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# water asset management INTERNATIONAL

PAPERS



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## Decision expected on European support for infrastructure

**The European parliament is due to vote soon on budget proposals for the European Union covering the seven years from next January. The budget will divert large grants financing for water and other infrastructure to the EU's 10 newest member states within the Cohesion Fund, which will also be reformed.**

Launched in 1994, the Cohesion Fund supports, mainly, environmental and transport infrastructure investments in the Union's poorest countries. Initially covering just three states, the fund will rise to over €60 billion for the period 2007-2013.

As part of a broad revision of regional grants to the neediest regions of the EU, the Cohesion Fund will in future be programme based. That will relieve governments from seeking project by project approval from the European Commission.

One of the biggest Cohesion Fund awards made last year went in December to a water and wastewater project in Warsaw, Poland. The Commission agreed to contribute €248 million to the €405 million project which is mainly aimed at cleaning up effluent emissions into the River Vistula.

The project is the third phase of the long term plan to improve Warsaw water supply and waste water treatment. The project will improve the quality of drinking water, while in parallel reducing the costs of surface water treatment and allowing a positive impact on the Baltic fishery industry. The project will allow the treatment of wastewater from the central and northern left bank part of the city, meaning the wastewater effluent discharged from the Czajka wastewater treatment plant will reach good quality standards and achieve the standards and norms specified in European Union Directives. In addition it will provide a long-term method of wastewater sludge management. ● **Peter Reina**

## US benchmarking survey underway

**The American Water Works Association and the Water Environment Federation have launched the data collection period for their latest Benchmarking Performance Indicator Survey for water and wastewater utilities.**

The data collection period runs from 1 March to 31 May 2006. The survey is requesting historical and analytical data from each utility's previous fiscal year. Data collected from individual utilities will remain confidential but will provide aggregate information for benchmarking. Each participating utility will then receive its own statistical summary to compare to the aggregate data, allowing them to measure their performance and efficiency in 22 key benchmarks.

Benchmarking is the process of identifying a utility's strengths and areas for improvement by looking at key operation and management areas, and comparing them to established standards of performance in those areas. The Benchmarking Program is a joint effort of the two organisations. The 22 benchmarks are in five areas: organizational development, business management, customer relations, water operations and wastewater operations. More than 200 utilities participated in the 2004/2005 survey.

A comprehensive data analysis report that more fully interprets each benchmark indicator is available from AWWA (www.awwa.org/bookstore). The full report, 'Benchmarking Performance Indicators Survey and Analyses', will be produced every three to four years and presents summary analyses and interpretive text for each performance indicator. ●

## UK water firm ordered to refund £42M to customers

**Economic regulator Ofwat has published its interim report into allegations about false reporting of information by UK water utility Severn Trent Water.**

The report sets out the regulator's interim findings into certain allegations made by an employee of Severn Trent Water, and the actions Ofwat will require the company to take. Ofwat's concerns about the reliability of leakage data are not covered in the report because this issue is currently being investigated by the Serious Fraud Office (SFO).

Ofwat's investigation found that Severn Trent Water had provided regulatory data that was either deliberately miscalculated or poorly supported. This led to price limits being set for the water company that were higher than necessary, which would have resulted in customers paying £42 million more by 2009-10. This is equivalent to between £2 and £3 each year on an average household customer's bill.

Severn Trent Water has agreed to reduce its price limits to return the £42 million to customers. The company is returning £7 million of this in bills currently being sent to customers. The remainder will be returned to customers over the next three years of the current price review period. ●

water
asset management
INTERNATIONAL

EDITORIAL

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**Water Asset Management International is an international newsletter on asset management in water and wastewater utilities. The focus of the newsletter is on the strategic aspects of this developing field, providing utilities with international perspectives on infrastructure planning and maintenance as they seek to deliver cost-effective services to their customers.**

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# US EPA under fire for lead rule data gap

**The US Government Accountability Office (GAO) has criticised the Environmental Protection Agency for not having in its database information from over 30% of large and medium-sized community water systems on the amount of lead in their supplies.**

The EPA also does not have data on the status of the efforts to implement the lead rule for 70% of systems, apparently because states have failed to meet reporting requirements.

The report from the GAO notes that ‘implementation experiences to date have revealed weaknesses in the regulatory framework for the lead rule. For example, most states do not require their water systems to notify homeowners that volunteer for periodic lead monitoring of the test results.’

It adds that in addition, corrosion control can be impaired by changes to other treatment processes and controls that might help avoid such problems may not be adequate. The report also warns that because testing indicates that some so-called ‘lead-free’ products actually leach high levels of lead into drinking water, existing standards for plumbing materials may not be sufficiently protective.

From the data available it appears few schools and child care facilities have tested their water for lead. The report also notes that ‘no focal point exists at either the national or state level to collect and analyse test results. Thus the pervasiveness of lead contamination in the drinking water at schools and child care facilities – and the need for more concerted action – is unclear.’

The GAO is recommending that it improve its data on key aspects of lead rule implementation, strengthen some regulatory requirements and oversight, and assess the problem of lead in the drinking water at schools and child care facilities.

The EPA’s spokesman noted that the agency has issued comprehensive new guidance for protecting against lead in schools and is close to issuing proposed changes to the federal rule. ● **Lis Stedman**

## Alliance wins first privatised water sector contract in Northern Ireland

**The Xansa-led Crystal Alliance has won a seven-year, £70M ($122M) contract to run the Northern Ireland Water Service’s customer billing system. The organisation will be responsible for billing some 760,000 domestic customers when the privatisation takes place. Under the contract, the Crystal Alliance will establish a customer relations centre to handle customer complaints and enquiries, which will be managed by sub-contractor Echo Managed Services.**

The contract will also eventually see the Alliance providing technical services to support the Water Service’s field force as it manages and maintains the water and wastewater infrastructure.

The billing centre, when it is implemented in April 2007, will create 180 jobs locally. Protecting the customers is a set of performance targets designed to ensure that industry-leading standards of service are achieved.

The Northern Ireland Water Service provides water and sewerage services to over 730,000 domestic, agricultural, commercial and business customers throughout Northern Ireland, with an annual budget before capital charges of £302M ($524M) and fixed assets of £4.9 billion ($8.5 billion). Each day it supplies 710 million litres of drinking water to customers.

Around 83% of households are served by the public sewerage system. The Water Service collects, treats and disposes of around 134Mm$^3$ of wastewater each year. In addition, it provides a desludging service for over 59,000 private septic tanks. The Water Service employs around 1900 staff in total.

To protect public health, meet European standards on water quality and respond to increasing demand sustained investment in water and sewerage infra-structure it is estimated that a £3 billion ($5.2 billion) spend will be required over the next 20 years. Over the next three years Water Service plans to spend £590M ($1024M) on the first tranche of this expenditure. ●

# Italian resort ‘future-proofs’ water network

**The Italian city of Fano has been using water network modeling solution InfoWorks WS from Wallingford Software, to future-proof its network and smooth out pressure problems.**

Fano is a resort town and fishing port at the mouth of the Metauro river on Italy’s Adriatic coast, in the Marche region, close to Rimini and Ancona.

Multi-utility ASET, which has an annual turnover of $33 million, provides potable water, wastewater and waste services for the area. The main municipality that ASET manages, Fano, has one water treatment works producing 13 gallons/sec (50 litres/sec), with the additional 52 gallons/sec (200 litres/sec) supply coming from a treatment works outside ASET’s area. Fano’s network is divided into three pressure zones, one taking in the southern area of Metauro.

ASET was already using a software package to model its potable water network but decided to upgrade and examine a number of other options to progress the improvement programme for its 600km of mains.

Dr Marco Romei, who heads ASET’s technical department, is in charge of the project. He says: ‘The main problem was that there is a prediction that in a few years the city’s population could be 80,000 and there are challenges for the distribution network with the new demands added. There were also some existing areas where there were pressure problems and we needed to understand why these were occurring.’

An initial model of the city centre and surrounding area has been developed. Dr Romei says: ‘After calibrating the model, we have undertaken some simulations, defining network districts and inserting pressure reducing valves controlled by flow and pressure. The results are good so we intend to go ahead and commission this work.’ ●

# Asset management around the world:
## the expertise of Australia/New Zealand, the UK and the US

The Australian and New Zealand approach to asset management is often touted in published literature and held up as the front-runner in asset management best practice. The tools and techniques born in these countries have been exported overseas and applied to many US utilities. Is this approach really the be-all, end-all asset management solution for US utilities? This paper will explore asset management best practices from around the world. While the Australia and New Zealand technique has its merits, so do tools and techniques developed in other regions of the world.

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### Common global challenges

**People in developed countries have high expectations for their quality of life. Physical infrastructure – transportation, health, education, water and energy – is a core enabler of that concept. Today's global economy depends heavily on the developed world's physical infrastructure – its components enable the international flow of goods and services.**

The expectation that these systems will perform with speed and efficiency is increasing, while many of our basic systems – water, roads, energy, power grids – are reaching the limits of their capacity. New demands for better security mean many countries are retrofitting existing infrastructure in order to bring it up to new standards, a process that is enormously costly.

The maintenance of aging and failing infrastructure is also an ongoing challenge – recent infrastructure report cards and studies have shown a common theme, that the state of existing water infrastructure is deteriorating and there is a significant backlog of investment, required to ensure that water utilities can continue to deliver sustainable services to their communities.

A dilemma also exists – whether to repair old infrastructure or upgrade to new. Many municipalities and private utilities have traditionally focused on meeting infrastructure needs through ongoing investment in infrastructure creation, without recognising the need to reinvest in infrastructure to maintain and renew existing assets. Finally, and perhaps most importantly, public policy makers are often prisoners of civic unwillingness to invest in what is not yet broken, and are unable to address – or even to recognise – the challenges ahead.

### Global contrasts

While utilities in developed countries do share these challenges, there are also many contrasts. Primarily, population and the sheer number of utilities have a significant impact on business drivers and how asset management is handled within each country.

Further details on each of these countries are outlined below.

*Figure 1*
Global contrast: populations, service provision and focus in English-speaking countries.

**New Zealand**
- Pop. 4 million
- 72 public water/wastewater utilities
- Asset management regulated
- Customer and continuous improvement focused

**Australia**
- Pop. 20 million
- 200 public water/wastewater utilities
- Asset management regulated at state level
- Customer focused

**United Kingdom**
- Pop. 60 million
- 27 private water/wastewater companies
- Asset management highly regulated
- Investment focused

**United States**
- Pop. 295 million
- 70,000 private and public water/wastewater utilities
- No real regulatory driver
- Technology focused

### The global evolution of asset management: New Zealand

Since the mid-1980s, New Zealand has undergone a period of structural reform aimed at improving the efficiency of the internal economy while simultaneously bringing greater stability to the macro economy. An effort has been made to open individual sectors of the economy to competitive pressures and to allow market signals to dominate investment, production and consumption decisions, with the aim of improving the productive potential of the economy. Public sector (including municipal) reform has been aimed at both reducing the role of government in the provision of goods and services, and improving the efficiency of the public sector.

Reforms over the last decade include:

- legislative reform, requiring transparent and prudent financial management and long-term financial planning by municipalities. A legislative requirement was passed for municipalities to adopt accrual accounting techniques, to include infrastructure assets in financial statements, and to recognise and fund depreciation of these assets to allow for future renewals and replacements.
- infrastructure age and decay, leading to failures and a heightened awareness of the implications and cost of failure, has caused the replacement and maintenance of assets to take up a growing proportion of municipal expenditure.
- a requirement for municipalities to move from 'protective' to 'competitive' practices, which has led to 'non-core' activities being outsourced to the private sector. Municipalities are required to produce and adopt an 'asset management improvement plan' that outlines the timeframe and physical and financial resources required to improve asset management practices.

As a result of the state of development, complexity and variety of asset management practices, and the diversity of people and organisations involved in implementation, municipalities developed an industry-wide approach to these issues.

In New Zealand, the Association of Local Government Engineers New Zealand (ALGENZ, who initiated the formation of the National Asset Management Steering [NAM] group) spearheaded this response. The NAMS group, comprising representatives from both government and industry agencies and associations, was formed to develop and promote infrastructure asset management practices, policies and systems in New Zealand. This is an autonomous group, and its activities are funded by contributions from its member organisations, sales of asset management manuals and subscriptions to training seminars.

Key initiatives undertaken include:

- development of the New Zealand infrastructure asset management manual, which provides municipalities with a comprehensive framework for complying with legislative asset management requirements.
- development and delivery of an intensive series of training workshops aimed at developing support and enthusiasm for asset management, introducing participants to the key principles and concepts and assisting in the development of appropriate implementation strategies.
- the use of common decision-making and management tools (such as infrastructure management software systems) to aid municipalities in developing asset inventories, recording physical and financial information, preparing valuations, predictive modelling and economic analysis.

This national industry approach has enabled New Zealand municipalities to make rapid advances in improving asset management practices, and has provided the resources for the industry to draw on best practices in municipal asset management from throughout the world.

### The global evolution of asset management: Australia

While Australia has not undertaken economic reforms to the extent that New Zealand has, both federal and state governments have implemented strategies to secure gains in efficiency and productivity. Australia has also sought to increase economic efficiency through programmes of commercialisation and privatisation, which has affected utilities and transportation.

As in New Zealand, these reforms are being implemented against a background of increased community expectations as to the quality and extent of services provided by federal, state and local governments. In Australia, the asset management concept was tied into municipalities by Australian Accounting Standard 27 (AAS27) 'Financial reporting by local government', which requires infrastructure assets to be accounted for and included in financial statements.

The regulatory environment in which municipalities and utilities operate varies from state to state, but there has been a focus on regulating the prices of utility services. This has led to utilities developing more robust asset management practices and detailed asset management plans, to support pricing audits undertaken by government regulators.

Australia's industry-wide approach to asset management has been driven mostly by municipal managers and the Institute of Public Works Engineers Australia (IPWEA), which has undertaken the development of an Australian infrastructure asset management manual (on which the New Zealand manual was based). However, these activities have not been implemented to the same extent as in New Zealand due to the differing regulatory frameworks between states, and a lack of explicit requirements for producing long-term asset management plans.

More recently the IPWEA and ALGENZ have agreed to prepare an international infrastructure asset management manual, which incorporates current international asset management practices.

Australian municipalities and utilities are progressively improving their asset management approach but lack the national coordinated approach of New Zealand. However, state level regulators are progressively introducing more robust asset management planning requirements and practices to support pricing regulation.

### The global evolution of asset management: United Kingdom

In the UK, the leading asset management practices have come from an industry that has been privatised since 1989 and is now heavily regulated. These private water companies are required to manage their capital programmes on a five-year cycle known as an Asset Management Plan or AMP. These strategic asset management plans (which outline the investments required to meet service obligations) are submitted to the Office of the Water Regulator (Ofwat) for audit purposes. This requirement has driven water companies to develop robust business cases for future expenditure and led to the development of a more comprehensive asset management approach.

The UK's long experience in a regulated asset management planning environment has led to the development of sophisticated analytical tools and techniques for forecasting and planning infrastructure investments. Relating this to the asset management model outlined earlier, UK utilities could be viewed as leading in the area of asset capabilities, having robust and highly developed techniques for assessing condition and performance and producing sophisticated long-term expenditure forecasts.

Many of the asset planning methodologies currently used in Australia and New Zealand are based on practices developed in the UK water industry.

### The global evolution of asset management: United States

In the US, the Government Accounting Standards Board (GASB) has introduced rigorous accounting standards for improved asset management. The standards require municipalities to value and calculate depreciation for assets via the depreciation method or modified approach, but most municipalities and utilities have chosen the depreciation method, which does not provide a better understanding of future infrastructure requirements.

The American Public Works Association (APWA) formed a sub-committee to define asset management and oversee its development and application in the public works field, a similar body to the NAMS group and IPWEA in New Zealand and Australia.

In 2002, the Water Environment Research Federation (WERF) and the Environmental Protection Agency (EPA) held a forum in Washington, DC to identify and prioritise an asset management research agenda for the US that resulted in a prioritised list of research projects, some of which are currently under way. These include projects such as the AMPLE (Asset Management Program Learning Environment) web portal project, and a condition assessment protocols project.

More recently, the EPA has taken a lead role promoting the asset management concept in the water sector and has held a number of workshops in the US aimed at promoting the concept of asset management in the water industry and hosted a collaborative working session on asset management. A key outcome of this session was the formation of the National Asset Management Steering (NAMS) council, with an objective of advancing asset management in the US.

Research and development of asset management concepts in the US is limited although some municipalities have developed advanced capabilities in specific areas such as business process, information technology and data management. However there is little evidence of an overall asset management framework, as in Australia and New Zealand, or an investment-planning regime as in the UK.

This can be partially attributed to the size and complexity of the water industry in the US, where it is commonly reported that there are 54,000 independent community wastewater systems and 16,000 waste-water systems. Compare this with 10 water and wastewater companies and 17 water only companies in the UK, 72 municipal-owned utilities in New Zealand, and approximately 200 in Australia.

While the US lacks an overall asset management framework, some municipalities have developed advanced capabilities in specific areas such as business process, information technology and data management as mentioned above. Much of the information technology used by leading utilities worldwide is developed in the US. One of the key enablers of modern asset management is recent advances in technology that have enabled vast amounts of asset data to be analysed in ways that were impossible 10 to 20 years ago.

An example of a leading US utility is the city of Fort Worth. Fort Worth provides water and wastewater services to 510,000 retail and 29 wholesale customers in 29 communities through 4000 miles of water distribution and 3700 miles of sewer collection infrastructure. The city needed a strategy for asset lifecycle management, asset data management, IT systems integration, and a system for managing its $200 million annual investment in capital infrastructure projects.

The city has implemented several business processes and integrated IT systems to support asset management. The IT solutions enable it to manage assets from a cost, failure, and operations perspective, which was not possible with previous systems. The city has also implemented a capital programme management system (CPMS) to improve the performance of its capital improvement programme (CIP). The city's CPMS provides an integrated set of tools for managing capital projects from inception to completion. The system automates and standardises the city's specific business processes, provides real-time project cost visibility, helps manage funding sources, and tracks performance both within and across projects.

### A model for asset management

Before summarising the strengths and weaknesses of asset management in each geographical area, it is useful to review a model that illustrates the key components of successful asset management. The model shown below breaks asset management in three components as follows:

- developing vision and strategic direction (business drivers and service levels)
- physical asset investment strategy (managing asset capabilities)
- business process, information technology and data management (managing business capabilities)

### Business drivers and service levels define vision and strategic direction

Business drivers define the environment and constraints under which a utility operates and influence how service levels are defined and achieved. Examples include regulatory requirements, population growth, and political influences.

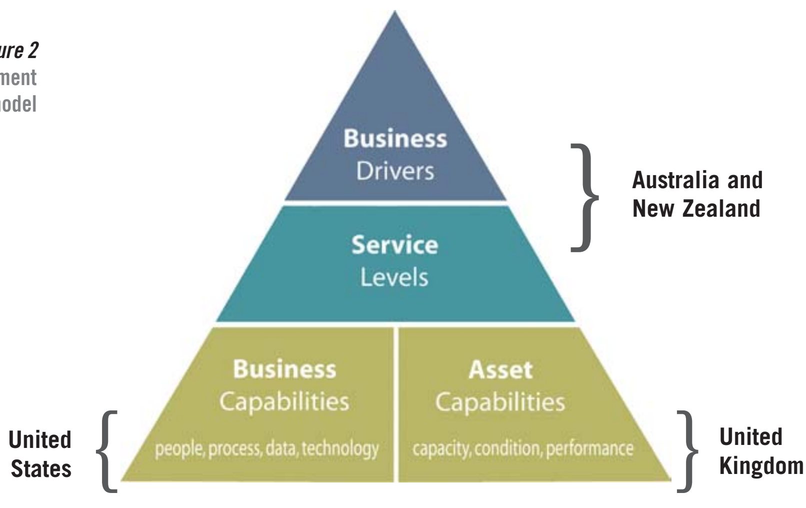
Service levels are the performance goals of the utility. Response times, number and duration service outages, and non-permitted discharges are examples of service levels. Business drivers and service levels are analysed, addressing both asset-specific measures (such as sewer overflows), and common business drivers such as regulatory compliance, customer, and stakeholder demands, and financial performance.

The definition of business drivers and service levels forms the vision that sets direction for future planning strategies. This is the area of asset management where Australian and New Zealand utilities lead the rest of the world. Asset management in Australia and New Zealand has a very strong emphasis on delivery of service to customers and definition of associated service levels that explicitly define the effectiveness of service provided to customers. The emphasis in Australian and New Zealand utilities is on publicly reporting service performance to customers and stakeholders.

### Business and asset capabilities enable achievement of vision

With service level objectives in place, the utilities can then focus on assessing both the business and asset capabilities

***Figure 2***
**Asset management model**



that are required to achieve service goals.

Business capabilities – people, processes, data, and information technology – form the foundation of successful asset management programmes. Being able to achieve service level objectives means having the right information, tools and processes for making decisions and undertaking work. It also means having organisational roles and responsibilities defined to achieve programme objectives. This is the area of asset management where US utilities lead the rest of the world. While utilities in the US lack a consistent asset management planning framework, investment in business capabilities, and in particular information technology, has developed powerful tools that enable sophisticated asset management.

Asset capabilities are the asset characteristics (asset condition, capacity, and performance) required to achieve service level targets. By aligning its infrastructure investments with its service level goals, utilities can gain a clear picture of how to best invest its limited capital and O&M dollars. This is the area of asset management where UK utilities lead the rest of the world. Regulation of water utilities has driven a robust investment-planning framework that forms the basis of UK utilities rate cases.

### Summary and conclusion

The tools and techniques documented in Australia/New Zealand have been exported overseas and applied to many US utilities. Australia and New Zealand have done an outstanding job in bringing best practice from other parts of the world (in particular the UK) and assembling this into an over-arching strategic asset management framework. The UK water industry is a clear leader in asset analysis and investment planning due to a long history of economic regulation of the water industry. The relatively small number, and large size, of utilities has assisted in the development of sophisticated investment optimisation techniques. While the US lacks an overall asset management framework, some municipalities have developed advanced capabilities in specific areas such as business process, information technology and data management as shown in Fort Worth. Much of the information technology used by leading utilities worldwide is developed in the US, and many US utilities embark on asset management in an attempt to better leverage technology investments.

In summary:

- asset management is a global issue that needs a global response
- best practice asset management comes from across the globe, and different drivers have created different approaches, that when coordinated and integrated can provide powerful solutions to asset management problems.
- the sheer size and complexity of the US water and wastewater industry means that implementing a common asset management approach is a significant task that will take time and resources. Many US utilities embark on asset management to gain more value from their investment in technology
- formation of a Global Asset Management Institute aimed at sharing knowledge and expertise amongst AM professionals (consultants, utilities and researchers) may be the next step. While the steering groups and councils established go some way to promoting the AM concept at the utility level, we need a global organisation with a focus on sharing best practice techniques to ensure we can live up to the promise of delivering asset management-based solutions. ●

# The AMPLE Tool: Asset Management Program Learning Environment

Modern water asset management requires new and sophisticated tools for effective operation. This paper records how the lessons we have learnt from around the world in asset management over the last twenty years through accumulated knowledge from traditional learning systems have been applied into a web based program-learning environment.

By researching and really understanding the key success factors for cost effective and sustainable asset management improvements across infrastructure rich businesses in both the private and public sectors, the authors hope to be able to show that by web enabling this information, we now have a powerful on line encyclopaedia of asset management knowledge.

This paper answers the two questions asked by asset managers, owners and stakeholders around the world:

i) How can we drive logical, sustainable, cost effective asset management across the organisation to derive the benefits available through advanced asset management techniques?

ii) How do we achieve best value asset service delivery at the lowest sustainable triple bottom line cost for present and future generations of customers and stakeholders?

By working with clients, and users the ideas formed into a product now known as AMPLE – the asset management program learning environment. This paper describes this product and the way it assists clients to answer the above questions and bed down the results in their work practices, attitudes and culture.

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## The strategic context

**We have been successfully building and operating water assets for generations. Quite naturally, the water sector has shifted from being oriented toward building and operating assets to focusing more on successful long-term (sustainable) management of assets.**

As this transition has evolved it has brought promising new approaches in systems monitoring capabilities, information handling and the maturing of decision support systems. The new tools and techniques are very timely in that they allow us to think about choices in more sophisticated ways; to better understand condition, to better predict failures, to consider consequences and to make better informed decisions about optimal strategies for meeting our service objectives.

The evolving asset management processes are good at guiding decisions about the most effective mix of maintenance, repair, renewal or replacement of components within the systems. These are the decision processes central to effectively managing mature water utilities. The efforts to improve service and control costs are an integral part of any forward-looking utility's organisational culture.

Successful strategies demand that these new approaches be applied broadly to the hundreds of decisions made within a utility to ensure that the whole portfolio of assets performs as required. These new techniques must ultimately become second nature, every day, to the thousands upon thousands of people who labour in the trenches of the water and wastewater profession. Change must be fostered in the management culture of many water businesses. The desire to coordinate, collaborate and facilitate the transfer of knowledge about these emerging practices has taken hold in the water sector.

Underpinning this feature is the understanding that there is a common framework that applies to strategically managing water assets, or for that matter, any infrastructure assets. This article explores how a web-based knowledge management support system can play a large role in supporting our learning and growth requirements and in helping us to collaboratively build on each other's experiences and effectively share critical information.

At this time, web-based applications are up and running in Australia and in the US. The lessons learnt from around the world about asset management processes and practices have been recorded and structured to provide the content of the Asset Management Program Learning Environment (AMPLE).

The critical next juncture is taking up the question of how we effectively collaborate in furthering this way of sharing knowledge. If we can solve the challenge of industry-wide and worldwide involvement, the potential to build upon and further expand AMPLE is without parallel in its prospects for enhancing knowledge acquisition and transfer across several infrastructure sectors. The authors hope to be able to show that by web enabling this information we now have a powerful on-line encyclopaedia of asset management knowledge. Our objective in presenting AMPLE is to help:

- drive asset management improvements across entire enterprises, including diverse business units such as those found in the large utilities and municipalities
- allow the cost effective training of staff at various levels in all aspects of advanced life cycle infrastructure asset management
- permit tailoring to suit individual organisations and their key divisions
- facilitate a roll up of information and strategies across the whole of enterprise, and for that matter across a whole state or nation.

Underpinning the development of AMPLE is an awareness amongst professionals and leaders in the water sector that the pursuit of excellence in the management of assets requires that we improve upon and modernise the way in which essential information can be broadly accessed, readily explored, shared, and easily updated to reflect new knowledge.

The AMPLE tool itself resulted from a series of commissions with portfolio managers ranging from the Brisbane city council, to whole-of-government asset management systems for the Australian state governments of Queensland and the Northern Territory, to more recently, the Water Environment Research Foundation (WERF) in its asset management knowledge tool known as the Sustainable Infrastructure Management Program Learning Environment (SIMPLE).

## Background

During the previous 15 years, many of us in the asset management fellowship have focused our thinking and energies on better understanding what has been successful in implementing advanced asset management. As a result of these learning experiences, we have come to identify a series of critical areas that are preconditions to improvement:

- developing a repeatable quality framework assessment process that allows asset owners and operators to really know whether they were improving or not and to decide to what level they should improve;
- building a methodology that enables an enterprise to tailor its process to meet its needs and determine a level of 'best appropriate practice' that is cost effective for it;
- driving logical and cost effective AM improvements to match available resources, so as to spend scarce resources on what really matters (better focus);
- ensuring that the improvements are sustainable through the adoption of sound cultural change management processes for both the organisation and individual staff and work groups;
- increasing awareness and training staff, managers and elected officials with adequate skills to ensure full ownership and accountability;
- enabling the application of Total Quality Management, ISO accreditation, balanced scorecards and continuous improvement techniques to these future activities.

## The Guiding Principles and Mechanics of AMPLE

AMPLE is a web-enabled knowledge management system that helps organisations and their staffs gain an understanding of:

- the principles of life cycle asset management, from basic to advanced infrastructure asset management (IAM), in a step-by-step process at three levels ranging from novice to sophisticate;
- the essential components of a state of the art asset management improvement programme;
- enough 'how to do it' information to enable users to drive their individual improvement programmes.

AMPLE has been developed to allow asset managers with varying degrees of experience to progress their thinking. It encourages the user to methodically flesh out the required skills. By completing a simple questionnaire the user can enter the system at a level where the information is most relevant for them. The guidelines are tailored to accommodate the current proficiency of the individuals; as users become more knowledgeable, they are able to drill down to more complex material. This approach allows user organisations to drive their asset management improvement programmes by tailoring their activities to suit their organisation, rather than trying to make one model fit all organisations. The basic businesses may be the same, or similar to others, (for instance, water/utility) but the assets (the position in their life cycle and performance), and the political environment, regulatory framework, and the consequences of failure are likely to be vastly be different.

The user can dig down to greater detail through a traditional tree structure menu, through a life cycle process or through the 'quality elements'. AMPLE is the web-enabled catalyst for collating the world's best practice methodologies. The AMPLE Tool is made up of the following key modules:

### *The underpinning foundation - the quality framework (TEAMQF)*

AMPLE is underpinned by an ISO-based quality framework called the Total Enterprise Asset Management Quality Framework (TEAMQF). This allows the organisation to compare its performance in each aspect or function of the asset life cycle by:

- monitoring progress and improvements
- benchmarking their input processes
- identifying and developing the most cost effective improvement projects
- incorporating training modules that match to specific assets and levels of sophistication
- adding or linking to specialist tools to assist in decision making
- adding case studies to demonstrate the benefits of making these changes and improvements
- helping organisations acquire ISO accreditation.

Under the primary element of life cycle processes and practices there are two distinct spheres. The processes needed to manage infrastructure life cycles are generic. We manage the life cycle of a road, sewer and piece of electrical equipment the same way, but we apply vastly different practices to these life cycle functions, for example, condition assessment techniques.

### *Best practice life cycle processes*

Figure 1 shows the life cycle processes or the journey of an asset throughout its lifecycle. AMPLE enables the user to link to a series of 'best practice guidelines', which explain processes in a step-by-step manner, up to the level of world's best practice. Each organisation can use these guidelines to drive asset management to a 'best appropriate practice' (BAP) for their organisation and their entire asset portfolio.

### *Industry and asset-related practices*

AMPLE conveys organised information on best appropriate practice for carrying out an activity to suit the type of industry / use and the assets involved, such as condition assessment practices for flexible asphalt pavements or a concrete gravity sewer. Again, the information is built on a step-by-step approach to foster practices that are applied only when required or economically justified. A series of related asset practices are

included in the searchable source material. These include:
- Asset data standards
- condition assessment techniques
- valuation and costing techniques (replacement)
- levels of service and performance indicators
- maintenance practices
- renewal/rehabilitation options
- failure modes
- causes of failure
- consequences of failure.

The tool allows users to understand the generic life cycle processes involved and then link to the actual practices best suited to the individual asset type. By matching these processes to improved data quality and timeliness, the idea is to raise confidence that the best decisions are being made. It helps validate for staff, management, elected officials, and other stakeholders that the investment decisions in operations, maintenance and capital are the very best that can be made.

## The Application of Gap Analysis tools

Central to the TEAMQF approach is the ability to determine the effectiveness of an organisation's management practices by identifying the distance between the current state or the 'as is' – and the desired state – the 'to be' for future sustainable business operations. The Gap tool identifies the actual improvements that need to be made to processes, practices, data, information systems, asset management plans, people and organisation issues, asset management plans and the commercial services delivery tactics, to give our stake-holders the best value sustainable service.

The Gap Analysis tool can be administered at three levels of sophistication.

### *Level 1*

The Level 1 assessment tool is a comprehensive multiple-choice questionnaire. The input data is compared with that of similar organisations and best appropriate practices, and reported graphically. A short text report and a detailed list of targeted and prioritised improvement projects accompany this benchmarked comparison. This tool assesses the 23 secondary quality elements and reports at the primary level.

### *Level 2*

This tool expands on the information requirements of the Level 1 tool, broadening the questions under each of the quality elements from around 150 to over 500. This increases the level of confidence and the detail of the reporting analysis. The generic processes of Level 1, which apply to all industry sectors, contain the same material content, whereas the Level 2 industry related practices drill down to specific questions. This process requires a hands-on approach through a series of workshops to identify all the key issues flowing from the primary, secondary and tertiary levels of the quality framework. This tool assesses at the tertiary element level and reports at the secondary element level.

### *Level 3*

The Level 3 tool takes the Level 2 tool to higher confidence levels. It involves a high level interview and analysis process to determine the current state of the organisation. This gap process can take up to 15 weeks to complete and requires a series of facilitated training workshops with all asset management staff, executive management and elected members to provide the sense of ownership that facilitates follow-through on the improvements. This tool assesses at the quaternary level and reports on 165 tertiary quality element levels.

This suite of Gap Analysis tools allows users to:
- identify world's best practice (WBP) by links to the quality framework and the guidelines
- identify and agree with the current practice, the current quality rating (CQR)
- observe how similar businesses perform, and benchmark themselves against them
- decide on a best appropriate practice (BAP) level that suits the organisation and forms their future improvement target
- identify all the improvement tasks and projects that will need to be completed to close the gap.

***Figure 1***
**Life cycle processes of an asset.**

## Understanding the benefit – the Benefits module

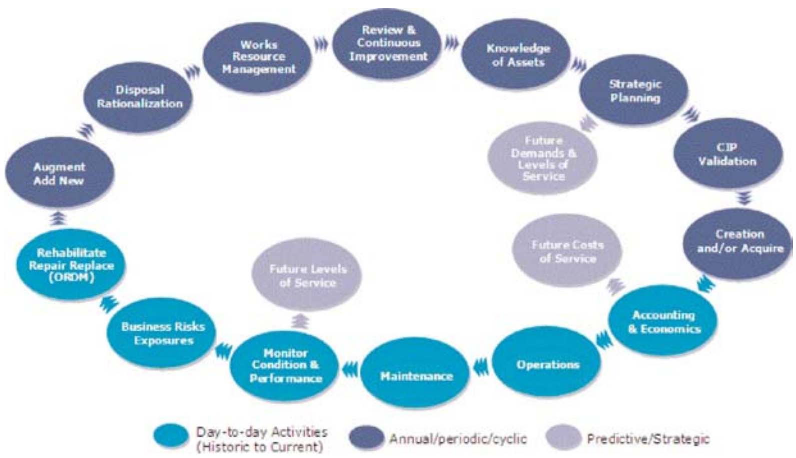
The outcome from any of the three levels of the gap analysis is a list of the areas of greatest priority for an improvement programme that is specifically designed to close the identified gaps. The benefits module enables the user to determine the benefit that will be achieved by accessing the experience of others who have made these improvements.

The major areas of benefit assessment include:
- understanding the full economic cost of infrastructure service delivery
- quantifying the real depreciation or consumption of assets, based on the cost of their life extension or renewal
- focusing the analysis on the whole of life cycle costs, including allowances for environmental and social impacts
- disclosing the issues of inter-generational equity
- recognising future renewal liabilities and operational issues
- understanding the implications of operating on a commercial business basis with a 'user pays' funding framework.

Once we know the benefits and costs, the next step is to identify what are typically called 'quick wins', (those tasks that need to be completed early but may not represent the best benefits or costs) and then to develop the full long-term roadmap, which is an asset management improvement plan.

## The Asset Management Improvement Plan module

The Asset Management Improvement Planning module identifies options that will deliver the 'best bang for the buck' while moving toward a sustainable asset management organisation. In simple terms, the enterprise will get the greatest benefit by doing the improvement projects that address the biggest gaps and where taking corrective measures will provide the



highest value to the business.

The module provides a vision, a full 'roadmap' for the ultimate journey, with the users and enterprise controlling how far, how fast and how much to spend. As we get further down the path, we learn more about our organisation and our assets (perpetual discovery), and we can adapt our approaches as our understanding matures.

### The Effective (Sustainable) Implementation module

The Effective Implementation module covers all the issues that ensure successful implementation, including planning, cultural change and people (staff) and organisational issues. The ISO aspects of the tool, its repeatability and the way it is all tied together to achieve logical and justified improvements in AM across the entire enterprise, are its unique strengths. Because the transition to advanced asset management is really a change management process, AMPLE is designed to ensure that individual staff and organisational change issues are fully addressed and supported.

### The learning environment – the training modules

Infrastructure-rich organisations, utilities and municipal businesses around the world have identified staff skills and training as a key risk. There is little formal advanced infrastructure asset management training available. The training or learning environment modules enable staff at all levels in the asset management programme to learn using a web-based curriculum. This learning avenue can be combined with the courses available in many of the elements of an asset's life cycle (such as maintenance and risk) and those directed at a specific industry or asset type.

The rate of change in new techniques and new technology means that organisations are in a continual state of change and this will place huge demands on training and mentoring. The training needs must also be linked to our roles and responsibilities and cover junior staff or apprentices right up through trades and supervisors to the professional engineers, accountants and other specialists through postgraduate degrees in this specialist area.

Effective change management is dependent on our ability to introduce new approaches and techniques and teach these to the staff responsible for those functions and assets. It drives the success of change and therefore the benefits that are derived. The opportunity exists to develop and deliver a comprehensive asset management training environment at a state level, national level and even globally. Like all parts of the tool, the training programmes use the step-by-step techniques to ensure that trainees get to understand the best way to complete improved AM practices with the scarce resources available to them.

With the AMPLE tool it will be possible to build a set of eLearning courses that would be at the forefront of developments in this learning environment. Delivery modes could be primarily through eLearning and distance education for individuals, but also through face-to-face training for corporate groups and individuals as part of their continuing education, right up to postgraduate degrees and even doctorates. AMPLE provides a common framework to build upon the concept of an eLearning environment.

### Conclusions

The world of infrastructure asset management (IAM) has advanced significantly over the last two decades. There have been many projects and activities that have driven the practices from an art towards a real science. However, the picture is still far from complete and there is much more that can be done. Too many times we have seen great efforts and tremendous resources not used as efficiently as they could have been because getting all the pieces of the puzzle in order proved to be too complicated. Infrastructure asset management is not easy, but it is vital to the future of our communities and their standards of living.

The current model of AMPLE provides a tremendous building block, a great vision for the future and offers incredible opportunities for infrastructure owners, managers, staff, regulators, users/ratepayers and politicians. In the end, getting better is all about improving the decision processes and the quality of information used to inform choices. AMPLE is a major step along this pathway toward more organised knowledge and improved ability to effectively share this knowledge. ●

### References

This paper is the second in a trilogy of papers relating to improving infrastructure asset management around the world including:
*Lessons learned in infrastructure asset management – world wide. IPWEA conference, Adelaide May 2005*

*The AMPLE tool suite – a response to the lessons learned in AM. Ingenium conference, Rotorua New Zealand, October 2005 (this paper)*

*Infrastructure asset management – a global approach and model. To be published in WAMI – Water Asset Management International – June 2006*

*AMQI Asset Management Quality International http://www.amqi.com/*

*WERF – SIMPLE project http://www.ism.com.au/WERF*

*Institute of Asset Management UK http://www.iam.org.uk/*

*NAMS Australia is an initiative of the IPWEA http://www.ipwea.org.au/nams*

*NAMS New Zealand – the development of asset management best practice within New Zealand. http://www.ingenium.org.nz/nams*

*NAMS Council USA – the Council is just being formed to develop asset management best practice within the USA Water Industry*

*Department of Infrastructure Canada – The national guide to sustainable municipal infrastructure http://www.infrastructure.gc.ca/info/innovation*

*WORLEY-GHD & NAMS ALGENZ & IPWEA Australia, International Infrastructure /Management manual, ALGENZ, first edition, November 2000*

*Byrne, R: The evolution of advanced asset management in Australia and New Zealand. Paper to the US General Accounting Office 2002*

# Benchmarking civil maintenance performances and practices in the urban water industry: *key perspectives and emerging challenges*

Benchmarking work undertaken by the Water Services Association of Australia (WSAA) has attracted international interest and participation. This article presents the latest process benchmarking study.

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**In early 2005, 17 WSAA members from Australia and New Zealand, with two water utilities from the US and Canada, embarked on a comprehensive process benchmarking study designed to measure the efficiency (cost) and effectiveness (service level) performance of and identify leading practices in a number of key Civil Maintenance activities. Table 1 shows the benchmark peer group.**

The benchmarked activities were classified into reactive, preventative and renewal (capital) Maintenance and included activities relating to water and wastewater assets and operations. Table 2 shows the 15 civil maintenance activities benchmarked.

Results of the study highlighted utilities that are leading and lagging in performance and the key drivers of such performance. Interestingly, all water utilities and the industry as a whole were presented with perspectives, insights, and challenges that were immediate and likely to last well into the long term and into the next round of civil Mmaintenance benchmarking.

### Project details and deliverables

UMS, with its alliance partner GHD, were selected from a WSAA tender process to carry out the engagement, with oversight of the project conducted by a WSAA steering group of five member companies including Barwon Water, Hunter Water, South East Water, Sydney Water, and Water Corporation of Western Australia.

An important element of project delivery is that WSAA should allow all programme participants to use their benchmarked performance results in public or show them to their respective economic regulators. All data and performance output information was therefore blind coded on an activity by activity basis to ensure that no utility was able to identify the specific performance of industry peers. Examples of this output are shown in Figures 1 and 4 later in this feature.

Key project deliverables included individual utility data validation reports and teleconferences, on-site interviews (conducted over one to two days), an industry report, individual utility reports and teleconferences, including customised improvement roadmaps. The industry report covered programme approach and methodology, key industry themes and leading practices, and overall industry performance results.

The individual utility reports were focused on specific utility performance results by benchmarked activity, practice observations and areas of improvement. Improvement roadmaps were used to communicate individual improvement initiatives and contained recommended improvement actions, implementation complexity issues, key success factors, the time frame for implementation and expected cost savings.

The programme culminated in a best practice workshop that was conducted over two full days and

***Table 1* Benchmark peer group**

| AUSTRALIA | | |
|---|---|---|
| **Queensland** | **Victoria** | **New South Wales / Australian Capital Territory** |
| Brisbane Water<br>Gold Coast Water<br>Ipswich Water<br>Logan Water<br>Maroochy Water | Barwon Water<br>Central Highlands Water<br>City West Water<br>South East Water<br>Yarra Valley Water | ActewAGL<br>Gosford City Council<br>Hunter Water<br>Sydney Water |
| **South Australia** | **Western Australia** | |
| SA Water | Water Corporation of WA | |
| **INTERNATIONAL** | | |
| **New Zealand** | **United States** | **Canada** |
| Metrowater (Auckland) | Seattle Public Utilities | City of Hamilton |

| Reactive | Preventative | Renewal/Capital |
|---|---|---|
| Repair of burst water main | Water main cleaning | Water main renewal |
| Repair of leaking water main | Sewer main cleaning | Water service renewal |
| Repair of stop taps | Wet well cleaning | Raising/lowering maintenance holes |
| Repair of water service pipes | | Sewer relining |
| Clearing blockages in sewer mains (no dig out required) | | |
| Clearing blockages in sewer branches (no dig out required) | | |
| Sewer repairs requiring dig out | | |

***Table 2***
**Civil maintenance activities benchmarked.**

provided opportunities for industry leaders to present their leading practices and technologies in civil maintenance. The best practice workshop further provided opportunities for all programme participants to liaise directly with local industry peers and global water industry thought leaders.

### Comparison of 2000 and 2005 civil maintenance benchmarking programmes

A number of enhancements and changes to measures were made in 2005 compared to the 2000 study, making detailed quantitative comparisons difficult. However, from a qualitative perspective, the industry has identified and made fundamental changes in a number of key strategic and operational areas relating to civil maintenance since 2000.
These include:

- Increased regulation: regulatory requirements are increasing, particularly for meeting environmental and service level standards. For utilities operating under licences, the requirements and accountabilities are becoming more stringent commensurate with increasing costs of compliance.
- Asset management: the industry has improved its approach to asset management. Many utilities are now organised around the separation of asset decision-making and service delivery.
- Systems: in 2000, the application of comprehensive and integrated asset management and field based systems was very much in its infancy. The industry now recognises the efficiency advantages of automated and integrated systems and is actively allocating funds to this area.
- Performance management: in 2006, many utilities better understand the drivers of their service level and cost performance, particularly those operating under increased economic and environmental regulation.
- Data management: whilst significant improvements have been made in the capture of cost and service level data in the last five years, the industry still struggles with identifying critical data requirements and conducting detailed data analysis. Some in the industry have recognised the importance of the collection, storage and retrieval of good asset condition data, and the use of this data in investment decision tools, but this remains an area of limited focus.
- Optimising the reactive and proactive maintenance mix: in 2000, there was an observation that in some areas too much preventative maintenance was being undertaken. In 2005, reductions in water main cleaning as a result of water saving measures under drought conditions, budget constraints and an inability for the industry to justify preventative programmes, has reduced the level of preventative maintenance. Many utilities across the industry do not have an assessment framework to quantify the benefits of preventative maintenance in terms of cost savings and service level impacts, and these utilities agreed that an improved understanding of the reactive versus proactive mix is important and requires development.
- Contract and resource strategy: the industry has moved to better optimising the mix between internal and external labour, and adopting high degrees of crew specialisation in order to support this strategy. In 2005, many utilities are adopting elements of alliances and partnering in order to achieve cost and service level targets, and in general are adopting new ways of working with the marketplace.
- Staffing: ageing workforces, staff recruitment and retention are emerging as major issues, which were not identified in 2000. There is a pressing need for the industry to give higher levels of attention to developing proactive and concerted strategies in dealing with ageing workforces, and attracting and retaining high calibre personnel. Developing effective knowledge management systems is also seen as important in addressing these staffing issues.
- Crew sizing: many within the industry have moved towards adopting single person crews on several reactive tasks such as hydrant repair, stop tap repair and replacement, and repair of water services. There are still some utilities with relatively large crews that are incurring high costs.
- Overtime: in 2000, overtime was identified as a problem area. In 2005, this problem still exists in some parts of the industry. Several utilities have adopted innovative strategies, including annualised salary arrangements and contractor schedules of rates for out of hours work in order to minimise these costs.

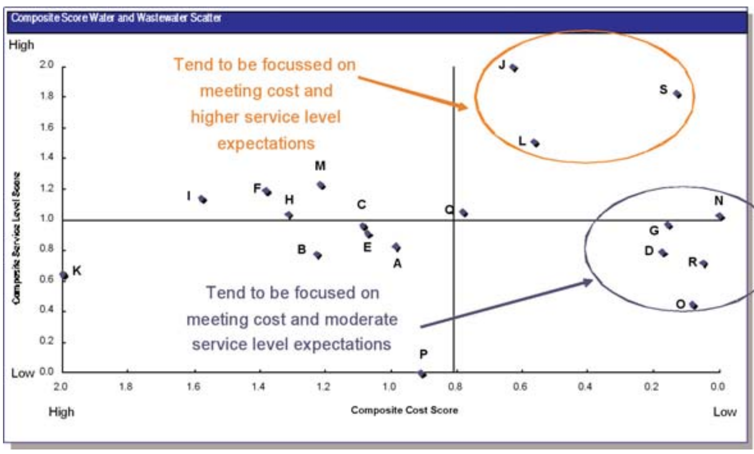



***Figure 1***
**Overall cost and service level performance.**

### Industry performance: cost and service level analysis

Analysis of cost and service level performance highlighted key differences in the industry. A major characteristic relates to the degree of corporatisation and/or the degree of economic and environmental regulation utilities may be subjected to. In general, non-capital city and economic regulated companies tend to be relatively low cost but with mixed service levels. Council-owned utilities tended to have moderate service levels but at higher cost. Figure 1 shows the overall performance and the spread of cost and service level performance across the benchmark peer group.

In terms of quantifying cost saving opportunities, two reference utilities were identified. Utility Q and N in Figure 1, representing respectively the highest cost ('prospective') performer and the lowest cost ('stretch') performer in the best practice (low cost, high service level) quadrant. Even for Utility N, which can be classed as the 'best of the best', a significant number of strategic challenges still emerge in maintaining that status and staying ahead.

Figure 2 highlights the significant opportunities that may be on offer for the industry, particularly in the renewals domain. A prospective to stretch cost savings range of $51 million to $107 million across all of the benchmarked activities has been identified.

Figure 3 breaks down the savings into their constituent benchmarked activities. The high spend areas of repair of burst water mains, repair of water services, water main renewal and sewer relining have also given rise to the high saving opportunity areas.

In terms of percentage of total benchmarked spend, a 22% to 46% potential range has been identified and influenced by laggard performers, particularly those with relatively large spend levels.

### Key themes and leading practice attributes of low costs and high service levels

Based on quantitative results and practice observations in managerial tasks, reactive, preventative and renewal civil maintenance, there are four key industry themes ientified. These four key themes, along with corresponding sub themes, highlighted the attributes of low cost and high service level found in many of the best performing utilities:

1) Human resources and resource strategy, comprising the following sub themes:

- Asset management structure and investment planning: asset management functions are centralised and joint decisions are made on opex and capex (as opposed to separated asset management which leads to a lack of understanding of opex and capex relationships and the relevant trade-offs). Utilities operating in high economic regulation environments place importance on understanding opex and capex trade-offs.
- Succession planning: the average age of the workforce is 40 to 45 years and above, adding to the challenge of all utilities to develop strategies for recruitment and retention of high calibre staff.

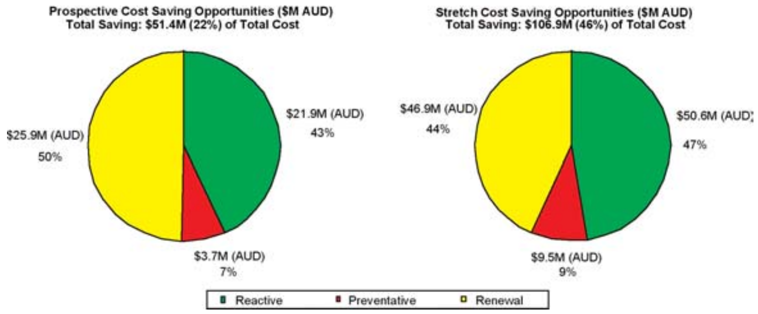



*Figure 2* Potential savings range: prospective to stretch target levels.

- Resource mix: the optimal internal versus external resource mix has presented a key challenge to the industry. Figure 4 shows varying resource mix options being adopted in order to achieve low cost outcomes. The significant increases in use of external resources and partners have increased the strategic resource mix options available to the industry.
- Partnering: partnering is increasingly prevalent in the industry, as exemplified by some of the leading utilities whose contract workforces are well integrated with their internal organisational structure. However, leveraging the benefits of the use of external partners has yet to be fully explored by the industry.
- Crew strategy: crew sizing does not always directly correlate with unit cost (Figure 5). Effective first response crew allocation strategies, processes and systems can overcome the impact of larger crew sizes and still achieve low cost service provision.
- Overtime: overtime remains a significant issue in some utilities where overtime costs are a significant portion of the average salary. In some cases, industrial relations requirements are forcing the adoption of overtime labour during peak reactive workload periods. Several leading utilities have adopted innovative strategies, including annualised salary arrangements, flexible local workplace agreements and contractor schedules of rates for out of hours work in order to minimise overtime costs.

2) Service level and cost focus, comprising the following sub themes:

- Business drivers: cost and service level performance varies across the benchmarked group, based on differing business drivers such as level of corporatisation and regulatory environment. Nonetheless, key leading practices include well-defined business strategies that are strongly linked to the business environment, and adoption of sophisticated customer

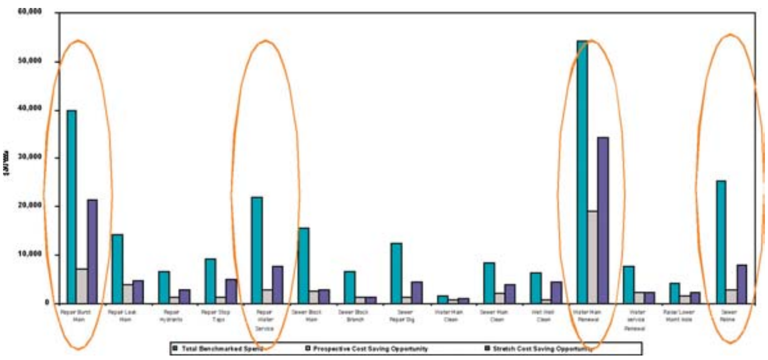


*Figure 3* Spend levels and prospective and stretch saving opportunities by activity.

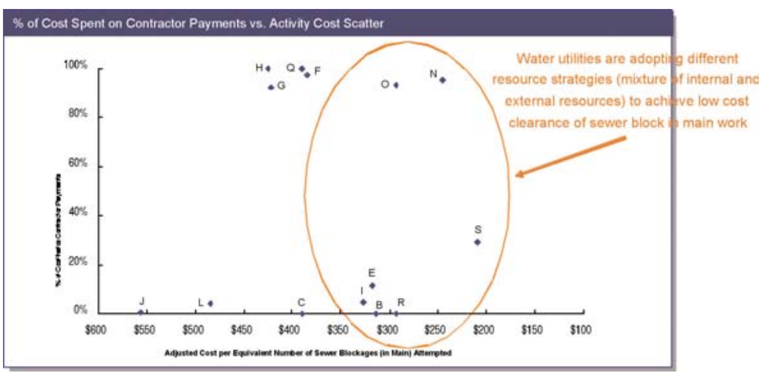



*Figure 4* Resource mix versus unit cost for clearance of sewer main blockage.

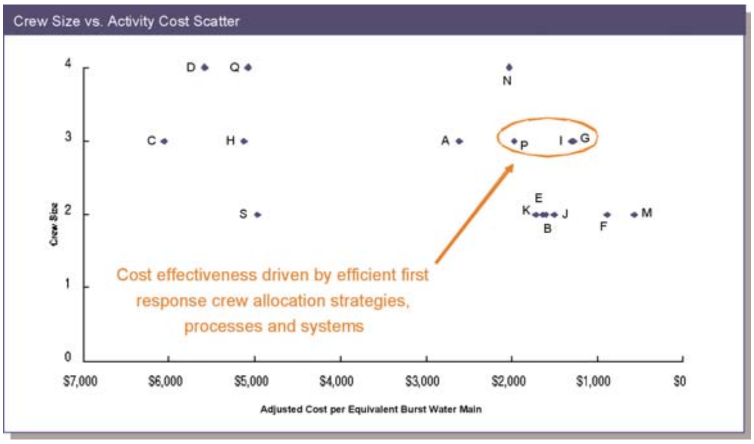



***Figure 5***
Crew size against unit cost for repair of burst water mains.

willingness-to-pay models in order to better understand the balances between regulatory cost, service levels and customer expectations.

- Performance management: performance management systems are in place across the industry, but the level of complexity and effective deployment varies greatly. Leading performers are characterised by a number of performance elements including strongly-aligned KPIs to business and regulatory environment, regular KPI review and reporting processes, formal continuous improvement in place, activity-based costing, productivity measurement programmes to drive lower cost and employee incentive programmes.

3) Defining the reactive versus preventative versus renewal mix, comprising the following sub themes:

- Maintenance planning: some leading performers and those utilities operating under higher economic regulation are attempting to quantify the benefits of preventative programmes in terms of cost savings and service level impacts, and using this information to determine the optimal reactive versus preventative versus renewal mix. Many utilities across the industry do not have the necessary information to develop a robust assessment framework to quantify preventative programme benefits, and this is limiting their ability to define the optimal reactive versus preventative versus renewal mix.
- Investment decision tools: few within the industry have formal processes and automated systems for the collection, storage and retrieval of good asset condition data. Some are adopting integrated investment decision tools, but acknowledge they lack the necessary asset condition data to make these tools truly robust. Investment decision tools incorporating risk probability and consequence, asset criticality and prioritisation based on triple bottom line are adopted by many utilities for renewals programmes.

4) Processes and systems, comprising the following sub themes:

- Data capture and management: several utilities were data rich, but information and knowledge poor. Leading utilities tended to determine and evaluate critical data requirements and actively collect critical cost by function and service level data. These utilities also tended to have the analytical expertise to validate this data and extract valuable insights for asset planning and work management purposes.
- Field-based systems and processes: some leading utilities are adopting low cost contact and operation centre arrangements based on centralising these two functions. Other utilities have adopted decentralised arrangements and have still managed to achieve low costs through efficient contact and operations centre processes and systems, as well as accurate fault diagnosis and prioritisation.

In order to comply with regulato-

***Table 3***
Specific leading attributes for reactive, preventative and renewal activities.

| **REACTIVE** | |
|---|---|
| **Policies** | **Technology / Practices** |
| • Minimum shutdowns and more extensive clamping techniques.<br>• For sewer repairs requiring dig out, location markers from previous clearing attempts.<br>• For clearing sewer blockages, define the optimal level of bore clean and/or escalate to routine cleaning or sewer relining as required. | • Targeted use of 'mini' style plant and equipment.<br>• 'Infra-stop' bladder valves for mains isolation.<br>• Advanced leak detection equipment for repair of leaking water mains.<br>• Hydro-excavation for repair of burst and leaking water mains.<br>• Pipe freezing for water service repair.<br>• Ball valve technology for repair of stop taps and water services.<br>• Jetting, cutting preferred to rodding, and small equipment to facilitate ease of access.<br>• Sophisticated jet designs incorporating different nozzles, flow rates, etc. |
| **PREVENTATIVE** | |
| **Policies** | **Technology / Practices** |
| • High focus and commitment to regular flushing having a significant impact on business outcomes.<br>• Developing proactive cleaning and flushing policies to meet drought conditions and changing legislation.<br>• Water sampling prior to flushing main.<br>• Define the optimal level of sewer main cleaning and optimal level of bore clean. For water main cleaning, defining optimal flushing point techniques. | • For sewer main cleaning, targeted use of root foaming, jet designs incorporating different nozzles, flow rates, etc. and on board CCTV and cleaning equipment.<br>• For pump wet well cleaning, use of float sensors isolated via submerged tube to reduce failure rates and risk of inoperability. |
| **RENEWAL** | |
| **Policies** | **Technology / Practices** |
| • Contract strategy based on either a turnkey approach or hiring of project management, design and construction specialists.<br>• Effective use of contractors based on innovation, credible delivery, quality, cost and safety records.<br>• Where practical, full commercial scrutiny, and generation and application of the best options. | • For water main renewal, optimal mix of trenching and trenchless technologies, minimum interruptions achieved through water supply bypass or alternative water supplies, use of pipe bursting or slip lining technologies.<br>• For water service renewal, adoption of polyethylene pipe lining.<br>• For raising or lowering maintenance holes, 100% use of pre-cast, prefabricated components or biodegradable formwork materials, and manoeuverable lifting equipment (Hiab crane and Bobcats) for work in restricted access areas. |

ry service level requirements, water utilities operating under higher economic regulation have systems in place that are able to accurately identify the number of customers affected by repair and replacement work. This has allowed these utilities to focus on service level targets and accurately prioritise work by customer criticality.

Furthermore, utilities are becoming more sophisticated in their choice of field-based systems, installing laptops in vehicles to capture comprehensive travel time, repair time, interruption time, type of fault, type of repair, asset location and condition data.

- Integration of asset management and field-based systems: some leading utilities are adopting and leveraging the benefits of fully integrated and automated asset management (GIS), works management and customer information systems (CIS). Many utilities within the industry have retained a combination of manual and automatic systems to link their asset management, works management and performance management systems. Some of these utilities have stringently defined end-to-end processes in order to deliver reactive tasks as cost effectively as utilities with fully integrated and automated systems.

### Specific policies, practices and technology: reactive, preventative and renewals

Table 3 provides a summary of specific leading polices, practices, and technologies as used by the leading performers in the benchmark peer group. The summary may be viewed as a series of actions that can be readily implemented, with a realisation of benefits in the short term.

### Industry improvement initiatives

Based on the findings of the study there are four key improvement initiatives for the industry:

- Review of the technology and the contracting arrangements for water main renewal: the industry challenge is related to determining whether trenchless technology is applicable to specific utilities, optimising the mix between trenching versus trenchless technologies, and the contracting arrangements that need to be put in place for undertaking trenching and trenchless work.
- Managing the mix between reactive tasks: improved reactive workforce management of repair of burst water mains, repair of leaking water mains and repair of water service pipes by adopting better allocation processes and systems to optimise the mix between these reactive tasks.
- Proactive development of preventative programmes: many across the industry believe the right mix of reactive, preventative and renewal work is not well addressed and a need exists to be more proactive in the area of preventative maintenance program development.
- Managing the trouble response process: the industry is managing the trouble response process in a variety of ways, and the cost and service level implications of the current techniques adopted and the opportunities for improvement may not be fully understood across the industry. Water utilities need to gain more knowledge of leading trouble response processes, practices and systems and their potential improvement opportunities.

These four improvements coalesced from a wide range of improvement opportunities and were seen to provide scope for major cost savings across most of the utilities.

### Further programme developments

International interest and participation in WSAA's benchmarking programmes is certainly not new, and a great deal of national and international interest has been generated as a result of this particular benchmarking study, which for many in the participating group has been one of the more incisive and challenging benchmarking programmes undertaken. A growing number of domestic and global enquiries are therefore currently being addressed. A presentation of the project approach and outcomes will also be held at the International Water Association (IWA) World Water Congress in Beijing, China in September.

Furthermore, arrangements and protocols are in place for those utilities seeking improvement insights from specific utilities that did particularly well in certain areas. UMS and GHD have put in place communication protocols to allow industry participants to share process, practice and technology information on a confidential basis.

Given industry commitment to these programs, WSAA is now progressing to tender the following benchmark programmes: 2006: mechanical-electrical maintenance; 2007: customer services; 2008: asset management; 2009: civil maintenance.

IWA has shown considerable interest in participating in these programmes and has been included in the steering committee for the 2006 programme, with the objective of bringing even greater international participation to the benchmarking programmes. This complements WSAA's strategy of making this programme truly global, which began with New Zealand's involvement in WSAA data several years ago, and more recently, the participation of two US water utilities in the asset management and civil maintenance benchmarking projects. ●

# Hawkeye pollution prevention system

Yorkshire Water worked with local technology company IETG to develop a unique solution to its Combined Sewer Overflow (CSO) problems that has enabled it to significantly reduce pollution incidents. The data collected will also be used to inform future decisions on asset invesment and expenditure. This article looks at the HawkEye system.

**Simon Balding**
Yorkshire Water
UK



**Yorkshire Water Services has had an inconsistent pollution profile over the last five years. The company has now focused on the need to demonstrate a sustainable improvement strategy for pollution.**

A snapshot of Yorkshire Water's pollution in 2004 shows:

- 19 serious category 1 and 2 pollution incidents
- 120 less serious category 3 incidents
- a perceived reduction in credibility with the Environment Agency
- large amounts of opex being spent in cleaning up and resolving events
- fines increasing all the time, with a resulting impact on company reputation
- the company's overall performance assessment score being affected due to the frequency of the incidents.

From Yorkshire Water's studies it is apparent that one of the major asset groups responsible for pollution was combined sewer overflows (CSOs). Around a third of all pollution is from this group.

The usual set of contributing factors could cause a storm overflow to operate at any time. Normal sewer debris such as fat, rags, grit, nappies and so on can all cause blockages within the sewer network. Such blockages inevitably lead to spills from overflows or other relief points in the system (manholes) and eventually to pollution.

Yorkshire Water is committed to reducing all aspects pollution from its infrastructure, and in particular from this asset group. To be able to achieve this we identified the need to implement a solution that would provide:

- prior warning of CSO dry weather spills
- quicker reaction to spills to mitigate environmental damage, minimise public criticism and reduce potential fines.
- a reduction in the number and impact of pollution incidents
- improve the understanding of system hydraulic performance
- provide additional information to help in design
- help identify infiltration and development issues
- support the case for capital maintenance at PR09
- help direct investment to where it will secure the best return.

## Solution identification

Having identified the need to monitor, the reality is that such a large-scale programme of data collection handling and management of the data obtained can be extremely costly and exhaustive in terms of manpower.

Having developed the business need, Yorkshire Water secured the services of local technology company IETG to assist in identifying suitable existing solutions. Any solution would need to provide the following features:

- minimum installation cost
- the ability to install in the existing network without civil works or street works costs
- it must not require mains power
- it must provide remote communications
- it must be able to operate in a potentially explosive atmosphere
- it must be out of sight – no aesthetic impact – no aerials or planning required
- it must provide low cost of

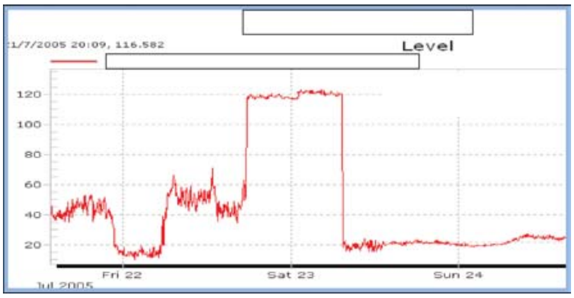



*Figure 1*
An example of how HawkEye trend and alarm information enabled YWS to respond to incidents within hours, rather than having to rely on the public reporting pollution.

ownership
- it must supply data in the form of alarms and also real time series data to allow trending and pattern recognition
- it must, where possible, use tried and tested solutions.

In reviewing the technologies available it was clear that a solution didn't currently exist that would fulfil these needs and it was decided that a new improved system would be required at a cost that would allow Yorkshire Water to implement its desired programme.

Working alongside Yorkshire Water's wastewater pollution, ICA and telemetry teams, the Yorkshire Water wastewater R&D team helped IETG define the specification from which the first fully self-contained sewer level monitor with onboard cellular communications, the HawkEye sewer monitoring system, was developed. Onboard communications protocols allow the unit to communicate directly with the existing Yorkshire Water regional telemetry system.

The technological developments implemented by HawkEye provided Yorkshire Water with the capability to monitor remote sewer overflow sites at a reasonable cost. However, to ensure that their requirements would be met and that the long-term benefits could be justified, 12 sites were selected for a pilot project early in 2004.

After a successful trial Yorkshire Water decided to roll out a monitoring network to its top 380 CSOs, based on risk of causing dry weather spills due to blockage or other operational problems.

Historically these 380 CSOs cause around 80 complaints per year, either from the public or EA due to dry weather operation. By providing early warning of spills and/or high flows it was envisaged that the number of complaints would be vastly reduced. Such was the success of this project that the system was rolled out to a further 230 sites to ensure that all potential pollution sites in one region were monitored.

## Measure of success

In the first six months after commissioning, the frequency of complaints has reduced to four per year (two complaints in six months). This represents an improvement of 95%.

Yorkshire Water calculates that in the first seven months of 2005, over 120 pollution incidents have been avoided through the use of this technology.

In addition to this headline benefit a great many other benefits have been generated. Yorkshire Water is now starting to accrue knowledge on how its systems really operate and this will undoubtedly inform decisions on future investment and expenditure. There has been an overall reduction in the number of pollution incidents. In addition the fact that any pollution events that do occur are identified at an earlier stage ensures that the impact of any pollution incident is greatly reduced.

Assessment of the data has also allowed some of the causes of dry weather flow spills at frequent offending sites to be identified and rectified on a permanent basis where this was appropriate or affordable, or management strategies applied to ensure that the risk is adequately controlled.

Yorkshire Water has now started to react to incidents as they occur, rather than relying on the Environment Agency or members of the public reporting pollution. Our aspiration is to develop this further so that we can react to changes in levels before a drop of foul water spills from the system.

In addition to the early warning provided by the alarms, the system is now providing real-time trend data, which provides additional information on:
- performance ranking of CSOs
- a historical database on individual CSO performance
- planned maintenance activities
- trend analysis to predict future maintenance activities.

## Business benefit

Yorkshire Water has now started to develop a real understanding of individual sewer profiles and performance. As well as having a significant impact on our pollution incident numbers and the knock-on benefits associated with this, it has enabled improved environmental performance and improvement in OPA performance

We now have the ability to improve the design of all wastewater assets from treatment works to sewers by using sewer trend data from the units. This will lead to improved capital efficiency and reduced operational expenditure

The long-term business benefits for Yorkshire Water following the implementation of this monitoring network are yet to be fully realised however already they are seeing the following effects:
- improved level of customer service – fewer customer complaints
- improved environmental performance – fewer pollution incidents
- improved financial performance – better maintenance and operational regimes.

These improvements can only increase as greater knowledge about the performance of the assets is built up, and this knowledge is disseminated across the whole of the organisation.

## Customer benefit

The benefits to customers occur in two specific areas: cost reduction and environmental improvements. The availability of the data and the alarms generated has allowed Yorkshire Water to reduce its operating costs. Avoiding pollution incidents reduce fines and remedial clean-up costs. Data has allowed early intervention before problems manifest themselves in a major manner, often enabling very low cost solutions at that point of intervention.

The environment of Yorkshire's natural watercourses has improved as a result. 120 pollution events have been avoided, many of which would have occurred during dry weather and caused significant public nuisance.

## Conclusion

The implementation of the CSO monitoring network across the Yorkshire Water region has demonstrated that improved management of sewer assets through data acquisition is realistically achievable.

Yorkshire Water has already achieved significant progress and business improvements through identifying the business need, developing a unique bespoke IT-based solution and wide-scale rollout over an aggressive timescale.

The technology in place is undoubtedly transferable to other collection system problems outside the CSO arena. It has already, for example, been adapted to provide data and advance warning of issues on problem sewers in relation to flooding (Ofwat service indicator DG5).

As reliable usable performance data is gathered, it is expected that Yorkshire Water will be able to use this information to benchmark the performance of different combinations of CSO/tanks and screens, allowing it to assess the whole life asset performance for future investment decisions. ●

## The future of sewer management

Jim Grandison, Associate Director of IETG, outlines how HawkEye's new flow monitoring technology will help shape asset management in AMP4 and beyond.

The tightening of environmental legislation coupled with a drive for water companies to provide better information to regulator Ofwat means that prevention of pollution incidents and a better, more quantitative understanding of assets is becoming critical. The HawkEye flow monitoring technology developed by IETG and used by Yorkshire Water has revolutionised the company's approach to asset management, and the future opportunities are both varied and exciting.

Obtaining information on asset performance and operation is a critical part of planning maintenance and capital expenditure requirements within water companies. But historically this has not been easy to achieve. Monitoring traditionally requires installation of expensive equipment with high capital and construction/installation costs and creates a requirement for power supply infrastructure. Introduction of the HawkEye system within Yorkshire Water Services has revolutionised the company's management of its sewer infrastructure and could set a new standard in how assets are maintained and operated in the future.

By providing real time information on water levels within CSOs, and sending this information directly to a water company's telemetry system, the device enables engineers to better understand these assets. If water levels are unusually high or peaking at unusual times – such as during dwf – leading to spill events, maintenance staff will know about it within minutes. They can respond to these events much quicker than ever before, preventing pollution incidents and avoiding the considerable fines and negative publicity that these events attract.

What is more, the technology has the support of the Environment Agency, which has long been a proponent of CSO monitoring. In the past water companies have resisted because business case calculations could not justify installation of expensive telemetry equipment. But with this new, less expensive technology the business case is much stronger.

The data that HawkEye provides will allow water companies to conduct an overall assessment of the performance of their CSO assets, in terms of actual operation and long term performance. Yorkshire Water Services are building knowledge on how the system really operates, enabling the company to inform decisions on future investment and expenditure. The company can now performance rank CSOs and therefore build up a historic database on them, allowing it to plan maintenance activities and predict future requirements. This will prove to be a huge benefit for the company moving through AMP4 and into AMP5 as the regulator Ofwat is increasingly asking to see more evidence-based justification for expenditure, rather than the traditional approach of risk analysis and expert opinion.

### How the system works

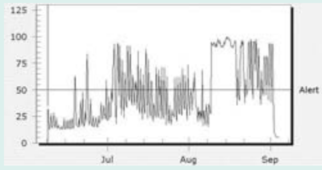
The HawkEye device is fully self-contained and carries cellular communications and a power supply, eliminating the need for an external power feed and reducing maintenance and installation costs. Using its level sensors and a data logger it records information at five-minute intervals. Effectively this gives the company real time information as to how the system works. Used first on 12 CSOs for Yorkshire Water Services, its effectiveness meant that it was soon rolled out across a further 610 sites (see corresponding paper). In the first half of 2005 the system has enabled Yorkshire Water to avoid 120 pollution incidents and the average number of complaints over spillages from CSOs has dramatically plunged from 80 complaints per year to four – an incredible 95% improvement rate!

The device meets some pretty challenging criteria set out by Yorkshire Water during development. It has a low installation and ownership cost; it can be installed in existing networks negating the need for civil or street works; it doesn't require any mains power, communication is done remotely and it is the first monitor of its kind to be hazardous area (ATEX) approved.

### Using measured data to adjust maintenance patterns and redesign infrastructure

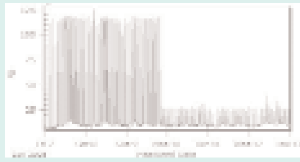
Identifying typical problems and monitoring the data over time allows engineers to employ both short term and long term maintenance solutions that will prevent future incidents. The system can be used to identify silt build up, root intrusion, incorrect weir settings, incorrect pump settings, river intrusion and transient blockages.

*Example 1: Using trend data to change maintenance operations*




This example shows the benefits moving forward of addressing trend data. Over time silt builds up in the system until a critical point is achieved where the build up of silt and debris accelerates until a complete blockage occurs and dwf operation follows. External specialist cleaning contractors were employed to remove the 18 tons of silt from the chamber. The data trends identified thanks to monitoring can now be used to identify a frequency at which more cost effective cleaning can control the problem. This is achieved by modifying the set point on the AMS to generate the alarm when the dry weather flow profile raises beyond a set level indicating a gradual build up of silt.

*Example 2: Redesigning infrastructure based on data set*



This site was spilling very frequently for very short periods of time every day (at 20-minute intervals). The data clearly indicates the operation of an upstream pumping station. By raising the weir height by a small amount, the chamber stopped spilling. This modification, combined with a change in the pump settings and frequency of operation upstream provided a simple low cost remedy to the pollution problem.

### Affordability

With efficiency targets for water companies becoming ever tighter a device such as this could prove to be a vital tool in future asset management. Its low capital and maintenance cost are more than recovered by the potential savings generated through prevention of dwf flooding incidents, installation of more hydraulically efficient infrastructure and more appropriate maintenance activities.

Remote sites of sewer flooding have historically caused problems because the costs of providing power and telecoms were prohibitively expensive. However using this equipment, flow levels and potential spills at remote sites can now be affordably assessed.

### Beyond the CSO

Monitoring of CSOs using HawkEye is now tried and tested within Yorkshire Water and the success of the device in this environment has opened up exciting new possibilities for future use.

Technical developments underway at the moment include improved alarm minimisation to make the system smarter and artificially intelligent. The system will effectively be able to learn from data patterns and allow improved performance via the opportunity to intervene earlier. This in turn will allow water companies to compare the operation of different types of assets. As more information becomes available it will be used to performance benchmark standard CSOs against tank and screen arrangements. Maintenance and operational requirements can be monitored and the cost implications calculated and compared to ensure that water companies are using the most cost effective infrastructure. What is more, sewer trend data, rather then design values, can be used to design wastewater assets ensuring that the system is performing at its most hydraulically and financially efficient

Possibly the most exciting aspect of future use of HawkEye is the transferability of the device to other assets. It could easily be adapted to provide data and advance warning on problem sewers, areas particularly prone to silting and properties on the DG5 flooding register. Further research on this is currently being carried out by IETG. ●

# Asset management:

## complex problems require sophisticated analytical approaches

The environment for introducing asset management (AM) techniques has never been more favourable. However, while AM is drawing attention and gaining popularity among water organisations in the US, the full extent of the problems involved, their complexity, and what solving them would entail are still rather poorly understood. In this feature, we attempt to illustrate this complexity by looking more closely at the structural degradation of water networks.

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**The environment for promotion of AM, and, in general, of moves towards better informed and rigorous rehabilitation planning decisions has never been more favourable. Capital needs are believed to be high and rapidly growing, water services are not adequately priced to recover full costs, and future estimates are difficult to obtain partly because of the lack of data and appropriate forecasting tools.**

Many systems in old urban centres will soon reach their average useful lifespan. To both limit and justify unavoidable rate increases, rehabilitation will need to be planned in a documented and cost-efficient way. Every four years, the US EPA undertakes a survey (the Needs survey) of the anticipated costs of future capital investments spanning the next two decades. In its third report to Congress released in 2005, and based on data collected from utilities in 2003, EPA found that the nation's 74,400 water systems will need to invest an estimated $276.8 billion between 2003 and 2023 (US EPA, 2005). Rehabilitating ageing underground networks will account for more than one third of these sums. Most professional organisations dispute these numbers and tend to come up with estimates up to two or three times larger.

Furthermore, the EPA GAP report (US EPA, 2002) has highlighted the fact that current funding mechanisms will create a capital gap between future needs and projected revenues. At the time of the study, the gap for the next 20 years had been estimated to be as high as $267 billion (2001 dollars). This figure was based in part on data drawn from the first EPA Needs survey in 1997 (US EPA, 1997), which anticipated costs of investment for the next two decades that were then estimated at only $77 billions or one fourth of the current figure.

One common characteristic of the studies and numbers mentioned is the very large possible range of costs. This is partly due to the uncertainty typically associated with such broad issues. In the case of water infrastructure, the data and tools that would allow reliable projections for the future are also lacking. Proper analytical tools could help communicate pressing challenges to the public and better prepare users for the impending increases.

In times of growing need and competing resources, programmes that can help to better evaluate, limit and justify costs have to be explored. From a legal standpoint, the Governmental Accounting Standard Board (GASB) statement 34 may soon be offering the kind of legal incentive that never existed before. GASB 34 requires that utilities and any organisation receiving public funding must be in a position to report in their accounting statements the present value of their physical assets.

No one knows yet how much GASB 34 will help boost AM techniques. It is worth mentioning that participants at a May 2005 US EPA workshop regarded the creation of a strong mandate as a priority. A detailed description of all the priorities identified at the workshop is found on the event's website at http://www.epa.gov/owm/assetmanage/assets_wksession.htm.

Opponents point to the lack of enforcement capability and favour increasing the level of awareness and promotion of voluntary mechanisms. In the bridges and pavement AM fields, a rehabilitation plan designed to enable a managing entity to access public funds is required. A wealth of data is soon to be available, and managed in a way that facilitates analysis.

A distinction should be made between buried (or not), network (or not) water and wastewater infrastructure. Buried networks present specific challenges and opportunities. Because they are underground, direct inspection can be difficult and expensive. On the other hand, the continuous and systematic nature of a network lends itself to analytical and, more specifically, statistical approaches.

This is further facilitated by the fact that, from a technical standpoint, probes, hydraulic models, and inspection devices are generating a wealth of data to enable operations to improve. This data could be recycled for long-term rehabilitation planning. In addition, because of their database and visualisation capabilities, increasingly-popular computer maintenance management systems (CMMS) and geographic information systems (GIS) in particular represent formidable and appropriate ports of entry for the introduction of AM, particularly for networks of water pipes and sewers.

### Complex problems

Asset management programmes encompass data-based practices and tools that aim to collect and analyse appropriate information on which to base maintenance, rehabilitation and replacement decisions and thus set out asset, risk, and condition-based capital improvement plans. In the past, both in Europe and in the US, rehabilitation decisions have tended to be pragmatic, subjective, often reactive or opportunistic. Very rarely has a system been put in place to ensure that expenses and impacts of failure are systematically minimised so that the right elements are replaced at the right time – the tools that could make it possible were simply not available.

Minimisation of failure involves complicated tasks that require sophisticated tools and years of development, especially for the more difficult-to-manage underground networks. We will pursue the argument of the complexity of the AM paradigm for the example of water networks. This does not constitute a full review of all the possible challenges inherent in the development of an AM programme for a network, the intention is more to illustrate the complexity of the problems and the fact that they cannot be addressed using simple tools – further research and development are necessary.

### Problems of degradation

Pipes may need to be rehabilitated for various reasons, mainly because:

- pressure has become inadequate; pipes are clogged due to tuberculation
- water quality is revealing pipes' degradation (red or brown water)
- pipes are showing structural weaknesses, leaking or breaking at an increasing rate.

While some networks or parts of a network may suffer only from, for example, structural problems, or red water, many rehabilitation decisions need to consider all of these problems. Table 1 shows that many research projects have addressed the first or third issue, structural or hydraulic deficiency, most often separately or in a way that concentrates on one of the problems. There has been no recorded research work on the relationship between water quality and pipe degradation. In Table 1, studies are classified based on the problem addressed, the objective pursued and the mathematical tool adopted.

We will concentrate on structural degradation while pursuing our effort to shed light on the complexity of the problems involved.

### What is a pipe?

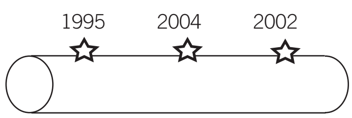
Traditionally, break analysis of water distribution networks has been performed through statistical techniques often borrowed from bio-statistics, which analyse populations of individuals. While one human can be clearly distinguished from another, this designation is not so easy when it comes to a pipe, which is often made up of distinct pieces (5 to 20 feet long) and then assembled in a trench. When the whole network is organised in a database, what constitutes a pipe depends on why the database was designed in the first place. For example, in a hydraulic model database a pipe is defined from hydraulic node to node, while in a GIS, a pipe is an object defined by its geographic position and its homogeneous attributes.

As a result, the rehabilitation database is likely to be populated with individual pipe sections of varying lengths, ranging from less than three feet to close to a mile or more. This considerable variation creates a problem for a rehabilitation planning partly based on the statistical analysis of past failures and the prediction of future failures.

In effect, a short pipe may have a high breakage rate but few actual breaks. Conversely a long pipe may have broken many times but its overall break rate remains low. Thus, using a break number or a break rate may be a potentially flawed choice for a rehabilitation plan. Additionally, rehabilitating very short pipes is inefficient and may have little effect on the overall network performance, while longer pipes may be too costly to rehabilitate as a whole.

In addition, break analysis can vary tremendously in its sophistication from use of a simple rate that describes an average experience over a past period to predicting future failure rates via more complex models. There has been active research in this field. In 1979 Shamir and Howard were the first to attempt to statistically analyse break records by drawing generic regression curves (Shamir, 1979). More recently survival models have been developed; these take into account both time and failure risk factors. In such models, the occurrence (here the failure of the pipe) can only happen once, so these models must introduce analytical strategies. For instance, failure forecasting in PHM, part of the CARE-W (Saegrov, 2004; Eisenbeis, 1994, 2000) suite of tools, requires i) the introduction of a new statistical individual every time a pipe breaks, and ii) the inclusion of the number of previous breaks (NOPB) as a risk factor.

PHM case studies have shown that the NOPB turns out to be a very significant risk factor; it also grandly influences the database. A small example will illustrate the problem. A 30-ft pipe laid in 1970 has had three breaks as follows:




After 2004, there would be four 10m long individuals in the database as follows:

- one 10m individual, date of installation 1970, NOPB = 0
- one 10m individual, date of installation 1995, NOPB = 1
- one 10m individual, date of installation 2002, NOPB = 2
- one 10m individual, date of installation 2004, NOPB = 3.

If the itemisation of the network had resulted in three 3.3m segments, installed in 1970, with one break each, there would be six individuals populating the database:

- three 3.3m individual, date of installation 1970, NOPB = 0
- one 3.3m individual, date of installation 1995, NOPB = 1
- one 3.3m individual, date of installation 2002, NOPB = 1
- one 3.3m individual, date of installation 2004, NOPB = 1.

Whatever the methodology, past, present or future, it is possible to intuitively envision that results are likely to be affected by the original itemisation of the network – that is, the database of pipe individuals. The solution may be to create more uniform segments of pipe, be it by grouping small pipes or dividing longer ones, improving current models, or investigating new models or new approaches that inherently mitigate the problem. Defining what constitutes a pipe is a crucial and complicated task, one that requires serious attention since most AM plans rely on a database of pipes.

### Prioritisation or optimisation

Rehabilitation planning can be undertaken with two overall objectives in mind:

- Prioritisation: at this level, the question addressed is limited to 'what elements should be replaced/repaired first?' based on the probability that a failure would occur on a specific segment and the impact such failure would have from many points of view. This provides a utility with a way to decide which pipes should be replaced in priority given a certain budget to be spent on a certain year.
- Optimisation: the ranking systems and failure probabilities calculated previously are introduced into a life cycle cost benefit analysis in order to determine the optimal time of replacement or of various maintenance actions. The question is now: 'When should tasks of rehabilitation be undertaken in order to minimise costs and optimise service over a planning horizon?'

This objective is further reaching than the first one, and means extensive data

| Author (date) | Problem | Objective | Mathematical tool |
|---|---|---|---|
| Woodburn (86) Lansay (92), Kim (94) | Hydraulic deficiency | Minimise costs due to increase pumping | Mixed integer non-linear programming |
| Li (92) (92a) | Structural deficiency | Minimise costs for each pipe based on rehabilitation action taken | Semi-Markovian model; Probabilities calculated with hazard and survival functions. Optimisation achieved with non-linear programming. |
| Cabrera (94) | Structural degradation (breaks) | Determine best time to start leak detection programme | Expert system.Pragmatic methodology. |
| Halhal (97) | Structural deficiency (breaks) and hydraulic deficiency | Minimise costs, maximise benefits and respect a given budget | Structured Messy Genetic Algorithm |
| Deb (98) | Structural deficiency | Determine length of water main to rehabilitate each year | Survival functions with limited data (realistic approach) |
| Kleiner (98), (98a) | Hydraulic deficiency | Minimise costs | Dynamic programming |
| Preston (99) | Corrosion and external loading | Calculate remaining service life of each pipe | Deterministic model |
| Loganathan (02) | Structural degradation | Predict break rate of a system | NHPP + determination of a threshold break rate based on economic considerations |
| Shamir and Howard (79) | Structural degradation (breaks) | Model number of breaks with time | Regression |
| Clark (82) | Structural degradation (breaks) | Model number of breaks based on risk factors | Regression |
| O'Day (89) | Structural degradation (breaks) | Model age at 1st break based on risk factors | Regression |
| Andreou (86, 86a) Marks (88) | Structural degradation (breaks) | Identify relevant risk factors | Survival analysis (CPHM) |
| Eisenbeis (94, 99) le Gatt (00) | Structural degradation (breaks) | Prioritise 'at risk' pipes. Obtain probability of failures. | Survival analysis (WPHM and Monte Carlo simulation to forecast future number of breaks) |
| Elbanousy (97) | Structural degradation (breaks) | Optimisation, minimise costs | WPHM to calculate failure probabilities and life cycle cost assessment/cost functions |
| Rostum (00) | Structural degradation (breaks) | Prioritise 'at risk' pipes | Survival analysis (NHPP + WPHM) |
| Malandain (00) | Structural degradation (breaks) | Prioritise 'at risk' pipes | Poisson regression model + WPHM + exponential model |
| Vanrenterghem-Raven (03) | Structural degradation (breaks) | Prioritise 'at risk' pipes | WPHM and CPHM |

CPHM= Cox Proportional Hazards Model; WPHM = Weibull Proportional Hazards Model; NHPP = Non Homogeneous Poisson Process

***Table 1*** **Summary of the research studies.**

must be available about cost and performance of the maintenance tasks and of the failures. All the authors (Elnaboulsi, 1997) (Male, 1999) who have addressed the dilemma of pipe maintenance and replacement from an economic perspective have acknowledged severe limitations when faced with pricing the costs involved, especially indirect costs. They have overcome these limitations by introducing assumptions that can be easily challenged.

### Prioritisation based on risk, probability of failure

Prioritisation is to be based on various criteria that incorporate not only the risk of failure but also the impact of failing. The probability of failure can be calculated – it depends on risk factors.

The probability of structural failure over a certain period of time can be simply calculated by dividing the number of pipes that have failed by the average number of pipes that were in place at that time. That probability can further be refined for certain groups based on their diameter, age, material or any alleged risk factor. These simple ratios provide us with a snapshot of current conditions but do not model future degradation.

However, in order to draw accurate short or long-term rehabilitation plans, it is also necessary to project future condition. In effect, one pipe may have a lower probability of failure compared to another pipe at a certain time, but that pipe is degrading faster than the latter, and the order will be reversed over the planning horizon.

There may be many risk factors of failure. Only sophisticated models can sort these out. Using simple risk ratios based on each single risk factor can quickly become too limiting. For example, on a specific site, based on simple descriptive statistics, engineers observe that:

- smaller pipes are more likely to break than larger ones
- cast iron pipes (CIP) are more likely to break than ductile iron ones (DIP)
- pipes laid between 1940 and 1970 are more likely to break than the ones laid between 1970 and 2000
- pipes in soil A are more prone to corrosion than pipes in soil B
- a pipe that has already broken at least twice is more likely to break in the near future than one that has not had any failure.

While the choice for action between a 150mm cast iron pipe (pipe 001) laid in 1955 and sitting in soil A that has already broken three times is easily made over another pipe (pipe 002; 600mm, ductile iron, laid in 1990, soil B, no break), mixing of these risk factors makes the choice much more problematic: is pipe 003, 600mm, CIP laid in 1955 in soil B with one failure 10 years ago a better choice than pipe 001 or 002?

Furthermore, other difficulties must be controlled:

- risk factors may be highly interdependent; they should not be counted twice
- because in a typical population of pipes, fewer than 5% experience breakage, it is productive to use statistical methods reintroducing the pipes that do have not experienced a break.

Future probabilities of failure are crucial to a valid AM plan. Sophisticated methods are required to calculate accurate projections.

### Prioritisation based on risk and impact criteria

If pipes must be ranked in terms of which one should receive attention first, in addition to the probability of failure, the following must also be taken into account: cost of failure, cost of replacement, impact of failure on the rest of the network, as well as on physical property, and so on. In effect, which pipe should receive attention first - the one with an 80% chance of breaking within the next three years but situated in a no man's land, or the one that carries a 50% chance of breaking but is in Main Street downtown?

The more factors and criteria, the trickier the problem is but the more informed and justifiable the rehabilitation plan can be. As an example, a list follows of all the criteria that have been considered in the multi-criteria DSS Electra adapted for CARE-W (Computer-Aided REhabilitation of Water networks) by Pascal le Gauffre at INSA, Lyon, (Le Gauffre, 2002).

- ARC- annual repair cost
- WLI- water losses index
- PWI- predicted water interruptions
- PCWI- predicted critical water interruptions
- PFWI- predicted frequency of water interruptions
- HCI- hydraulic criticality index
- DFH- damages due to flooding in housing areas
- DFI- damages due to flooding in industrial (or commercial areas)
- DSM- damages due to soil movements
- DT- traffic disruptions
- DDI- damage or disruptions on other infrastructures
- WQD- contribution to water quality deficiencies
- AUCR- annual unit cost of rehabilitation
- COS- co-ordination score (with other utility).

Predicted water interruption, PWI, for example, is defined as follows:

$$PWI(i) = PBR(i) \times EDI(i) \times NPS(i)$$

Units: (No./100m/year) x (hours) x (persons)

Where: PBR(i) = predicted break rate for pipe i over a pre-defined future short period of time; typically three or five years (No/100m/year); EDI(i) = expected duration of interruption (hours); NPS(i) = number of customers supplied by the pipe, within a length of pipes between two valves (persons).

Each criterion is defined with similar precision. The predicted probability of failure (PBR) must be known in order to compute the value of 10 out of the 14 above criteria.

The above comments illustrate the point that the development of a serious but potentially far-reaching AM programme is nothing but a simple enterprise. Advanced and analytical tools often adopted in other industries ought to be introduced and adapted to the field of water infrastructure.

## Unleash the power of data by adopting advanced and analytical AM

The rehabilitation of existing buried infrastructure networks presents challenges because physical condition is hard to assess, local redundancy is limited, potential damages and hazards can be severe, and failure or rehabilitation occurring in the heart of communities can be highly disruptive.

Water pipes or sewer AM systems are currently being marketed to utilities, but they are often limited to computer databases with little analytical capacity often drawn from a CMMS. When decision support systems are added, the models offered tend to be based on expert judgments. In some cases, matrices are designed; weights are applied to risk factors or to impact criteria in ways that present problems:

- some factors are counted several times. For example one such matrix accounts for the type of soil – because of the risk of corrosion – and then the level of known or alleged corrosion based on real observations after a break
- future probability of failure is never calculated or taken into account even though any attempt at calculating a risk should incorporate the probability of failure since risk = probability x consequence
- hydraulic criticality (impact on the rest of the network's capacity to deliver water in case one segment breaks) is not taken into account
- typically all risk factors and criteria are multiplied by their assigned weight and are then added up. Methods adding up unrelated criteria are not always adequate. There is little attempt at using demonstrated multi-criteria methodologies.

In other words there is little effort to tap into the full analytical potential of the wealth of data already made available. The US water industry is now showing interest in AM, but in the past there has been a lack of both ambition and resources to embrace the kind of planning or management tools with an analytical power comparable to the ones used in other industries (medical, aeronautic and manufacturing to name just a few), including infrastructure industries (pavement and bridges) or that are found in water utilities within more advanced countries.

Water AM specialists are quick to point to the most important obstacle to the adoption of AM – the absence of data or to the fact that when the data exists, it is often not in a digital form, which makes it difficult to conduct any analysis at all, let alone an advanced one. Therefore, building a relevant digital database dedicated to the planning of rehabilitation is the most pressing need and investment.

However, once a database is built (a task greatly simplified if a GIS or a hydraulic model already exists. Even better, if such a tool is being built taking into account the requirement in data collection for a sound rehabilitation planning programme), a rehabilitation planning strategy is in place, and the necessary personnel trained, the 'black box' can contain either advanced tools or simpler ones.

There is disagreement over the level of analysis AM data should be subjected to. A WERF workshop report quoted utility personnel as placing no trust in models and analytical approaches (WERF, 2003). At the same time, there is little knowledge of the advanced tools that already exist and there have been few opportunities to connect them to what AM professionals express as priorities and needs that have nevertheless been very well documented.

As well as the WERF workshop and report, the US GAO issued its own study (US GAO; 2003). The US EPA held a workshop in May 2005 attended by more than 100 professionals who were given the opportunity to express what they perceived as the most pressing priorities in the field of AM. The GAO report and EPA event both revealed the disconection between current developments and expressed priorities.

AM of water infrastructure, especially of its buried elements, is a very complex undertaking. Even though no exhaustive cost benefit study has ever been run (the task of identifying and collecting all costs involved is a massive one) that could quantify the advantage of an advanced analytical AM approach versus basic AM or no AM at all, it is possible to intuitively assume that decisions based on more advanced models, accurate data and worthy projections will help avoid unnecessary expenses, untimely initiatives (too late or too soon), unwanted damages, and overall waste.

AM is attracting a lot of attention and professionals are getting accustomed to its basic principles and requirements. However, the profession should not settle for simplistic solutions: tasks are complex; many tools already exist or can be further developed to provide adequate solutions. A research community must be fostered, one that works closely with the field professionals to reconcile perceived needs with existing or future tools, and ultimately further advance the overall current state of practice. ●

# Assets Oracle for Thames Water

**Oracle Corporation has announced that the UK's Thames Water is to adopt Oracle Spatial as the heart of its asset data management programme. Thames has chosen the Oracle technology because of its proven robustness and ability to scale to support all of its customer-facing applications.**

The software will enable Thames to centralise asset information into one integrated repository, allowing the utility to enhance customer service and help to ensure it meets its regulatory obligations.

Historically, Thames had built up a disparate portfolio of departmental tools and databases that made it difficult to obtain a consistent view of all its assets and made it costly to implement new applications.

As a result, in 2003, when the Ordnance Survey announced a new background map format, MasterMap, Thames decided to fundamentally reorganise its asset information management architecture to obtain a single view of all its asset information.

The company started on a programme to reduce the number of databases from 23 to one and create a single data repository. Using Oracle Spatial to achieve this will enable the utility to respond more accurately and consistently to regulatory requirements, and to improve operational performance.

By integrating all its asset information Thames will be able to achieve a range of improvements such as increasing visibility of its water network performance, improving capital planning, oper-ational reporting and asset life cycle analysis. ● **LS**

# *Cybit launches new SME fleet management system*

**Online telematics service provider Cybit has launched Fleetstar-AVL - a new affordable telematics solution that provides SME organisations with the benefits of internet-based fleet and asset management.**

Developed as an 'out-of-the-box' telematics solution for SMEs, Fleetstar-AVL will be available through Cybit's network of 20 UK resellers and will provide them with extensive telematics functionality, including real-time GPRS-based tracking and comprehensive reporting.

Fleetstar-AVL is based on Cybit's market-leading Fleetstar-Online telematics solution, and will give clients the ability to capture live location-based information, use exception-based reports to measure performance and refine business processes, and ensure enhanced duty of care provision by analysing driving practices and live tracking.

Fleetstar-AVL will also help in compliance with health and safety legislation and current ➤ *cont:*

# St Petersburg adopts InfoNet asset data system

**St Petersburg, in the US state of Florida, has purchased InfoNet, Wallingford Software's asset and data management system for water networks, to enable it to build a central data repository for the management of all data relating to its collection systems infrastructure.**

Like many engineering departments, in the past, data about St Petersburg's network was held in many different locations around the organisation - computer files in corporate and personal systems, paper records, and in the case of network piping surveys, VHS CCTV tapes.

'The catalyst for our purchase of InfoNet was our adoption of the US PACP (Pipeline Assessment & Certification Program) standard for CCTV surveys of our collection network,' explains Matt Wilson, an engineer with the Water Resources Department of the city of St Petersburg. 'We needed a tool to enable us to both better analyse and prioritise asset condition data, and store and retrieve the clips of the new surveys that we are now receiving.'

InfoNet can store very large volumes of CCTV files online, and display the specific clip automatically when the related pipe is clicked on in the network diagram.The system helps to identify the precise location of any defect within the surveyed pipe or sewer, and to link that with the network records.

InfoNet will in time become the central location for all collections systems infrastructure data, and will make that data easily available to all users across the organisation.

Mr Wilson points out: 'At present two different departments need immediate online access to the CCTV data, and InfoNet will make that possible. This principle of needing one accurate source of data with shared access applies to most of our data, and InfoNet is a highly cost-effective way of achieving this.'

He added that St Petersburg selected InfoNet for the task because 'functionally, it met our requirements very closely. As users of InfoWorks CS, we know that the user interface is very straightforward. Finally, in training and support, again we already know that Wallingford Software score very highly in this important area.'

● **www.wallingfordsoftware.com**

# MWH develops integrated leak management

**Environmental engineering consultant MWH has developed an integrated approach to managing leakage that is currently undertaking with several UK water companies.**

There has been a reduction in overall leakage of 6 million LPD since MWH became the main provider of two leakage frameworks for Northumbrian Water. The company hopes the level will continue to fall over the next two years by a further 3 million LPD.

The Leakage Control programmes developed by MWH provide an integrated approach to the problem, and consist of leakage strategies that provide a balanced combination of leakage detection, pressure management, leakage economics, meter accuracy and water balance components arrived at from thorough analysis of the data on their clients' many activities.

The programmes are designed to help UK water companies to meet, if not exceed, Ofwat targets for control and management of leakage levels.

MWH leakage manager Ian Christie says: 'It is important to stress that our work with a number of top water companies is not a knee-jerk reaction to the current situation. They chose to work with us because of our proven track record in this field and because they wanted to develop a pro-active, long-term integrated strategy and solution to what has been a long misunderstood problem in the UK.

'We use our engineering judgement and substantial global knowledge to provide the best overall approach and tailor-make a solution to match that clients' needs. The approach recognises that water restrictions and substantial resource deployment can only ever be a small, short-term part of the solution.'

Northumbrian Water leakage manager Ken Maddison said: 'We take this issue very seriously. We have been working with MWH for the past four years, when they worked alongside us as framework partners on both of our leakage frameworks.

'The first covers the supply of leakage detection resources and a second provides a leakage analysis framework including activities such as pressure management, metering and field services. They have played a significant part in helping us to always achieve our leakage targets.'

● **www.mwhglobal.com**

# South East Water implements GIS technology

**South East Water, one of Melbourne's water utilities, has implemented its G/Technology to support a company-wide GIS system that it says 'will streamline operations and provide a model of best practice for geospatial technology in a water utility'.**

Kevin Hutchings, general manager, infra-structure, for the Australian utility said: 'The water configuration of this advanced location-aware technology is a first in the Australian water industry and represents the future of the utilities community.

'The GIS system is the hub for our asset management information system. With more than AUD$1 billion ($0.73 billion) in assets, reliable and comprehensive asset information is critical to the success of South East Water. The water industry has a strong interest in this project and our success will provide a strong foundation for future implementations in Australasia.' ●

➤ road transport regulations.

Fleetstar-Online is a scalable solution that provides organisations with the level of telematics functionality they require, while ensuring an easy upgrade path so that the system can evolve to meet changing business needs. Fleet vehicles are fitted with a small electronic in-vehicle-unit (IVU), which is tracked by GPS and the data transmitted to Cybit's online control centre in real time.

It provides companies with a cost-effective, ASP-based, fleet management solution, which offers users anytime, anywhere access to the system through a standard web browser.

Simon Jones, managing director of Fleetview Solutions, a Cybit reseller focusing in the Midlands, said: 'We're finding that there's a growing number of SME organisations in our target area who want their business to benefit from the advantages of telematics, but aren't always able to find the budget for a major technology project. As an out-of-the-box offering, Fleetstar-AVL gives us an ideal solution to take to the SME market.'

Key Fleetstar-AVL features include live vehicle tracking, exception reporting, a journey replay mode and customised reporting. ●

# MWH licences InfoWater Suite to Lebanon

**MWH Soft has announced that the Council of Development and Reconstruction in Lebanon (CDR) has chosen to deploy multiple licences of InfoWater Suite, the ArcGIS-centric infrastructure modeling and optimisation software, at the water authorities of Beirut, Mount Lebanon, and the Bekaa.**

CDR plans to use InfoWater Suite to support the establishment of a more advanced, complete information system designed to facilitate daily operations in the water authorities.

A commercial and tourist center of the Middle East, Lebanon is a water-rich state in a water-stressed region, with a geographical area of 10,452km2 and a population of 3.8 million. The country has been rebuilding its water infra-structure since 1992, and more than 2,500km of pipelines have been constructed.

The country is served by four water authorities that manage, operate and maintain a potable water infrastructure comprising 141 sources, 27 treatment works, 470 boreholes, 161 pumping stations, and 1,085 reservoirs. The water authorities aim at achieving international standards, defined as continuous provision of potable water as well as wastewater services extending to all households, by the year 2015.

The implementation of most capital investment projects falls under the responsibility of the Council for Development and Reconstruction. Over the past decade, CDR has managed approximately 290 contracts with a total value of about $930 million. Some 100 of these projects are still ongoing.

The deployment of InfoWater is a key part of a complete utility information system project awarded to Khatib & Alami, MWH Soft's representative in the Middle East and a leading utility solutions provider, and Adelior Gestion, a French consulting and software firm.

K&A will deploy ESRI and MWH Soft's geospatial technologies and develop interfaces with other leading business applications, including financial, customer information and asset management, to deliver a comprehensive utility information solution. ●

## Diary

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

*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**

*Water 2006*

**13-14 June 2006, London, UK**

Now in its 7th year, this conference has become a leading event in the water industry. With a thoroughly researched programme and excellent speaker line up, this conference offers you the opportunity to hear from key industry figures commenting on the pertinent issues facing the sector. In addition to an update on established topics, this event will provide an in-depth focus on Ofwat's structural transformation and the operational impact of the Water Framework Directive.

Key topics to be discussed include:

- The implications of the new regulatory board structure
- Creating profitable business strategies post PR04
- Exploring the impact of the Water Framework Directive
- Producing an optimal finance structure
- Managing infrastructure assets efficiently and planning for PR09
- Engaging effectively with the customer

For more information, contact the conference producer Katie Singer (+44 (0)20 7760 8666), or visit: **www.marketforce.eu.com/water**

*Managing Infrastructure Assets*

**19-20 June 2006, Paris, France**

This inaugural conference from the Adam Smith Institute will provide a unique forum for the discussion and debate of key issues concerning the successful management of infrastructure assets across the utilities and transport sectors.

The programme will explore:

- What are the most successful strategies for managing infrastructure assets?
- Effective methods for asset tracking: data collection, management and analysis
- Achieving optimal resource allocation
- The issues surrounding outsourcing
- Planning for long-term infrastructure efficiency
- Looking to the future: adapting to changes in infrastructure requirements.

For more information and to register, visit: **www.marketforce.eu.com/mia**

*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**