THE ESSENTIALS OF PLANNING PIPELINE RENEWALS

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ABSTRACT

Local authorities are under pressure to spend ratepayer's money wisely, now more than ever with the current global recession. It is possible to get a better "Bang-for-your-buck" through effective planning of renewal works. However, renewal planning for pipelines remains a difficult and challenging task facing all water utilities in New Zealand. Many kilometres of the pipelines installed in New Zealand between the 1860s and about 1980 will be coming to the end of their useful lives within the next 30 years, placing a strain on budgets and resources. Therefore, it is crucial that Local Authorities implement a well-planned renewal programme to ensure the right pipelines are replaced at the right time.

Renewal planning is complicated by the many factors that must be considered when choosing which pipelines to replace, and when. This paper introduces the basic principles of pipeline renewal and focuses on two of the key factors that are at the foundation of any renewal programme; data collection and condition assessment. Understanding and effectively implementing these two steps will greatly assist the efficient and sustainable planning of pipeline renewals. The decision support systems used by many overseas utilities are also introduced and briefly discussed.

KEYWORDS

Pipelines, Renewal planning, Data collection, Condition assessment, Pipe risk profiles, Decision support systems.

1 INTRODUCTION

1.1 BACKGROUND

Over the next thirty years, thousands of kilometres of cast iron (CI), steel and asbestos cement (AC) pipes will be coming to the end of their useful life. Therefore, the greatest challenge facing pipeline asset managers is prioritising which pipeline to replace and when. To do this, asset managers need to ensure they develop a robust pipeline renewal programme that uses robust and defendable asset management techniques to ensure the network is operated efficiently while keeping renewal and maintenance budgets to a sustainable level.

Asset managers can apply either a reactive or pro-active strategy for the management of pipelines (Moglia *et al* 2006). A reactive strategy is basically a "sit back and wait" for pipe failures to occur to determine which pipeline to replace and when.

In contrast, a proactive strategy involves asset management techniques that balance the performance, risks and costs associated with operating the pipeline (Livingston et al, 2008). By using a proactive strategy, an asset manager will be able to produce long-term pipeline renewal programmes and budgets that result in improved cost efficiency, reliability and quality of service (Christodoullou, 2008).

1.2 PIPE LIFETIMES

1.2.1 AC PIPES

Asbestos cement (AC) pipes have been used in New Zealand between approximately 1942 and 1987 with the majority of these pipes installed between 1960 and 1980. During this period, an estimated 11,800 km of AC water, sewer and stormwater pipes were installed (Black *et al*, 2007). AC pipes can deteriorate quickly (externally and internally) when subjected to aggressive soil, groundwater, potable water and sewage. The useful life of AC pipes is typically between about 50 and 70 years[1] with some AC pipes installed in very aggressive conditions requiring replacement within 20 years (Black, *et al*, 2007) and some with estimated lifetimes exceeding 100 years. A high proportion of the small diameter AC pipes (DN 50 and DN 80) have already been replaced due to increasing frequency of failure.

1.2.2 CAST IRON AND STEEL PIPES

Many of the CI pipes that were installed from the late 1860s until the 1950s and the steel pipes installed from the early 1900s to the 1940s will also be reaching the end of their useful lives at around the same time as the majority of AC pipes.

The combined quantities of these pipe materials typically make up the bulk of most of New Zealand's water reticulation networks. Therefore, asset managers are likely to need to renew a significant percentage of their networks within the next few decades.

1.3 WHY UNDERTAKE PIPELINE RENEWAL PLANNING?

It is commonly accepted that pipeline failure rates follow an exponential function towards the end of a pipe's lifetime (Ugarelli et al, 2008; Wright & Dent, 2007). The exponential growth rate of pipe failures is represented in Figure 1.

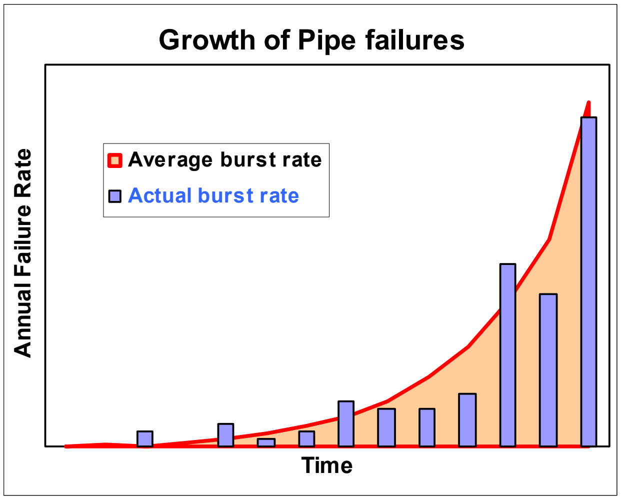

Figure 1: Exponential growth of pipe failures

Before the exponential growth period of pipe failures is reached, annual pipeline failures frequently fluctuate often making it difficult for asset managers to identify trends. It is common that only a marginal increase in pipe failures will be noted over the period leading up to the pipelines end-point giving asset managers a sense of control. However, once the steepening section of the exponential growth phase is reached, asset managers can suddenly find that their forecast budgets are inadequate as pipe failures escalate. They may be forced to replace large lengths of pipelines in a relatively short time frame, placing a large financial burden on ratepayers. To minimise such large scale problems in the future, asset managers need to carefully plan and implement robust, pipeline renewal strategies.

The planning of renewals is particularly challenging due to the many factors that have to be considered when determining which pipelines to replace, and when.

There are numerous renewal strategies used by Councils around New Zealand but two key items that are common to all renewal strategies are:

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[1] This is the typical useful life observed during AC pipe condition assessments over the past 12 years. The deterioration rate for AC pipes is dependent on factors including: pipe wall thickness, operating pressure, the aggressiveness of potable water / sewage / soil / groundwater.

- Data collection, and
- Condition assessment.

In this paper we introduce two of the key elements of renewal planning: data collection and condition assessment. We also introduce the use of decision support systems (DSS) that are being used by overseas Utility operators to assist in the management of their pipelines.

2 DATA COLLECTION

2.1 THE IMPORTANCE OF DATA

The success of a pipe renewal programme is dependent on the collection of meaningful and reliable data. A lack of meaningful data on pipeline assets can lead to asset managers relying on over simplistic renewal models and thereby increasing the risk of over or under spending on pipeline renewals (Cox, 2003).

The pipeline data collected must assist the asset manager in undertaking the long-term planning of pipeline renewals. Data is expensive to collect and store and therefore it is essential that asset managers understand what the data is to be used for and what data to collect. By having a thorough understanding of data requirements an asset manager can decide how much effort and expense should be devoted to data collection.

The data necessary can be divided into two groups:

1. **Pipeline attributes data** – This describes the pipeline characteristics and is used as input data into condition assessment and hydraulic models.
2. **Performance data** – This is used to determine if the pipeline is operating at the desired Level of Service. This information is also used to help identify trends in deteriorating pipeline performance e.g. monitoring the rate of pipe bursts occurring for different pipe materials, ages and ground/installation conditions.

The required data and what that data is generally used for, is listed below in Table 1.

Table 1: Required data and what it is used for. (See also section 2.4)

Data required	Condition Assessment	Hydraulic Model	Criticality Assessment
Pipeline attributes			
Location	✓	✓	✓
Pipe Diameter	✓	✓	✓
Pipe Material	✓	✓	✓
Pressure class	✓	✓	✓
Year installed	✓		✓
No. of customer connections		✓	✓
Pressure zone		✓	✓
Soil type [1]	✓		✓
Pipeline performance			
Failure date			✓
Failure type [2]			✓
Failure location			✓
Number of failures on pipeline			✓
Cost to repair			✓
Cost of damage			✓
Hydraulic performance [3]		✓	✓
Replacement year [4]			✓
Criticality rating			✓

1. *The soil type can be used in conjunction with burst failures to possibly identify any relationship between failure rates and soil type.*
2. *The definition of failure type could be in accordance with Davis et al. (2001):*
    a. *Blown section: Removal of a piece of pipe wall. Size can vary depending on pipe material but generally larger than 100 mm diameter.*
    b. *Perforation: Small holes usually less than 10 mm diameter.*
    c. *Circumferential crack: A single crack extending part or full way around the pipe circumference.*
    d. *Longitudinal split: A crack along the pipe axis. The length can vary from a few mm to the full length of the pipe.*
    e. *Joint leaking: Water leakage through the pipe joint.*
    f. *Fitting failure: Damage to pipe fitting e.g. leaking service connection.*
    g. *Other: Failures that do not fit one of the above classes.*
3. *Hydraulic performance is output data from the hydraulic model and/or customer complaints regarding flow and pressure.*
4. *The estimated replacement year is output data from the condition assessment model.*

2.2 MAINTENANCE AND REPAIR DATA

Data that is commonly overlooked in New Zealand are the costs associated with the maintenance and repair of pipelines as this is funded from long-standing maintenance budgets. A widely recognised step in the planning of renewals is life cycle analysis where the cost of pipe replacement is compared to the cost of retaining the pipe and forecast repair costs (Shamir and Howard, 1979; Davis *et al*, 2008). Lifecycle cost data can also be used for evaluating rehabilitation versus replacement options. Cost data can play a significant role in renewal planning and justifies the collection of that information.

The collection of the following cost data was recommended by Dandy and Engelhardt, (2001):

1. Capital costs of installing new pipelines,
2. Maintenance costs associated with repairing and preventing pipe failures,
3. Costs of operating the reticulation network e.g. pump and water treatment costs,
4. Damage costs resulting from property damage, inconvenience and loss of water.

The collection of the above information will help ensure that the reticulation network is operated efficiently, that failure rates and maintenance costs are contained and the money spent on capital works is optimised.

2.3 THE QUALITY OF THE EXISTING DATABASE/S

An assessment of the quality of the existing database and how well staff work with it should be undertaken to identify gaps or quality issues (Heltzel, 2003). Incorrect data entered into the condition assessment and hydraulic models will significantly reduce the reliability of output data from the models, which in turn increases the risk of poor renewal planning. Two methods for improving the quality of database records are:

1. Increasing staff knowledge about the history of pipe materials, and
2. Verification of pipeline attributes every time a pipe is uncovered.

2.3.1 STAFF KNOWLEDGE AND DATA QUALITY

The level of background knowledge that operational staff and asset management staff have regarding the different pipe materials in the network/s will impact on the quality of data collected. It is important that field staff can differentiate between the pipe materials so that the correct pipe material (and pipe diameter) are recorded in the database. For example, it is common for field staff to mistake steel pipes for cast or ductile iron and not to be able to distinguish between HDPE and LDPE.

It is also important that any data recorded by maintenance staff about pipelines is reviewed by knowledgeable asset management personnel that have access to the Pipe Manufacturing Standards applicable at the time of installation of the pipes in their networks. This allows the correct pipe pressure class and diameter to be recorded. Office staff that have access to old standards and also have an understanding of the history of pipe materials, will be able to recognise anomalies in data and either query the data further or make changes as necessary. For example, asbestos cement pipes were installed in New Zealand starting after World War II and few were installed after 1988. Therefore any AC pipeline with a recorded installation year prior to about 1950, or after about 1990, is unlikely to be correct. AC pipe jointing systems can also provide valuable clues to the pipe manufacturer, pipe production method and the approximate year of manufacture.

The pressure class of pipes installed has seldom been recorded in asset registers. The difference in pipe lifetime between the different pressure classes can be several decades and can be responsible for unexpected (earlier than planned) renewal or premature replacement.

2.4 DATA VERIFICATION

A cost effective means of collecting and/or verifying pipe data is to inspect all pipelines whenever they are uncovered e.g. for maintenance, repair works or new connections. A standard form should be developed and filled in by maintenance staff. The asset management staff should then compare the data with the existing database and update records as required.

In developing a standard form for recording field data, the form should be kept as simple as possible. The data that should be recorded for most pipes exposed includes:

1. The location of the pipe - street or road number or GPS coordinates and sufficient detail to identify the pipeline inspected.
2. The pipe diameter - by accurately measuring the external diameter.
3. The pipe material - some materials are not easy to distinguish without experience and training.
4. The operating pressure, including the presence (and magnitude of) pressure transients - a pressure log recorded at 1 -2 second intervals provides the best information (by asset management staff),
5. The pipe exterior condition – by observation and some simple, easily learnt techniques,
6. Pipe wall thickness – usually requires a cut-out section or an under-pressure tapping core. This information allows the pipe pressure class to be determined. The internal deterioration can also be measured on a cut-out section or core. However, this requires some experience and training. The wall thickness of plastic and steel pipes can be measured in-situ with an ultra sonic thickness gauge. The wall thickness is needed to determining the pressure class. Cast iron pipes generally do not respond well to ultrasonic measurement equipment.
7. Record the depth of cover and the surface type – paddock, road berm, footpath, metalled road, street, State highway and indicate if there is frequent heavy traffic.
8. Record manufacturers' markings if any are still visible. New Zealand standards required the manufacturer to print the pipe diameter, pressure class and date of manufacture on each pipe. This data can be used to cross-check against existing records.
9. Record if previous maintenance works have been necessary on this pipeline. .
10. Make a judgement call on the cause of failure. Operational staff can identify the type of pipe failure (from the different types of failures are listed in Table .1).
11. Take photos of the pipe in situ. Asset management staff can use the photos to confirm the accuracy of the data sheets recorded by maintenance staff.
12. If taking a pipe sample for record purposes or assessment, mark the top of the pipe before it is cut out and clearly label the sample location and record the date of the work.

If critical pipelines are to be isolated for any reason it is important to take the opportunity to collect a sample so the pipe condition can be assessed. Even if critical pipes are only uncovered (without shut-down) a significant amount of attribute information can be obtained, including an in-situ condition assessment – refer to section 3.1.

2.5 STORING OF DATA

A Geographic Information System (GIS) is probably one of the most useful tools available for the storing and viewing of pipeline data. Two of the key advantages of GIS are that it is a cost effective data storage system[2] and can graphically represent the pipeline attributes along with performance data. For example, the ability to generate colour thematic maps of the various pipe materials in the network and also overlay the location of pipe bursts (along with soil types) can allow asset management staff to quickly identify trends in pipe bursts by area and/or pipe material.

It is important that the asset manager has sufficient training to be confident in making regular use of GIS and understands how to get the best from it. In general, if the asset manager relies on others to operate the system and generate maps and trends then the viewing and analysis of data is likely to be less frequent and the GIS system may not be fully utilised.

Another major advantage of GIS is that all the data required for the long-term planning of renewals can be stored in the database. The storing of data in electronic form reduces the likelihood of data being "lost" when the next generation of asset managers take over.

3 CONDITION ASSESSMENT

3.1 ADVANTAGES OF CONDITION ASSESSMENT

Knowing the condition of pipeline infrastructure is crucial for the effective planning of renewals. A proactive approach to pipeline renewal requires that the asset manager has a good understanding of the rate of deterioration and average life for the various pipe materials.

It is important to note that condition assessments only represent a single snapshot of pipe condition and as such, do not necessarily show the maximum (or minimum) deterioration along the pipeline. It is quite common to find that deterioration varies both around the pipe circumference and along the pipeline.

Therefore, it is important that data on the range of deterioration is gathered from pipe samples representing a "cross section" of pipe materials and installation years. The pipe attributes and deterioration data can be used to estimate remaining life and to develop a "risk profile" to assist in the planning of renewals (refer to section 4).

Undertaking programmed and opportunistic condition assessment has many advantages, including:

1. The pipe attributes are confirmed and records can be improved,
2. The pipe condition is determined and the risk of "surprises" is minimised,
3. More reliable asset valuations and assessment of depreciation funding can be made,
4. Long term financial planning can be carried out and objective, defensible and robust decisions can be made on pipeline renewals
5. The risk of unplanned expenditure on renewals can be minimised
6. Potential for major renewal budget blow-out can be identified and managed to optimise expenditure.

3.2 ASSESSING THE CONDITION OF CRITICAL PIPELINES

Asset managers need to identify the critical pipelines in their networks to determine which pipelines should be targeted for formal condition assessment. Pipe diameter can be a good approximation of criticality but this must be considered along with other issues.

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[2] The International Infrastructure Management Manual (2006) states that data entry through GIS can achieve time savings of 60% and eliminate input errors.

Critical pipelines that cannot be isolated to allow a sample to be taken can be assessed by in-situ techniques. In-situ assessment involves exposing up to 2 m of the pipeline so the exterior can be measured accurately and observed. The exterior of the pipe is cleaned, the outside diameter measured and the depth of deterioration determined. The interior deterioration can be found by taking an under-pressure core sample (Hoyle et al, 2008)

In-situ testing involves traffic management, excavation, establishment of specialist personnel, backfilling, surface restoration and reporting. To help optimise the costs of in-situ testing, a number of pipelines should be assessed at a time. Exposing pipelines in berms or unpaved areas will help to reduce restoration and traffic management costs. The costs associated with in-situ testing and assessment can be less than the cost of recovering samples for off-site assessment if careful planning and preparation is carried out. However, in-situ assessment does not provide as much information as a pipe sample but the information that can be gained is still very useful for producing lifetime estimates.

Photo 1 below shows a DN 375 AC pipeline, which could not be shut-down for sampling, being assessed in-situ.

Photo 1. In-situ assessment of DN 375 AC pipeline.

3.3 NON-CRITICAL PIPELINES

For pipelines with low criticality, or where the pipeline can be shut down, a pipe sample (normally 300 mm length) can be taken and assessed off-site. It is not always practical (or cost effective) for all pipe elements in a network to be directly sampled due to the large number of pipelines involved. Instead, representative pipelines should be selected and sampled and the data extrapolated to the remainder of the network. This allows for reasonable renewal programming for the entire network. With time, an ever increasing proportion of the network will be covered by condition assessments and deterioration trends identified.

It is possible to have maintenance and operations staff trained in basic attribute data gathering and condition assessment techniques so that general maintenance and repair works can add significantly to the knowledge of the networks, assist with renewal planning and replacement prioritisation.

3.4 PIPE SAMPLE ASSESSMENT

Pipe samples are assessed using a variety of methods which depend on the pipe material. While the assessment methods may vary, the overall methodology is similar as shown below.

1. Dimensional check: The pipe wall thickness, internal and external diameters are measured as accurately as possible. This information allows the pipe pressure class to be established.

2. Visual Assessment: Provides a quantitative assessment of pipe surface condition and the corrosion protection coating (if present).
3. Deterioration measurements: The deterioration depth is measured (externally and internally) around the pipe circumference to determine the worst deterioration depth - usually done by CT scanning for AC pipes. Once the pipe attributes and the depth of deterioration is known, the time to failure can be estimated.
4. For the plastic pipe materials (PVC and PE), more sophisticated testing is needed as these materials do not deteriorate in ways similar to AC and ferrous pipe materials.

Once the pipeline attributes have been found, condition assessments and remaining life estimates have been made, risk profiles for the various diameters of AC pipes in the networks can be prepared.

4 RISK PROFILES

The following steps are used to develop a risk profile for the non-critical pipelines in the network – it is assumed that the critical pipelines will have individual assessments and stand-alone remaining lifetime estimates. To date, the risk profile technique has only been applied to AC watermains but it should be possible to extend it to other pipe materials that deteriorate in a relatively predictable manner.

4.1 IDENTIFICATION OF PIPELINES TO BE SAMPLED

The type and age of pipe materials in the network/s are reviewed to determine which pipelines to sample. Pipe burst data (if available) is also useful to help identify if there are trends for particular pipe types which can assist with prioritisation. The number of pipe samples required to develop the risk profile will depend on the number of different pipe types, diameters, soil condition variability and the age of the pipelines in the network. About 15 samples for each pipe type is usually sufficient to develop an initial risk profile for an “average” sized New Zealand reticulation network.

4.2 ASSESSMENT OF SAMPLES

Pipelines are sampled and assessed using a variety of methods to arrive at an estimate of the remaining life of the pipe samples.

4.3 DEVELOP A RISK PROFILE

The Remaining Life Estimates from the individual samples are used to develop a risk profile for each pipe material and pipe diameter (see Figure 1). There are many factors that influence the rate of deterioration for a pipe material. Pipes installed in the same year can have significantly different deterioration rates and therefore failure years. The risk profile graph allows the asset manager to visualise the risk associated with the pipe age. Pipe burst data should also be reviewed to identify if pipes from particular area/s should be elevated (or otherwise) on the risk profile graph.

The development of a risk profile using a relatively small number of samples can result in a reasonably high level of uncertainty. It is important that pipe samples are taken and assessed whenever the opportunity arises. These samples will serve to verify and improve the reliability of the asset data, lifetime estimates and risk profiles.

Figure 2 (below) shows a risk profile for DN 100 Class C-D AC pipes. Similar charts are produced for other pipe diameters and pressure classes. The level of uncertainty can be clearly seen as a DN 100 Class C-D AC pipe installed in 1970 could need replacement anywhere between 2015 and 2032. This variation is mainly due to the manufacturing tolerances for the pipe but there are other influencing factors, e.g. the variability of deterioration due to ground conditions, the relative stability of the water pressure (e.g. pressure surges), the support (or lack of) from pipe bedding and ground stability, etc.

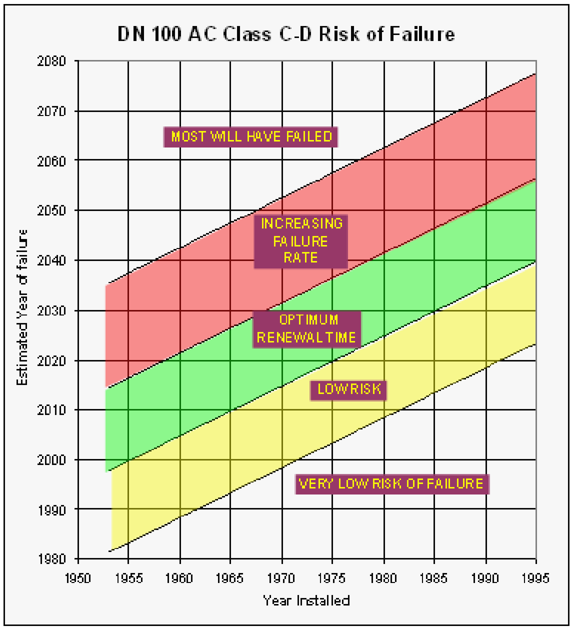

Figure 2. Risk profile graph for DN 100 AC pipelines

5 ESTIMATING ANNUAL RENEWAL QUANTITIES AND EXPENDITURE

5.1 ESTIMATING THE RENEWAL EXPENDITURE REQUIRED

Once the sampling, condition assessment and lifetime estimates have been completed and risk profiles have been prepared, first-cut estimates of the annual renewal quantities can be made.

To determine the renewal quantities for the non-critical mains requires further work which involves relating the year of pipeline installation to the estimated year of failure within the optimum renewal time band on the risk profile graph.

The optimum renewal timing for each pipeline in the network is then combined with the estimated cost of renewal and a first-cut of the required renewal budget prepared. This first-cut usually results in some extreme "spikes" in renewal spending. These can be smoothed somewhat by starting renewal early for some pipelines and delaying renewal for others, however, major renewal expenditure "spikes" can still be expected (see Figure 3 below). Once the "smoothed" annual renewal quantities have been produced, they can be carefully reviewed and refined at a number of levels within the water authority and adjusted to allow the long-term renewal budgets to be set.

Each of the identified critical mains should have been sampled and have their own assessment/s and recommended replacement year. These costs can be added to the annual renewal quantities.

Figure 3 (below) shows the partly "smoothed" annual expenditure (in 2008 $) for AC watermains in a "large" provincial town in New Zealand. To this must be added the renewal budgets for other watermain pipe materials as well as renewals for sewage and stormwater pipelines so that the full costs for pipeline renewal works are accounted for.

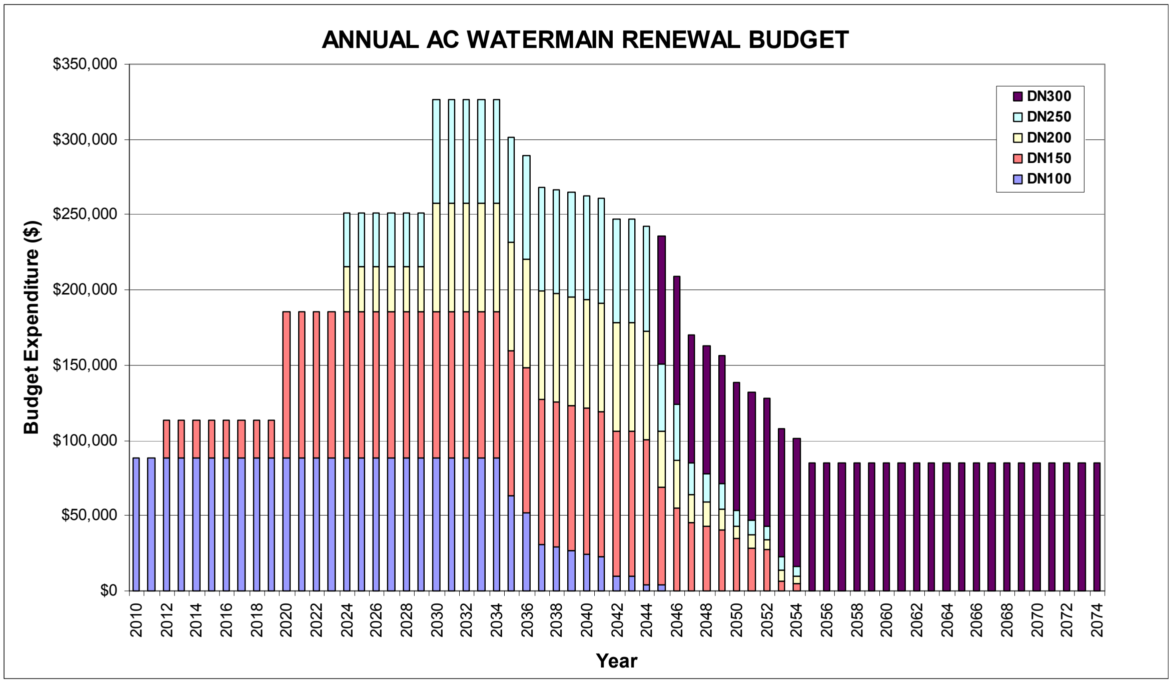

Figure 3. Annual renewal budget amounts for AC watermains

5.2 PRIORITISING RENEWAL WORK

Setting the budgets (based on the average expected lifetime for the various pipe materials as above) and having funding available does not show precisely which pipelines to replace or when.

There are a number of factors that need to be considered when determining the renewal priorities. These include (at least):

1. The pipelines assessed (or estimated) condition and their estimated times to failure.
2. On-going collection of condition and performance data from day-to-day maintenance and repair works as trained staff add to the knowledge of the network and its condition.
3. The consequences of failure for each pipeline (this will involve local knowledge and usually requires the input of experienced maintenance staff).
4. Level of service - the pipeline can no longer deliver the required level of service – on-going customer complaints of water pressure or quality.
5. Economic criteria - the cost of maintaining the asset is higher than the cost to replace it e.g. it is more cost efficient to renew the pipeline than continue to repair bursts

It is important that some flexibility is allowed in the renewal programming and that all pipelines are not "locked-in" for renewal in a certain year as some may need to be renewed before those programmed due to unacceptable consequences or burst rates.

6 DECISION SUPPORT SYSTEMS

The planning of pipeline renewals is well recognised as a complicated process due to the issues that need to be considered to in setting priorities. For example, the Greater Cincinnati Water Works (GCWW) considers 76 different factors when considering which pipeline to replace (Hanson, 2008). The growing awareness of deteriorating pipe condition combined with the complex nature of planning pipeline renewals has resulting in the development of Decision Support Systems DSS software.

Most DSS systems contain some (or all) of the following modules:

- Pipeline physical attributes, *Asset records/GIS system*

- Performance data, *pipe bursts, customer complaints*,
- Statistical analysis tool, *for pipe performance data*,
- Genetic Algorithms, *A genetic algorithm is a search technique used in computing to find exact or approximate solutions to optimisation and search problems.*
- Risk module,
- Fuzzy logic processor, *processes information to arrive at estimated risk-of-failure calculations* (Christodoulou *et al*, 2008),
- Life cycle cost analysis, *uses time value comparison of repair costs versus renewal / rehabilitation*
- Prioritization of renewals module,
- Data query and reporting system,

There are several different types of DSS used in America, the United Kingdom and Australia by water utilities. At the moment, DSS software does not appear to be widely used in New Zealand (if at all) but as awareness of deteriorating pipe condition increases, it is likely that DSS systems will become more widely used.

Deciding on which DSS software to use will need to be given careful consideration. Some of the factors to be considered include:

- Compatibility with existing software, e.g. hydraulic models, GIS and other asset management systems,
- Ability to import existing data directly into the DSS,
- System is easily used so that it will be well utilised by asset management staff,

It would be worthwhile consulting with overseas utilities who are working with the DSS systems before deciding.

The International Infrastructure Manual (NAMS 2006) propose a method for evaluating software which should be considered by asset managers considering their options.

It is also important that asset managers do not place their full trust in software programmes that provide a one-size-fits-all solution to renewal programming. There is no substitute for common sense and taking responsibility for the decisions that are made.

7 CONCLUSIONS

A significant proportion of the pipelines installed in New Zealand will be reaching the end of their useful life in the next 20 to 40 years. Asset managers who are not practicing sound asset management techniques run a very real risk of be being caught unawares by the exponential growth rate in pipe bursts that can be expected.

Annual maintenance and renewal budgets will need to increase significantly to maintain levels of service and many pipelines will need to be replaced earlier than their end-of-life in order to optimise renewal expenditure.

Data Collection is the foundation of renewal planning. Collection and storage of data is expensive. Therefore, it is important that only data that is relevant and has a purpose is captured.

Knowing the condition of pipelines and the risk profile for each pipe material can help asset managers set budgets and prioritise replacements.

Determining the criticality of pipelines will assist with deciding on sampling frequency and the method/s to be adopted for condition assessments.

The likely condition of the majority of the non-critical pipelines can be determined from a relatively small number of samples that have been taken to represent the various pipe types, installation periods and ground conditions. From the assessed remaining lifetimes, it is possible to produce pipeline risk profiles and annual renewal budgets that will provide for renewal times to smooth as far as possible the annual expenditure.

The use of DSS software is increasing overseas and such systems are likely to be used in New Zealand over the next few years. Software packages are normally expensive to own and operate. It is important that asset managers carefully consider their options when looking at DSS software.

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