DATA, DATA EVERYWHERE – LIFE AFTER DATA COLLECTION

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ABSTRACT

Since 2014, Christchurch City Council has invested in the collection of asset condition data for over 500 km of open channel waterways. The purpose was to understand the impacts of the earthquakes and to help derive the current condition of the watercourses across the city. Over the past two years, a specialised condition assessment specification has been developed and over 3,500 hours have been logged collecting data in the field.

With data collection and verification now complete, the true benefit of this data is becoming evident. Over 25,000 data points have been captured through the field assessments, showing that about 15% of the faults identified on the waterways have been directly caused or impacted by the earthquakes. With 25GB of data and photos available, the focus shifts to analysis of the data to guide asset management and operations & maintenance decisions.

The critical benefits that have been accrued to date are:

- obtaining a baseline snapshot of network condition and damage;
- identifying a series of critical asset failures;
- validating and augmenting Council GIS information;
- highlighting the prevalence of compliance issues affecting hydraulic capacity of the waterways;
- delivering baseline information for a long term operational and maintenance contract;
- feeding the long-term asset renewals pipeline; and
- providing information to support the Council's asset valuation activities.

This paper summarises the benefits of a comprehensive data collection process and shows examples of how a large amount of data can be utilised for strategic decisions that ultimately lead to better planning and cost-savings.

KEYWORDS

Data, condition assessment, information, long term planning, renewal strategy, asset management

PRESENTER PROFILES

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Liam Foster is the global Water Sector Leader for Water Resources and Flood Risk Management at Opus International Consultants. Liam has led several LDRP projects over the past years and has been extensively involved with the LDRP works from data collection to issues and options and concept design.

Jules Scott-Hansen is a civil engineer at Opus International Consultants in Christchurch. Jules has been extensively involved with the LDRP data collection – from survey specification development, leading field surveys, data quality/amalgamation, and summary reporting. Jules presented the LDRP data collection methodology at the 2015 Water New Zealand conference.

1 INTRODUCTION

When an asset portfolio is perceived as lower priority than others, there is less appetite for investment in improving the data quality, which ultimately compounds the issues. Unlike water supply and wastewater, stormwater assets are 'passive' – they generally operate at a low capacity level until their full capacity is required in response to one-off events, generally occurring intermittently and over a short timeframe. In the aftermath of performance failures, public attention can often be scrutinising and high-profile in the media, but the time between significant events often means that attention and funding fades with the memories of the floods.

Historically in New Zealand, making the case for stormwater management has not been as straightforward as that for other asset classes, and the issues have been compounded by a general lack of legislative requirements and clear levels of service. Collection of data on network condition allows better understanding of the risks and consequences of network failure, and enables a move from the status quo of reactive maintenance to a more planned approach. In terms of operations and maintenance, a programmed approach generally has a better output both in terms of meeting levels of service and cost-effectiveness.

The relative costs and benefits of comprehensive stormwater management are not commonly well understood and, as a result, stormwater assets are often underfunded in a competitive market of limited resources. A case study from the United States found that although stormwater management programs can be expensive to implement, their potential benefits in the form of eventual reduced spending can be much greater than the initial capital expenditure. In addition to this, non-fiscal benefits of social, cultural and environmental values are also likely to occur through appropriate stormwater management systems (Visitacion, et al., 2009).

1.1 THE IMPORTANCE OF DATA

Data is fundamental to evidence-based decision-making. Data that is collected and managed appropriately allows us to make powerful arguments and optimise our investment decisions. In the case of stormwater assets, this does not only lead to reduced spending but can also have positive effects on social, cultural and environmental values.

Collecting the right data is not necessarily a simple exercise. Asset management standards, such as ISO 55000, provide detail on the type of data that should be collected to support various functions, more commonly known as metadata schemas. The data categories range from 'basic' information such as inventory/component attributes to more sophisticated measures such as criticality, risk and performance.

Data collection on stormwater assets can be a complex exercise as stormwater assets are diverse. Unlike water and waste water conveyance, which generally rely solely on pipes, a stormwater network can be made up of a wide-ranging mix of conveyance systems such as pipes, culverts, road-side swales, lined drains and river channels. As a result, creating a one-solution-fits-all for data collection on stormwater assets can be challenging.

The New Zealand Metadata standards, when adopted, will provide national standards for how data is captured, described and stored. The standards, which cover three-waters assets, roads, and buildings, will enable data consistency which will ultimately support decision-making and increase collaboration across sectors. The standards are also key to achieving the 2015 Thirty Year Infrastructure Plan which aims to create infrastructure that is resilient, coordinated and contributes to a strong economy and high living standards for New Zealanders.

Benefits of a consistent and national approach to data collection and description include:

- Transparency in condition assessment and how this is reflected in the potential looming asset renewal bow wave. This will be of assistance both within the industry and to central government.
- Value for money asset renewal and avoidance of premature replacement of assets.
- Reduced dependency on individuals with unique in-house knowledge of asset condition and a greater pool of experienced people to draw upon (ProjectMax, 2016).

1.2 BACKGROUND

The Canterbury Earthquakes of 2010 and 2011 caused significant damage to the stormwater and land drainage network of Christchurch, examples of some worst-case scenarios are shown in Photographs 1 and 2. This extensive damage, combined with wide-spread differential ground settlement, contributed to several unprecedented flooding events throughout the city, which had detrimental social, economic and health impacts on communities that were already heavily affected and recovering from the earthquakes.

Photograph 1: Example of severe earthquake damage to timber lined drain

Photograph 2: Example of severe earthquake damage to unlined waterway

As a response to the damage to the stormwater network, the Land Drainage Recovery Programme (LDRP) was initiated by the Christchurch City Council (Council) in 2012. The LDRP's mandate is to deliver projects to repair damage to waterways and land drainage infrastructure and to reinstate pre-earthquake levels of flood risk.

To support this mandate, the LDRP project teams required information on:

- The current condition of the land drainage assets;
- The effect of the earthquakes on the condition and drainage capacity of the assets; and
- Where there is damage, is it earthquake or non-earthquake related, and is there sufficient damage to require repair?

It became apparent that to understand these questions better, a comprehensive data collection process was required.

1.3 DATA COLLECTION

A city-wide condition assessment data collection survey was undertaken to answer the questions specifically relating to the LDRP's requirements. The data collection focused on open channel assets, as underground infrastructure was mainly covered under the rebuild alliance Stronger Christchurch Infrastructure Recovery Team (SCIRT). The surveys gathered data on the land drainage network's attributes and drainage condition, as well as a high-level assessment of non-performance related values of culture, ecology, heritage, landscape and recreation (which together with drainage are known as the Six Values of waterways in Christchurch).

The data collection was extensive; data was collected over two years, under different LDRP projects, and by various consultants. A visual survey specification was developed to ensure consistency in the data. Tablet-based data collection was developed to increase efficiency of the data collection and reduce double-handling and errors associated with paper-based data collection methods. The tools developed were described in the paper *An Innovative Approach to Condition and Damage Assessment of Land Drainage Assets*, presented at the 2015 Water New Zealand conference.

The final dataset was amalgamated into one consistent database and delivered to the Council in November 2016. The database is extensive, covering 516 km of channels, and includes over 25,000 data points involving open channel attributes and condition, damage and fault locations, and associated structures. Nearly 56,000 geo-tagged photographs were taken throughout the surveys and delivered with the dataset, providing valuable visual context for anyone using the dataset.

The dataset is a comprehensive database of information that facilitates further works within the LDRP. Now complete, the data will be used to inform further work packages as well as facilitating improved decision-making and strategic direction for the LDRP, asset management and operations teams at the Council.

1.4 PURPOSE OF PAPER

This paper focuses on the "aftermath" of data collection, rather than the data collection process itself. For information on the data collection process, refer to Scott-Hansen & Foster, 2015. The purpose of this paper is to show how a comprehensive condition assessment process can derive significant benefits for an asset proprietor with regards to planning, operations and cost-savings. The paper showcases two external examples of how asset and condition data are being used to derive strategic outcomes such as deterioration models and renewals programmes. The paper describes the benefits Christchurch City Council and the LDRP team have achieved to date through the LDRP dataset and presents a case study for a specific asset type of how the data is being used to achieve specific outcomes.

2 EXAMPLE APPLICATIONS OF CONDITION ASSESSMENT DATA

A comprehensive data collection and condition assessment is vital to develop well-informed maintenance and renewals programmes. Best-practice guidelines for the data collection process are plentiful, however the real challenge lies in how the data is used and applied once it has been collected. Misinterpretation of data can result in erroneous conclusions and poor decision-making which will diminish the value of the data and make it harder to justify expenditure on future data collection programmes.

Two examples are showcased below of how condition assessment data has been used to develop strategic programmes for asset renewals.

2.1 NEW ZEALAND – PIPE DETERIORATION MODEL

2.1.1 OVERVIEW

New Zealand has a relatively long history of using pipe condition assessment derived through CCTV inspections as a key consideration in pipeline renewal planning. The first New Zealand Pipe Inspection Manual (NZPIM) was created in 1989 to set a standard approach for inspection and classification of defects and condition in non-pressure pipelines for the New Zealand water services industry. Having a nationally consistent approach for the past three decades has enabled a lot of progress and collaboration across the industry. The example in the following section introduces a pipe deterioration model that was developed through combining a standard deterioration model with information gathered from CCTV inspections.

2.1.2 USE AND METHODOLOGY

To demonstrate how pipe condition data can be used for strategic asset management purposes, we will introduce an example of using condition assessment to predict the likelihood of failure (LOF) and thereafter develop a condition assessment and renewals programme. The project, undertaken by Opus in 2015, developed a pipe deterioration model by using a deterioration prediction model developed by the Canadian Institute for Research in Construction (NRC) and adjusting it based on observed condition from a sample of 72 km of local CCTV inspections.

The resulting pipe deterioration model for all pipe materials excluding reinforced concrete and plastic (which had much flatter deterioration patterns) can be seen in Figure 1.

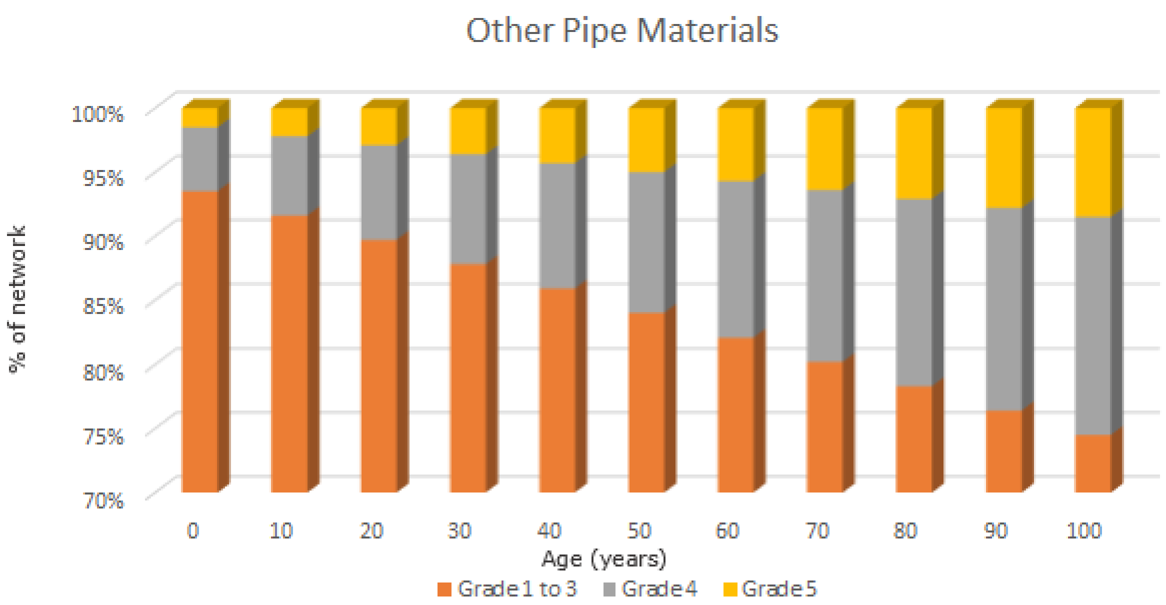

Figure 1: Pipe deterioration model based on standard model combined with condition information from local CCTV inspections (Opus International Consultants, 2015).

The subsequent process of developing a condition assessment programme involved:

- Assign ***maximum tolerable likelihood of failure levels*** depending on pipe criticality
- Age of first inspection is calculated from:

Age 1st Inspection = Max Tolerable Likelihood of Failure / Likelihood of Grade 5

- Based on condition found during first inspection, two questions are raised:
  1. Does the pipe need to be repaired or replaced? (Grade 4-5)
  2. When does the pipe need to be inspected again? (Grade 1-3)

1. Grade 4-5: Pipes with condition grade 5 should be scheduled for repair or replacement as soon as possible. To address the pipes with condition grade 4, a Maskov type analysis was undertaken to estimate the likelihood of these moving to Grade 5. It was found that 44% of Grade 4s were likely to become Grade 5s within the next decade.

2. Grade 1-3: For non-urgent assets, the recommended period to the next inspection was calculated with:

Period to next inspection = Maximum tolerable likelihood of Failure / Likelihood of deteriorating to Grade 5

The next question for the Grades 1-3 is whether to repair or replace now or retain the asset until the next inspection is due. This was answered through a net present value analysis which concludes that the cost of retaining a pipe is generally cheaper than installing a new standalone pipe. Applying economies of scale can however be cost effective and therefore renewals can be justified if the pipe can be replaced as part of a larger project for less than 40% of the cost of replacing it on its own.

- A condition assessment framework was developed from the above analysis as shown in Table 1.

Table 1: Condition assessment and inspection programme based on pipe deterioration model

Period to Inspection			
Criticality	Very High	High	Medium
Age at 1st Inspection (years)			
	10	15	20
Action if pipe found to be:			
Grade 5	Repair/replace	Repair/replace	Repair/replace
Grade 4	Repair/replace	Repair/replace	Repair/replace
Grade 3	Re-inspect in 2 years*	Re-inspect in 4 years*	Re-inspect in 6 years*
	**Renew if, as a result of adjacent pipes being renewed, this pipe can be renewed for less than 40% of the cost of renewing it on its own*		
Grade 1 or 2	Re-inspect in 10 years	Re-inspect in 15 years	Re-inspect in 20 years

2.1.3 OUTPUTS AND BENEFITS

The example described above shows a relatively simple yet effective method for how condition assessment gradings and criticality can be used to define an inspection and renewals programme. The resulting programme gives the asset owner a clear roadmap for inspections and renewals which can be used to justify budget requirements over short and long-term timeframes.

The methodology could be refined further by running a Multi-Criteria Analysis (MCA) and including criteria such as pipe diameter, material, and in-situ ground conditions to produce a more sophisticated deterioration model. The deterioration model could also be continuously updated and reviewed by analysing samples from replaced assets.

2.2 UNITED KINGDOM – NATIONAL FLOOD AND COASTAL DEFENCE DATABASE (NFCDD) AND FRAGILITY CURVES

2.2.1 OVERVIEW

The National Flood and Coastal Defence Database (NFCDD) is a comprehensive database that stores core data on the flood and coastal defences in the United Kingdom. The aim is to provide a single source of truth for flood and coastal defences that is easily accessible across all operating authorities. The vision is that provision of better data and a greater understanding of flood and coastal defence risk will enable expenditure to be more effectively targeted, thereby making more efficient use of limited resources and reducing damage (New Forest District Council, 2017).

The database stores information on an assets location and defence type, as well as two principal terms:

- **Standard of Protection (SoP)** – the severity of a storm event that will exceed the performance level of the asset, i.e. overtop or overflow. Expressed as a return period in years.
- **Condition Grade** – the ability of the defence asset to remain structurally intact during an event. Expressed on a scale from 1 (Good) to 5 (Poor) (Allsop, 2005).

Both of these terms are derived routinely through visual inspections and judgement and stored within the NFCDD. The case study below describes how these terms are used to develop fragility curves that describe a particular defence element's probability of failing during storm events of varying magnitudes.

2.2.2 USE AND METHODOLOGY

The information collected in the NFCDD is used to develop specific fragility curves that describe the likelihood of a defence failing during a particular storm event. Developing the fragility curves is not a trivial exercise and relies on frequency analysis of previous failures and rigorous probabalistic analysis of different defence types (Environment Agency, 2003).

The inputs to the fragility curves include defence information, including SoP, condition grade, element type, element sub-type, material and revemtment type. The primary outputs are fraglity curves that show conditional probabilities of failure for each flood defence section in the system by mechanisms of overtopping and breaching (Environment Agency, 2003).

The different failure mechanisms of overtopping and breaching are considered separately. In the case of overtopping the primary consideration is water level, defined by an estimate of the return period that produces given water levels. In the case of breaching, the additional consideration of the condition grade of the defence is included, resulting in five different curves for each condition grade 1 through 5. An example of a generic fragility curve for the latter is shown in Figure 2.

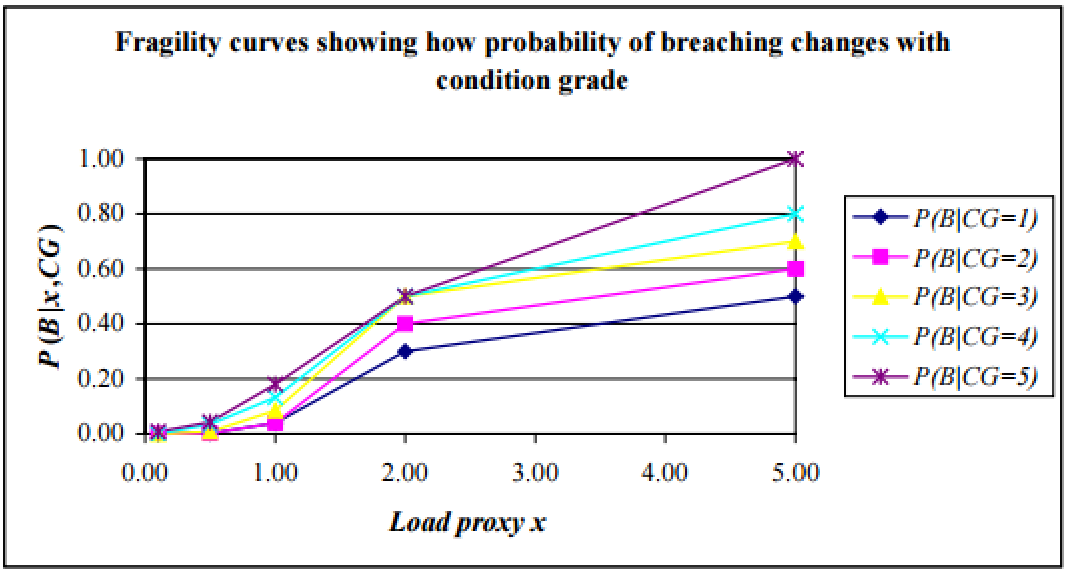

Figure 2: Conditional Probabilities of breaching for water levels relative to a defence's Standard of Protection (SoP) and its Condition Grade (CG) where P(B/x,CG) is the conditional breaching probability, for load x (water level) given CG (condition grade) (Environment Agency, 2003).

The generic fragility curves are used to provide an output of defence failure bounds which is achieved by integrating probability of a conditional failure over the expected probability of encountering a given event. This analysis will give two different outputs for the overtopping and breaching scenarios, with the probability of breaching being naturally higher than that for overtopping.

2.2.3 OUTPUTS AND BENEFITS

The NFCDD and fragility curves are part of a comprehensive national flood risk management programme in the United Kingdom. Other components that support this include the RASP methodology (Risk Assessment of flood and coastal defence systems for Strategic Planning), the Modelling and Decision Support Framework (MDSF), and PAMS (Performance-based Asset Management). The intention is that all these initiatives integrate to manage flood risk in the most effective and informed way possible.

The application of using condition assessment grades for development of fragility curves is only a small part of the overall portfolio of tools and systems to manage flood risk. However, the example above has showcased a pragmatic application of how condition grades, in combination with other quantifiable measures, can be used to develop solutions that aid asset managers in defining acceptable levels of service and subsequently appropriate asset management frameworks.

3 IMPLEMENTING AND USING THE LDRP DATASET

After looking at some best-practice examples of using condition data to aid asset managers with strategic decisions and programmes, the focus will shift back to the local arena and the LDRP dataset. This section provides descriptions of how the data is being implemented and the benefits this creates across the Council.

It should be noted that the LDRP dataset is still in the process of being fully integrated into the Council's systems, and so the full potential of the data has not yet been explored or validated. However, benefits are already being realised, including:

- Supporting earthquake recovery work for the LDRP team
- Identifying critical asset failures in the network
- Assisting Operational Team with developing works and maintenance programmes
- Justifying and setting the baseline for a rolling condition assessment programme
- Informing planning and compliance teams about potential compliance issues
- Improving quality of asset register for criticality development
- Informing valuation investigations

These examples showcase how the data is an important resource and providing value for the LDRP, Asset Management, Operations, Earthquake Recovery, and Planning teams across the Council.

3.1 EARTHQUAKE RECOVERY

The initial purpose for the condition assessments was to assist the LDRP team with earthquake recovery efforts. With an extensive open waterway network, the Council needed to identify damage and act accordingly to repair critical areas. Repairing damage to the land drainage network was a critical activity for minimising risks of flooding, in particular due to the widespread land subsidence the earthquakes had caused which is a significantly more difficult issue to address on a large scale.

The LDRP data collection specifically focused on differentiating between reduced performance levels and damage caused by earthquakes or business-as-usual (BAU). Looking across the entire network, around 15% of faults were identified as being caused by earthquake damage. This overall figure is lower than what was initially expected before the data was collected and highlighted the importance of continuous assessments and rigorous maintenance regimes and feedback systems for the maintenance contractors. One interesting insight that arose from analysis of the data was that earthquake-related damage was significantly more prevalent on the high severity faults; overall the severity 5 (catastrophic) faults were caused by earthquakes in 50% of cases, whereas the lower severity faults were caused by earthquakes in around 15% of cases.

The LDRP team is using the condition assessment data collected to inform the programme of works to restore flood risk to pre-earthquake levels throughout the city.

3.2 IDENTIFYING CRITICAL ASSET FAILURES

The survey specification specified that any urgent issues, specifically defined as severity 5 (catastrophic) faults, identified during the field surveys should be reported immediately to the Operations Team to review and action appropriately. The notices were useful in bringing attention to issues that would otherwise potentially have gone unnoticed for a long time. The resulting actions were typically to either undertake dayworks to address the issues or contacting customers (sometimes leading to enforcement notices).

Looking at 'critical asset failure' in more broad terms, in many cases the data confirmed what the Council's Operations Team and Land Drainage Contractor already knew about the condition of the network. Furthermore, it also provided hard evidence that can be used to make a case for appropriate levels of funding for both planned and reactive maintenance and renewal programmes through the Long-Term Planning (LTP) process. Work can be prioritised using a risk-based approach that allows looking at the big picture and moving towards reducing the proportion of work that is undertaken on a reactive basis. By its nature, a reactive approach often results in funding not going to the highest priority candidate and increases the potential for politically-based rather than needs-based decision making.

3.3 OPEX PLANNING

Operations and maintenance decisions can be informed through up-to-date and comprehensive condition data. Presently, due to the lack of data, maintenance tends to be reactive, responding to notifications from the public or the maintenance contractor. While this allows for a response to obvious faults, it can reduce the ability to undertake preventative maintenance.

Combining the data obtained through the condition assessment with a criticality assessment allows for a works programme to be developed. Programmed works are more cost effective and makes it easier to resource accordingly. The data obtained also allows for operational budgets to be developed from first principles, with different levels of service costed for decision makers to evaluate. Being able to demonstrate that the budgets are based on current condition assessment provides reassurance that the level of service decisions are based on hard data.

The data also allows for refinement of the maintenance contract as it can show where more attention is required, and it provides a baseline by which to assess the effectiveness of the contract. If future contracts update the condition assessment data and maintain a live database, this will enable Council to track performance and improvements across the network.

Combining the data with criticality assessments also allows for a targeted operational response ahead of wet weather events. This helps to direct actions toward assets which need to be checked or cleared to prevent flooding. Having a live condition assessment database allows this to be updated as various parts of the network are improved, thereby more effectively utilising constrained resources.

The immediate reporting of critical asset failures was highly beneficial from an operational point of view, as it ensured that the most critical issues were actioned quickly without waiting for the whole data collection process to be completed.

3.4 CONTINUED CONDITION ASSESSMENTS

Condition assessments of waterways have historically been undertaken as a reactive response to major events and minimal budgets have limited the extent of the assessments. The learnings from this project in terms of development of a standard condition assessment specification, along with an improved understanding of realistic rates and timescales to undertake this type of work, will be invaluable in developing and resourcing future condition assessment programmes.

The data is also being used to update Council's existing asset database (e.g. where assets not in the database were identified in the field), and this in turn is encouraging further data collection to fill gaps in the GIS. It should be noted that the data collected for the LDRP was, due to its intended purpose, a rapid assessment and therefore data that may be useful for wider purposes within the Council may was not collected to strike a balance between complexity of data and efficiency of data collection. However, the assessments identified the need for collection of more detailed information and has instigated this process for several asset types.

Ideally, a rolling condition assessment programme would be undertaken at regular intervals (e.g. every 5-10 years). This kind of continuous data feed will greatly enhance analysis of asset deterioration under normal circumstances, not just due to extraordinary events. It also helps keep the information current and relevant, thereby enabling better informed decision-making.

3.5 PLANNING & COMPLIANCE

The field assessments identified several potential compliance issues including private boundary fences and other obstructions in the waterways, as well as livestock not being properly fenced and having free access to the waterways causing damage to the banks and pollution issues.

The LDRP dataset has for the first time highlighted the potential scale of the problem and this can be used to help make decisions around enforcement of the Council's powers under the Land Drainage Act and the Christchurch District Drainage Act. The information can also help inform future updates of planning guidance documents and ensure a consistent approach is used when tackling compliance issues and educating the public around their responsibilities.

The photographs below provide time-based evidence of a waterway that has been altered without appropriate consents being in place. It is particularly important that investigations are made where compliance issues either result in a loss of hydraulic capacity or have a negative impact on other values such as ecology.

BEFORE

AFTER

Photographs 3 and 4: Examples of before and after shots of a waterway that has been altered without appropriate consents

Another example of how the Council's Stormwater Asset Planning Team are actively using the data is checking for existing compliance issues when consent applications for works within the waterway setback are received. The existing compliance issues can then be addressed as part of the new resource consent.

3.6 CRITICALITY

The Council is currently developing a multi-criteria model which assigns criticality grades to individual stormwater assets using FME (Feature Manipulation Engine) software. The model uses data held in the asset register and GIS datasets as inputs and applies a defined set of rules and weightings to assign a criticality grade from 1 to 5.

The data collected through the LDRP project will help improve the quality of the asset register, and influence the quality and confidence in the outputs from the criticality model.

3.7 VALUATION

Valuation investigations are currently being undertaken by the Council to understand the financial value of their asset portfolio which is invariably important with regards to matters relating to insurance. However, the quality of the valuation output is limited by the asset data provided. The improved asset register and condition information provided by the LDRP dataset will ultimately allow more accurate valuations and greater confidence in insurance coverage which will have significant benefits in case of another destructive event caused by a natural hazard.

4 CASE STUDY – TIMBER LINED DRAINS

Apart from piped reticulation, the highest value land drainage asset owned by the Council is waterway lining. Prior to the LDRP data collection, no comprehensive condition data was held on this asset category, and the asset register was in need of review and updating.

Timber lining with top struts is the most common construction method for lined drains and accounts for 27% of all lined drains with a total length of 46 km. Of these 46 km, 35 km (76%) were assessed as part of the LDRP data collection.

Timber lining of utility waterways was mainly undertaken in the 1970s and 1980s by the then Christchurch Drainage Board, who employed lining gangs to install the lining. The lining typically consists of hardwood posts and struts with timber planks behind. As the useful life of the timber lining is around 30-40 years, it is expected that most of this lining will need renewal shortly or at least within the next 10 years.

A combination of high average replacement cost (approximately $2,000/m), a relatively short expected useful life, and an imminent renewal bow wave, means that this asset type now requires careful management and appropriate levels of funding. For this reason, timber lined drains have been selected as the asset type to provide a common theme for the practical examples that follow, which include;

- Understanding whole network condition
- Long-term renewals planning
- Linking levels of service to asset renewal scenarios

4.1 UNDERSTANDING WHOLE NETWORK CONDITION

Building a picture of the condition of the whole network is an important part of asset management and something that needs to be conveyed through the Asset Management Plan. In terms of available levels of information, the worst-case scenario is that no physical asset condition data is available and the condition needs to be implied based on other related information such as the installation date, expected useful life and standard deterioration curves for the asset type. The best-case scenario is that up-to-date condition grades have been assigned to every asset through physical assessments using standard criteria. In reality, the most common scenario often lies somewhere between these two extremes.

To demonstrate the difference in how the overall network condition will look when using different condition data quality scenario, three simple models have been created, as described:

Model 1 – Using install date and estimated useful life only (worst-case scenario)

Approximately 77% of the assets in the network had install dates assigned and where the install date was not known, it was assumed based on the average of the available dates. A standard deterioration curve was used for an estimated useful life of 40 years.

Model 2 – Using physical assessment condition grade combined with implied grades based on install date

This method uses the physical assessment condition grades where available and for the assets where this is not available, the condition grade is implied using the same methodology as that used for Model 1.

Model 3 – Using physical assessment grade distribution and applying it to the whole network

This method assumes that the assets that have been physically assessed are representative of the whole network and the relative proportion of grades obtained from the physical assessments assets can be applied across the whole network.

Results

The results of applying the three models listed above to the 'timber lining with top struts' asset category are shown in Figure 3 and the differences are clear. Model 1 shows an over-estimation of the percentage of assets that are condition grade 4 and 5 when compared to the (more accurate) Models 2 and 3. This could indicate that review of the expected useful lives and/or deterioration curve is required.

MODEL 1 **MODEL 2** **MODEL 3**

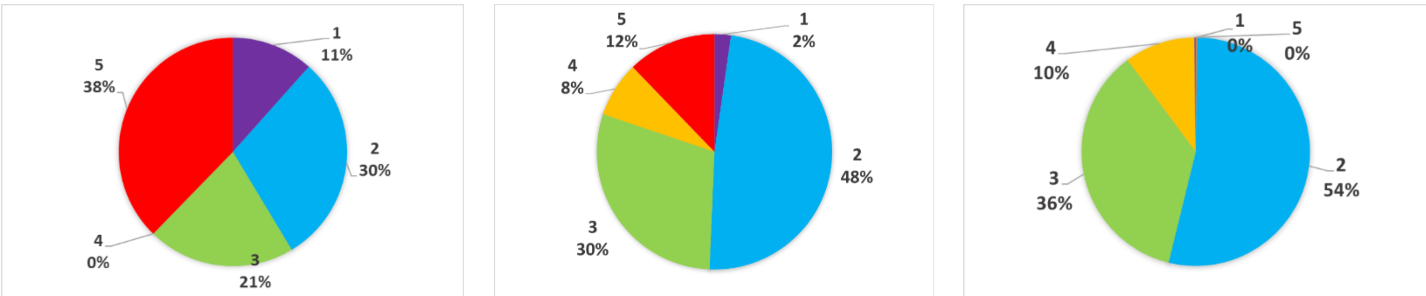

Figure 3: Results of applying different complexity models to an asset dataset to estimate condition grades

A decision would need to be made between Model 2 and Model 3 based on which appears to provide the best fit. A weakness of Model 2 may be reliance on implied condition based on install dates for around a quarter of the network, whereas a weakness of Model 3 may be the assumption that the assessed portion of the network is representative of the whole network. Ideally, a combination of Model 2 and Model 3 would provide the best solution, i.e. around 15% of the network is Grade 4/5.

→ Key Message – Physical condition data allows the true overall condition of the network to be understood and shown.

4.2 LONG-TERM RENEWALS PLANNING

As discussed above, without condition data, renewals programmes are often based on the age of the asset (where known) and the expected useful life. Figure 4 shows the estimated total renewal lengths for a series of 5-year periods between 2019 and 2048, obtained using the Model 1 and Model 2 methodologies as described. This indicates that when real condition data is used, rather than theoretical figures, more investment is required in the first 10 years. Without the physical condition data, there would be a risk of underestimating the risk of failure and underfunding the short- to medium-term renewals programmes.

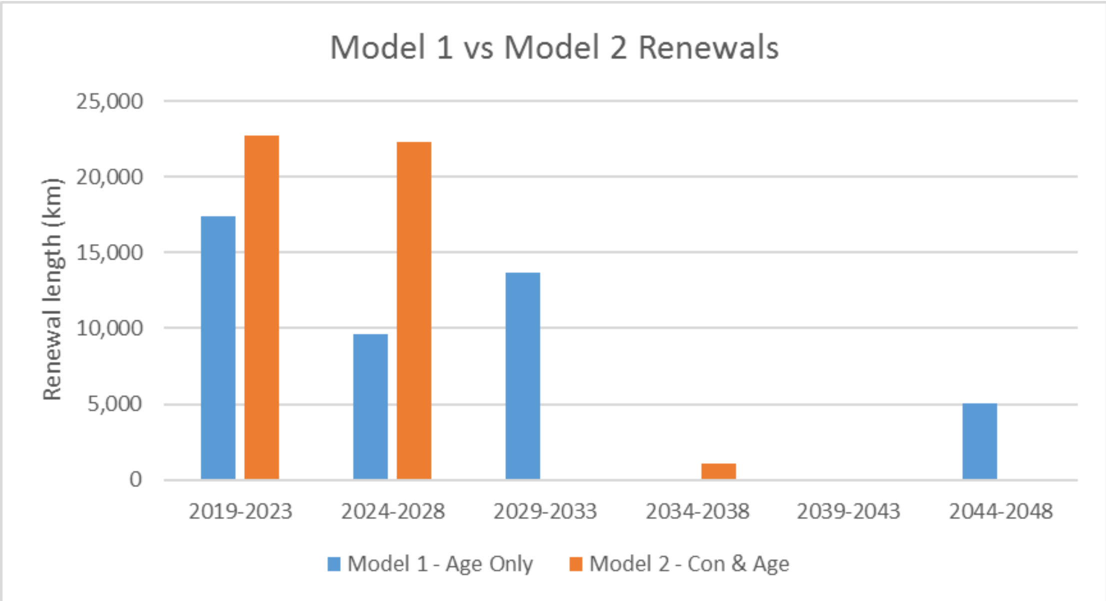

Figure 4: Estimated renewals requirements over a 30-year timeframe using different condition grade models.

→ Key message – Condition data allows more accurate renewals programming.

4.3 LINKING LEVELS OF SERVICE TO ASSET RENEWAL SCENARIOS

The levels of service set by the Council are high-level and difficult to use directly to inform the renewal programmes for individual asset types. However, the introduction of clear and meaningful technical measures provides a link and helps to demonstrate to stakeholders how different levels of funding will impact the condition and performance of the network over a variety of timescales. Figure 5 is an example of how a Council level of service may be linked to a tangible outcome and budget requirements through use of an appropriate technical measure. In this example, the technical measure used is the rate at which condition grade 5 assets are renewed; three scenarios are considered with renewal completions timescales ranging from 1 to 5 years. Figure 6 shows the estimated funding requirement associated with each scenario.

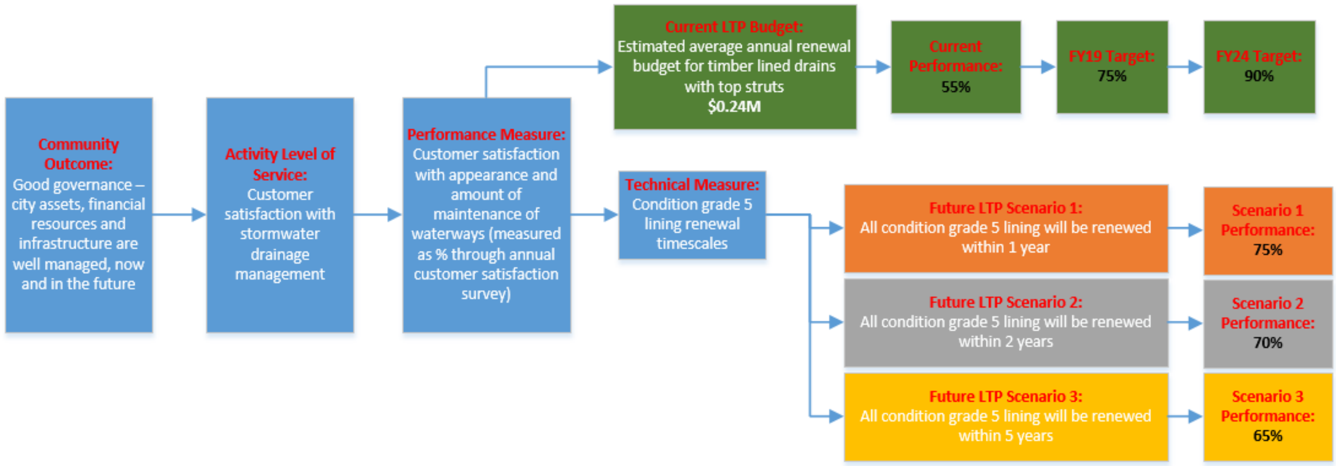

Figure 5: Example of how levels of service can be linked to a range of tangible outcomes and budgets through use of technical measures and scenarios

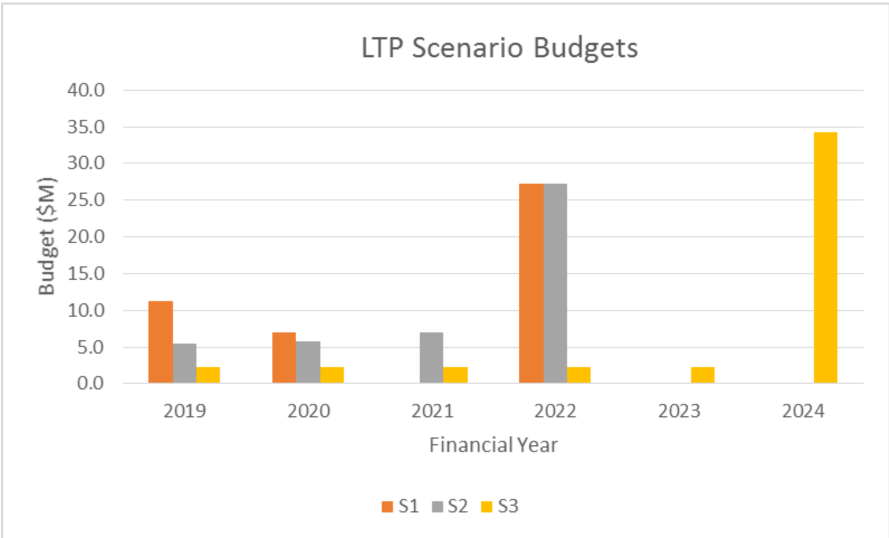

Figure 6: Comparison of a range of funding scenarios based on rate at which condition grade 5 lining is renewed.

It should be noted that in reality the link to levels of service would be through more complex risk-based criteria rather than condition alone, but condition has been used to provide a simple example of how the linkages could be applied. The example used the Model 2 condition grade data, as described above.

This approach helps to understand and communicate the potential risks of underfunding and identify areas where current levels of service may not be achievable. In this case, the availability of condition data has highlighted a significant gap between the funding required to meet the levels of service and the current funding available. It also provides a robust case for increased funding in future years, or else an acceptance that reduced levels of service may occur.

→ Key Message: Without good-quality technical data such as condition, it is very difficult to clearly demonstrate a range of options and the associated funding implications.

5 FUTURE APPLICATIONS

In addition to the direct benefits that have already materialised, the LDRP dataset has potential for creating further value across the various teams within the Council. As the LDRP team were set up for a specific purpose, the findings from the LDRP data collection will create a good precedent for future investment in stormwater activities. Some of the further potential applications of the LDRP dataset are described below.

5.1 TARGETED COLLECTION OF ADDITIONAL ATTRIBUTE DATA

As the data collection was undertaken through LDRP, which is focused mainly on returning the networks to pre-earthquake level of service, the survey specification was specifically tailored to meet the requirements of this focus.

The LDRP data collection provided a valuable opportunity to collect basic attribute and condition data (type, location, material, condition, photos etc.) on an asset type that had limited existing information available. If anything, the dataset has highlighted the need for further desktop studies and gap-analysis. Further data collection can then be undertaken by the Three Waters and Waste Asset Management Team (3W&W AM) to improve data quality for their purposes.

5.2 DEVELOPMENT OF DETERIORATION MODELS

Another future use of the LDRP dataset will be to inform deterioration models, and this process will be significantly improved if rolling condition assessment programmes are implemented.

Accurate deterioration models will require further improvement of the asset data including validation of installment dates, EQ impacts, repairs and maintenance undertaken etc. however the LDRP dataset provides a solid baseline on which to build further investigations and development on.

5.3 INTEGRATION OF LIVE DATA AND FEEDBACK

The emergence of live data technologies can further supplement the information stored in the LDRP dataset. With regards to stormwater assets, one of the most useful types information is that which is captured by the public and maintenance contractors. Implementing and optimising systems (e.g. Snap Send Solve) that allow direct input from customers and contractors can create immediate benefits for the Operations Team in highlighting issues before they create a problem.

6 CONCLUSIONS

This paper has focused on how collection of condition assessment data can derive great benefits for strategic decision-making purposes on stormwater assets. The LDRP dataset that was collected in 2015 and 2016 covers just over 500 km of watercourse assets and includes 25,000 data points detailing information on asset attributes, condition and fault and damage locations.

In summary, the main benefits that have been obtained to date include:

- obtaining a baseline snapshot of network condition and damage;
- identifying a series of critical asset failures;
- validating and augmenting Council GIS information;
- highlighting the prevalence of compliance issues affecting hydraulic capacity of the waterways;
- delivering baseline information for a long term operational and maintenance contract;
- feeding the long-term asset renewals pipeline; and
- providing information to support the Council's asset valuation activities.

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