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Latin America's infrastructure needs highlighted

Water and wastewater provision in Latin America and the Caribbean (LAC) has improved in recent years, but has not escaped the region's decline in infrastructure spending, according to a new World Bank review. While public sector spending dwindled in the 1990s, private sector investment has failed to compensate to the degree earlier predicted, it adds.

LAC infrastructure investment has fallen behind other developing regions for electricity, roads and fixed telephony. But spending is 'performing comparatively well' in the water, sanitation and mobile phone sectors, says the report 'Latin America and the Caribbean: Recent Developments and Key Challenges'.

The report urges governments to spend more on infrastructure and improve private sector participation. Attracting private investors needs stronger legal, regulatory and institutional frameworks, more transparent contracting, and innovative financing structures making projects less commercially risky and more profitable, it says.

'Increasing infrastructure investment presents considerable challenges for governments,' says co-author Marianne Fay. 'But the potential payoffs make it well worth the effort, both in terms of growth and competitiveness, as well as the enhanced opportunities and living standards for the region's poor.'

In terms of access to safe water, LAC surpasses the middle-income average, as well as China, with poorer regional nations making the greatest gains. The share of the regional population with safe water supplies rose from 82% to 89% between 1990 and 2002. Sanitation coverage went from 68% to 74% at the same time. ● **PR**

See p4 for full report

Report critical of Ireland

A report on wastewater infrastructure in Ireland records serious deficiencies in sewerage systems and treatment capability and many deficiencies in the relevant data records.

The report on the National Urban Waste Water Study was published in August, following a data collection and verification exercise that began in late 2001 with development and testing of a questionnaire suitable for issue to the Local Authorities responsible for systems operation and management.

The gathered data relates to all 170 catchments with population equivalents of over 2000 outside the urban area of Dublin, Ireland's capital city. It gives a snapshot of the national position on the extent and condition of assets in the base year 2002 and makes predictions for the target year of 2022, founded on information readily available to the Local Authorities in mid 2002.

The study found that the local authority sewer records were significantly deficient in terms of asset base, condition and performance. It also established that treatment plant effluent quality data (flow and load) was frequently either unavailable or of limited value and that the flow and load data on industrial flows was often open to question.

In view of the inadequacy of sewer network information the report recommends future detailed survey work as a basis for maintenance and development needs and provision of network models. If extended to include network analysis for the 170 catchments, this work is estimated to cost over €26M ($31.8M).

As in other EU states the overall direction and status of wastewater service provision in Ireland is driven largely by EU directives.

Ireland's chosen route to service provision is through funding from central government, with planning, operation and management of the service administered by local authorities. The deficiencies exposed by this study – both in the record keeping and in the condition of the infrastructure – must in turn raise questions about the administrative framework itself.

It might be said that similar faults were prevalent in the UK when the wastewater systems of England and Wales were managed by local authorities rather than on the basis of specialist catchment-oriented water authorities or (latterly) private companies with independent performance regulation.

Indeed this report, in recognising that one of the major omissions here has been a service monitoring system, recommends resorting to that used by the Office of Water Services for England and Wales.

That is just one of many recommendations designed to address the catalogue of listed faults and to meet the end objective of developing guidelines to facilitate implementation of a national programme of rehabilitation on a planned basis, including criteria and indicators for prioritising future capital investment and monitoring the performance of schemes. ● **BM**

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US spending estimates soar

The United States Environmental Protection Agency, in its third Drinking Water Infrastructure Needs survey, has warned that $276.8 billion needs to be spent over the next 20 years to ensure the physical integrity of the systems, convey water and meet regulatory requirements. The figure represents an increase of 60% on the last assessment in 1999.

The estimate of investment need, based on data from 2003, includes installation of new infrastructure as well as rehabilitation or replacement of deteriorating or under-sized infrastructure, as well as the need to deal with ageing infrastructure that is adequate now but will need to be replaced or rehabilitated within the next 20 years.

Costs of the improvements needed by the country's 53,000 community water systems and 21,400 not-for-profit community organisations are likely to be split between water customers and the Drinking Water State Revolving Fund, established by Congress in 1996 to help public water systems gain financing for necessary improvements, as well as smaller local, state and federal funding programmes.

To assess funding requirements for large and medium utilities, the EPA sent questionnaires to the 1041 organisations that fall into the large category (50,000 or more customers) across the nation, as well as the 301 medium sized (40,000 to 50,000) systems. Questionnaires were also sent to a random sample of 2553 of the 7337 systems that serve smaller amounts of customers, from 3301 to 40,000 people. Smaller and native systems were assessed based on data from the 1999 survey, which involved EPA site visits to nearly 700 systems and therefore provided information in which the agency had considerable confidence.

The EPA then had to review all 128,600 projects submitted to ensure they met strict documentation requirements and were allowable under the State Revolving Fund rules. Following this, 23,600 projects were removed as ineligible.

The 2003 estimates are based on updated cost models originally developed for the 1999 survey, as well as new cost models for automated meter reading projects and for transmission and distribution pipe installation and rehabilitation, which used 2003 data.

The estimate of investment need includes installation of new infrastructure as well as rehabilitation or replacement of deteriorating or under-sized infrastructure, as well as the need to deal with ageing infrastructure that is adequate now but will need to be replaced or rehabilitated within the next 20 years.

Most of the needs do not relate to regulatory breaches, but to ongoing investments needed to ensure systems continue to deliver water to customers and comply with legislation.

The original 1995 estimate of need was $167.4 billion, and the 1999 assessment suggested $165.5 billion was necessary to fund the systems. Although the methods used to assess 2003 needs remain largely unchanged, there was an emphasis on more accurately capturing previously under-reported needs for infrastructure rehabilitation and replacement, in line with the EPA's 'sustainable infrastructure' initiative.

The report says: 'For the 2003 Needs Assessment, it is likely that a more systematic approach to asset identification and evaluation led some systems and states to consider and report a larger number of replacement and rehabilitation projects. EPA has some anecdotal evidence that states began to investigate the backlog of projects that had been deferred in the past.'

The drive appears to have been successful - states reported many more projects, covering all types of need, than in the previous assessments. The 1999 report said there were 61,400 projects for medium and large systems, whereas the 2003 assessment reports 128,600 projects. The largest increase was in the estimate of future need – current need estimates increased by 50% but future estimates went up by 100%.

The 1041 largest systems account for $122.9 billion, or 44% of the national need. Medium and small systems have reported needs of $103 billion and $34.2 billion respectively. Not-for-profit systems have needs of $1.3 billion, and Alaskan native village systems report a need of $1.2 billion.

Some 60% of the total needs are identified as current – although these have increased in pure dollar terms, they are a smaller percentage of the total need – 60% compared to 68% in 1999. The assessment did not include projects to be undertaken purely to accommodate future growth.

Projects fall into five categories: transmission and distribution, treatment, storage, source and 'other'. Transmission and distribution is the largest area of need, with a requirement for $183.6 billion over the next 20 years, almost two thirds of the total.

Treatment projects are the second largest category of need, representing one fifth of total need at $53.2 billion. This involves projects to reduce contaminants by various means, such as filtration, disinfection, installing or upgrading infrastructure.

The bill for storage needs comes to $24.8 billion and includes projects to build or rehabilitate water storage tanks. The storage category projects a $12.8 billion need and includes projects to install and rehabilitate drilled wells and surface water intakes.

'Other' needs account for around $2.3 billion. Examples of projects include installation of emergency power generators, computer or security equipment.

Regulatory needs fall into three categories – meeting existing Safe Drinking Water regulations, which is estimated at $35.2 billion, and addressing microbial contaminants such as E.coli, which is estimated at $30.2 billion. Projects to eliminate chemical contaminants require $5 billion and projects associated with proposed or recent regulatory requirements will take a further $9.9 billion.

It is assumed that the amount estimated for security needs, $1 billion, will increase as the work undertaken to assess protection measures against terrorist attacks has only recently started and may not have been fully captured in the existing surveys.

The EPA plans to include two extra issues in future needs assessments – engineering assumptions of life cycles for rehabilitation and replacement projects, and encouraging greater responses in states currently receiving the minimum 1% in State Revolving Fund grants. ● **Lis Stedman**

Pump sums:

a look at the role of life cycle costing in asset management

Many water utilities will agree that whole of life costs should be considered when purchasing equipment such as pumps, but actually putting the concept into practice is another matter. Bob Went, chair of the Life Cycle Cost group explains an initiative aiming to move application forward. Interview by **LIS STEDMAN.**

One of the most critical aspects of asset management is the consideration of life cycle costs. This is a view that Bob Went, chair of the Life Cycle Cost group of UK-based membership organisation the Pump Centre, would support.

Mr Went introduced life cycle costing to the water industry back in 1993, though he adds 'it is nothing new. Life cycle costing has been there since time immemorial. It's also used in other industries, including defence.'

'It's about considering all the costs of ownership, operation, the need to pay for power, maintenance and servicing, and not just the purchase cost,' Mr Went points out. He uses the analogy of a domestic consumer purchasing a television. 'For instance, there will be a range on offer from the very cheap, from the country you never knew existed, to the 42 inch plasma screen. Most people don't buy the cheapest, even though this fulfils their specification in terms of the colours, size of screen and so on. If you were objective and detached you would ask why not…

'Neither do they buy the most expensive – generally people buy a TV in the middle, or lower end of the middle of the price range. It's more expensive, but it's better quality; over its life they will pay less for breakdowns and repairs. That's effectively life cycle costing in its simplest form. You don't buy the cheapest, because it costs more to repair and maintain.'

In 1993 Mr Went tried to apply this in the water industry, as Thames Water's then principal mechanical engineer, responsible for pump specification. He tried to introduce LCC methodology on Thames pump purchases using a simple equation of LCC = A + B + C, etc, where the various letters represented the different components of lifetime cost. However, he realised that this was in fact too simplistic an approach.

'It's a simple principle, but the application is complex. How do you forecast over a lifetime of 20 years all of the maintenance costs, when you don't know where the plant will be installed or how it will be maintained, or what energy costs will be like?'

Thames tried to model all of these costs, and it made use of the model it developed. The LCC approach was taken up by the Hydraulics Institute in the US and EuroPump. Together, they formed a working group that subsequently published an LCC guide. In 2001, Mr Went chaired the conference that launched the guide in the UK.

> *…You don't buy the cheapest, because it costs more to repair and maintain. That's effectively life cycle costing in its simplest form…*

Alongside this, Mr Went chaired the Pump Centre from its inception in 1992 and also promoted LCC through that route. He has since joined pump manufacturer ITT Flygt, becoming group consultant two years ago. He therefore resigned the chair of the Pump Centre, but has continued the link as chair of the new LCC group.

'What we are trying to do, firstly, is get a LCC working model that the water industry can actually use for the purchase of pumps. It is a group with water industry members, working, with the Pump Centre, to create a model,' he says.

'The second thing is to raise the profile of LCC. Everyone understands what life cycle costing is – there is not a pump manufacturer brochure that doesn't mention it, you can't go to an exhibition or conference where it is not talked about. The problem is in the implementation. How do you model LCC objectively, and how do you then compare one pump with another, let alone one manufacturer with another?'

Another area of challenge, he says, is the project side of the equation – often companies don't take a holistic view of procurement. In reality this means that the person whose job it is to design, procure and commission has a target of reducing capital costs, which can then put this side of the business in immediate conflict with the operational side. Operations will also have a target of reducing costs, but, if it is supplied with cheap equipment that breaks down frequently, it will inevitably find its costs rising. 'It's like the TV analogy,' says Mr Went. 'The operational side finds it then has got to spend money.'

There are a number of companies that have realised this contradiction and are beginning to change, bringing together capital expenditure and operational expenditure under one umbrella. 'Only then can they realise overall cost reductions. It costs less over the lifetime of the pumps if you spend slightly more at the outset; in so doing you are getting more reliable plant in the first place.'

The LCC group is also trying to bring together other aspects of business – trying to reach more senior levels, and get them to understand this point of view. Within the next 12 to 14 months the group hopes to organise a conference to put this point across – not just aimed at the engineers, who generally understand the issues, but to a wider audience including senior executives, who are in a position to facilitate one side of the business spending slightly more in order to achieve overall cost reductions.

For further information visit: www.pumpcentre.com

Latin America’s investment challenge

● Latin America is losing its broader infrastructure lead to China but retains its water sector record, although there are still substantial investment needs. **PETER REINA** reports on the findings of a recent World Bank review.

Water and wastewater services have emerged with relatively good marks from a recent World Bank analysis of Latin American and Caribbean infrastructure investment in recent years. But the sector has not wholly escaped the plight of the region’s other sectors, and needs much more investment than is available to approach universal coverage.

According to the report, ‘Infrastructure in Latin America and the Caribbean: Recent Developments and Key Challenges’, by Marianne Fay and Mary Morrison, to satisfy demand in Latin American and Caribbean for water, sanitation and electricity infrastructure over ten years, and maintain existing systems, would need annual spending of about 3% of gross domestic product (GDP). But that would be some 50% higher than the level of total infrastructure investment the region is making, having halved spending since the 1980s.

By contrast, China and other emerging economies, which previously lagged Latin America, are spending 4-6% of GDP on infrastructure. But while raised spending in those countries has advanced their transport and communications provision, the water and wastewater sectors of Latin America and Caribbean are still ahead.

With poorer countries in the region improving fastest, regional access to clean water rose from 82% of the population in 1990 to 89% in 2002. Sanitation coverage, meanwhile, went up from 68% to 74%. In water and wastewater services, the region was well ahead of China's coverage (77% and 44%) and better than the average of middle-income economies (83% and 61%).

Yet, 58 million Latin Americans still lack access to safe or potable water and 137 million have no adequate sanitation, according to the World Bank. As ever, coverage is lowest in rural areas. In Brazil, for example, only 35% of country dwellers are served with sanitation, while urban coverage is 83%. In Mexico, the gulf is even wider.

‘Recent experience in Latin America illustrates that governments remain central to infrastructure provision,’ according to Mary Morrison, co-author of the report. ‘Not only is public funding sometimes indispensable, but the state has an essential role to play in partnering and overseeing private operators and protecting consumers.’

Privatisation, once seen as a panacea, has failed to meet expectations. Latin America and the Caribbean did attract close to half of the developing world's $786 billion private sector infrastructure investment between 1990 and 2003, says the World Bank. But nearly all of it flowed to only six countries: Argentina, Brazil, Chile, Colombia, Peru and Mexico – and it went mainly to the telecommunications and energy sectors.

Rather than compensating for swingeing public spending cuts of the 1990s, private sector interest dwindled in recent years. The value of the infrastructure projects with private sector participation actually fell from a $71 billion peak in 1998 to $16 billion in 2003, says the Bank.

Dramatic difficulties in some concessions have done little to stimulate interest. The ousting of France’s Suez Group from the concession serving La Paz and El Alto, Bolivia, was a recent low point in the region's private utility story.

Another deterrent to private investors, says the Bank report, has been the extent of contract renegotiations. While nearly a third of the region's concessions have, reportedly, undergone late revisions, the proportion rises to nearly three quarters for water and sanitation deals.

A possible cause for such chaotic contractual dealings is said to have been the need to rush in legal, institutional and regulatory reforms. The report questions the wisdom of regional governments adopting concession models tailored largely to European needs. And, adds the report: ‘it is quite clear that analysts and reformers were overly optimistic as to the ability of reforms and regulation to isolate transactions from political influence’.

With this troubled backdrop, Latin America is no longer seen as core business for some of the biggest sector investors. Having built up a substantial business in Chile, the UK's Anglian Water, for example, has withdrawn as part of a retrenchment plan, while German-owned RWE Thames Water is also leaving the country to concentrate on the home market.

Attracting back the private sector to the region’s infrastructure market ‘will require stronger legal, regulatory and institutional frameworks, more transparent contracting, and innovative financing structures that make projects less risky and improve returns for investors’, advises the report.

With some innovation, the Paraguayan government is encouraging the development of small private operators supporting as few as 300 water connections. Such companies already provide over 15% of the country’s piped supplies, having developed without state funding over the last two decades. Now, to spread their coverage, the government is offering World Bank-backed subsidies under ten-year franchises.

Peru, meanwhile, recently awarded a 30-year concession to provide water and wastewater services to the municipality of Tumbes, with 180,000 people. A joint venture of local and Argentinian companies pledged to invest over $30M in the first five years. To draw such companies deeper into the provinces, the government has secured a $200M World Bank credit guarantee facility to underpin its financial commitments to privately financed projects. Private investments and operations in a handful of utilities are among the 15 or so target projects that would otherwise attract little interest. ●

User-friendly report template proves a success for Southern Water

Global environmental engineering consultancy MWH has facilitated a technological project system, called mProve, for Southern Water in the UK. The system is designed to be as user-friendly and intuitive as sending an email, and at Southern Water has allowed 120 water-based projects to be approved in a record time of three months.

The projects included schemes for water, wastewater treatment, cess, sludge and drainage networks, and involved 120 site visits with SW Operations staff to retrieve specific asset survey information and assess the issues at each site. Scheme solutions then had to be developed, matched to scheme drivers and the business case established.

The mProve system is an electronic templated report which is structured around the decision-making process throughout the whole life of a project, ensuring the right information is provided at the correct point in the most efficient format. This helps the user focus on providing enough information to make effective decisions. The template is held centrally with a custodian who incorporates modifications and lessons learnt into the master copy. This means that any team starting a new project will have an mProve that reflects the latest client requirements.

Martin Baggs, Asset Director at Southern Water, adds: 'The approach to the development of this programme of work has been a major success for Southern Water. The combination of the systems and processes has enabled a running start into the delivery of the new capital programme. The use of mProve has been impressive but we shouldn't forget that it's not just about systems, it's more about the people that have worked together to make it happen.' ●

Decentralised wastewater systems: an asset management approach

Decentralised systems are increasingly recognised as a permanent part of the wastewater infrastructure. As such, processes to improve their long-term management are now critically needed and asset management has the potential to fill this gap. However, it is yet to be applied in the decentralised wastewater sector. This article presents some initial insights into how the principles of asset management might be translated to the context of decentralised systems. This work was conducted for NDWRCDP (National Decentralised Wastewater Research and Capacity Development Project) in the United States and forms part of a larger project focused on improving the reliability and life-cycle cost of decentralised systems. We first present a synthesis of the key dimensions of centralised urban water asset management, as useful parallels can be drawn from these. However, important differences exist between centralised and decentralised management and we therefore elucidate such differences in some detail. These differences stem from the distinctive characteristics of decentralised wastewater management and the large spectrum of management, regulatory and policy scenarios that confront decentralised asset managers. In addition, for decentralised wastewater, we argue that the functions of an asset management system must be interpreted broadly, and facilitate the management of engineering, ecological, public health, and socio-economic risks. Based on these premises, we present the ways in which asset management principles must be modified and adapted to make them appropriate for strategic management of decentralised wastewater assets.

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About a quarter of homes in the US rely on decentralised treatment of wastewater, and both the number of systems and percentage of users are growing (USEPA 1997). Unfortunately, many decentralised wastewater treatment systems have been poorly designed and installed, and receive little or no effective management. Where systems are not properly managed, they have a higher rate of failure (Hoover 2002).

It is only relatively recently that decentralised wastewater systems have been fully accepted as a permanent part of the wastewater infrastructure in the US (USEPA, 1997). It is increasingly being recognised that sound management is key to enabling such treatment systems to function at a level of reliability that protects public health and the environment.

There is now a trend towards improving the management of decentralised assets – for instance many states, counties and municipalities are now regulating these systems and requiring regular inspections and system upgrades where necessary. Efforts are also being made at a federal level to improve decentralised wastewater system performance by providing the tools for system managers so they can administer these assets in a way that parallels the management of centralised wastewater systems.

To this end, the US Environmental Protection Agency (US EPA) has developed voluntary guidelines for introducing five alternative management models to decentralised systems (US EPA, 2003a). These aim to increase the level of management as environmental sensitivity and/or system complexity increases, for configurations ranging from individual on-site systems to cluster systems serving dozens or hundreds of homes and businesses (USEPA, 2003b).

The synthesis and discussion presented in this feature represents those parts of the findings of a larger federally-funded project which are specifically concerned with asset management. The larger project aimed to develop a framework for asset and risk management of decentralised wastewater systems. It also involved evaluating the methods, tools and data that were available and needed, as well as adapting some tools for the decentralised context.

This work was undertaken for the NDWRCDP, a cooperative effort funded by the US EPA through a cooperative agreement with

Washington University in St Louis. Comprehensive coverage of the findings of the overall project are published elsewhere (Etnier et al, 2005) in a handbook that illustrates the usefulness of these approaches to service providers, regulators and other workers in the field.

In this feature we have limited our scope to the question of how asset management concepts can apply to the decentralised sector. We base our assessment on a discussion of the key elements of management in centralised urban water and a consideration of the key differences between decentralised and centralised infrastructure.

Key elements of asset management in centralised urban water systems

Asset management has been used for over 15 years within centralised water and wastewater utilities in Australia, New Zealand, and the UK, and more recently in the US. Asset management is based on a fairly simple idea: find out what assets you have, where they are, what condition they are in, and how they affect your ability to meet performance requirements, then use this information to make decisions on investing in new assets and maintaining the existing ones.

The Association of Metropolitan Sewerage Agencies (AMSA) handbook describes asset management as 'An integrative optimisation process that enables a utility to determine how to minimise the total life-cycle cost of owning and operating infrastructure assets while continuously delivering the service levels that customers desire' (AMSA 2002).

Asset management for centralised urban water will involve having an information system that is used to characterise the risks associated with failure to repair or replace particular infrastructure components, and a decision-making approach that uses risk assessment to measure the benefits of alternative approaches to infrastructure maintenance, rehabilitation and replacement (USEPA, 2003c).

Drawing on the experience of centralised water and wastewater utilities with asset management covered in the literature, we identified – among numerous approaches – four key elements that commonly constitute the framework of a functional asset management system. These are:

- the setting/regulating of clear service and performance standards
- a regulatory and organisational structure conducive to least cost optimisation
- the use of comprehensive asset information systems, asset inventories, databases, asset monitoring and Geographic Information Systems (GIS)
- the use of a variety of tools for reliability analysis and life-cycle costing, including methods to estimate asset condition, useful-life and the cost of asset operation, maintenance, rehabilitation and replacement.

We will now discuss each of the key elements in turn, exploring how they have been utilised under various circumstances.

Performance goals and standards

Performance goals and standards answer the question: 'What are we trying to achieve by managing these assets?' They are largely driven by the service expectations of customers and other stakeholders of the organisation.

In the ASMA handbook, performance standards and goal are discussed in terms of 'strategy' and of a utility developing objectives and policies in consultation with customers that then frame performance standards for assets. For example, a standard may be set for the maximum number and duration of water interruptions that customers can expect to experience during a year. Alternatively, the policy may be one of continuous improvement in service continuity or maintaining asset condition (Young, 2002).

In other areas, regulators set mandatory performance standards in operating licences (Young and Blez, 1999). The regulator, acting as a proxy for other stakeholders, can play a strong role in asset management by setting and enforcing unambiguous performance standards that the utility must meet. Asset performance standards may be set for environmental (Ashley and Hopkinson, 2002) as well as more commonly-considered outcomes: potable water quality, service provision (continuity of supply and the number of on-property sewer overflows) as well as customer service levels.

> *…AMSA describes asset management as: 'an integrative optimisation process that enables a utility to determine how to minimise the total life-cycle cost of owning and operating infrastructure assets while continuously delivering the service levels that customers desire'…*

Organisational and regulatory structures

Traditional asset management occurs within a regulated corporation that owns and manages its own assets. Motivated by financial interest and applying a corporate accounting standard, the corporation should manage its assets to meet agreed performance standards at the least life cycle cost to the corporation. This will involve balancing the operation, maintenance, rehabilitation and replacement costs of assets against the risk and consequence of not meeting performance standards (Young and Blez, 1999).

The Australian urban water sector is an example of the importance of regulatory and organisational structures in promoting asset management. Asset management came to the fore in the water industry in Australia after the commercialisation of the country's utilities and the clear delineation of the role of independent regulators. If urban water systems use other organisational structures, effective asset management is still possible but considered business process redesign may be needed to promote the least cost optimisation of managed assets (ASMA, 2002).

Asset information systems

Asset management requires an information system that tracks assets, how they are being managed, and their costs and reliability under that management system (USEPA, 2003c). Central to the information system will be an asset inventory, which covers as a minimum the location, condition, and criticality of assets. An accurate asset inventory sets the stage for effective management (WERF, 2002). Monitoring will be important in keeping the information system and inventory updated. This can be achieved through periodic inspections, or continuously via telemetry.

Reliability analysis and life-cycle cost tools

The primary focus of reliability analysis for centralised systems is on technical or engineering reliability, related to pipe networks. This is because in terms of risk, pipe breakage represents a significant risk and water distribution and sewerage pipes are centralised utilities' principal assets.

The potential for pipe failure can be assessed both by an analysis of technical reliability and an analysis of the asset inventory. Ostfield (2001) describes stochastic simulation for reliability analysis of distribution assets. Fenner et al, (2000), Babovic et al (2002) and Silinis and Frank (2003) describe various approaches to analysing asset inventory information (and in the case of Silinis and Frank, biophysical data such as soil type) in order to group assets into classes and make failure risk assessments based on previous experience.

Various cost-risk models such as those described by Young and Bletz (1999) and CSIRO Urban Water (2003) have been developed for asset management in centralised water and wastewater systems. These identify optimal pipe maintenance and replacement strategies based on life cycle cost, with reliability analyses used to estimate the risk of pipe bursts under various management scenarios.

A corporate utility will decide to replace a pipe before it bursts if this avoids the risk of expensive consequences. Alternatively, the corporation may calculate that it makes financial sense not to replace some ageing pipes, and that performance goals will be met at least cost if the utility waits for particular classes of pipes to burst before they are replaced.

Differences between centralised and decentralised wastewater management

We have identified three major differences that have implications for how the principles of asset management found in the centralised sector might be translated to the decentralised sector: the relative importance of the distribution network compared to the treatment process; the range of management issues that arise; and the interpretation of risk.

In terms of focus, water distribution and collection dominate the life cycle costs of a centralised system (AWWA, 2001). Asset management in the urban water sector has therefore focused on the question of how to best manage pipe infrastructures. By contrast, for decentralised wastewater management the treatment process itself is of much greater importance to the total cost and system risk. This means that for on-site processes, the treatment system and final effluent disposal are the major factors of concern.

Management of decentralised wastewater systems involves particular challenges not encountered in centralised wastewater collection and treatment. The complexities of managing decentralised systems include siting issues, the impacts of wide flow variations, the common lack of effluent data, and the multi-faceted risks from system failure. Like the systems themselves, ownership is generally dispersed. Usually no single organisation co-ordinates investment decisions for decentralised wastewater infrastructure, though local regulators and policy makers may use financial incentives, regulations and penalties to encourage system owners to manage their systems in specific ways. While management (and possibly ownership) of decentralised systems by responsible management entities (RME) would increase the parallels with management of centralised systems (US EPA, 2003b), few systems are currently controlled by such entities. Figure 1 highlights some of the important differences between centralised and decentralised wastewater systems from the perspective of asset management.

Management issue	Relevant to centralised systems?	Relevant to decentralised systems?
Quality of site is critical	Unusual	Usual
Performance of pipe assets critical	Usual	Occasional
Performance of treatment assets critical	Usual	Usual
Performance of effluent disposal assets critical	Occasional	Usual
High flow variability a concern (seasonality or other)	Occasional	Usual
Lack of effluent data	Unusual	Usual
Dispersed ownership and operational responsibility	Unusual	Usual
Poor understanding of maintenance requirements from asset owner	Unusual	Usual
Probability that individual asset failure will go undetected	Unusual	Occasional
Potentially high consequence individual technical failure	Usual	Unusual

Figure 1 **Relevance of management issues to centralised and decentralised wastewater**

The final key difference between decentralised and centralised wastewater systems is the necessarily broad interpretation of risk for decentralised systems. Risk is a key determinant of the level of technical reliability required within a decentralised system and its various components. As mentioned above, the risk of pipe breaks is one of the main concerns for centralised systems. This risk is normally acute, with a sudden, serious consequence.

By contrast, decentralised systems have a wide range of critical modes of failure with an even larger range of possible consequences that range from low impact to high impact. Most of the impacts of decentralised asset failure are chronic rather than acute in nature. They are also often cumulative over time. As Jones et al (2000) state, there are four types of risks associated with decentralised systems: engineering; public health; ecological and socio-economic. Such a broad definition of risk makes the task of asset management complex and means a greater understanding of these different risks is required.

The range of reliability analysis tools for decentralised systems needs to include various types of risk and impact assessment tools as well as actual engineering reliability tools. In addition, since decentralised systems are often operated and even maintained by homeowners, reliability analysis needs to account for homeowners' probable actions and ways of influencing these to reduce risk of failure.

Asset management for decentralised wastewater systems

The four key elements of asset management in centralised urban water are now examined in relation to how they might be applied to decentralised wastewater, taking into account the differences described above. In addition to these four, a further element of 'stakeholder communication' has been added to account for the need for good interaction between the various parties involved in decentralised systems.

Performance goals and standards

As indicated in the discussion on asset management for centralised urban water systems, setting clear performance standards and defining who is responsible for meeting them facilitates good asset management. In decentralised wastewater treatment, however, most regulation is prescriptive, rather than performance-based, and an asset management framework is less easily adapted to prescriptive regulations.

Some authors argue that these prescriptive regulations are often unnecessarily conservative and might be better replaced by risk-based performance standards (Hoover et al, 1998). Current efforts by the National Onsite Wastewater Recycling Association (NOWRA) to develop a model performance-based code (NOWRA Model Performance Code Committee, 2003) should lead to greater use of performance standards by state and local jurisdictions. This development would significantly increase the applicability of asset management to decentralised wastewater in the US. Similar developments are taking place in Australia.

In applying asset management to the decentralised sector, the goals and performance standards also need to address all four types of risks associated with such systems (engineering, public health, ecological and socio-economic). Such goals must also account for the regulatory and policy context, the organisational context, the current and projected performance of the systems, and the many views of the various stakeholders.

Agreement needs to be reached with stakeholders on performance standards for catchments and customer service in each of the risk areas. The goals and performance standards may also need to be set at various levels, such as for the individual wastewater system, for a set of systems defined, for example, by location or time of construction, and for the management organisation. It is clear that for decentralised wastewater the definition of the performance standards will differ substantially from the centralised urban water field.

Organisational and regulatory structures

In the discussion on centralised asset management, it was clear that organisational and regulatory structures play a significant role. The reason for this is that these define how and by whom the risks and costs of water and wastewater management will be borne.

The voluntary guidelines set out by the US EPA describe five management models for decentralised wastewater management (US EPA, 2003a). The alternatives are: a homeowner awareness model; a maintenance contract model; an operating permit model; a RME operation and maintenance model; and a RME ownership model.

Of these, the RME ownership model most strongly parallels utility management of centralised urban water. Least cost optimisation of managed assets becomes more complicated for the other four management models, where no single entity owns and manages all assets. However, even with the RME ownership model, decentralised wastewater management decisions are not purely in the hands of the RME. Indoor plumbing and fixtures are an important part of the decentralised wastewater system and changes made indoors by customers (for instance, low-flow fixtures, separate systems for black and grey water) can have significant effects on a decentralised treatment system.

This means that with all management models, the least-cost optimisation of decentralised wastewater assets will involve taking account of the negotiated interests of many different parties. For example, with permit-based models some of the roles of the asset owner/manager and the regulator may be consolidated within a local regulatory body such as a 'board of public works'. Such a body will manage collective assets through a permit system, with decisions about asset maintenance, rehabilitation or replacement enforced on the asset owners.

Asset information systems

An asset information system for decentralised organisations will need to contain a larger variety of information than is needed for centralised systems. Depending on the US EPA management model, the detail and diversity of information stored in such a system would be expected to vary considerably. A database might be expected to include information such as:

- ownership and maintenance arrangements and responsibility
- an asset inventory (system type, age, location, capacity, scale, design flow, maintenance history
- ongoing performance information (site condition assessments, monitor ing, loading rates)
- bio-physical information (planning and land use, lot size and soil density, wetness, slope, water courses, vegetation, catchment characteristics)
- cost data for capital works and operations (historical cost of capital, operations and maintenance)

Reliability analysis and life-cycle cost tools

Earlier we discussed the tools used in centralised asset management to assess reliability and life cycle cost, in particular those relating to distribution network assets. Here we consider the tools required for decentralised wastewater asset management. This is a broader set, with four types of tools needed to inform decision-making on asset operation, maintenance and replacement. These are inventory analysis tools, technical reliability analyses tools, impact assessment tools and investment decision-making tools.

...A new framework of asset management and reliability analysis, which can be used to make decisions about least-cost ways to deliver performance, is justified...

These tool types could also be used in asset management for centralised systems, but the specific tools within these groups would differ. More detail on the tools available for decentralised wastewater asset management is provided in the publication, Etnier et al, (2005).

Inventory analysis tools

Tools that use information directly from the asset inventory and predict or infer life expectancy and performance of individual assets. Examples include data mining of the inventory, cohort analysis, condition tracking and monitoring and GIS/soil type analysis. These are also sometimes known as Inventory Condition Assessment tools (WERF, 2002).

Technical reliability analyses

These are tools for determining or predicting the probability, mode, and location of asset failure. Mechanical, structural and system reliability tools feature in this group, as failure may occur due to breakage or malfunction of components, or may be related to the treatment process itself.

Examples include probability assessments, predictive models, fault tree analysis, failure modes and effect analysis, and critical component analysis. Human factors must also be taken into account in such analyses because of the importance of homeowners' actions. Particular methods such as FACTSS (failure analysis chart for troubleshooting septic systems (Adams, 1998)) help provide systematic methods for evaluating the causes of failure. Quantitative and qualitative tools will both be useful, though quantitative tools need data, which is often not available and qualitative tools are limited to comparative analyses.

Impact assessment tools

This group of tools is for predicting the consequences of poor performance in terms of public health, ecological and socio-economic impacts. Monitoring, modelling and risk assessment tools for emissions feature here. Tools to determine and predict both the impact of individual assets and the collective impact of multiple assets are also required and might be based on particular emissions (such as nitrogen, phosphorus, and pathogens), or might be based on assets having assumed performance levels.

A good example is the On-site Sewage Risk Assessment System (OSRAS) tool, developed in Australia, which integrates spatial, natural resource, infrastructure, and operational data to create a cumulative spatial assessment of risks (Irvine and Kenway, 2003).

Investment decision tools

Once the consequences of various management strategies are understood, asset management calls for a process to decide on the preferred management strategy. When performance standards are sufficiently clear and comprehensive and organisational structures allow true least cost optimisation, the management strategy that carries the least financial cost while meeting the standards may be chosen.

When clear performance standards cover only a small proportion of the impacts of the managed asset, or where multiple stakeholders and the cost perspective need to be considered, different tools are needed. These are likely to include risk management, economic analyses, multi-criteria assessment, use of sustainability criteria, and participatory and deliberative approaches.

Stakeholder communication

The disaggregated nature of decentralised systems presents challenges because many different parties are involved in their use and operation. Homeowners, installers, managers, inspectors, and regulators all play a part. In addition, since impacts from such systems directly affect other parties such as neighbours and other community members, the circle of stakeholders for such systems is even wider. There is therefore a need for communication with the relevant stakeholders at virtually all stages of the asset management process.

Discussion and conclusions

With decentralised systems now acknowledged as a permanent and in some places growing part of our wastewater infrastructure, frameworks for the longer term management of these assets are now being sought. Asset management has the potential to fill this gap, but is yet to be applied to such systems.

It is apparent that while there are some strong parallels between decentralised systems and centralised urban water asset management, important differences also exist. These mean that a novel framework of asset management and reliability analysis, which can be used to help make decisions about least-cost ways to deliver agreed-upon performance, is justified. A number of tools used in centralised system asset management can be applied to decentralised systems and existing management tools already used for decentralised system management can be seen to have applications within an asset management, and reliability analysis framework. The differences, however, mean that there is still a significant potential for tool development in the decentralised wastewater asset management area. ●

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A national asset management steering council: the time has come

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For several years, utilities have been struggling with the concept of asset management, what it is and how to implement and understand it. They have received some great guidance or support from the professional and/or consulting communities, but they also are struggling to come to terms with how to deal with this new concept and philosophy.

These struggles have come at a time when the impetus from the rate-paying public is for more productivity with no increase in cost or even a reduction in cost. The growing need for data to manage a well-run utility requires more and wider comparisons with other neighbouring utilities and those determined to be 'best in class', to ensure that their operations and economics justify the financial demands placed upon their rate payers. Research and educational institutions demand much of this same data and information as they try to make sense of water and wastewater industry operations and evaluate the importance of asset management to the industry.

Utilities' need for the latter resulted in attempts several years ago to create a uniform process for marrying water and wastewater research components. The idea was to ensure most of the overlap in data collection and data requests could be input into a central clearing-house of similar information, enabling researchers and academia to obtain better information and responses to their requests, lead to better research results and encourage more utility participation in industry-advancing research.

Further complicating the advance of the concept of asset management were the varied methodologies used by the consulting industry when marketing services and support for this emerging operating philosophy. It has been suggested that the industry currently supports as many as 38 separate definitions of asset management, ranging from total asset management to strategic global life cycle asset management. It is therefore unsurprising that there appears to be confusion among small, medium and large utilities as to exactly what asset management is, and what its basic tenets and requirements are - but most of the concepts and ideas can be seen to be one and the same, or at least a part of the overall concept of asset management. For the purposes of this article, asset management is defined as 'an integrative optimisation process that enables a utility to determine how to minimise the total life-cycle cost of owning and operating infrastructure assets while continuously delivering the service levels customers' desire.'[1]

Around two years ago, several asset management proponents and 'best in class' utilities that had begun to fully embrace the overarching concepts of asset management on a broad utility basis and that had become the 'go-to agencies' in the US, began to talk about the need for greater clarity in the industry. They also helped to work out in more detail how to publicise the benefits of asset management, the need for a strong, long-term commitment and the pitfalls in implementation.

These utilities, along with several individuals and professional association representatives, initiated discussions both by email and at national conferences and training sessions and ultimately became the convening group that inaugurated the collaborative session on asset management. The group's discussions concluded that there was a great deal of 'spam' circulating about asset management and that most consultants, professional associations, industry manufacturers and suppliers, as well as research and education groups, appeared to have vested interest in the products they sold and the work that they generated.

Many organisations had asked the

group how to start an asset management programme. They would say: 'We have had a great deal of help from consultants and are now incredibly confused and frustrated by all their explanations of why an asset management programme would be of value, and exactly how to initiate such a programme.' No one association, consulting firm or industry supplier had the utility perspective fully in mind. They were all willing to help, but there was no single location to which an agency could go for definitive assistance and clarity without expending significant staff time and effort.

It became apparent to the convening group that it was important to create some form of national clearing-house or central repository of research information. At the same time as this work was taking place, Steve Allbee of the Environmental Protection Agency (EPA) was continuing his work to educate and train utilities about the value and need for asset management programmes.

His view was that such programmes could be a major step toward establishing a long-term sustainable infrastructure system in the US, and could also confirm the growing need to deal with the hidden problem of ageing and deteriorating infrastructure highlighted in a number of EPA surveys.

This problem persisted even after the EPA and Water Environment Research Foundation (WERF) funded a working session of experts to evaluate and establish a research agenda that would prioritise asset management in the US. This forum was held in 2002 in Washington DC, and was the first national opportunity for utilities and professionals to share information and consider the future needs for research to further asset management.

...It is unsurprising that there is confusion as to exactly what asset management is - but most of the concepts and ideas can be seen to be one and the same...

The two-day session drew 35 participants from the US and Australia in a workshop setting to review current activities, document the status of asset management implementation to date, share lessons and establish a priority listing of future research initiatives. The sessions were a huge success, and resulted in a WERF report and list of research initiatives to further asset management in the US.

The results revealed the value of and need for additional research, and also proved to these professionals that these types of information and assistance were valuable to utilities and agencies pursuing asset management efforts.

Following these discussions and largely as a result of the dialogue initiated around this time, real-life examples of the value of the asset management philosophy continued to spread, and further discussions focused on the needs of both big and small utilities. The convening group continued to formulate their strategy, and continued to believe there was a need for a utility perspective to asset management.

At the same time, consultants and professional associations were expanding their presentations and discussions on the topic, tempered with their own spin as to what asset management should or could be, based on their own evaluations of the issue. This led to a rapid expansion of the philosophy throughout the industry, but without a coordinated structure or central thread of implementation. None of the attempts to push the boundaries of asset management were wrong, but few were broad-based or took into consideration the breadth of cultural change that a strong commitment to asset management really involves.

Many felt that implementing a strong maintenance management system was asset management. Others argued that asset management was a strong capital planning process that took into account risk and life-cycle costs. And some organisations began to realise that to effectively implement asset management a complete change in organisational culture and operation was needed throughout at all levels. The process needed to include changes to capital and operational planning, systems evaluations, data acquisition, financial operations and historical references to past actions.

Agencies in cities such as Seattle, Sacramento, San Diego and in organisations such as the Massachusetts Water Resources Agency and Orange County Sanitation District continued to be tracked as the leading edge agencies as they continued on their paths towards an asset management-based culture, each in their own way but with help and input from experts in Australia and New Zealand.

Utilities in these countries had been required many years previously, by both local and state laws, to enhance their financial and operating arms by managing their assets on a life cycle basis rather than a traditional 'build and ignore' approach. Many of the techniques that they had been required to undertake brought about documented savings and a better understanding of the real life cycle an asset goes through.

In addition, these utilities were also asked to find out exactly how their customers felt about their operations, and how willing they were to finance and operate utilities on a 'best business practices' basis. As the larger US utilities began to witness the substantive results of the Australian experience, they began to take these techniques and modify or expand them to fit their own needs.

At the same time, these agencies and a number of professional associations, in tandem with Steve Allbee's ongoing presentations, initiated a dialogue about the value of asset management. This recognised that there was a need to export the results beyond their own agencies to the larger community of US utilities. These discussions took place at various national conferences and meetings, where many of the participants formally discussed the results of their own utility's asset management implementation.

The group also established an email information exchange with many leading-edge promoters of asset management in the US and Australia. The aim was to establish a way for utilities to have a say in the development of asset management, and to provide a forum for utilities to share experiences and results from their asset management implementations.

These were the actual case studies that utilities were looking for to prove that asset management would bring about better business practice, based on documented results. In addition, many of the leading-edge proponents of asset management found other organisations were asking them: 'How do I start asset management?' or 'What should I do first to check this new concept out?'

In October 2004, the convening group decided that to continue to reach out to other agencies and the industry in general, it would have to establish a vision and mission that would enable its own expansion and establishment as a recognised expert in the asset management field. The group realised that it would be important to start formalising and defining the details of establishing a coordinating group.

They decided to prepare a draft business plan that could be discussed at the next meeting of the group, if it was decided to pursue this path. These discussions also focused on how the various sectors, including academia, research, professional organisations and consultants, fitted into the process of moving asset management forward. The group strongly agreed that any new organisation must commit to putting the needs of utilities before anything else, as they are the real focus of asset management and where the results for ratepayers and customers will ultimately be seen.

The convening group received many requests to participate, and also witnessed other countries and regions pursuing various pieces of the asset management puzzle. The group realised that a broader representation, particularly from small and medium utilities, was required in the development of the business plan. They also understood that other elements of the asset management community would have a direct and fundamental impact on the success of any coordinated effort to push asset management forward in the US.

Early in 2005, in conversations leading up to the draft business plan meeting, it became increasingly clear that as part of the wider discussion on developing asset management there was a need to find out more of what was happening not only in the US but globally. At about the same time, the EPA was considering another national working session similar to the 2002 events to determine the national status of asset management and as a follow-up to 2002.

The convening group agreed to help the EPA in developing a working session to highlight their concerns about the need to broaden the input to developing a coordinated national asset management programme. These discussions led directly to the collaborative working session held in Washington DC on 5 and 6 May 2005.

The Collaborative Working Session

As the convening group and EPA (the convening team) began to develop the philosophy for the working sessions, they realised that there were many interests and viewpoints that needed to be involved in any programme. They saw that all had valuable and meaningful perspectives on the actions needed to push forward the national asset management agenda and enhance the opportunities for collaborating with water and wastewater utilities.

In addition the session provided a perfect opportunity to highlight the many agendas currently being pursued under the global banner of asset management. What started as a meeting of water and wastewater utilities was expanded to include representatives from academic and research institutions, professional associations, regulatory interests and the consulting community, not just from the US but around the world as many other countries are involved in asset management. Those represented at the event included Australia, New Zealand, Canada, the UK, Sweden and France. The purpose of the working session was to identify a three to five year agenda for action to advance asset management practices in the water industry and state and local government.

Next, the convening team identified likely participants who could provide a strong input and represented cutting-edge asset management philosophy and experience. Invitations were extended, and 140 people from 11 countries agreed to attend. It was decided that it was necessary to use a facilitator to get the most from the two-day sessions. The GHD LLC consultancy was chosen to develop the programme and act as the facilitation experts.

The agenda provided an opportunity to update attendees on the state of any activities that could affect and influence the national asset management initiative. An overview of the state of asset management practice was provided from the perspective of water industry programmes, from university educational trainers and professional organisations. The session also looked at global research currently being undertaken on asset management, as well as governmental and regulatory activities that are or could affect asset management.

The end of day one and most of day two were devoted to breakout sessions identifying the most critical issues facing asset management. Attendees also developed working agendas for the future of utility coordination and collaboration, education and training, research and institutional relationships, and looked at regulatory issues arising over the next three to five years.

Separate breakout sessions were held on each topic and the attendees broke into four smaller groups that then rotated through each of the four specialist areas. At each breakout session, the smaller group first discussed the needs for action in that particular area and then identified the top ten actions to be taken. At the end of the four rotations, the four top ten needs from each of the small groups were then presented to the full plenary session of participants for review and evaluation.

After discussing and clarifying the meaning of each of the 40 identified action items, the full plenary session participants were asked to vote for the top ten needs for actions to help promulgate asset management in the US over the next three to five years.

The voting results were then computed and the final top ten scores from the full group were identified. The scoring was also recorded according to the area of expertise of each voter, so that a further analysis could be undertaken after the sessions. These more detailed voting segregations would ensure that one type of participant, such as consultants or academia, could not significantly weight the results in one direction or another. This approach also allows separate business development plans in each of the four specific areas of asset management to be developed.

The top ten actions for the water and wastewater industry in order from most to least necessary were as follows:

- define best practices
- define asset management by building business cases
- develop a central depository of high quality data available to researchers
- develop an international training and resource clearing house
- develop an asset management level of service business model
- develop research tools for cost effective physical conditions assessment including design standards
- develop uniform national standards for condition assessment and asset reporting
- develop common best practices for risk management framework
- evaluate whether asset management plans should be made a requirement for government funding
- cultural change

The two action items receiving the highest ratings were actually a combination of several ideas and concepts that offer a further insight into the attendees' desires and intentions for asset management over the next five years including:

Best practice

- adopt asset management as a best management practice and develop standard terminology and processes
- develop and implement training on operation and maintenance best management practices
- define life cycle maintenance – best practices for process, procedure, risk, and timing
- develop common standards for asset management
- develop mechanisms for accreditation/certification
- create a credible authority that develops standards

Defining asset management/building business cases

- define asset management
- ensure the asset management definition have objectives and benefits
- publish a US version of the international asset management manual
- get agreement on a definition of asset management among professional water/engineering associations

The central theme from the

collaborative session was that knowledge transfer, which can be defined as the effective and efficient accumulation, organisation and dissemination of best practices for asset management concepts, processes and practices relevant to the US management culture, was needed as quickly as possible.[2] Clearly, the lack of communication and ability of utilities to find and use asset management tools and techniques is seen as a significant impediment to the advance of asset management in the US.

While these outcomes represent the consensus opinions of the leading experts in asset management, evaluation of the data by separate industry sectors reveals different drivers for success. This suggests that individual business plan strategies will be required for a central clearing house in order to fully advance asset management in the US.

This also indicates that any national organising effort must not only strive to meet the global needs of asset management, but must also listen and allow individual sectors to pursue their needs via their own experts. This implies a governance structure that oversees the broad goals and objectives, with separate coordinating groups for each individual industry sector that inputs into the general governing body.

The result of this collaborative effort are similar to the views and needs identified by the convening group over the past two years. There were few surprises or differences in opinion from the group voting process. It is apparent that a national asset management steering council or clearing house is needed to enable asset management to advance rapidly in the US. This effort would help all the industry sectors, which would benefit from a central coordinating repository of information and best practices. This clearing house or council would necessarily receive input from all sectors of the industry, but must focus on the interests and needs of utilities, regardless of size, as they are ultimately responsible to the ratepayers and customers who will benefit.

For more detailed information and the full summary overview of the collaborative session please visit the EPA Asset Management website at http://www.epa.gov/OW-OWM.html/assetmanage/index.htm.

Next steps

Using the results and outcomes from the collaborative sessions, the convening group has formally called itself the National Asset Management Steering council (NAMS) and believes that it can now move forward to establish a broad coalition of interests that will help advance asset management globally and specifically in the US.

NAMS has identified several possible funding sources and has initially submitted, along with the Buried Underground Asset Management Institute (BAMI), a request for a cooperative agreement from the EPA for seed funding to establish the national steering council.

In addition, with support from BAMI and its affiliates, other funding opportunities are being explored to establish a long-term funding approach for this vital council. It is expected that further outreach and input from utilities, professional associations, academia and educational programmes, research institutions and consultants will add substance and a governance structure to the draft business plan, resulting in the establishment of a formal non-profit organisation within the next few months.

NAMS is currently seeking input and participation from water and wastewater utilities, whether small, medium or large, that need information and support for asset management programmes. Input from medium and small agencies that have experience with implementing asset management or who are looking for support and help with the development of an asset management programme and desire to see an active national asset management support system would be of particular interest. Please contact the author at causeywc@astound.net or look for the National Asset Management Steering Council website, which will be created within the next few months.

NAMS is also seeking input and collaboration from academic and educational organisations or educators interested in helping with the development of training and education programmes that advance the philosophy and culture of asset management among leaders and utility personnel in a broad and coordinated manner.

Finally, NAMS needs professional assistance and support for the development of the national clearing-house of research and best business practices information as identified and presented in many of the professional conferences and training sessions that continue to support and advance the concepts of asset management in the US and globally.

If anyone reading is interested in assisting the effort, has ideas and opinions regarding a national clearing house effort or has excellent asset management experience, please contact the author or the chair of NAMS, Doug Stewart, at dstewart@ocsd.com.

Conclusions

The national collaborative working session has identified many of the current water and wastewater asset management efforts underway in the US, as well as in other countries. Even to the asset management devotee, the results of this session were both gratifying and astounding as, without great fanfare, much is happening. There is a huge amount of information available, but not in a uniform or easily accessible form. If the philosophies and concepts of asset management are to reach out and be available to more than a few hundred utilities in the US, a national effort to coordinate and simplify utilities' efforts to understand the value and benefit of asset management must be undertaken.

An effort to help a utility quickly understand and evaluate the business value of a programme without having to deal with all of the extraneous semantics and confusing terminology is needed. We need a way to enable utilities to quickly see the benefits and assist with justification and support for programmes at management and elected official level.

It is time for a National Asset Management Steering council to fill the void and provide coordination, assistance, support and guidance, across the industry but particularly to the utilities that should be embracing this new and exciting cost-effective and decision-enhancing philosophy.

It is in the national best interest for an industry that depends on highly capital-intensive and long life cycle (20 to 100 years) infrastructure to make asset management central to its business and economic activities, to benefit all customers, whether domestic or commercial. Following the basic tenets of asset management will bring about better business decisions that match customer desires and the utility's ability to pay. The National Asset Management Steering Council's time has now come. ●

References

[1] *Association of Metropolitan Sewerage Agencies/Association of Metropolitan Water Agencies/American Water Works Association/Water Environment Federation: Managing public infrastructure assets to minimise costs and maximise performance.*

[2] *Environmental Protection Agency, Office of Wastewater Management: A summary overview of the working session exploring opportunities to enhance collaboration by water and wastewater utilities in advancing asset management; Washington DC, May 2005.*

Canada's Infraguide: bringing the best of research and practice together for sustainable asset management

Significant increases in expenditure are looming, despite the fact that Canadian municipalities already spend CAN $12 to $15 billion ($10 billion to $12.6 billion) annually on an infrastructure that is aging faster than we are replacing it. This is happening at a time when demand for higher standards of safety, health and environmental protection as well as population growth are also increasing. This is not dissimilar to what is happening in other municipalities around the world. The solution is to change the way we plan, design, build, manage, rehabilitate and ultimately complete the cycle by replacing infrastructure.

Leo Gohier
Infrastructure Dynamix
Canada

In the mid-1990s, a number of concerned practitioners met informally to discuss common asset management issues and to start developing a network of professionals around the country. A number of Canadian municipalities were already in the throes of developing long-term asset management strategies, and information was shared freely at national and international conferences. This ultimately led to the federal government, through its Infrastructure Canada Program (INFC) and the National Research Council (NRC), joining forces with the Federation of Canadian Municipalities (FCM) to formally create Canada's National guide to sustainable municipal infrastructure, also known as InfraGuide, in 2001.

It is important to note that InfraGuide is not legislated in any way. It is a guide, not a Code, or an Act, or a Law, or Regulations. It is made up of two very different but essential components for success: it is both a national network of people (from elected officials to practitioners and researchers as well as professionals in the field) and a growing collection of user-friendly best practice documents for use by decision makers and technical personnel in both the public and private sectors.

InfraGuide is an institution that continues to permeate sustainable asset management practices across Canada. It was made possible through a CAN$12.5M ($10.7M) grant from Infrastructure Canada, as well as in-kind contributions from various elements of the industry, technical resources, and the collaborative efforts of municipal practitioners, researchers and other experts.

Volunteer technical committees and working groups – with the assistance of consultants and other stakeholders – are responsible for the research and publication of the best practices. This is a system of shared knowledge, shared responsibility and shared benefits. Based on Canadian experience and research, the reports set out the best practices needed to support sustainable municipal infrastructure management in six key areas: municipal roads and sidewalks, potable water, storm and wastewater, decision-making and investment planning, environmental protocols and transit. Some of these best practices are strategic; others are tactical and others are operational. Nearly 50 best practices have been published so far, and they are available on-line (www.infraguide.ca) and in hard copy.

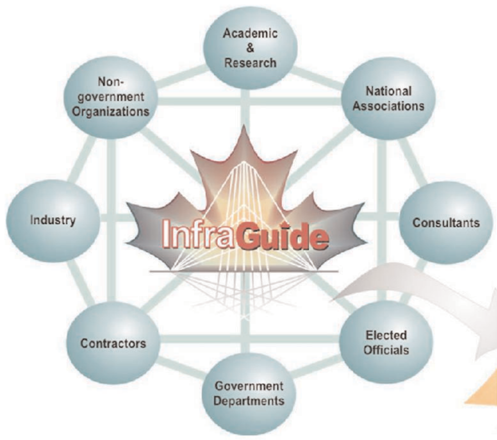

Figure 1 Infraguide is intended as a common resource for all industry sectors

The core best practice for developing a strategic asset management plan, based on principles of sustainability and life-cycle analysis, is found under the umbrella of decision-making and investment planning, and is entitled Municipal infrastructure asset management.

Infrastructure management is actually quite simple to describe, as illustrated in Figure 2: annual operational budget, rolling up into a tactical five to ten year budget, that ultimately rolls up into a life-cycle budget (for illustrative purposes a 100-year financial investment plan for a 100-year life asset). We must also not forget that these financial and engineering plans should include operating costs as well as capital costs.

But wait: should this planning be botoom-up (ie, operational > tactical > strategic), or the other way around, that is, strategic > tactical > operational (top-down)? In reality, the answer is that both approaches are

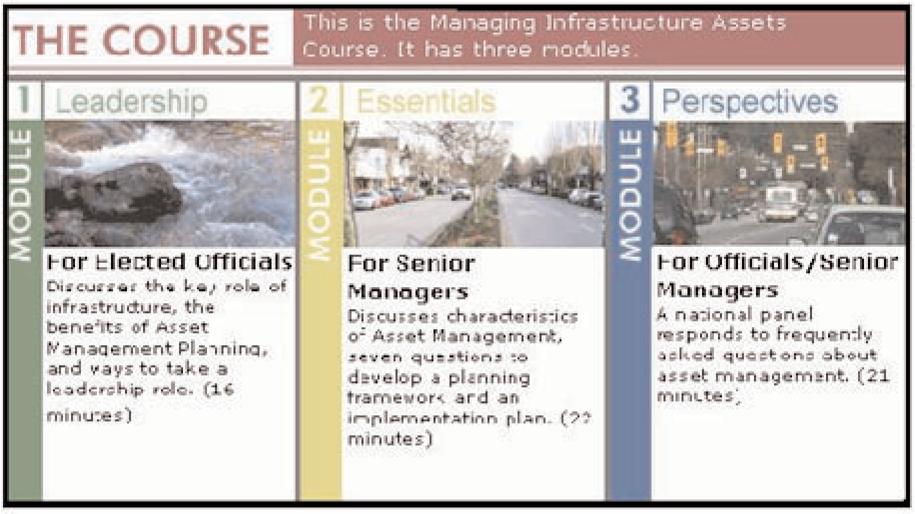

Figure 3
The infraguide multimedia learning tool is designed to save municipalities time and money.

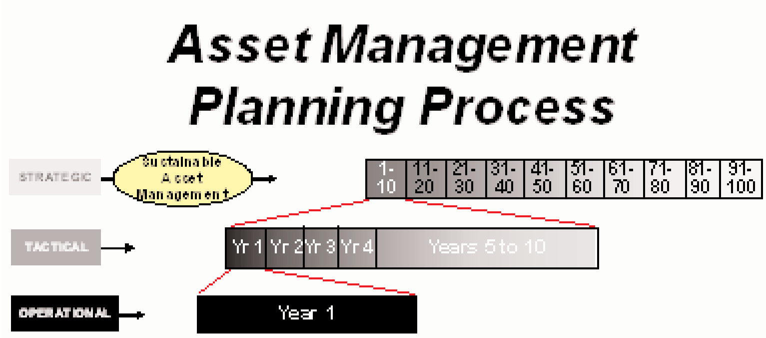

Figure 2
The asset management planning process for a 100-year life asset

needed, with the common ground being the tactical component. If the bottom-up approach (which is much more data-intensive) yields the same tactical plan as the top-down approach (which is much more intuitive), then the overall asset management plan is a good one. The tactical plan can in fact be described as the 'hinge' that makes it all work.

The Municipal infrastructure asset management best practice deals mostly with the strategic components of life-cycle planning. It describes the fundamental concepts, components, and considerations inherent in an asset management plan. Canadian municipalities realise that a strategic asset management plan will be required to address the rising costs for, and competing priorities associated with, infrastructure renewal programmes. An asset management plan is also needed to address public demands for a higher level of service, more stringent regulations, population changes, limited financial resources, competition, and technology. Other best practices deal with these issues separately and in a greater detail.

The framework for a life-cycle asset management plan can be described in terms of seven questions:

- what do you have and where is it? (inventory)
- what is it worth? (costs/replacement rates)
- what is its condition and expected remaining service life? (condition and capability analysis)
- what is the level of service expectation, and what needs to be done? (capital and operating plans)
- when do you need to do it? (capital and operating plans)
- how much will it cost and what is the acceptable level of risk(s)? (short and long-term financial plan)
- how do you ensure long-term affordability? (short and long-term financial planning, that is, ensuring that the funding is in fact sustainable)

This simple framework is applicable to both the senior-directed and operational approaches, obviously with very different levels of detail and data requirements. It has been used in a few municipalities with considerable success, success being measured by voluntary increases in expenditure, which means an increase in taxes or rates in order to fund ever-increasing investments in infrastructure.

The public understood the strategic plans as well as the consequences of not proceeding in that general strategic direction, and much to their credit so did the elected officials even though these strategic, long-term and life-cycle plans were obviously outside their political lifetimes. There are great challenges in developing these strategic plans, and even greater challenges in presenting them to elected officials and the community at large.

On the other hand, the perils and consequences of not doing them far outweigh those challenges. Life-cycle asset management plans are a bare necessity if the community is to make informed decisions, albeit difficult and sometimes unpopular ones.

InfraGuide, Canada's national guide to sustainable municipal infrastructure, has recognised the importance of leadership from elected officials and senior administrators in successfully developing and implementing strategic asset management plans. As a result of a demand from many of its volunteer members, InfraGuide has just recently launched a unique and essential knowledge product, Managing infrastructure assets.

This product turned one of InfraGuide's most popular best practices on asset management into a practical, easy-to-use, multi-media learning tool. This key educational product is designed to help elected officials and senior administrators to quickly learn about what asset management is and its related economic, social and environmental benefits.

Given its clarity and ease of use, it is an ideal tool for non-professionals, practitioners and senior management as well as elected officials. An invaluable tool for training, orientations and presentations, it will help bridge the gap between all stakeholders, by providing strategic and long-term information on the life-cycle requirements of infrastructure.

The managing infrastructure assets knowledge product is available online and to order on compact disc, at www.infraguide.ca. ●

Discolouration risk modelling

In preparing its Business Plan for the 1999 Periodic Review, Yorkshire Water observed that determining the risk of discolouration required complex analysis, because of the multitude of factors which influence the level of risk and the need for an appropriate hydraulic trigger for an event to occur. The Company set out to develop a risk-based framework and commissioned Ewan to develop a software vehicle capable of reading in network models and GIS details, applying risk algorithms and providing outputs detailing relative 'pipe-by-pipe' discolouration risk. Discolouration Risk Modelling (DRM) is now being applied by Yorkshire Water as part of its approach to mains rehabilitation under the Section 19 Undertaking and it is an integral part of its Distribution Operation and Maintenance Strategy (DOMS). A 'DRM Club' has also been established, which will give access to the technology to other water companies and will evolve the approach to reflect progressively improving understanding of the discolouration phenomenon and industry Best Practice. This paper sets out the origins of DRM, the contribution of academic research programmes to risk algorithm development, Yorkshire Water's implementation experience and potential future development directions for the approach.

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Water companies operating within the regulated water industry in England and Wales have a responsibility to provide water to customers, to acceptable levels of service, as measured by Serviceability Indicators applied by the Regulators. In the case of water service provision these include aspects of performance that are relatively easy to measure, such as interruptions to supply and low pressure. Water must also be wholesome – largely measured by assessing compliance with required standards at the Treatment Works – but also in terms of aesthetic water quality: odour, taste and discolouration.

Discolouration presents water system managers with some interesting challenges. Experience has shown that discolouration events cannot easily be explained by relatively 'static' factors such as pipe material; different systems have widely varying levels of sensitivity to discolouration events which frequently don't align with intuitive expectations. This is because, regardless of the potential for discolouration based on levels of material generation and deposition, this potential will only manifest itself as an event (and therefore a service failure) if the material present is resuspended through some appropriate hydraulic trigger, i.e. a significant change in the hydraulic conditions within an individual pipe.

Evolution of the regulatory system is placing increasing pressures on water companies to verify that their proposed capital maintenance spending is justified in terms of managing service level risks. The principles are set out in 'The Common Framework'[1] and essentially involve analysing past performance, considering what differences will apply in the future and then determining the appropriate maintenance needs. Ofwat has stated that it expects to see this approach applied by all water companies in their Business Plan development.

There is also a progressive requirement from the Drinking Water Inspectorate (DWI), as set out in Information Letter 15,[2] to demonstrate that appropriate distribution operational and maintenance strategies (DOMS) are in place to manage day-to-day and longer term risks. The application of systematic procedures, which provide evidence that due diligence has been carried out and generate an audit trail of how risks have been assessed, is clearly advantageous for the water companies.

Both aspects require an approach to assessing discolouration risk which, because of its dependency on hydraulic triggers, ideally needs to link asset and environmental causal factors with hydraulic simulation. Whilst most companies had in the past addressed discolouration risk through the analysis of past performance (e.g. customer complaints) or by considering static risk factors at say Distribution Management Area (DMA) level, the more stringent demands of the regulators indicate that this complex area cannot be addressed in these ways indefinitely. A more dynamic means of assessment is therefore required.

The Discolouration Risk Modelling approach (DRM) was conceived by Yorkshire Water whilst preparing for the 1999 Periodic Review. The Company embarked on a process of developing risk algorithms, described below together with the software development process. The paper goes on to describe the initiatives which are currently underway to strengthen and expand the approach in the future.

Overview of the DRM approach

DRM is a risk assessment tool which calculates the propensity of each pipe to give rise to discolouration, expressed as a combination of likelihood and consequence, in the event either of its own failure affecting the network in general, or failures elsewhere in the network giving rise to discolouration from that pipe. It assesses a range of factors including asset characteristics (e.g. pipe material, age, diameter, rehabilitation history), source characteristics (history of Fe or Mn discharge) and environmental characteristics (e.g. soil fracture index). These are combined with model results in terms of changes in flow conditions associated with system events.

DRM makes a pragmatic assessment of hydraulic impacts using velocity and pressure surrogates (rather than more sophisticated erosion and transportation models which are under development). The conditions assessed include flow reversal, significant velocity increase and depressurisation. It can be applied either to assess relative risk of all pipes (i.e. priority rank) to help inform rehabilitation or planned flushing decisions, or to investigate the likely risks associated with operational activities (e.g. rezoning or valving to isolate sections for planned works). It allows details of prospective rehabilitation scenarios to be entered (using dialogue boxes) and their various impacts on discolouration scores simulated, with flexible output of results available.

The DRM approach provides a comprehensive risk assessment 'frame-work' which can be enhanced in future through better quantification of relationships which define the likelihood or consequence of an event. Such enhancements could take account of better knowledge of the impact of pipe materials on likelihood of failure, or more sophisticated modelling of discolouration processes arising from research programmes.

DRM DEVELOPMENT

Risk Tree Development

The serviceability approach developed by Yorkshire Water Services (YWS) has been extensively used within the AMP planning process to support both the "Asset Inventory and system performance" submission and also the investment requirements for both base and quality capital programmes.

In 1999 and 2004 as part of the PR99 and PR04 planning process, Yorkshire Water made an assessment of the serviceability of its clean water distribution network. For each service-ability indicator (Interruptions, Discolouration, Low Pressure and Leakage) a risk tree has been developed which describes the tendency of an effect occurring and the consequence of its occurrence.

The Company has been able to make a quantitative risk analysis of the serviceability of its assets at a zonal level based on a snapshot in time. The potential benefits of making serviceability assessments at pipe level and incorporating dynamic event driven data was thought to be considerable and led to the development of risk trees which considered pipe level functions. The risk trees are based on standard fault tree analysis methodologies with some adaptation made to suit the application. A panel of experts identified factors which were judged to influence either the tendency for failure with respect to that aspect of serviceability, or the severity of the consequence of that failure. At the initial stage no account was taken of the availability of data. The factors were arranged into a hierarchical structure describing the dependencies between the factors, as shown in Figure 1.

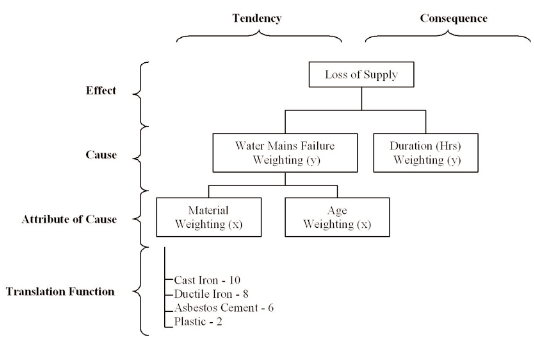
Factors may be combined together in a number of ways in order to best represent the manner in which they are believed to interact to influence serviceability. The relative importance of each factor is then assessed by a 'pair wise' comparison, resulting in weights being allocated to each node within the tree. Data sources are identified which can be used for each bottom level factor. These include GIS data, water quality sample data and performance data. Each set of data is grouped according to the appropriate translation function and scored. Systems for scoring include look up tables, linear functions and dynamically variable data.[3]

DRM currently incorporates three of the trees developed for serviceability assessments; specifically, interruptions risk, discolouration risk and hydraulic effects. The trees were designed to relate to each other such that the following risk was described:

1. the risk of material being present within a pipe
2. the risk of the pipe being interrupted
3. the risk of the interruption causing a hydraulic effect which mobilises any material present.

Part way through the development of the software, additional research was published which provided a significant insight into the hydraulic characterisation of deposits. The serviceability trees were developed to incorporate a scoring mechanism which allowed the software to differentiate mains which were likely to be self-cleansing as opposed to mains where the velocities were likely to lead to deposition. Where possible, expert panel judgement has been validated by proven research. The robustness of the hydraulic effects tree in particular has been increased through application of findings from UKWIR, EPSRC and WRc research.

Figure 1 **Typical structure of a tendencey to fail serviceability tree**



The DRM software

The development of the DRM software was initiated through a research and development project which proposed to merge serviceability assessments with hydraulic models, to develop a risk-linked hydraulic model. The aim was to support discolouration issues via capital and operational feasibility studies, and to better inform planned operations on the network.

The hydraulic model information imported into the application was often old and derived from sources other than the corporate GIS. This led to a number of translation issues when trying to match the two data sets. The first phase of work concentrated on setting up a complex process of geometrical matching which enabled the user to combine the two datasets at the touch of a button. A second phase of development brought together the DRM analyzer and the hydraulic engine component through use of the EPAnet software accessed through an interface written in XML. Additional Windows functionality was incorpo-rated using windows and menus. The Discolouration Risk Model can be run in two modes to support business decisions:

A Capital Risk Analysis enables an asset manager to identify those mains that have a high risk of interruption combined with a high discolouration performance score following a hydraulic event. Rehabilitation scenarios can then be created and run simultaneously to identify changes in the discolouration risk score. These scenarios and their associated risk movements are utilised to inform capital planning decisions and to support design of rehabilitation schemes.

An Operational Risk Analysis enables an asset operator to analyse alternative operational events in order to select the event that will have the least risk of causing adverse effects on service levels. The asset operator can choose to add exceptional demands and close pipes to simulate valve operations and flushing programmes.

YWS APPLICATION EXPERIENCE

The use of DRM is inherent in the Company's application of DOMS at DMA level. Iterative rehabilitation scenarios are developed within the Capital Planning environment to determine the most cost-beneficial solution.

A technical approach for capital maintenance within the Distribution Operation and Maintenance Strategy (DOMS) has been developed. A scenario is created which sets out what is colloquially known as the 'Full Monty', within which all non-preferred materials are renovated (Renew / Scrape and Reline) and all preferred materials are cleaned (Air scoured / swabbed / flushed). This provides a point on the graph representing the nominal limit of greatest percentage change in Discolouration Performance Score plotted against highest solution cost. Rehabilitation scenarios are then created and simulated iteratively, each time selecting combinations of mains to be rehabilitated and a range of rehabilitation techniques. The process is continued until the most cost-beneficial solution is identified.

Figure 2 illustrates the scenario results for a typical DMA. The highlighted scenario is the one judged by YWS to give the greatest value in terms of discolouration risk reduction per pound invested, and was taken forward for detailed planning and maintenance programming. A similar pattern of results has been obtained for each DMA analysed using the DRM Capital Risk Assessment mode to date.

The ability to identify cost-effective solutions in the context of a key maintenance driver is perceived as a major benefit by the Company. Better targeting of rehabilitation towards the highest risk mains is expected to result in significant capital efficiencies to achieve a given level of performance compared with the broader interventions that would be necessary were DRM not available.

FUTURE DEVELOPMENT POSSIBILITIES

Extending the approach to other performance areas

The calculation of a discolouration risk value requires the input of numerous pieces of information, either on a global or a pipe-by-pipe basis as indicated figuratively in Figure 3a. In principle, little additional information would be needed to derive some form of risk score for a comprehensive range of performance areas as illustrated in Figure 3b. Whilst the detail of how this should be developed will depend on numerous factors, an extension of this type has been identified as a longer term objective of the DRM Club.

Optimising intervention options

Because DRM simulates the system hydraulics of the failure of each pipe in a system in turn, it is computationally demanding and the current software requires the user to test manually selected interventions (e.g. rehabilitation schemes) before selecting the one which offers an appropriate level of risk reduction for the investment required. The ultimate objective for the future would be to optimise these interventions to identify the most cost-effective combination. Optimisation, using a technique such as Genetic Algorithms, is expected to become increasingly feasible through a combination of more computing power but, more significantly, by developing the rules surrounding the number of hydraulic simulations required for each failure

SUMMARY

The DRM approach, originally conceived by Yorkshire Water in 1999, comprises the combination of asset, environmental and hydraulic discolouration risk factors through a series of risk trees weighted to reflect the latest research findings and expert understanding. Developed jointly by YWS and Ewan since then, DRM application software has now been rolled out by the Company and is generating real business benefits.

Discolouration affects some companies more than others but it is nevertheless an area in which all companies must seek to address and effectively manage risks. A DRM Club has been set up and is now well on the way to providing other companies with a generic version of the software, with further objectives moving forward aimed at keeping the approach in line with latest understanding perceived Best Practice.

Constant improvements in computing technology, data availability and confidence and risk modelling create several exciting potential areas of development for DRM in the future. These include applying an optimisation technology such as genetic algorithms to select the most cost-effective rehabilitation scenarios (rather than testing manual selections); or using the mass of information required to calculate a Discolouration Performance Score to extend algorithms to other areas of serviceability risk. ●

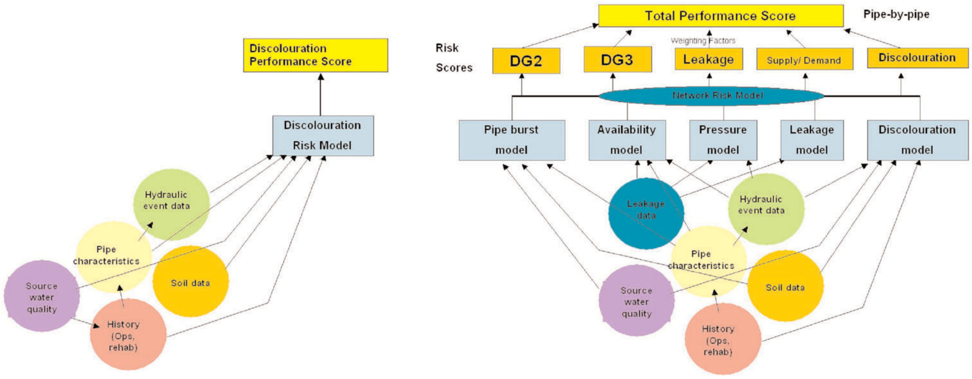


Figure 3a and 3b
Extending DRM to model overall distribution risk

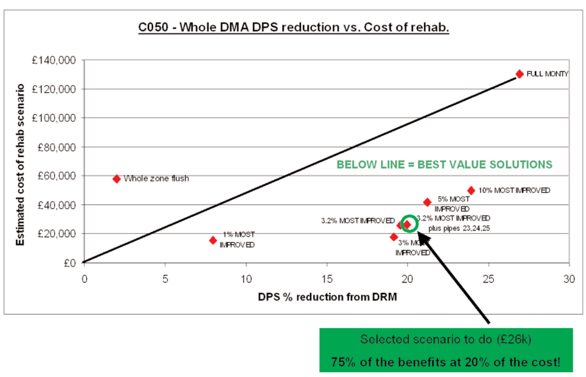


Figure 2
Assessment of rehabilitation scenarios to establish the most cost-beneficial solution

References

[1]*Tynemarch Associates, Capital Maintenance Planning: A Common Framework, UKWIR, UK, May 2002*

[2]*URL: http://www.dwi.gov.uk/regs/infolett/2002/info1502.htm*

[3]*Heywood, G., and Lumbers, J., Assessing the Serviceability of Sewerage Infrastructure, WaPUG Spring Meeting, 2000 URL: http://www.wapug.org.uk/past_papers/Spring_2000/S2000Paper05a.pdf*

University of Sheffield, Prediction and Control of Discolouration in Distribution Systems, EPSRC, June 2004

Introduction of a substandard supply minutes performance indicator

The Dutch drinking water companies have extended the performance indicator Customer Minutes Lost (CML), which measured unplanned interruptions, to a measure of continuity of supply of drinking water. The new performance indicator is referred to as Substandard Supply Minutes (SSM). Substandard supply is defined as lack of water quality or lack of quantity (too little pressure or an interruption of the water supply); the standards for water quality and pressure are defined in the Dutch drinking water act. SSM includes both unplanned and planned interruptions (failures as well as planned repair and replacements).

From September 2004 to March 2005 a pilot project ran to measure SSM. Out of 13 Dutch water companies, seven joined in this project. This paper describes the experience and results from the pilot, with the specific contribution of two water companies. SSM gives an insight in which factors are significant with respect to the total interruption of supply or quality of drinking water and thus supports asset management. SSM can be used both for comparison between water companies (benchmarking) and for comparing different distribution areas within a water company.

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Dutch water companies are publicly owned and are water supply only companies. The association of Dutch water companies (VEWIN) undertakes a three-yearly (voluntary) benchmark that compares the companies on water quality (index), service, environmental impact and cost (VEWIN, 2004). The benchmark does not yet include an indicator for continuity of supply.

The water companies and Kiwa have participated in a joined research programme on asset management that was begun in 2003. The first task was to agree what asset management is; the agreed definition being 'an integrative optimisation process which enables a utility to minimise the total life cycle cost of owning and operating assets while continuously delivering service levels demanded by customers and anticipating environmental developments'. The water companies stress that 'customers determine the service level, and asset management should be used to deliver that service at the lowest cost' (Boomen, 2003).

One of the steps in the process of implementing asset management is measuring performance and directing this towards providing the desired service level at the lowest cost. Ideally, by measuring several high level performance indicators (PIs), information should also be gathered about which process is the so-called 'performance killer'. In this way, it will be possible to identify the process that contributes most to the PI and where the effort must be made to bring about performance improvement.

The Dutch water companies want a common definition for the relevant PIs so they can learn from each other and use the PIs for comparison, for instance through the VEWIN benchmark.

The water companies' main activity is supplying drinking water, so a performance indicator that quantifies this service is needed. Alegre et al (2002) have collected a vast amount of performance indicators used by water companies all over the world. Performance indicators for quality of service include continuity of supply as a percentage of time, water interruptions per customer as a percentage, and the number of interruptions per connection.

They also mention some water quality-related indicators that measure compliance with water quality standards. In the energy sector, the performance indicator that is widely used is customer minutes lost (CML), which represents the amount of time in a year on average that a customer does not have access to electricity because of an unplanned event (failure).

Combining the performance indicators found in the literature led to one new PI on the continuity of supply of drinking water, which we entitled substandard supply minutes (SSM). This PI measures the average time in a year that a customer is not supplied with drinking water, in the sense of quantity and quality of the water, because of both planned and unplanned activities. The standards for drinking water quality and quantity (pressure) are defined in the Dutch drinking water act. SSM is defined by the following equation:

$$SSM = \frac{\sum_{i=1}^{N} d_i * c_i}{\sum_{i=1}^{M} c} = \frac{\sum_{i=1}^{N} d_i * c_i}{M}$$

with i counting all events of substandard supply (from 1 to N), d_i the duration of event i and c_i the number of connections affected by event i. M is the total number of connections.

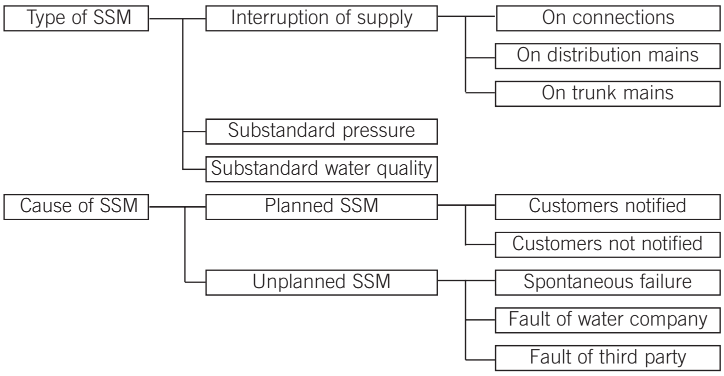

Figure 1
Subdivision of SSM into categories

A connection, by our definition, is a billable address. To be able to identify the performance killers it is necessary to subdivide into categories. Those proposed are a division into type of SSM and cause of SSM, as shown in Figure 1.

After agreement on the definition of SSM and preparation of the registration systems, a pilot project for SSM implementation was begun in September 2004. Seven out of Holland's 13 water companies joined from the start. Kiwa coordinated the pilot. In March 2005 the pilot ended with an evaluation of the project.

Implementation of SSM

The challenge in measuring SSM is to identify all the events (N), assess their duration (d_i) and the number of customers affected (c_i). The next step is to register all events and tag them with the correct category. First, we will look at some SSM events that occurred during the pilot project as an example.

Interruptions of supply are mainly caused by closing valves, for instance when a water meter is being replaced, when a water main is being repaired or when part of the network is being flushed. Substandard water pressure (below 200 kPa) was mainly caused by problems at production points; these caused large areas to suffer low water pressures.

In addition to these major events some individual customers complained about their water pressure, and a technician was send over to their properties to check whether the pressure was below the agreed level. During the pilot there were no major substandard water quality events, just individual complaints and some boil water advisories. A good example of a substandard water quality event would be the outbreak of giardia that occurred in Norway in the autumn of 2004.

Identifying the number of events (N)

Interruptions of supply are mainly caused by technicians closing valves, both for planned work and to repair failures. All companies have registration forms for the technicians to fill out per task, even if it is only for inventorying the used materials and travel cost reimbursements. This means that for interruptions of supply it is fairly easy to assess N. To register SSM it is necessary to write down some extra information: whether the valves were closed and for how long, which valves were closed or how many connections are within the closed area and the reason they were closed.

The pilot gave no confidence that all substandard pressure and substandard water quality events were being registered, nor that all companies equally underestimated the number of these events. This is mainly because water quality and pressure monitoring programmes do not cover the whole network at all times. The programmes may also differ between companies.

The Dutch drinking water act contains a mandatory monitoring programme for water quality, and most of the companies have extended their water quality monitoring beyond the decreed minimum. The water company and the inspectorate agree on a final proposal regarding when and where samples are taken.

A substandard water quality event is recorded when a reading is positive for any of the indicators, and a duplicate measurement is also positive. At the production location, there is a high probability that substandard water quality will be detected, because of the continuous measurements being taken. Substandard water quality events caused by problems in the distribution network are, by contrast, very difficult to spot. The current monitoring programmes are not accurate enough to ensure all SSM events are detected.

Water companies are obliged to provide a pressure at the connection of at least 200 kPa. However, pressure measurements are not decreed in the drinking water act. One proposal that has been made is to use a network model to assess areas where there is possible low pressure and define strategic monitoring locations to supervise the problem areas.

Boil water advisories are all issued by the water company, so counting N is easy.

Assessing the duration (d_i)

When a technician closes a valve it is easy to record the duration of the interruption of supply. However, for very repetitive tasks an alternative is to use a standard duration. Replacing a water meter, for example, is done frequently and takes little time, so logging the duration of every such interruption seems to require a disproportional effort. Instead, it is much easier to use a standard of, for example, five minutes for the actual d_i.

For substandard pressure and quantity identified through complaints from customers, d_i could be assessed by starting the substandard supply minutes from the time that the complaint was called in. Since the pilot showed that individual complaints contributed very little to the total SSM and the end of such cases of substandard supply is hard to identify, it was agreed that in this case too a standard duration could be used. Discussion about what the standard duration needs to be is still ongoing.

When boil water advisories are in place, the times when these are issued and retraced determine the d_i. The duration of major events of sub-standard water pressure and water quality are determined by reading the measurement logs.

Assessing the number of connections (c_i)

Again, for interruptions due to closures of valves it is relatively easy to assess the number of connections inside the closed area. For any activity at the (technical) connection, such as replacing a water meter, c_i usually equals one. For activities at distribution mains the number of connections can be checked via the information systems, if the closed valves are identified. By definition, no customers are connected directly on a trunk main, and because of redundancy built into the network usually no connec-tions are deprived of water because of activities on trunk mains.

Complaint-driven SSM affects one connection, by definition. This means that every customer complaint must be recorded. For large-scale substandard pressure and substandard quality events, a network model must be used to assess c_i.

Results of the pilot

The results from the seven water companies that measured SSM over five or six months show an average SSM of 36.3 minutes per year. The

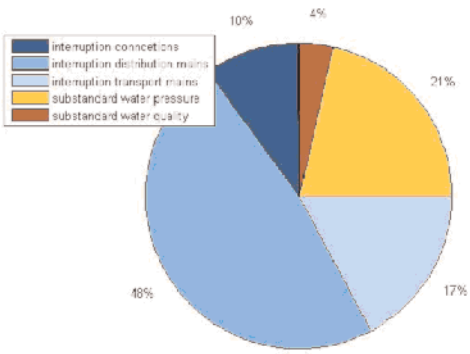

Figure 2
Total SSM discerned by type

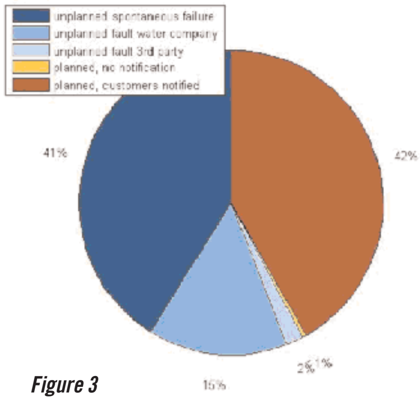

Figure 3
Total SSM discerned by cause

divisions into type and cause are shown in Figures 2 and 3. Figure 2 shows that 75% of total SSM is due to interruptions of supply, 21% to substandard water pressure (mainly because of problems at production points) and just 4% to substandard water quality (mainly via boil water advisories).

Figure 3 shows that 42% of SSM is due to planned work. This means 58% of SSM is unplanned, of which the majority of events seem to be spontaneous failures. However, during the pilot it wasn't possible to identify the proper causes for all failures. This means that for some companies all unplanned work was categorised as 'spontaneous failure'.

The part of SSM that represents unplanned interruptions alone is comparable to CML. The CML as measured in the pilot equals 11.1 minutes. The Dutch energy sector reported a CML of 24 minutes in 2004.

DZH's experiences

DZH is short for Duinwaterbedrijf Zuid-Holland, a water supply company that provides potable water to 1.25 million people in the west of The Netherlands, including the Hague. Dunes are used to produce high quality drinking water through a natural filtration process.

In order to join the pilot SSM in time, DZH decided to use its existing registration and reports from activities as much as possible. DZH wanted to report once a month and use figures from information it had on two separate distribution areas within its total supply area.

An inventory of DZH's existing information revealed that not all of the required information was to hand. The company had no separate registration for the length of interruptions from SSM events, and in some cases a standard interruption time was needed. The current systems could not generate and automatically report the number of addresses with substandard supply so it was decided provisionally to do this by means of estimates made by site personnel.

This implies that a number of improvements are needed to obtain a more accurate SSM result. When DZH introduces a mobile logistic computer system later this year it will be possible to obtain reasonable interruption times for a number of types of activities.

Also later this year, the customer address registration system and the GIS system for registering mains will be linked. This will provide accurate and immediate information about the customer addresses where interruptions are experienced because of valve closures. Both improvements will contribute to the accuracy of the SSM results and simplify SSM report generation.

The SSM pilot showed that the monthly outcome is usually fairly constant and is mainly due to failures and planned activities in distribution areas. A different situation arises in the case of incidents. In the first month of the SSM pilot, a problem occurred in a local district of the city of The Hague. This district is situated in the dunes, at varying heights, and its water supply is provided by means of a high pressure pumping station.

This pumping station failed, which temporarily reduced water pressure in the district. During the event, the pressure dropped below the minimum 200 kPa at street level only in one part of the district, so that part alone was counted within the SSM system. In addition, the effect of the daily peak hours (which caused a temporary additional pressure loss during the incident) was taken into account in the SSM. This event doubled the normal monthly SSM result.

The separate registrations in the two DZH distribution zones makes it possible to observe the contribution of both individual areas to the total SSM. To compare both areas properly the total number of substandard supply minutes has to be based on the number of connections per distribution area. Figure 4 shows the difference contribution of both distribution areas (West and East) to the DZH SSM, and the separate SSM results per district for supply interruptions in distribution mains during a given month.

The SSM pilot results give DZH a clear insight into which activities contribute most to the total SSM during both normal and anomalous situations. The separate SSM figures for the two distribution sections show the effects of the differences between these zones.

For example, in one specific month a large number of mains failures in the East area led to a far lower contribution to SSM than a relatively low number of failures in the West area. This was due to the much lower average number of customer addresses per distribution section in the East area. SSM is thus able to contribute to a more balanced design for the distribution network, taking customer's interests into greater consideration. In this way, repair activities and maintenance operations can also be optimised. For the personnel involved, SSM registration brought about a greater awareness of customer interests and a motivation to keep the SSM as low as possible.

Evides' experience

The Evides water company is responsible for the production and supply of drinking water in the south-west region of The Netherlands, including the city of Rotterdam and its surrounding area. Evides was created from a number of water companies, each with 100 years or more of experience in maintaining drinking water infrastructure.

With the growth of the supply area, the company needs tools to enable a balanced and uniform judgment about the quality of the supply system in order to improve rehabilitation decisions ('decision tools' for existing pipe materials). In addition, Evides is

Figure 4
SSM of DZH by distribution selection

	SSM per district		Total SSM of DZH
Distribution area	WEST	EAST	WEST + EAST
Failures in mains	0.7	0.01	0.43 + 0 = 0.43
Planned activities in mains	2.54	1.27	1.55 + 0.49 = 2.04
Flushing projects in mains	0	0.05	0 + 0.02 =0.02
TOTAL	3.24	1.33	1.98 + 0.51 = 2.49

Part of the system	Planned activities	Unplanned activities	Total
Connections	6%	10%	16%
Network	65%	10%	75%
Water quality	0%	9%	9%
TOTAL	71%	29%	100%

Figure 5
Contribution of the different activities to the SSM of Evides

looking for a performance indicator suitable for finding the optimal balance between failure-based maintenance and a replacement strategy. This PI also has to be in agreement with the VEWIN benchmark process.

Evides had two main objectives for participating in the pilot SSM project: to provide insight into the technical possibilities of this performance indicator for optimising maintenance activities, and to estimate the necessary efforts in management and IT development that would be needed to comply with the expected benchmark demands.

'It is better to be roughly right than precisely wrong'; with this credo in mind Evides uses estimated interruption times if appropriate and measures when it needs to. Because there is no link between the GIS and the connection system, gathering information about the length of interruptions and the number of connections in a section of network takes some effort.

Within the total SSM (Figure 5), Evides can be compared with other companies (see also Figures 2 and 3). Evides made a relatively large contribution to SSM because of planned activities. A significant part of this contribution was caused by third party infrastructure activities, as can be expected in urban areas with a dense population.

For asset management purposes Evides decided to collate equal work order activities by post code. Figure 6 shows the total SSM caused by all distribution mains-related activities for each postal code during the pilot. Similar levels were expected for all areas, though some areas have higher values. A high level of unplanned activities can point to poor construction techniques, deteriorating pipeline materials, or high stresses on the pipes because of building activities or unexpected soil movements.

A high level of planned activities may be due to a rehabilitation programme. Districts 3 and 4 show high SSM values for both planned and unplanned activities. This could be due to either a high level of connections per section or valve problems.

SSM can be used to optimise maintenance activities by comparing SSM by district or as a benchmark across all water companies. SSM registration can be undertaken with relatively little effort, and existing information systems and workflow processes are a good starting place. Weekly reports can be generated from various databases and combined in a standard office PC application. The extra yearly costs are low (around €20,000, or $24,950) and are mainly caused by extra administrative activities. A 1% cost reduction due to a more effective (SSM driven) replacement programme would justify this extra effort.

Summary

The pilot has taught the participants several lessons, some of which are for individual companies; others are valid for the whole sector.

First, the effort needed to undertake the basic implementation of SSM registration appears to be fairly low; for a more embedded registration more effort would be needed. A benefit-cost ratio can be determined from the pilot project experiences.

Second, the pilot showed that awareness of SSM throughout the whole company is very important. Good registration depends on the cooperation of a lot of people. SSM makes it easy to show everybody why they need to record all the different data and what management can do with the information.

A third lesson is that incidents have a considerable effect on total SSM. To even out the occurrence of incidents it is advisable to determine SSM over a registration period of at least one year. Furthermore, it is necessary to investigate ways of ensuring all sub-standard water pressure and water quality events are identified and come to an agreement on how the duration of complaint-driven SSM is determined.

One of the results from the evaluation of the pilot was advice for VEWIN on how to incorporate SSM into the benchmark. The advice given is to include unplanned interruptions (CML) and planned interruptions as part of SSM in the benchmark. There was no confidence that the registration of sub-standard pressure and sub-standard water quality is currently fit for the benchmark.

Despite this, the evaluation group agreed to work towards incorporating these elements into the benchmark at a later stage. In September 2005 VEWIN will decide whether or not to incorporate the unplanned plus planned interruption data in the benchmark for 2006.

For internal performance assessments and asset management, the complete SSM is seen as a very useful PI. The seven companies that joined in the pilot have all continued reporting the SSM, and the other six companies have begun to report either the total SSM or the part of it that is needed for the 2006 benchmark.

A small team of representatives from the water companies is working on a way to guarantee all sub-standard water quality and pressure events are recorded. This implies both a better definition and implementation of a monitoring programme.

The next step for the water companies will be to continue measuring SSM, enhance their IT systems to enable easier report generation, identify the performance killers and to keep improving their asset management. As part of the joint research programme several projects have begun that focus on these issues. ●

Figure 6
SSM values for five postcodes in the Evides supply region

Postal code district	Total SSM (planned network activities	Total SSM (unplanned network activities
XX01	122	0
XX02	1750	228
XX03	2933	1595
XX04	8173	2191
XX05	0	403

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New publications from IWA Publishing

Computer Aided Rehabilitation for Water Networks CARE-W
Editor: Sveinung Saegrov
CARE-W was a joint European initiative to develop a framework for water network rehabilitation. The project was supported by the European Commission under the Fifth Framework Programme for Research and Development and had a budget of €3M.

The aim of CARE-W was to support European water companies in their decisions on upgrading their water supply. The system has been developed for and tested by cities representing all parts of Europe.

CARE-W consists of software dealing with fundamental instruments for estimating the current and future condition of water networks, including tools to assess performance indicators (PI), to predict pipe failures (FAIL) and to calculate water supply reliability (REL).

Based on the results of these tools, annual rehabilitation projects are selected and ranked (ARP tool). Information of network is further used for the estimation of long-term investments needs (LTP).

The tools are operated jointly within the 'CARE-W Manager', which also contains facilities for using pipe network databases, geographical information systems (GIS) and input/output routines. The results from using the procedures are presented by reports, in tables and graphically.

Aimed at planning engineers, water utilities and municipalities and consultants working in the increasingly growing field of the planning of rehabilitation of water networks in cities.

EU project number: EVK1-CT-2000-00053
IWA Publishing, 2005; 208 Pages; Paperback
ISBN: 1843390914; IWA Members Price: £45.00 / €90.00 / $67.50
To order visit: www.iwapublishing.com

Decision Support Systems for Wastewater Facilities Management
WERF Report: Managing Utilities and Assets (00-CTS-7)
Author: Z Vitasovic
Municipalities not only have a need for purely transactional systems (accounting, personnel, billing, etc.), but they also need to integrate the sophisticated analytical tools that are used to address the scientific or engineering issues that are very important for the performance of wastewater utilities. Most commercially available systems are structured to function within the transactional paradigm and may be inadequate for full range of business processes encountered in a wastewater utility.

Wastewater utilities are overwhelmed with data, yet often, managers do not have enough information to efficiently support many of their business functions. Although significant investments into information technology have been made in the last two decades, decision makers often cannot access their organisation's information.

Decision analysis provides the conceptual framework and specific tools for describing the decision-making process. The framework provides methods and a standard notation for presenting decision-making processes in a structured way. This project describes decision support concepts, examines how private industry has approached this problem, and discusses how this technology could be applied to improve the management of wastewater facilities.

This report:
- Assists decision maker to better use their information technology (IT) resources to address their business needs
- Highlights the diversity and complexity of decision support system applications
- Describes how investments into IT are best leveraged to improve the management of wastewater agencies
- Defines the specific functional

➤ *cont:*

Diary

A listing of upcoming asset management-related events and conferences. Send event details to WAMI for inclusion.

The Adam Smith Institute's 4th Annual Conference: Infrastructure Asset Management
7-8 November 2005, London, UK
Faced with increasing demands on service levels and efficiency, the management of a company's physical infrastructure can have a huge impact on safety, predictability and performance. Clear asset management strategies are crucial for the effective maintenance and enhancement programmes required to meet obligations and surpass targets.

This conference acts as a forum for debate pulling together important figures, spanning industries that all face the challenge of managing a vitally important asset base. Key topics will include:
- Embedding Asset management practices across the company
- Collaboration and partnerships for successful projects
- Optimising asset use through risk management and understanding asset life-cycles
- The role of regulation in driving infrastructure improvements
- Analysis of best practice models

Among the speakers confirmed is Bill Emery, Director of Costs and Performance & Chief Engineer, Ofwat. For more information and to register, visit:
www.marketforce.eu.com/index.cfm?obj=conferences.overview&confid=68

Water Loss Task Force Visit to Italy
13-21 May 2006, Genoa, Ferrara, Italy
This week-long visit to Italy takes in two main events: on the Monday, delegates will atttend the Workshop for Water Industry Representatives in Genoa, followed by the H20 Fair - Ferrara International Fair, which runs from Wednesday through to Friday. On the Tuesday and Saturday visitors will take in the sights with a boat tour of the scenic coast and a day in Venice. For more information, contact Marco Fantozzi:
marco.fantozzi@email.it

1st World Congress on Engineering Asset Management (WCEAM)
11-14 July 2006, Queensland, Australia
The objective of WCEAM is to bring together leading academics, industry practitioners and research scientists from around the world to:
- Advance the body of knowledge in engineering asset management
- Strengthen the link between industry, academia and research
- Promote the development and application of research
- Showcase state of the art technology

This will be a refereed congress, with all final papers peer reviewed in full by a panel of international experts. Industry case studies will also be featured. The Congress will also host selected short courses in Asset Management on July 14 2006. Delegates will attend from all parts of the world and will include professionals from many areas of government (including policy makers), academia and industry.

The Congress will consist of keynote presentations, oral submitted presentations and poster submitted presentations. Suggested topics include:
- Strategic asset management
- Risk management in asset management
- Asset data warehousing, data mining and fusion
- Asset condition monitoring and intelligent maintenance
- Intelligent sensors and devices
- Fault diagnosis and prognostics
- Deterioration and preservation models for assets
- Human dimensions in integrated asset management
- Design and life-cycle integrity of physical assets
- Maintenance strategies in asset management
- Asset performance and level of service models
- Information systems and knowledge management

For more information and to apply, visit:
www.wceam.com

➤ requirements for DSS that would work well for a wastewater agency.

- Describes decision support systems and identifies their components.
- Demonstrates how private industry addresses issues related to decision support.
- Reviews practices related to decision support in wastewater industry.

The title belongs to WERF Report Series.
IWA Publishing, 2005; 66 Pages; Paperback
ISBN: 184339720X; IWA Members Price: £77.25 / €116.25 / US$124.00
Non Members Price: £103.00 / €155.00 / US$165.00
To order visit: www.iwapublishing.com

2nd IWA Leading-Edge on Water and Wastewater Treatment Technologies

Editors: Mark Van Loosdrecht, Jonathan Clement

Wastewater and drinking water treatment are essential elements of urban infrastructure. In the course of the last century there has been enormous technical development, so successful that for the general public in industrialised countries this infrastructure is hardly noticed.

Nevertheless there is ongoing activity to further improve the existing processes. The IWA Leading Edge Technology conference held in Prague helped to stimulate this development and this book helps disseminate the results.

A selection of presentations from the conference are included in this volume. Wastewater and drinking-water treatment are normally considered as two separate fields due to the very different boundary conditions that apply. Nevertheless several issues such as membrane processes, removal of micropollutants and water reuse are of crucial importance to both. This potential for cross-fertilization further enhances the value of this collection of high-quality articles that delineate the leading edge of research and development in water and wastewater treatment.

This title is No.8 in the Water and Environmental Management Series (WEMS).
IWA Publishing, 2005; 400 Pages; Paperback
ISBN: 1843395088; IWA Members Price: £60.00 / €90.00 / US$120.00
Non Members Price: £80.00 / €120.00 / US$160.00
To order visit: www.iwapublishing.com

Managing Water Demand: Policies, Practices and Lessons from the Middle East and North Africa Forums

Authors: Ellysar Baroudy, Abderrafii Lahlou Abid, Bayoumi Attia

The vast arid and semi-arid regions of the Middle East and North Africa region (MENA) constitute 85% of the region's land area and are home to approximately 60% of the region's population. Limited water resources pose severe constraints on people's economic and social progress, testing their resilience and threatening their livelihoods.

Water Demand Management (WDM) is about governance and tools that motivate people and their activities to regulate the amount and manner in which they access, use and dispose of water to alleviate pressure on freshwater supplies. It is also about protecting water quality. The development and promotion of such WDM practices, primarily for governments in the Middle East and North Africa (MENA) region, have constituted the core objectives supported by Canada's International Development Research Centre (IDRC) and its partners through the Water Demand Management Forums.

Managing Water Demand provides a comprehensive account of the tools used to manage water demand in the MENA region. A critical review is presented of the efficacy of WDM techniques in the areas of wastewater reuse, water valuation, public-private partnerships and decentralization, and participatory irrigation management.
IWA Publishing, 2005; 80 Pages; Paperback
ISBN: 184339104X; IWA Members Price: £37.50 / €56.25 / US$75.00
Non Members Price: £50.00 / €75.00 / US$100.00
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