MANAGING A KEY RESOURCE USING ADVANCED WATER ASSET MANAGEMENT

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Abstract
In order to manage water as a key resource more effectively we require advanced asset management strategic processes. Underground pipe assets are tricky to manage, in part because we cannot see them, and in part because information about their performance comes from multiple sources.

This paper is based on interviews with New Zealand water suppliers on pipe renewals and replacements decision processes. The research suggests that many of the larger water suppliers believe they have management practices in hand and that the smaller water suppliers have budgets too small to contemplate proactive replacements. In the middle are water suppliers that want more integrated, interactive asset management systems, greater certainty around remaining pipe life, and a better understanding of the effect of maintenance and replacements on network-level performance. These water suppliers also indicate they would welcome more guidance from the industry.

The key to overcoming the major obstacles in management of underground pipe assets is to share information – both between asset groups within each council and between water suppliers – related to level of service (LoS) performance in a single viewing platform. The following are some ideal management situations that would be made possible by this single viewing platform:

1. **Roading and utilities communications**. Councils' roading and utilities teams discuss and agree their works programs at the beginning of the year to ensure the road is not dug up for pipes after a new road surface has been laid. Because there is a system to view the most up-to-date programs for all assets, even program changes throughout the year are captured. The asset groups making the changes are made aware of who is affected, and affected asset groups are alerted of potential changes. The single viewing platform can support all utilities coordinating their short and longer term work programmes, as required under the National Code for Utilities Access to the Transport Corridors.

2. **Expected life and probability of failure**. Expected life and probability of failure are based on LoS performance targets and predicted risks associated with a large set of pipes of similar materials, sizes, pressures, and environmental conditions, so there is a high level of certainty around predicted performance. This pipe performance inventory is based on a centralised database that holds copies of all water suppliers' pipe characteristic and performance data. This database provides analytic and reporting abilities that show how different pipe selections might perform under particular conditions. By pooling this information, New Zealand would be on a fast

learning path to setting appropriate data collection strategies and improving design standards.

3. **'What if' scenarios**. Water asset managers understand how network performance, customer levels of service and budgets are likely to be affected by different maintenance, renewal or replacement strategies. Water asset managers and operational staff alike are able to undertake 'what if' scenarios for renewal policy and for individual pipes.

In this paper we outline the results of the survey of New Zealand Local Authorities' views on the use of and needs for advanced asset management software. We also discuss the benefits of bridging the gaps between current and advanced asset management practices.

Introduction

In order to manage water as a key resource more effectively we require advanced asset management strategic processes. Underground pipe assets are tricky to manage, in part because we cannot see them, and in part because information about their performance comes from multiple sources such as customers, water quality sampling, and condition assessment processes.

Most water suppliers develop pipe renewals programs without sound knowledge of the most effective means of achieving agreed levels of service. The suppliers do not have the means of linking pipe inventory data to 'performance' and costs. They compile renewals programmes by juggling scant or randomly collected condition data, suspect age and inventory data, variable quality maintenance records, and hydraulic model outputs.

Objectives of the Paper

The main purpose of this paper is to review the current practices with regards to managing water pipe networks in NZ. In order to do this, the three main objectives were to:

- Critically assess the status of asset management processes in relation to advanced asset management requirements;

- Suggest an approach that would improve on the status by including Level of Service (LoS) performance targets (and consequences of failing to meet them) as part of the decision making process; and

- Consolidating the approach through an integrated platform that underpins a LoS approach and addresses some of the operational shortcomings of current processes.

The Importance of Advanced Asset Management

Across New Zealand typical asset renewals on pipe infrastructure varies significantly. The authors' experience suggests that, as a percentage of asset value, pipe renewals may be less than 0.1%, as is typical for newer stormwater networks, or well above 2%, as is the case for wastewater and water supply networks where some Asbestos Cement types are proving problematic. Getting this expenditure right is key to Territorial Local Authorities (TLAs) ensuring the optimum CAPEX or OPEX expenditure is committed to the right pipe asset at the right time, such that risks and costs to customers are managed to acceptable levels.

By understanding asset condition, performance, criticality, and the consequence of failure, water suppliers can programme short- and long-term asset renewals to maintain confidence, meet LoS targets, and limit risk exposure and asset failure consequence. A flawed asset renewal programme could lead to critical asset failures causing OPEX and CAPEX budgetary pressures, and significant service losses resulting in environmental and health and safety implications and associated damage to the TLA's reputation (as outlined below and in Figure 1). On the other hand, poor decision making could lead to unnecessarily high planned maintenance and renewals programmes, resulting in higher charges than necessary to achieve customer level of service requirements.

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Use of a suitable predictive LoS-based model will allow TLAs to programme CAPEX expenditure based on actual useful asset lives and condition including acceptable risk and the consequence of pipe asset failure. Demonstrating this LoS-CAPEX linkage will allow asset managers to prepare robust Asset Management Plans and LTCCPs that link costs to target LoS performance.

Incorporating Risk into Decision Making

Risk management is a fundamental aspect of asset management, as identified in PAS-55 (The Institute of Asset Management 2004) and the International Infrastructure Management Manual (NAMS 2006a). Asset management policies and strategies must align with corporate risk management frameworks. Risk management is defined as the application of a formal process to estimate likely outcomes and probability of occurrence for a range of key risks influencing the organisation (NAMS 2006a).

Further, risk is a key consideration for many types of decision-making at "strategic" and "operational" levels, such as identifying which activities or projects are the highest priority and/or are economically justified. The NAMS Optimised Decision Making Guidelines (NAMS 2004) illustrates a number of ways that risk can be built into decisions; through quantification of risk-cost associated with each option in benefit-cost analysis through to inclusion of risk reduction as a factor in multi-criteria analysis. However existing asset management software tools do not forecast risk in either of these ways.

Risk events are generally managed using a balanced approach to manage both likelihood and consequence, ideally using predictive models. The key risk criteria for assessing the consequences of pipe failure are typically:

- **Service loss/reduction.** Reduced or loss of service to the customers and consequential personal/business impact within the community;
- **Health and safety.** Illness or injury to members of the public, staff and contractors/consultants through action or inaction by, on behalf of or for the TLA, or through the operation and/or failure of the infrastructure, systems or other assets;
- **Environmental.** Damage to the natural environment as a result of action or inaction by, on behalf of or for the TLA, or through the operation and/or failure of the infrastructure, systems or other assets;
- **Consequential damage.** Damage to third party property, infrastructure and business due to action or inaction by, on behalf of or for the TLA, or through the operation and/or failure of the infrastructure, systems or other assets;
- **Financial.** Direct exceptional or unbudgeted costs and/or loss of revenue to investigate and rectify the issue (which may in the case of asset failure include the repair of the failed infrastructure and reinstatement of the surrounds), restore service, compensate affected third parties and meet any applicable fines/penalties;
- **Cultural/Social.** Social or cultural impacts within the community through the operation and/or failure of the infrastructure, systems or other assets;
- **Organisational Integrity.** Damage to reputation within the industry and community and consequent organisational actions required.

Complexities Involved with Renewal and Replacement Planning Processes

An organisation will waste resources on responding to failure events if its maintenance and renewals strategy is too reactive, and conversely may waste too much resource on proactive activities. Finding the appropriate balance between the planned and reactive maintenance and renewal strategies is important and will have significant impact on the cost effectiveness of the organisation. Figure 1 illustrates this to be a complex balancing point to establish. Both external and internal drivers complicate the challenge of finding the technical "perfect" balance between the pro-active and reactive strategies.

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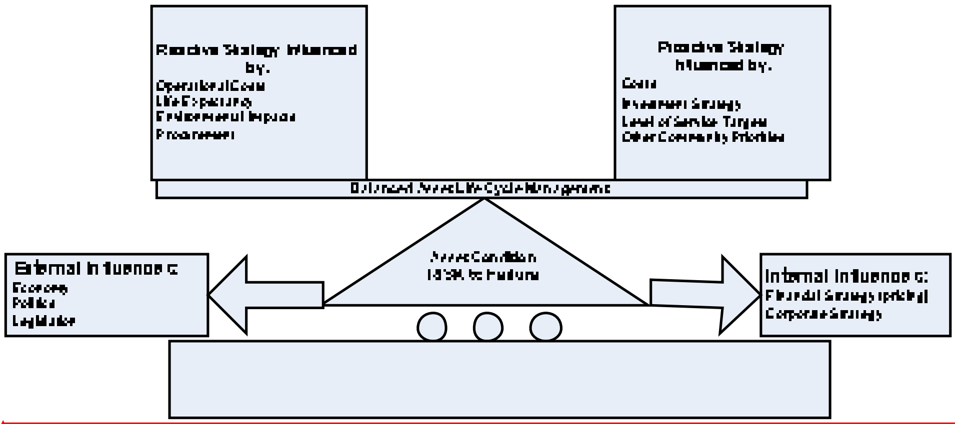

Figure 1 Balanced Asset Management (based on Schlotjes, 2009)

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For example, too much investment into a proactive strategy would reflect a conservative approach that would provide certainty on investment levels but could appear to be more expensive for the short-term planning horizon. In comparison, a more reactive strategy would reflect a more risky approach and is often associated with the occurrence of "unexpected" expenditures and larger variations on planned costs. Although, this approach seems to have a lower short-term planning horizon cost, there is often an associated build-up of maintenance backlog leading to price shocks.

Although many water companies already use a risk matrix type analysis for prioritising their renewals, the risk matrix analysis process has a number of shortcomings. Typical risk decision processes, based on a matrix analysis, are not able to forecast risk profiles and investment needs into the future. Although organisations may have a good understanding of the consequences of failure, the inadequacy of these risk decision processes is aggravated by a lack of processes or data to robustly estimate the probability of failure events. The net result is that organisations have a degree of certainty around their current and short-term operating risk profile (1-5 years), but with the lack of understanding future risk demands, they are unable to maintain a constant work programme and are often confronted with cost fluctuations on the forecasted short-term renewals programme.

The water industry needs a renewals decision framework that is based on forecasted risk models. These models need the capability of predicting the probability of failure due to known input parameters such as material, soil condition and install date. These models can be reasonably simple, but the input data must be robust to ensure meaningful predictions. Experience has shown that water organisations in NZ mostly lack robust data stored in a common database framework. A fragmented data management approach is highly inefficient for those trying to understand system performance, and in some cases may even cause the duplication of data collection efforts. Therefore, step one in an improvement initiative of renewal planning processes starts with having "one source of the truth" in terms of data storage.

TLA survey
At the end of 2009, the IDS Consortium interviewed asset managers from a sample of 16 TLAs across New Zealand to paint a picture of NZ's renewals decisions processes for underground pipe assets. This survey suggested that renewals decision processes and tools vary significantly, with significant concerns at all levels. Asset managers generally had a lack of confidence that their current practices and tools were cost effective and were frustrated by the lack of ability to coordinate with other activities. They are currently looking for systems that can help them or are beginning to develop their own. They would welcome a lead from industry, but due to the high level of frustration the assistance needs to be quick and targeted. Only the smallest water suppliers seem to feel that their existing decision processes are adequate because either (1) they are working with very low budgets and can only afford to address the most urgent issues, which they feel they are addressing adequately, or (2) their contractor develops and manages the works program and the approach feels 'about right'.

TLAs' specific concerns were

1. an inability to effectively integrate all relevant information for planning and communicating
2. an inability to analyse trends and cause-effect relationships with unreliable data or inadequate sample size

These findings supported an earlier survey of 27 water authorities carried out by the Water Information Managers Steering (WIMS) Group in 2008 (WIMS 2009), which found that at that time

- Only 40% captured unplanned maintenance work history against assets in their Asset Management System. The majority held work history in hard copy form only (though it may be available electronically in some form by contractors).
- 70-80% considered their basic asset dataset (dimensions, material, age) to be of medium-high confidence and completeness, but there is much lower confidence in condition, performance, cost and criticality data.
- Half did not record any condition data against assets, the other half generally have some CCTV data available for wastewater assets, though often in separate systems. 'Top-down' approaches are often used for the Asset Management Plan and renewal forecasting approaches.
- Two thirds applied standard asset lives to assets, one third analysed specific lives for individual assets using a range of life factors (e.g, pressure or service load, etc).

Information integration
For most TLAs, programming maintenance and renewals is a very manual process that involves gathering information from a variety of sources – works orders, customer complaints databases, historic maintenance records, operators, GIS, roading asset managers, and asset inventory databases. Working with all of these sources is a juggling act. A typical approach is for asset managers to enter the data they believe is relevant from each of these sources and develop a programme of works in a spreadsheet or

database. Then, using a combination of factors such as expected remaining useful life and criticality analysis, asset managers prioritise the projects.

The WIMS survey and our own survey found that approximately 85% of water suppliers store their data in purpose-built asset management databases, most commonly Hansen and BizeAsset, with a few using in-house developed software or other specialist software. The remainder used Excel spreadsheets. All water suppliers appear to use GIS to store some asset information. Despite the high uptake of purpose-built software, the majority of asset managers export their data from various sources to a spreadsheet or database for analysis such as criticality assessment and renewals forecasting.

A number of asset managers expressed embarrassment around the lack of coordination with roading and other activities. Despite comparing roading and pipe renewals programmes at the beginning of the planning year, programmes changed throughout the year so that a road was resurfaced one year, then dug up the following year to replace a pipe. It is uncommon for longer-term roading and utility programmes to be fully coordinated.

The National Code for Utilities Access to the Transport Corridors (NZUAG 2009) will increase expectations regarding of coordination of roading, water utility and other utility projects in the roading corridor. The new Code, which aims to improve management of works under roads, is expected to be legislated in the near future and requires that

- Utility Operators provide information on their forward schedules of upcoming works to Corridor Managers to facilitate coordinated and efficient outcomes, and

- Corridor Managers must provide information on forward schedules of upcoming roadworks to Utility Operators to facilitate coordinated and efficient outcomes and coordinate regular liaison with meetings with all Utility Operators, on the nature and timing of future works, so that these can be accommodated with any other proposed or planned works in that section of the corridor.

Confidence in data and analytical tools

In terms of data collection, all TLAs collect asset age data, and 90% collect some level of asset condition and historical maintenance data though, as the WIMS survey found, this was not always held in electronic form. Many asset managers are not confident that the data are robust, and are also unsure how to use the data to estimate remaining useful life or probability of failure. They are aware of some software that can prepare maintenance and renewals programmes for them, but express an aversion to complex predictive models for which underlying decision processes become hidden. They want the ability to manually adjust programmes to allow a degree of human reasoning, such as clustering works in the same geographic area to occur in the same year. This manual adjustment would provide feedback on LoS achievement that would allow for 'what if' scenario analysis.

Another problem for asset managers is that, when broken down by pipe material, size, and age, a single TLA has a small sample size from which to analyse failure trends. One asset manager suggested that despite likely regional differences in pipe performance and longevity, a central nationwide database could make the sample size large enough to develop useful predictive models.

Asset Valuation, Depreciation and Renewals
Interestingly, there still seems to remain in the industry the belief by some authorities that the valuation process is an 'accounting' process and that the asset lives used are not necessarily the same as those derived from predictive renewal models developed by engineers. However, the NZ Infrastructure Valuation and Depreciation Guidelines (NAMS 2006b) state that valuation and depreciation should be calculated based on the assessed remaining useful life of the assets. The accurate calculation of these lives is critical to ensuring that renewals and depreciation is being funded appropriately, and that costs are paid for equitably across time by those that receive the services.

Predictive models that improve the robustness of remaining life assessment, taking into account knowledge of condition, capacity, performance, risk, etc, are therefore a key requirement for the industry. Software that automates valuations and has transparent valuation methodology is also needed. The WIMS survey found that, despite most existing Asset Management software having valuation capability, 60% of water authorities export their data to Excel for valuation calculations.

The Gains from Advanced Water Asset Management
When compared to core asset management, advanced asset management aims at significantly improving the decision making processes. This improvement is largely based on an ability to analyse data in a more meaningful manner and to have forecasting capabilities added to the long-term renewal forecasting process. Moving to advanced asset management benefits the organisation in the following ways:

- A **more effective data collection** regime collects the minimum data required to make a quality decision. Although high data quality does not guarantee good decisions, making good decisions is very difficult on limited or poor quality data. Through a proper understanding of network risk and criticality one can statistically determine where and when to collect data;

- Advanced asset management also **promotes an over-all information flow** on a shared platform. Many parts of an organisation use the same data items for different applications. Having a corporate data server allows for sharing of information using the appropriate level of detail and sophistication;

- In order to have robust forecasting capabilities, there also needs to be a comprehensive **understanding of historical performance**, maintenance and renewal costs;

- Robust, targeted data collection will allow suitable expenditure forecasts to be developed with **demonstrable links to LoS performance** measures;

- Establishment of **contractual key performance measures** for maintenance and capital works, with the ability to demonstrate cost effectiveness to auditors, customers and other key parties;

- Lastly, an advanced asset management process is capable of optimising maintenance investment to achieve an over-all optimised programme that **maximises achievement of corporate drivers**. It also has the ability to optimise allocated funding into the different planning consideration areas "silos". For example, once an over-all investment strategy is developed and fund allocation for different planning considerations such as capacity improvements, or renewal and replacements are available, each one of these silos then have to optimise the budget according to its own unique optimisation considerations. When the renewal and replacement "silo" is considered in isolation, the main objective for the planning analysis would be to minimise the failure risk profile for the available budget. Likewise, the capacity budget needs to be optimised available funds to provide the best level of service in terms of pressure to all customers.

Addressing these needs will allow TLA's to show advanced asset management processes which ensure efficiency in the over-all decision process by requiring quality data, data being shared across the organisation and analysis of the data to ensure robust decision making processes.

Therefore, the capability of the advanced system therefore allows for an integrated data collection regime focused on the LoS performance measures. The decision support process then links historical and forecasted LoS with the most correct effective strategy to achieve the required performance levels. An advanced system can provide an auditable process that demonstrates the full decision process to stakeholders such as auditors and senior management of an organisation.

Recommendations for bridging the underground pipe asset management gaps

An asset managers' core problem is how best to make an informed decision based on limited or no data or data in disparate databases, whilst maintaining confidence, meeting LoS, and managing risk exposure and costs to appropriate levels. Based on concerns raised by asset managers, it seems that their current practices are not yet advanced enough to begin considering whether or not current practice has the most cost effective balance of planned and unplanned expenditure to achieve LoS performance measures. Existing commercial asset management software tools being used by the water industry do not predict future risk and have limited optimised decision-making capabilities and these are key to achieving advanced asset management. Our recommendations for advancing water (pipe) asset management practices in New Zealand are as follows:

Recommendation 1: Integrated software system

From our interviews and assessment, councils' most immediate needs are integrated data and software systems. In general this is likely to involve one or more new pieces of software that can talk to and query existing systems including: GIS, asset management database, document management, hydraulic modelling, and customer relations software. The system would enable ready importing of data from those systems so that it can be used to make effective decisions, as well as exporting to systems that the user wishes to use for reporting. The system would allow manual interference and be highly visual and user-friendly.

Recommendation 2: Improved predictive modelling / decision making capability.

Knowledge of pipe deterioration has improved significantly in the past decade through research and practice in New Zealand and internationally. The software tool recommended above should draw on the best available knowledge to include robust condition and performance deterioration models for all New Zealand's more common pipe types and defined relationships between condition, performance, risk and cost.

The decision-making functions should enable asset managers to take different approaches that reflect their business objectives such as minimising risk, managing within budgets, meeting LoS and performance objectives. The software should also provide flexibility to meet different needs; simpler 'plug-in' approaches for smaller authorities, with the option for larger authorities to access and modify functionality if desired.

Recommendation 3: Coordinated national database and life prediction/failure probability analysis system

The third most immediate need appears to be an improved method for analysing failure data and its relationship to maintenance history, age, and condition, which is partly addressed through Recommendation 2. We further recommend establishing a national database and life prediction / failure probability analysis tool. This national tool would:

(1) provide a larger sample size from which to estimate useful life and probability of failure;
(2) help water suppliers understand the critical drivers for asset life;
(3) drive more coordinated and targeted data collection strategies; and
(4) provide a platform for asset managers to begin discussing asset management strategies nationally.

Conclusions

Existing water asset management tools in use in NZ do not:

1. Forecast risk;
2. Show linkages between forecast risk and predicted LoS performance; or
3. Coordinate across activities

Most water suppliers are aiming towards more user-friendly, integrated systems and would welcome a lead from industry. This integration is a basic need for coordinating existing systems and managing assets effectively. The next step towards confidence in pipe maintenance and renewals decision processes would be through a central database and asset condition / life prediction / failure probability analysis tool.

This paper has demonstrated that there is currently a significant divide between current asset management processes and what is required for advance asset management. It demonstrated that there should be an integrated process linking data collection, LoS performance measurement and reporting and an integrated decision processes that links LoS with investment needs. The decision platform should also be structured in such a way that it shares information to the entire organisation to assist with the coordination function within an organisation and with other service providers such as roading engineers.

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