Overview of Infrastructure Asset Management
A View from Both Sides of the Atlantic Ocean

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Abstract
Europe and the United Kingdom (UK) are at the forefront of Asset Management for water utilities. This is primarily due to the fact of privatization of water utilities in the UK. The UK is currently in the third generation of the Asset Management procedures and has well defined methods for identifying and managing assets. In the United Kingdom (UK), large scale Asset Management has been practiced for approximately 20 years when computer modeling and pipe inspection techniques allowed the current performance and impact of potential improvements to water or sewerage networks to be evaluated for whole systems.

As the industry understanding of the asset base has grown in the UK, so has the variety and application of risk based techniques to aid investment decisions on rehabilitation and replacement decisions. Asset Management and associated risk based techniques are now considered to be standard business practice for utility infrastructure owners and engineers and are well entrenched in the utility infrastructure culture. In the UK, Asset Management practices have contributed to significant savings in capital expenditure through the efficient identification of far more selective work programs, and moreover, have resulted in a savings in operational cost, a consequence of which staff levels have dropped by some 25% over a decade.

Several asset management techniques employing risk elements are within the toolkit of most UK water companies and which help to inform decision support for investment prioritization of critical or vulnerable water supply assets such as trunk mains, protection against raw water contamination, dam safety, environmental protection, capital maintenance and plant reliability and selection.

In the United States (US), it is a different story. There are a number of forms that Asset Management takes in the US including SSES Programs, Infiltration / Reduction Programs, Capital Improvement Programs and CMOM, flow monitoring, SCADA Systems, etc., but very few public utility infrastructure owners have a true Asset Management Program in place. Furthermore, Risk Assessment as used in the UK is now only beginning to be understood and used in the US. The Risk Assessment in the US is done in terms of Criticality of the system components and the effects it will have on the users and public in general should the component of the system go off line. In the US, Risk Assessment is generally not used for investment decisions when it comes to Capital Improvement Programs, but is beginning to be used in the Operations and Maintenance
of the systems. This paper will review Asset Management practices in the United States and in the UK, and compares the two sets of practices. The review will also identify key business and technical practices, how Asset Management is perceived by the owners on both sides of the Atlantic Ocean, and will identify lessons learned from the UK for the North American utility infrastructure owners and engineers.

Keywords
collection system, water system, asset management, risk, performance, capital improvement, maintenance, operations, management, infrastructure

INTRODUCTION

The United States Environmental Protection Agency (USEPA) defines asset management as “managing infrastructure capital assets to minimize the total cost of owning and operating them while delivering service levels customer’s desire.” It is successfully practiced in urban centers and large regional sewer collection systems to improve operational, environmental, and financial performance. Many of the large organizations base asset management planning on sophisticated information systems and extensive personnel resources, but a simple form of asset management can also be used by smaller collection systems owners with existing staff and resources.ii

Despite this statement, owners of many of these collection systems operate in crisis mode versus planning mode. These organizations cannot or will not change their methods of operations due to internal pressures or because of lack of resources. Water and wastewater utilities, like most organizations, are commonly organized into functional departments that tend to become organizationally isolated and become focused on achieving their individual departments objectives.iii That is, engineers-engineer the systems; operations-operate the systems; and accountants collect money and pay bills to responsibly manage the cash flow associated the system. Each of these departments is attempting to assure the survival of the individual departments and is competing for limited resources. There is no common goal within the overall organization to provide custom oriented services in a cost effective business like manner while providing the required services at what would be known in the private industries as competitive rates. This method of operation leads to a cycle of trying to maintain the rapidly decaying infrastructure while competing with the interest (organizationally internal and external) for capital improvements and expansion of the sewer system with limited funds and resources. It is the breaking of this cycle in the U.S. that is required in order to proceed with successful asset management programs.

In the United Kingdom (UK), asset management practices have become standard methods of operations for water and sewer utilities (water utilities). This is primarily due to the fact that many of the water utilities in the southern portions of the UK and were sold to private companies in the late 1980’s. These private companies own and operate the water and sewer infrastructure and are responsible for operating the utilities in a businesslike manner while maintaining profit. To prevent overcharging of user rates to the customers and to assure customers that the private utility owners of the water and sewer systems operated in a fair and business like manner, the UK government’s Office
of Water Services (OFWAT) established stringent requirements as to how these private water utilities operated financially. With approximately 15 years of operating in this manner, the practice has become widely accepted and standardized. These standardized methods include benchmarking of cost and expenditures to operate the water systems Operations Expenditures (OPEX) and to improve and expand the water systems Capital Improvement Expenditures (CAPEX). The methods include constant 5 year cycles of reviewing expenditures, planning for capital improvements based on service and cost forecasting, assessing deficiencies in the existing system, assessing risk and consequential damages due to failure of system components, and implementing capital improvements while maintaining the existing system in a cost effective that minimizes impact on user rates.

ASSET MANAGEMENT PROGRAMS IN THE UNITED STATES

Components of Asset Management Program in the US

Asset Management in the United States consists of a number of components including:

- Desired Level of Service
- Performance Goals
- Information Systems
- Asset Identification and Valuation
- Consequences of Failure Analysis and Risk Management Planning
- Condition Assessment
- Capacity Analysis and Assurance
- Maintenance Analysis and Planning
- Financial Management
- Capital Improvements and Expansion of System

NEED FOR ASSET MANAGEMENT IN US

Many public utilities in the United States have some form of asset management or incorporate at least some of the components of asset management. These include CMOM, Government Accounting Standards Board Statement 34 (GASB-34), Global Information Systems (GIS), SSES, Preventive Maintenance Programs, Capital Improvements Programs (CIP), and hydraulic modeling. However, most public utilities only incorporate parts of an overall Asset Management Program.
The need for asset management is being driven by a number of issues. In June 1999, the Government Accounting Standards Board (GASB) issued Statement 34 (GASB-34) requiring all governmental entities to report capital assets on financial statements at historic cost. GASB-34 broadened the definition of capital assets to include general infrastructure assets (e.g. drainage systems, water and sewer systems, etc.), which until this time were essentially exempt from traditional financial reporting methods due to their long service lives. Now, all public agencies must either depreciate their general infrastructure assets or employ a modified approach to their financial statements, which requires a fully functional asset management system. A fully functional asset management system would include an up-to-date inventory of all eligible infrastructure assets, a condition assessment of those assets, and estimated annual budgetary requirements to maintain the assets to appropriate condition levels.

In addition to GASB-34, many public utilities are under pressure to upgrade the sewer systems due to the Clean Waters Act and USEPA requirements (Consent Decrees). These upgrades are expensive and the Federal Government is lagging in funding to assist the utility owners in meeting these requirements. The demand for funding to meet these demands has meant that some of the funding earmarked for general maintenance has been reduced thus leading to deferred maintenance. The longer the general maintenance is deferred, the more costly it becomes to fix or rehabilitate the infrastructure. Finally, many of the larger metropolitan areas such as Atlanta and Las Vegas are growing in population and size thus requiring expansion of the water and sewer systems. Without the expensive expansions, the metropolitan areas can not grow or are limited in growth thus affecting the potential tax base for the cities, towns, region, and state in which the growing metropolitan area is located.

Combining GASB-34 with other federal regulations and the demand to expand the water and sewer systems have had to significantly increase user rates charged to the public in order to raise the necessary capital in maintain the existing systems, improve on these systems, and expand these systems. These increased rates are putting financial strain on the lower income public. These increased user rates also have political implications that are now starting to rise to the fore front. This is leading to an obvious demand control cost while providing adequate service to the public. The utilities need to be operated on a business model in order to maintain control of cost. Asset Management offers many obvious business benefits to the water and sewer utilities in terms of reduced operations and maintenance costs, better decision-making regarding allocation of resources, more efficient data management, and more accurate financial planning.

ISSUES OF IMPLEMENTING ASSET MANAGEMENT IN THE US

Asset Management is a continuous process that includes life cycle analysis of existing water and sewer systems. This includes both the treatment plants, pump stations, and other above ground facilities (vertical assets) as well as the underground pipelines for both water distribution and wastewater collection and transport including manholes, vaults, valves, etc (horizontal assets). This requires continuous condition assessment of the horizontal and vertical assets. One key issue identified as being costly is the need to go from “static to digital,” that is, obtaining the data that is maintained in paper record
drawings or on some form of storage media and transferring this data to a format that can be useful for data management such as GIS, hydraulic modeling programs, and other associated software programs. This can be time consuming and labor intensive if the utility owner does not already have in place the data in a digital format. Many water and wastewater utilities already have significant CMOM and or SSES Programs in place. It is only a matter of having the data in the correct digital format that can be recognized and shared by other Asset Management software packages. This is where information management and selection of software packages becomes critical. However, there is a lack of understanding in this area.

In addition to the static to digital issue noted above, there is an issue related to lost knowledge or “Brain Drain” due to an aging water and wastewater workforce. Findings indicate that 35% of the current utility employees will be eligible to retire in the next 10 years. Attrition rates, currently at 7%, are expected to rise to 8%. Because the people retiring are the most senior employees in the utility, these retirements will result in serious brain drain and an accompanying loss of institutional knowledge. Tools such as workforce planning and knowledge capture to safeguard against loss of institutional knowledge (to) ensure optimal operation during this transitional period is required by the utilities. This can be overcome by interviewing the retiring employees and recording their knowledge into digital format, however, this also can be time consuming and costly.

When a capital program is begun by a water and sewer utility, proper design and well timed implementation of technology can increase program success and help the utility better manage its assets over the entire course of the assets life cycle. As an asset progresses through phases of planning, design, construction, operation, and maintenance (O&M), and/or renewal, valuable data is generated at each step. The capture of this information in a useful format that can readily be incorporated into an Asset Management Program is, and will be imperative for the management of the water and sewer system in the future. Some utilities owners have this type of system fully or partially in place, but many do not. This is a large hurdle to fully implementing an Asset management Program to many water and sewer system operators.

One of the key issues for Asset Management is assigning value to the existing water (and wastewater) infrastructure. That is to say, what is the value if the asset in today’s dollars or how much would it cost to replace or renew the asset. However, a condition assessment of the asset must be conducted before a value can be assessed. When it comes to treatment plants and pump stations (vertical assets), the condition assessment is relatively easy since access to the particular asset is generally easy and visual. However, when it comes to pipeline transmission lines or buried assets (horizontal assets), the condition assessment is not so easy since access for visual inspection is not so readily made. A committee for the American Society of Civil Engineers (ASCE) Pipeline Division was formed to review national and international practices for Underground Pipeline Asset Management (UPAM). A subcommittee reviewing Condition Assessment practices determined that there are four (4) components to Condition Assessment. The consensus was that “Condition Assessment” includes more than merely looking at CCTV pictures to determine if rehabilitation is in order. Our industry, since its inception
in the 1970’s, has been dominated by the belief that rehabilitation decisions are to be based on the condition of the pipe. If it is broken-fix it and if it is not broken-don’t fix it. EPA’s original guidance even restricted repair to those defects that “appeared” to be cost effective. The measured performance of a system was too often ignored and today’s practice often relies more on condition than performance. The conclusion is that performance must be considered an equal element in “assessment”.

The example below was drawn on the white board at the committee meeting. In this situation, without I/I information, most approaches taken today using just defect and risk information would rank the west basin the highest since it has many defects (more assumed I/I sources) and has a higher risk factor since it passes under a major highway. The east basin would rank lower in most scoring because of fewer defects and lower risk due to failure. With actual I/I information the conclusions change and the greatest risk to the Pump Station may come from the east basin.

Consider two identical defects (red X’s) in each basin. The east basin defect should have a higher (worse) performance score because it resides in a poorly-performing basin. Every defect in the east basin should have this higher (worse) score.

To be effective in managing a collection system and assessing its needs, the Manager has to have three (expanded to four) types of information available for every component of the system – Inventory, Condition, Performance and Risk. Risk originally was considered a subset of Condition, but became an element of its own.

- **Inventory** includes the types of information that are commonly considered attributes in a modern GIS. They include the map itself, pipe type, depth, material, year built and similar characteristics. From this information one can determine proximity to other features (e.g. wetlands) that imply risk.
• **Condition** involves what we traditionally learn from CCTV, SSET, physical inspection including knowledge on the stability of the material of construction, its structural integrity, history of rehabilitation etc.

• **Performance** refers to what is measurable or observable and can be compared to any established goals. It includes Average Dry Weather Flow, d/D ratio, Operational Capacity, I/I from its hydraulic basin, basement flooding etc. This would also include model results.

• **Risk** refers to the environmental, social and other damage that could occur as a result of failure of an element or sub-system of the sewers. Risks include the consequence of failure and likelihood of failure.

The combination of these four components provides a rating system to determine if the asset is critical and requires immediate or near future renewal or replacement. For example, the physical condition of a pipeline may be severe; however, the consequences of failure along with the inventory or performance analysis may indicate that this pipeline may not require expenditure of limited capital to replace as much as another area. This is as opposed to a pipeline that may be in good to moderate physical condition but the asset is not performing to needed levels or if it fails the consequences of failure would be significant. The overall rating system would indicate that the limited capital is better utilized by renewing or replacing this particular asset.

As noted in the introduction to this paper, many water and sewer utilities are unwilling or unable to implement an Asset Management Program. However, this may also be due to a lack of understanding by the utilities management and staff. Many texts on asset management are either so theoretical or include such exhaustive list of activities that they can be discouraging reads. Water and wastewater utility managers are left thinking that asset management is either an academic exercise or an overwhelming “all or nothing” endeavor. This is not true. While asset management is often spoken of in theoretical terms, it is characterized by practical, common sense practices, and tools that can make utility management easier. The idea that a utility must do everything in an asset management model to achieve significant results is not supported by experience. Each piece of an asset management system has value in and of itself.

**EXPERIENCE WITH ASSET MANAGEMENT IN THE US**

The USEPA, in conjunction with municipal and other industry representatives has developed a framework for a dynamic management approach to collection systems called Capacity Management Operation and Maintenance (CMOM) approach. The CMOM is information based approach to setting priorities for activities and investments. These, in association with the GASB-34 requirements are forming the basis for what is now being called Asset Management Practices. However, Asset Management in the United States is in its infancy stages with regards to public utilities and the services provided by companies providing expertise in Asset Management. The United Kingdom, New Zealand, and Australia have been leading the Asset Management push internationally. In the United States these companies are primarily engineering consultants with detailed
knowledge of the water and waste water industry. Some of the Asset Management services provided by engineering consultants include:

- Management consulting (strategy, process optimization, change management, benchmarking, etc.)
- Maintenance management (preventive, predictive, and reliability centered maintenance, etc.)
- Computerized Maintenance Management Systems (CMMS) (selection, design, and implementation)
- Information Technology (hardware, software, networks, system integration, etc.)
- Project Management (planning, design, and implementation of an Asset Management system)
- GIS (mapping, coding, data management, etc.)
- Condition Assessment (SSES, I/I Studies, non-destructive testing, planning, costing, etc.)
- Hydraulic Modeling (metering, planning, software programming, interpretation, etc.)
- Security (assessment, design, and management)
- Financial services (valuation, accounting, project financing, revenue management, etc.)

Despite the diversity of services required, the mix of services provided by the Engineering Consultants varies widely. There are no common definitions of what should be included in an Asset Management Program. This is primarily due to, until recently, a lack of a centralized authority or clearing house where the various public utilities and engineers can obtain information on the latest standards and general knowledge base on Asset Management. However, there now are several organizations dedicated to Asset Management for public utilities that have recently been formed. These are BAMI-I (Buried Asset Management Institute-International, NAMS (National Asset Management Steering) Committee, and ASCE’s Pipeline Division-UPAM (Underground Pipeline Asset Management).

With respect to what each Engineering Consultants provides with respect to Asset Management services, it varies from offering limited information specifically addressing asset management on it’s web site with no web pages focused totally wholly on either asset management or GASB-34 to a full spectrum of services with multi-disciplinary approaches from information systems, financial management, to implementation of asset
management programs. Some engineering consultant even offers specialized management and information services based on best practices in Australia, New Zealand, or the United Kingdom. But until the water and sewer utilities in the United States become more aware of the benefits of an Asset Management Program, and until Asset Management becomes a common practice in the United States, it will remain embryonic.

**ASSET MANAGEMENT PROGRAMS IN THE UNITED KINGDOM (UK)**

**Development of the Asset Management Approach in UK**

The origin of large scale wastewater Asset Management Planning in the UK goes back to the late 1970’s when the National Assessment of Sewers\textsuperscript{xix} was carried out. Sewer condition assessment techniques (CCTV) had been introduced a decade earlier, however it was not till the early 1980’s that the hydraulic and structural performance of a complete sewer network could be fully assessed on a city wide basis, and capital investment plans prepared with a reasonably sound understanding of the hydraulic and environmental implications.

Standardized procedures and software developed for this purpose included a manual of sewer condition classification, a classification system for sewer and water mains records, the UK Sewerage Rehabilitation Manual\textsuperscript{x}, and a sewer computer simulation program. This suite of procedures and software has been subject to almost continuous development over more than two decades as the needs of the sewerage service providers increased and computers became ever more powerful. One of the key drivers behind this activity was a backlog of underinvestment in aging infrastructure, resulting in visibly poor performance (pollution, flooding and sewer collapses) and the consequent need to support applications for increased funding with investment plans, which clearly demonstrated value for the customers’ money. Increasingly strict legislative standards and rising customer expectations were also high on the agenda of water utility managers.

Asset management investigations revealed that despite the age and condition of some of the sewer networks, the greater part of future capital investment would initially be required to ensure compliance with pollution control legislation. Similar investment needs also affected the UK water supply infrastructure. In response to the growing need for capital, the UK government privatized the ten major water and sewerage utilities in England and Wales in 1989. These utilities provided sewerage services across the country with a slightly less comprehensive coverage of water services; the gaps being filled by a larger number of small water only companies, which were already in private ownership.

All the private companies were formally licensed to provide water and waste water services and recover charges from some 50 million customers across England and Wales. To manage the associated economic issues, the Office of Water Services or Ofwat was formed with a brief to look after the interests of customers and at the same time, ensure the private water utilities remained financially viable. Ofwat's approach has been to simulate a competitive environment for the utility companies, which are effectively in a monopoly situation.
Ofwat requires the companies to submit their ‘Asset Management’ (AM) or business plans for review and approval on a five yearly basis and to report annually on the levels of investment accomplished and on the level of service provided – failure to comply would jeopardize a company’s license to operate. The asset management plan and annual reporting requirements are very detailed and could be said to represent the information a well run company should have at its fingertips if it is to remain efficient and stay on top of the market.

Asset management is now a reasonably mature process in the UK, driven on the one hand by the need to comply with ever stricter legislation and regulations and on the other, by the need to demonstrate value for money to both the customers and the shareholders. All of this must be achieved under the watchful eye of the regulatory authorities; the Environment Agency (EA) as regards waste water quality compliance, the Drinking Water Inspectorate (DWi) in the case of drinking water quality and Ofwat as regards levels of service and financial/economic issues.

EXPERIENCE OF THE ASSET MANAGEMENT PROCESS IN UK

Jacobs Babtie has been involved in the development and implementation of asset management procedures from the start, having carried out one of the earliest sewerage asset management planning studies in 1983/84 and subsequently played a key role in evaluating the saving which could be achieved at city and regional level through effective application of the then new UK sewerage rehabilitation procedures. Potential capital cost reductions of the order of 20% were identified at this stage.

Since privatization of the water utilities in England and Wales, projects have involved all the key steps in the asset management process set out in Table 1 below, from development of the capital investment business plan, through management of the capital works programs to provision of auditing or monitoring services in UK and on the wider international stage. For example, we have recently completed an asset management study covering all medium and large wastewater systems (sewers and treatment works) in the Republic of Ireland, excluding the Greater Dublin area. This work included provision of an asset database and GIS, identifying and costing the future network investigation and modeling requirements, assessing the future demand and upgrading needs and providing guidelines for prioritizing future capital works. It is worth noting that, on commencement of this study, the quality of records was poor and maximum use was made of the substantial but unrecorded knowledge of some local operators.
Table 1 - Key Steps in the Asset Management Process

<table>
<thead>
<tr>
<th>Steps</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Define the rules and strategy</td>
<td>Define the standards of service, the performance and maintenance requirements (trigger and target levels for action), the system upgrading strategy to meet future growth and the legal, safety and regulatory requirements. Survey and inspect the assets, assess their condition and performance and prepare an inventory. Assess the probability and consequence of failure, derive the effective asset life and the priority for action, value the assets and categorize them by condition and performance.</td>
</tr>
<tr>
<td>2. Assess the current assets</td>
<td></td>
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<tr>
<td>3. Determine the asset life and value</td>
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<tr>
<td>4. Assess the system upgrading requirements</td>
<td>Assess the upgrading requirements in order to; maintain the current or base level of service (e.g. repair failing sewers), to achieve the standards of service defined in step 1 above and to provide capacity for future growth in demand. Develop alternative capital and/or operational solutions, optimize and approve the solutions (including regulatory approval) and develop robust cost options. Assess the impact of the proposed capital program on operating costs, the sensitivity of costs to changes, the impact on tariffs, the priority for action (the program) and finalize the Business Plan or Asset Management Plan.</td>
</tr>
<tr>
<td>5. Develop cost effective solutions, capital and operational</td>
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<tr>
<td>6. Prioritize and program the works, i.e. the AM plan</td>
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<tr>
<td>7. Confirm the AM program and price or tariff limits</td>
<td>Obtain approvals for the program and the associated tariffs from the regulators and customers, including any required adjustments to the AM program. Review the program risks, develop and implement capital program procurement arrangements (e.g. design, construction and program management contracts) and associated operational improvements. Monitor the delivery of assets and services as against the business plan and strategy. Carry out post project appraisal, assess capital and operational efficiencies achieved and identify actions to improve the process in future.</td>
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<tr>
<td>8. Implement a rolling program of capital and operational improvements</td>
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<tr>
<td>9. Monitor the capital program and levels of service delivered</td>
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Stopping to look for a moment at some of the detail under the heading of say item 2; ‘Assess the current assets’. This can be a very major task when it is considered that there are nearly 300,000 km [186,500 miles] of storm water, sanitary and combined sewer in England alone. Ideally a sewerage system manager should have a complete record of his...
networks in digital form, to allow easy access to information for a wide range of management activities. For the purposes of planning, sewer survey or hydraulic simulation modeling, good records are clearly essential. Starting from scratch the task of preparing records can be daunting. However, the use of Geographic Positioning Systems (GPS) and rugged in-field computer tablets should make it somewhat easier than in the past, not forgetting that the critical pieces of information (e.g. sewer levels and dimensions) are still likely to be obtained under the most adverse conditions by the lowest paid staff – beware data quality.

To further ease the assessment task, the sewer inventory is divided into ‘critical’ and ‘non-critical’ sewers based on the potential consequences of a failure, for example a sewer running under the access road to a hospital would be identified as ‘critical’ as would a sewer crossing under a highly trafficked road. The aim of this approach is to apply pre-emptive maintenance to the critical sewers, where the impact of failure would be very high in terms of direct repair/compensation costs or disruption to business and social life, and to take a reactive approach to the non-critical sewers; renovate them if and when a failure occurs. On this basis AM planning activities, including records updating, sewer condition surveys and sewer modeling tend to concentrate on the critical sewers otherwise termed the ‘core area’ sewers.

Typically the critical sewers comprise less than 25% of the total length of a network. This part of the network should be subject to regular survey by, for example, CCTV survey at intervals which may be from 5 to 15 years depending on the conditions found. Sewers are graded 1 to 5 according to both the internal condition and external environmental factors, such as the likelihood of local subsidence. Condition Grade 1 means the sewer is effectively in ‘as new’ condition where as Grade 4 is suffering serious deterioration and Grade 5 has failed or is on the verge of failure. Pre-emptive action will be taken in the case of critical sewers in Condition Grades 5 and 4, however in the latter case action could depend on available funds.

In order to provide condition and performance monitoring statistics that are meaningful, the percentage of the assets in each of the five condition grades is estimated in monetary terms, i.e. the value of all assets in each grade is calculated as a percentage of the total value of the asset base. For this purpose, all assets are valued on a current cost rather than historic cost basis using their ‘Modern Equivalent Asset’ or MEA value. For sewers this is the current cost of providing a new sewer in the same location and with the same capabilities as the existing asset when new, e.g. the same flow capacity, the theory being that pipes in the ground are maintained indefinitely and should not be depreciated. You could say it is the ‘hole in the ground’ that is being valued. For above ground assets, such as treatment works, the net MEA value is utilized and taking account of the current condition and the remaining life of the asset, in other words a depreciated current cost.

This approach allows condition and performance changes to be tracked over time and used in considering the appropriate level of future maintenance expenditure. It is but one of the tools used by the economic regulator, Ofwat, in his judgment as to suitable levels of capital maintenance expenditure which may be recovered by the utilities through

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customer charges. Further discussion of this issue is given in the next section of this paper.

Now, some 15 years after privatization, the UK water industry has commenced its fourth asset management cycle and the benefits are evident from the quality of service, which has risen significantly, and the customer charges which have been carefully managed. Capital investment has nearly doubled since the late 1980’s to some US$ 6B\textsuperscript{xii} per annum (see Figure 1) whilst customer charges have risen by approximately 25% in real terms over the period to January 2005 (see Figure 2), when the average household charge for water and sewerage services was approximately US$440\textsuperscript{xv}. Operating costs rose in the first five years following privatization and then dropped steadily to a level lower than that pre-privatization and whilst these costs are now rising again, the 2010 figures are expected to be lower than those which occurred in the mid 1990s\textsuperscript{xvi}.

**Figure 1 – Actual and projected capital investment (water and sewerage) 1981 - 2010**

![Graph of capital investment](image)

**Figure 2 – Actual and projected average household bills (water and sewerage) 1991 - 2010**

![Graph of household bills](image)

\textsuperscript{xii} Based on 2000-2003 prices, exchange rates taken as US$1.00 = £0.57 or £1.00 = US$1.75

Whilst the focus of this paper is on water and sewerage utilities, it is worth noting that broadly similar procedures and regulatory regimes apply to other utility operations in UK and a dialogue between the different economic regulators has helped to ensure an appropriate degree of consistency in approach.

CURRENT GUIDELINES IN THE UK

Asset management is essentially demand led and customer focused; it is designed to meet legal/regulatory requirements and the customer needs and expectations, at a price the customer is willing to pay and the utility can live with, thus the outputs could be classified under the headings listed below - these represent the aims of the UK water industry asset management process.

- Maintain the base or current level of service and serviceability of the assets
- Meet new quality enhancements under legal/regulatory obligations
- Maintain the supply demand balance for future years
- Provide enhanced levels of service where affordable/sought by the customers
- Achieve all of the above within an acceptable charge/tariff level
Stakeholder interactions required to achieving these objectives can be likened to the sides of a triangle; on one side we have the quality regulators (the EA or DWi) on the other, the economic regulator, Ofwat and on the third side the utility and its technical staff, whilst the customer sits in the middle. Each party round the outside has its own principles and guidelines.

For the sewerage engineer, the 4th edition of the Sewerage Rehabilitation Manual (SRM) provides a comprehensive approach to the technical aspects of asset management for waste water infrastructure along with a full list of guidance documents for the condition and performance assessment, design and implementation stages of a wastewater asset management plan.

The urban drainage network modeling package, InfoWorks, provides software to compile the base data, evaluate the current system performance and assess the impact of rehabilitation or upgrading options, including consideration of flooding and pollution controls. This package includes database and GIS capabilities.

The content of the SRM and the associated sewerage modeling processes are reflected in the document, “Development of Guidelines for the structural, hydraulic and environmental rehabilitation of sewers”, which provides a Europe wide guide to the rehabilitation of drains and sewer systems. This document is not intended to supersede national procedures and methodologies but to provide information on current methods of best practice in relation to:

- Measuring the structural, hydraulic and environmental performance
- Assessing and prioritizing the need for rehabilitation

The EA is concerned with interpreting the relevant legislation and regulations as applied to each utility’s situation, monitoring compliance, seeking to ensure that pollution and flooding problems are minimized and the environment we all live in is protected. In the context of a utility’s five yearly asset management plan, the EA reviews and approves (or rejects) the proposals for pollution control before the overall business plan, including proposed customer charges, is submitted to Ofwat for final approval.

Within the European Union, the broad principles of pollution control are set out in Directives which are subsequently translated into national legislation. It is likely that the UK legislation and regulations are not dissimilar to the pollution control legislation affecting water and sewerage utilities in the United States.

For the economic regulator, Ofwat, the utility’s business plan is the key document required for the purposes of the five yearly periodic reviews. It should set down the utility’s application for new price limits, take account of all issues facing the utility including quality improvements, and provide information relevant to the price limits and statutory duties facing the company. The structure of these business plans has evolved over the last 15 years in light of increasing levels of knowledge about the asset base and
its performance and the need for more sophisticated and transparent method of predicting future investment requirements with particular reference to capital maintenance.

The key elements of the 1994 asset management or business plan submissions to Ofwat by the utilities were as listed in Table 2 below. Detailed guidelines were provided to identify exactly what was required at each level. The most important issue for many of the water utility companies at this stage was to prepare reasonably comprehensive asset inventories, including assessments of condition, performance and future capital maintenance requirements. This was the first time many of the utilities were likely to have prepared such detailed records.

Table 2 – Ofwats’ Key Reporting Requirements for AMP2 in 1994

<table>
<thead>
<tr>
<th>Company Strategy</th>
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<tbody>
<tr>
<td>Obligations, policies, assumptions, including demand forecasts, targets and objectives that the company has applied in drawing up their AM plan</td>
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<thead>
<tr>
<th>Existing Assets – Performance &amp; Summary Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current performance of the company assets, which will include outputs, performance, condition, serviceability, and current cost asset valuation (termed the modern equivalent asset value or MEAV).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Investment Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>The approach used by the utility to develop and assess future investment needs, together with the key unit cost relationships and explanation of any statistically derived figures.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment of outputs and Total Expenditure Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>The outputs, activity and investment profiles together with the services targets. This section to include an assessment of charges the utility considers necessary to maintain and/or replace its asset base over time.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating Expenditure and Financial Projections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating expenditure not included above together with justifications, plus the background to the financial projections</td>
</tr>
</tbody>
</table>

The 2004 business plan comprised three elements, Part A, Company strategy, Part B Key components, and Part C supporting information. Part B comprises 8 sections as listed in Table 3 below. The issue of capital maintenance costs has become a key concern in recent years and this is reflected in the regulators requirements for detailed information under the heading, ‘Maintaining service and serviceability’.

Table 3 – Ofwats’ Key Reporting Requirements for AMP4 in 2004

<table>
<thead>
<tr>
<th>Post 2005 environment</th>
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</thead>
<tbody>
<tr>
<td>This looks at the achievements to date and considers how the key risks and uncertainties will be managed to the benefit of customers</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Improving efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>This identifies the targets for the company to improve its efficiency over the succeeding investment period</td>
</tr>
</tbody>
</table>
Maintaining service and serviceability

In this key section, the company should identify the activity it considers necessary to maintain the service to customers and serviceability of its assets. This is a risk based approach which makes forward projections based on analysis of historic maintenance and serviceability data.

Quality enhancements

This sets out the company strategy for dealing with any additional quality obligations placed on it.

Supply and demand balance

This sets out the company strategy for maintaining the balance between supply and demand for services and the implications for expenditure where it is not offset by increased revenue generation.

Customer service /service enhancements

This sets out the company strategy for delivering services over the following investment period and the service improvements it expects to achieve.

Financial projections

This sets out the company plan to finance its functions, including the cost of debt, return on capital, availability and sources of finance, taxation etc.

Customer bills/tariffs

The company presents its forecast for charges in the period based on the approved tariffs, metered and non-metered customers and supply demand balance issues – it should be noted that the majority of domestic customers in UK are not metered.

The principle applied by the economic regulator in making his assessments is that of comparative competition. Capital works unit costs and econometric methods are used to assess the relative capital and operating efficiency of companies and the results provide a stick to encourage the less efficient to catch up with the more efficient.

Up to 1999, the regulators assessment of capital maintenance investment requirements, to repair, refurbish or replace assets and ensure continuity of service, was based largely on a backward looking assessment of the condition and performance of each utilities asset base. The approach did not consider the future risk to maintenance of the service and so in 2002, a new approach, termed the ‘Common Framework’ was introduced. This requires the utility to identify the historical levels of maintenance expenditure and the associated trends in serviceability of the assets. By analyzing past data, the probability, consequences and cost of failures can be assessed along with the benefits deriving from pre-emptive rehabilitation strategies. From this, forward predictions can be made of the probability and cost of future failures, assuming different levels of maintenance expenditure. The level of intervention can then be optimized to produce an estimated economic level of maintenance investment. The approach was successfully utilized in 2004 to identify and justify capital maintenance investment needs for the sewerage and/or water utility companies in England and Wales. Different utility companies took slightly different approaches and it is interesting to note that the most successful approaches were found to be:
• ‘Service modeling’ for asset types where there is potential for asset failure to affect service to customers or the environment. These approaches include estimation of the service consequences of asset failure and identification of interventions required to maintain levels of service, taking account of forecast asset deterioration.

• ‘Least-cost alone’ approaches for assets with negligible service consequences of failure, or where consequences are avoided by operational responses. These approaches seek to minimize costs to the company.

By contrast, the least successful approaches were found to be:

• ‘Age-based maintenance’ approaches in which interventions are planned only on the basis of standard asset lives or asset lives modified according to condition, performance or risk.

• ‘Prioritization only’ approaches that provide no quantitative or non-arbitrary means to identify the dividing line between those interventions required in the next 5 yearly planning period and those that could be deferred.

This is part of a continuing process by which the regulator ensures the customer receives good value for money and the utility comes to a better understanding of his business requirements and maintains a competitive edge.

CONCLUSION AND KEY DIFFERENCES IN THE US AND UK ASSET MANAGEMENT PROGRAMS

The UK approach is a government driven and enforced, utility compliant, overarching approach to business practices, customer care and product quality, which requires detailed records to be maintained of all related issues. The US approach is government driven only in the areas of product quality (through EPA and state agency water standards) and customer water rates (through local water boards). Financial compliance with accepted standards (GASB 34) is voluntary. Utility compliance is suggested and the expectation was that the utility bond marketplace would enforce compliance through higher bond costs for non-compliant utilities. This has not happened principally due to two problems: 1) There are many other factors (overall financial health, utility customer base, etc.) that go into a utility's bond rating, and 2) Utilities that rely only on water rates alone for their financing have felt no obligation to comply. To some degree, the US utilities have been keeping their heads in the sand and hoping that both equipment and underground pipelines would last far longer than failure history suggests or the US government would contribute large portions of the money required to rebuild these systems. The underground piping in the US suffers from the adage “out of sight, out of mind”. As areas have grown, utilities have also become dependent on developer and builder financing of infrastructure needs. These approaches will not be sufficient as older plant and piping assets age. Instead of "reinventing the wheel" and attempting to craft a
new approach to AM for the US, we believe that many of the methods of the UK's approach could easily be used to assist in assembling AM plans for US utilities.

However, the primary drivers for a water or waste water utility are essentially the same be they in the UK or USA; comply with environmental legislation and provide the customer with a good and continuing service at an acceptable rate - as in any other business, the customer is king. The data requirements to run a water utility are also the same. However, without internal or external pressure to build and maintain a comprehensive database relating to both the assets and their performance in the US, much of the information remains in operators and manager’s heads and decisions may be made on the basis of very limited hard data and gut reaction or an imperfectly informed mental assessment.

Regulators in the UK are driving water utilities to improve their records and their business practice through the vehicle of asset management. AM represents good business practice which should benefit all stakeholders, the utility, its shareholders, bondholders or bankers, its customers and the environment at large. In the US, the regulators are only recommended business practices. These business practices have not passed legislation. But the most important of all in the US and the UK, AM should make the money go further so the customer gets more for his buck.

AM objectives and practices as identified by the USEPA and in regulations such as CMOM and GASB34 are in essence not very different from UK objectives and practice. The real differences are perhaps in terms of the level of experience and the degree of sophistication which is developing in the UK water industry. Some of these differences are due to the structure of the industry whilst other such as the use of current cost data in monitoring long term condition and performance and the ‘Common Framework’ approach used to assess future capital maintenance requirements could be considered as transferable. In practice, much of what the UK industry is learning to its advantage is derived from good practice in other industries – it goes back to the old saying, “there is nothing new under the sun” but we some times need to re-learn old skills. Jacobs is currently working to integrate the two approaches to craft a template that could be implemented incrementally depending on each utility's commitment and infrastructure condition.
REFERENCES

i Similar papers presented at North American Society for Trenchless Technology-No-Dig 2006 in Nashville, TN and at AWWA ACE 06 in San Antonio, TX.
iii American Water Works Association Journal- “Breaking Organizational Silos” Volume 97, Number 6, June 2005
v CE News - “Improving capital programs with information technology” – September 2005
vi ASCE UPAM Committee Meeting Minutes dated March 26, 2006