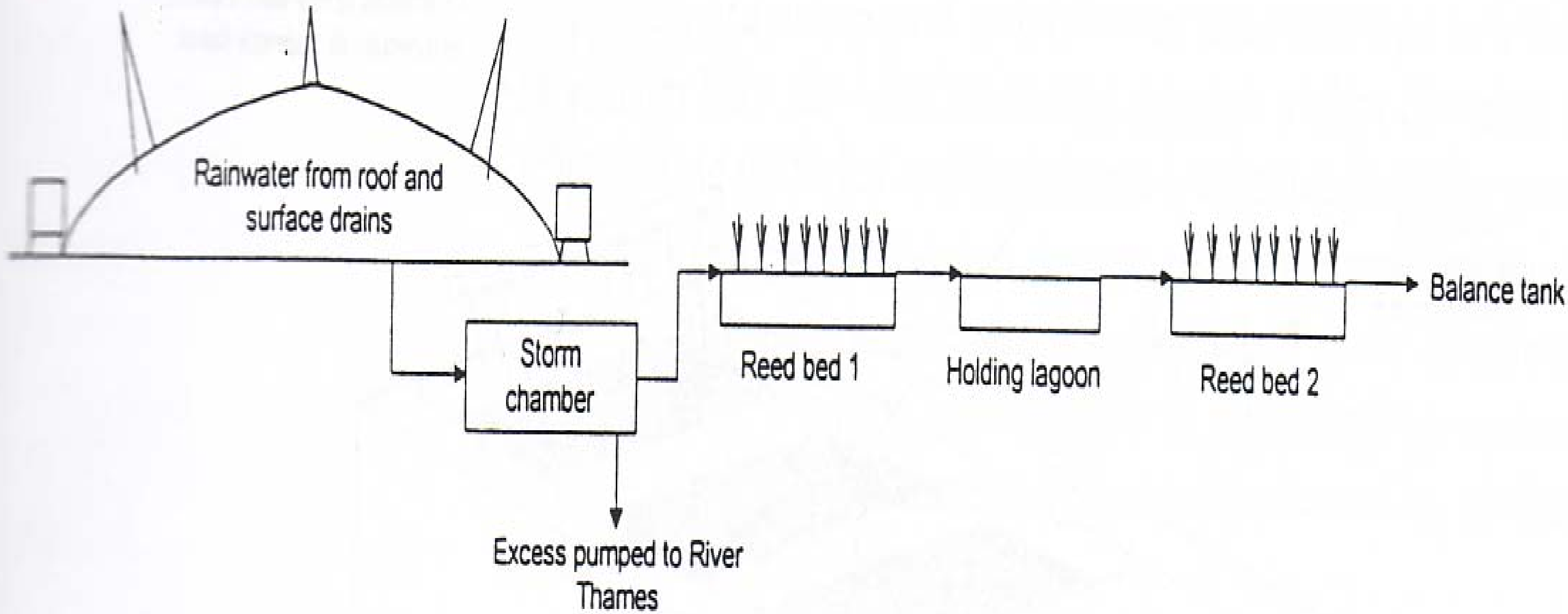
- It can be regarded as a unique project in its own right since it uses **greywater, rainwater** and **groundwater** at the same time.


Rainwater
Greywater
Groundwater
Oxidation
Reed beds
Biological Aerated Filter (BAF)
Granular Activated Carbon (GAC)
Balance tank
Ultrafiltration membrane
Reverse osmosis (RO) membrane
Chemical Disinfection
Rehardening
Emergency mains tops up
To supply

Project -3
Millenium Dome

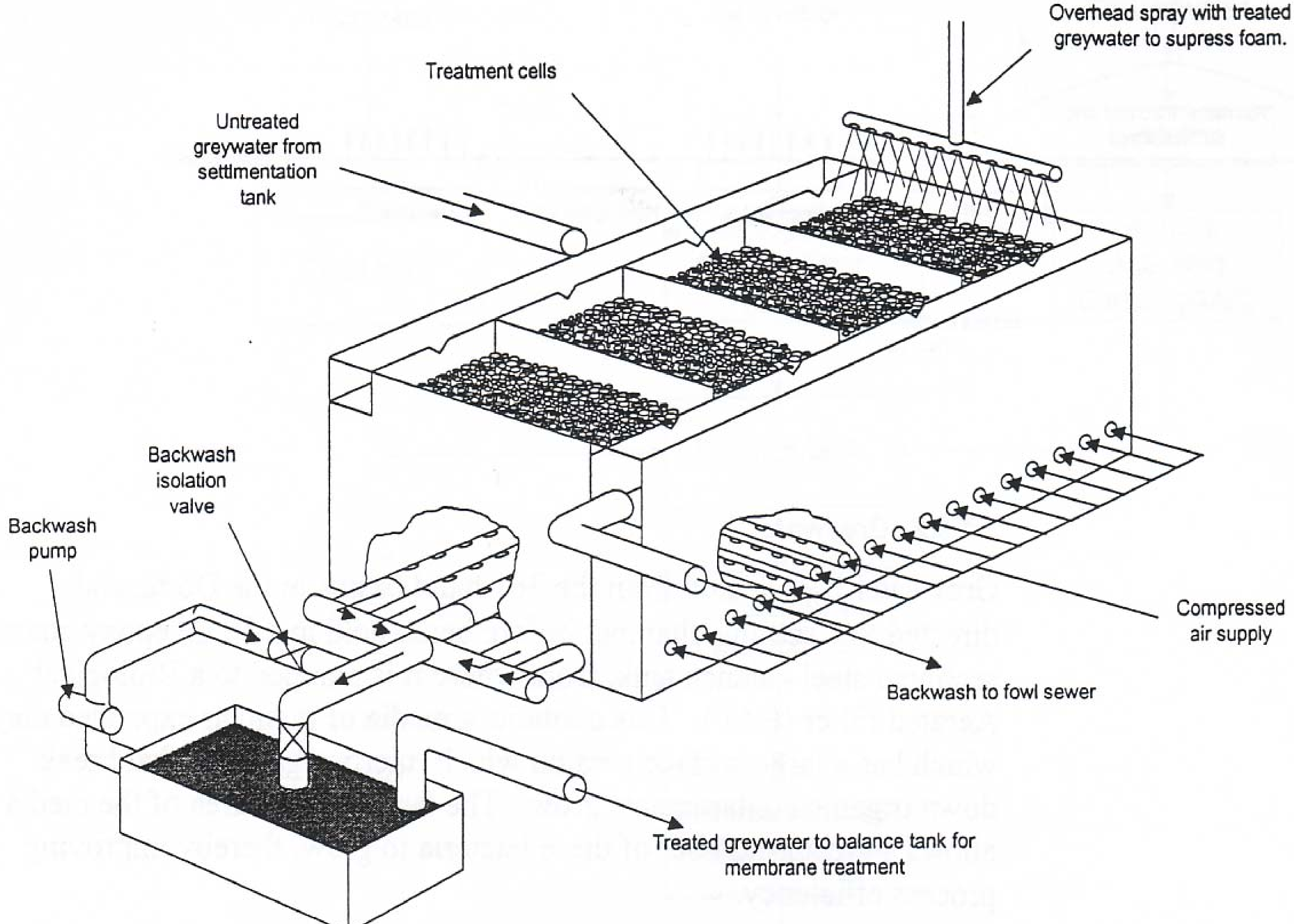
-Rainwater is collected from dome roof and adjacent area (100, 000 m^2)
-Size of collection tank is 800 m^3
-Reed beds are used for treatment

Project -3
Millenium Dome



Project -3
Millenium Dome

-Greywater is collected from 361 hand washbasins. passed through settling chamber and stored in 50 m3 tank
- Water is treated through biological aerated filters (BAF)



Overhead spray with treated greywater to supress foam.
Treatment cells
Untreated greywater from settlmentation tank
Backwash isolation valve
Backwash pump
Compressed air supply
Backwash to fowl sewer
Treated greywater to balance tank for membrane treatment

Project -3
Millenium Dome

-Groundwater is extracted from 87 m borehole at a discharge rate of 10 l/s

-Quality of groundwater is poor as it contains high level of salts, hydrogen sulfide, iron and organics

-water is treated in two stages

- -oxidation with hydrogen peroxide
- -GAC

Project -3
Millenium Dome

- Groundwater (67 %)
- Rainwater (22 %)
- Greywater (11 %)
-Quantity of treated water (80 %)
-Water lost in backwashing (20 %)
-System produces 350 m^3/d of treated water (saving 50% of freshwater)

WATERSAVE

The Network for Water Conservation and Recycling

www.watersave.uk.net