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ASSET MANAGEMENT COUNCIL

DIGITAL ASSET MANAGEMENT

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Maintenance 4.0: Digitalisation of Maintenance in the Civil Engineering Industry

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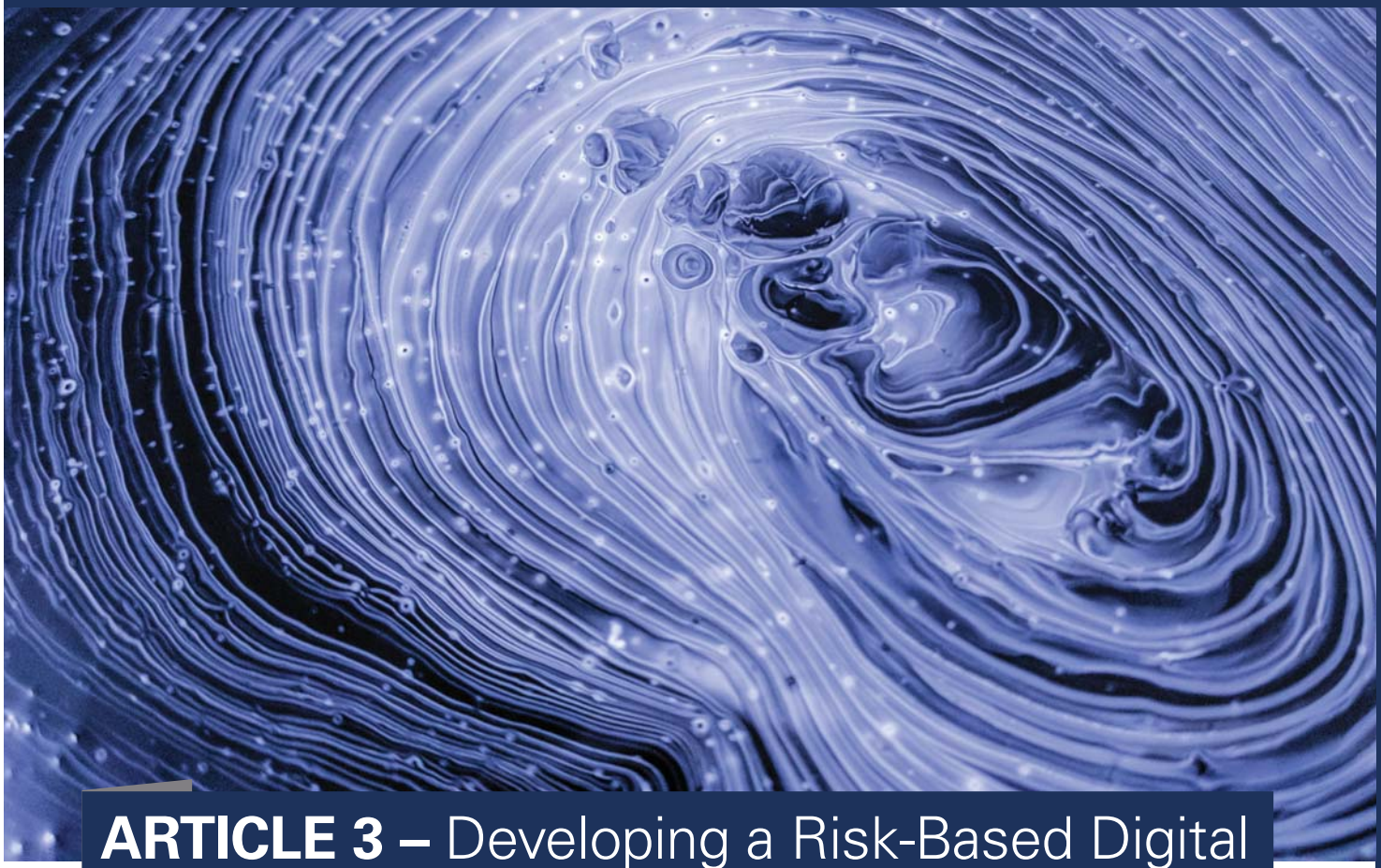

ARTICLE 3 – Developing a Risk-Based Digital Asset Planning Tool for Water / Wastewater Networks

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ABSTRACT

Asset class strategies and plans are an integral component of asset-intensive organisations. However, while these plans and strategies are often content heavy, their most important aspect can be missed: Effective communication and engagement across the organisation. This case study outlines the development of a digital asset management planning tool for water and wastewater networks to facilitate this in Mackay Regional Council, Queensland. The planning tool is fully interactive and allows a simple overview of the state of the asset portfolio (quantities, replacement costs, age), its asset health, criticality and current risk level. The digital tool uses a novel approach that combines satellite, geospatial and client-owned data with advanced AI (artificial intelligence) to provide a validated asset health profile across the pipeline network. Future deterioration and asset risk is modelled over a planning period together with planned interventions for maintenance and renewals. Outputs from the modelling are then visualised in a dashboard tool that is fully interactive and transparent. The digital planning tool allows asset owners to effectively engage stakeholders, communicating investment needs at all levels, from

board/executive to field crews and the community.

Keywords: Water/Wastewater Networks, Asset Risk, Digital Planning Tool

INTRODUCTION

Mackay Regional Council (MRC) is a local government authority in Queensland that provides infrastructure services to approximately 125,000 people across a service area of almost 7,600 square kilometres. The services that MRC provide include Water & Waste Services, Transport & Drainage, Community Facilities and Parks & Environment (Mackay Regional Council 2023). The infrastructure that Council operates and maintains to provide these services is worth almost $5 billion (gross replacement cost) with an annual depreciation expense of more than $85 million. MRC has a responsibility to effectively and efficiently manage the services provided by its assets to its community. Asset class management strategies and plans are under development to provide the linkage from the organisational objectives of the council, community outcomes and the asset management objectives to be delivered by the infrastructure portfolio. In the context of water/wastewater networks, these plans are intended to outline the activities to ensure that assets perform and provide community services, while cost and risk are managed appropriately.

Asset management practitioners are required to develop strategies and plans to articulate business investment requirements. While these written documents can be highly effective, they can sometimes also be lengthy, and difficult to communicate and engage with across a large organisation. As a result, rather than be embedded in decision making and supporting actions in the field, many large volume asset plans can be consigned to the shelf.

While a robust, well thought out strategy and subsequent plan are recognised as essential building blocks for success, many sources claim 90% of strategies and plans fail. Even well-formulated plans can result in failure rates of 67%-70% according to two well-reputed institutions. (Bridges Business Consultancy, 2016; McKinsey and Company, 2015). The reasons for failure are many (Mills, 2018) and include:

- Overwhelming initiative lists due to inadequate prioritisation
- An asset focus rather than a service outcome focus
- A lack of top-down direction
- Large documents that are difficult to read and gain insight from

This case study presents MRC's approach towards a smarter, interactive, and more engaging asset class plan for water and wastewater networks that is aligned with ISO 5500X guidelines.

THE DIGITAL ASSET PLAN ARCHITECTURE

Considering the limitations outlined above, rather than follow the traditional path of written asset management plans, MRC began development of a digital asset class management plan that, by virtue of its interactive nature, would help planners engage across the entire organisation and collaboratively answer questions such as:

- **Asset portfolio quantities** – What assets do we own? Where are they? When were they installed? How much would it cost to replace them?
- **Asset health** across the network – What condition are our assets in? What is their probability of failure?
- **Asset criticality** – which assets impact our organisation and the community the most and why?
- **Asset risk** – where is the risk across the network and how large is it?
- **Risk mitigation** – Can we mitigate the risk and continue to provide service with the budget we have?
- **Investment planning** – What are we doing and where are we doing it? When?
- **Business approvals** – Can activities be aligned with other project drivers? Can we demonstrate prudency and efficiency?

The BetterAMP digital asset planning tool was proposed, as shown in Figure 1.

The foundation of the BetterAMP digital plan is a 'State of the Asset' register and Lifecycle Intervention Model (LIM). The register is housed in a secure cloud-based SQL database in a cloud-based environment that can be updated on any frequency. The data in the asset register is securely imported from the client's existing Asset Management Information System (AMIS). It is then structured using an appropriate classification/

Figure 1 The Digital Plan: 3-tier architecture

location hierarchy to enable analysis and insight generation. This ensures that maintainable units in the register are considered in the context of the process/facility/scheme/service chain in which they reside/contribute to. The asset location/classification hierarchy for the register is based on the UNICLASS system and is shown in Figure 2.

Based on the attributes of the units in the register, the BetterAMP LIM forecasts the change in asset health (probability of functional failure) over time as the asset base ages over the planning period. This probability of failure is combined with asset criticality (a measure of the consequences of failure) to forecast the level of asset risk over time (number of, $ replacement cost of assets in different risk categories). Once a risk level is assigned to each asset in the portfolio, the LIM defines a series of risk-triggered interventions (e.g. 'renew all high/extreme risk assets'; 'inspect medium risk assets yearly' etc.). This forms the basis for a lifecycle investment forecast, based on known replacement costs and unit rates for different activities. The LIM then configures a range of budget scenarios (e.g. 'Do Nothing', Capital Budget = $5M/ year, etc) that are then applied, allowing the user to see the effect of their budget scenario on asset risk across the portfolio.

The second tier of the BetterAMP digital plan architecture visualises output from the LIM in a Microsoft Power BI interactive dashboard-style report. This creates a digital representation of the asset management plan, allowing planners to drill into and interact with content to develop and share insights, rather than search through a static document. The Power BI dashboard report is designed to generate insights at all levels of the hierarchy (as shown in Figure 2), pulling content directly from the cloud-based database. Typical insights gathered include:

- The state of assets within the portfolio
- Priority assets for upcoming condition assessment programs
- Proposed multi-year intervention/investment forecasts
- Estimated investment benefits from reduction of risk
- Performance insights relating to Levels of Service
- The residual effect of constrained investment scenarios (e.g. budget constrained for renewals)

The digital plan also identifies the sources and quality of critical data, informing key decisions to target asset information improvements. The visibility of data quality gives decision makers an understanding of confidence when planning. Data from the digital plan can also be exported to external third-party reporting and quality assurance tools.

The third tier of the BetterAMP architecture is the production of a concise, broadsheet-style Microsoft Word Asset Management Plan. It is focused on the headline insights, target outcomes and specific asset improvements to be undertaken over the plan period. The written plan is generated directly from the Digital Asset Management Plan and aims to form a 'plan on a page', rather than traditional content-heavy plans that are difficult to engage with (Rippon et al. 2019).

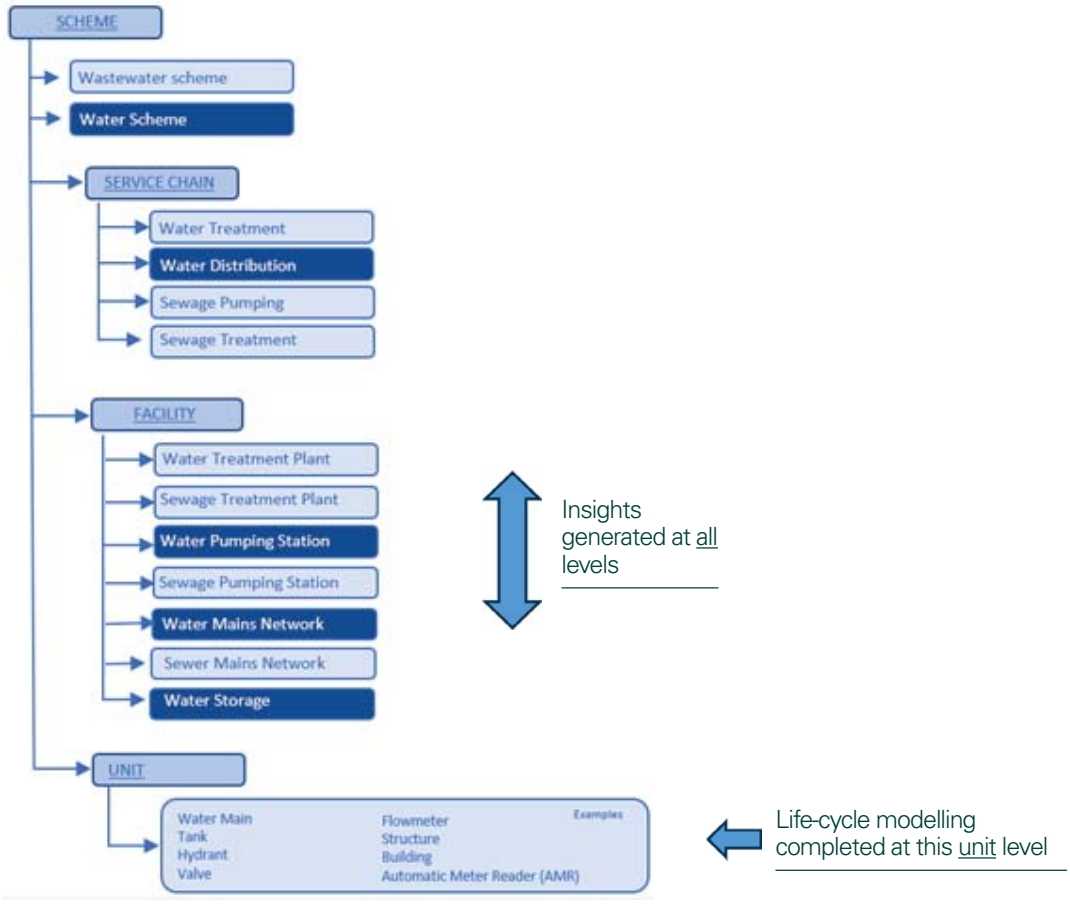

Figure 2 Unit types and asset location/classification hierarchy for the State of the Asset register

Modelling Asset Deterioration

For buried pipelines in MRC's water/wastewater network digital plan, a novel approach to asset deterioration modelling was taken. First, a snapshot of current probability of failure was estimated using a machine learning model , which takes environmental datasets from the previous 3-years, such as soils, satellite derived ground motion and vegetation, slope and weather, and pipeline attribute data, such as age, material and historical failures over three-year period. The MRC network was broken down into smaller pipe sections (less than 100 metres long) and the model was trained on the historic failure data. The machine learning algorithm analyses the signature of failure from all the datasets, then assigns a predicted probability of failure for each pipe section. To validate and improve the model, MRC undertake leak detection and CCTV inspection of pipes in their network that were not used as part of the machine learning. This ensures that the predictive capability of the model is continually tested and improved. The algorithm currently works effectively, identifying 70% of failure incidents within the highest risk 20-30% of the network.

This current snapshot of failure probability was then extrapolated into the future using the library of Weibull curves within the BetterAMP digital plan for the pipe section and its attributes. The BetterAMP digital plan contains a library of in-built asset deterioration curves based on the Weibull probability distribution (Ahammed and Melchers, 1997). These curves leverage available research literature (Burn et al., 2003; Davis et al. 2007, 2008, Hughes, 2009) and were calibrated using against asset-intensive organisations, using both historical failure data, and operational/maintenance subject matter expertise. The example extract below shows the spread of asset health across MRCs water network in the BetterAMP digital plan.

Risk-Based Decision Making

As outlined above, the BetterAMP digital plan combines asset health forecasts with an assessment of asset criticality (consequence of failure) to provide a risk basis for decision making. The LIM assigns a risk score to every asset in the MRC network portfolio, using the MRC enterprise risk

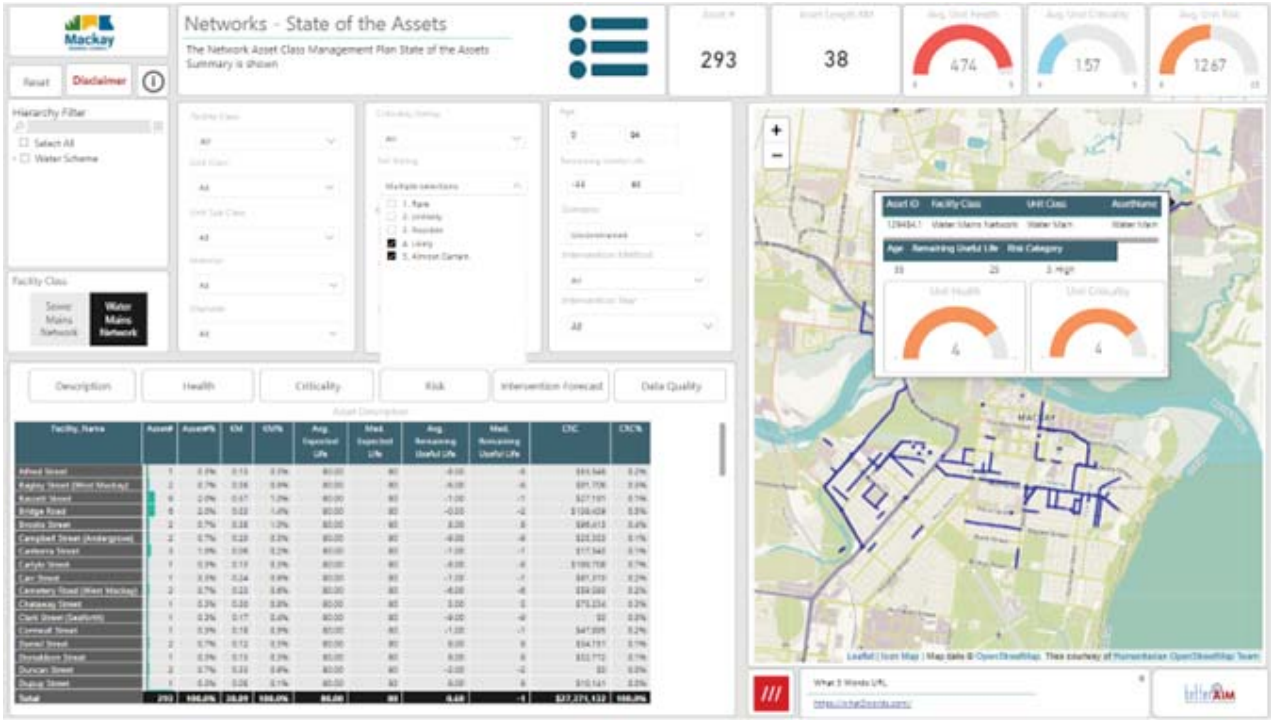

Figure 3 BetterAMP State of the Assets GeoView – Water Mains Asset Health

matrix. Interventions (e.g. replace, refurbish, repair, test/exercise, inspect etc.) are then defined to be 'triggered' in the model based on the risk level attained (Figure 4).

With Weibull curves in place for all unit types (e.g. pipes, pumps, motors, switchboards, valves, PLCs etc.), the LIM positions every asset in the MRC networks portfolio within the 5x5 enterprise risk matrix for every year of the planning period. It also captures intervention types and costs that are specific to the unit types in place (e.g. testing of switchboards, exercising valves, functional flow/ pressure testing of pumps, full asset replacement). These interventions are triggered at risk levels that reflect the organisational risk appetite.

Example Outputs

With risk-based decision making configured in the LIM, the BetterAMP digital planning tool allows the user to forecast the future risk profile (number of, $ replacement cost of assets in different risk categories) and compare the benefits of different investment scenarios. Figure 5 shows an extract

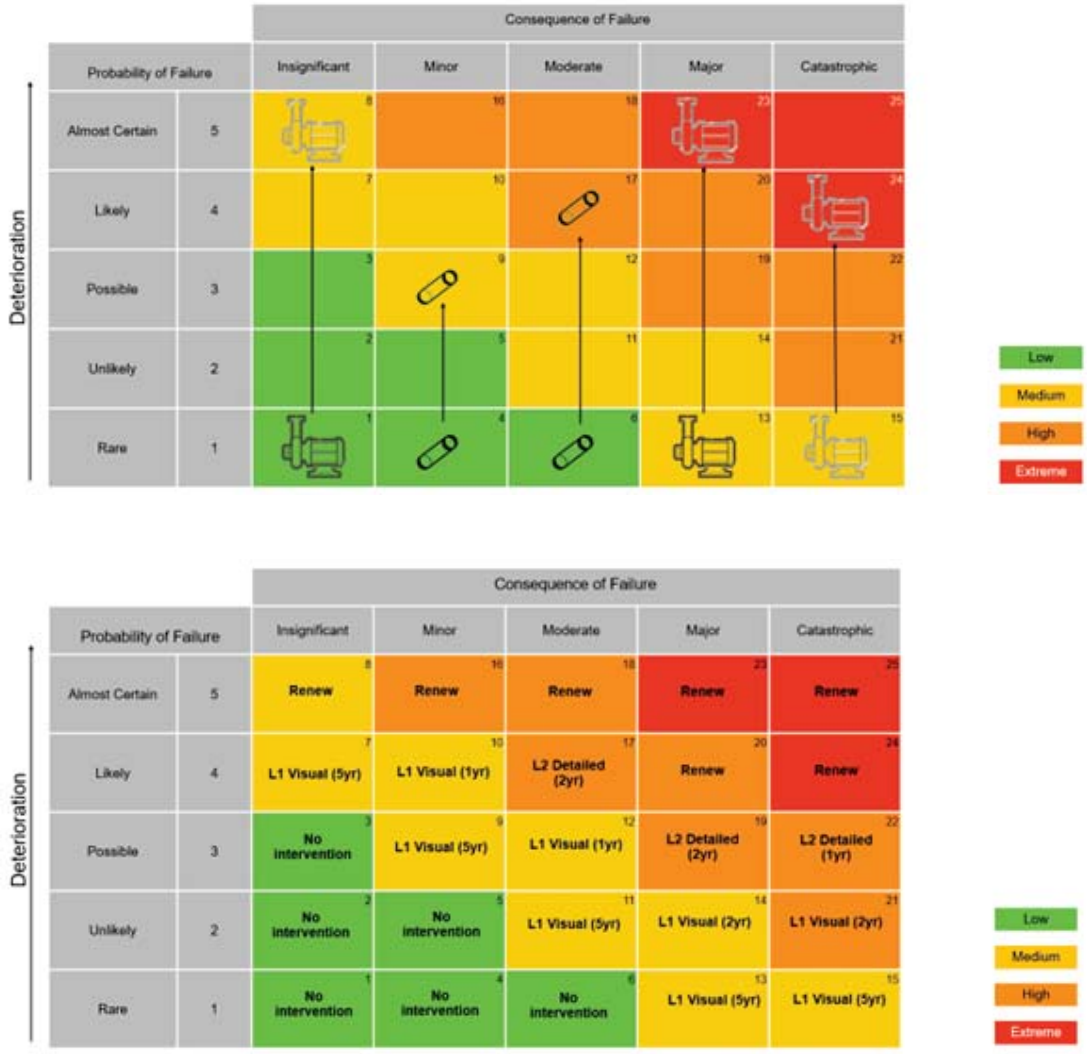

Figure 4 MRC's Corporate Risk Matrix and triggering interventions based on asset risk

from the BetterAMP digital plan, with the change in high/extreme risk sewer assets (non-linear) over time. The top chart shows the risk exposure under a "Do Nothing" scenario and the bottom chart shows the residual (improved) risk exposure under a defined annual renewals budget.

The digital plan also allows the user to identify specific interventions on assets, and the timing that is required to achieve the risk-reduction benefit. Figure 6 shows an example extract from the MRC digital plan outlining interventions and investments over the planning period to achieve the required risk reduction.

CONCLUSIONS

This paper has described the development of a digital asset management plan for water and wastewater networks in Mackay Regional Council (MRC), Queensland. The BetterAMP digital plan was developed comprising a cloud-based asset data model and Life-cycle Intervention Model (LIM) together

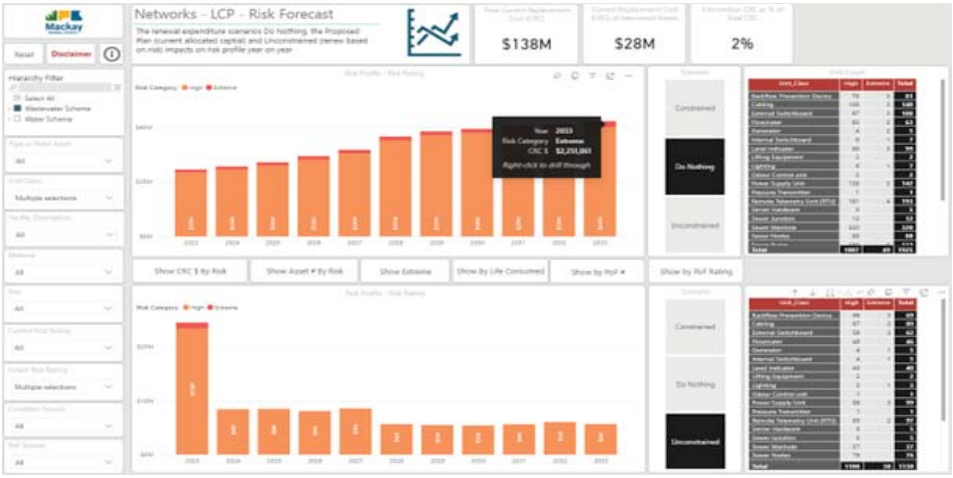

Figure 5 High/Extreme Asset Risk exposure for Sewer Point assets under "Do Nothing" vs Defined Renewals Budget Allowance

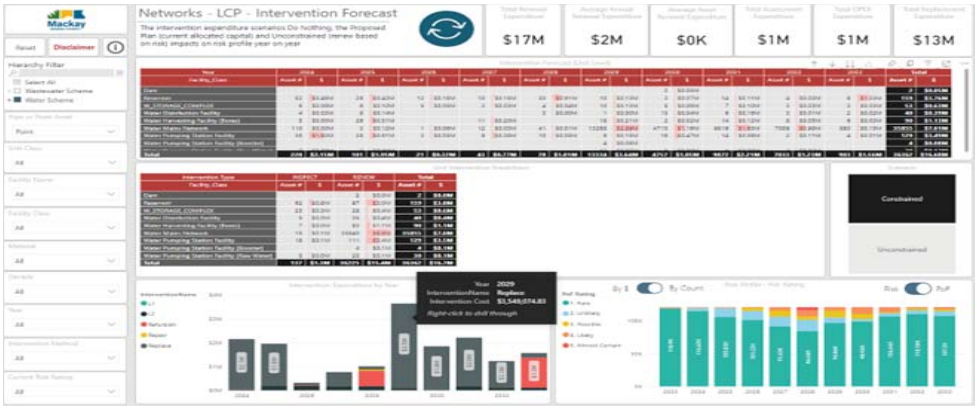

Figure 6 Life-cycle Intervention forecasts from the BetterAMP digital plan

with a business-intelligent dashboard report. The digital plan is interactive, fully drillable and allows MRC asset planners to engage and communicate insights on the state of the asset portfolio, its risk exposure and planned investment across all levels of the organisation.

The objective of developing the digital asset management plan was to ensure effective communication and engagement across the organisation. Following the development of this plan for the water network, digital plans for other infrastructure types in the MRC portfolio have been completed (or are close to complete). These include water and wastewater treatment facilities; solid waste management facilities; and property infrastructure.

Although these asset classes have installation and operating environments, the approach to plan development has been consistent. The focus on data sources and quality in the digital plan means that MRC asset planners consider them repeatable and defensible. In practical terms, the suite of digital plans is currently being used to inform a review of prudency and efficiency for planned capital upgrades and renewals in the Long-Term Financial Plan. The digital plans are also informing a program of inspection, condition assessment and maintenance across the portfolio.

While the uptake of digital plans at MRC is encouraging, further work is required to refine future forecasts of infrastructure asset deterioration, accounting for climate change impacts in the region. Examples are cyclones and flooding severity (impacting low lying facilities such as wastewater pump stations), bushfire risk, (impacting power supply and buried plastic pipelines), and extreme wet/dry periods (impacting buried pipelines). As with previous retrospective investigations (Brabhaharan et a. 2021), quantifying the reduction in expected service life under increased frequency of extreme weather events in the region is planned to refine the library of BetterAMP curves in the longer term.

The model, like all AI models, has been trained on historic data, yet climate change, particularly in Queensland, is rapidly changing the life and residual life characteristics for infrastructure. How this would be taken into account in order to ensure the model stands up to climate change over time would be a useful addition to the paper.

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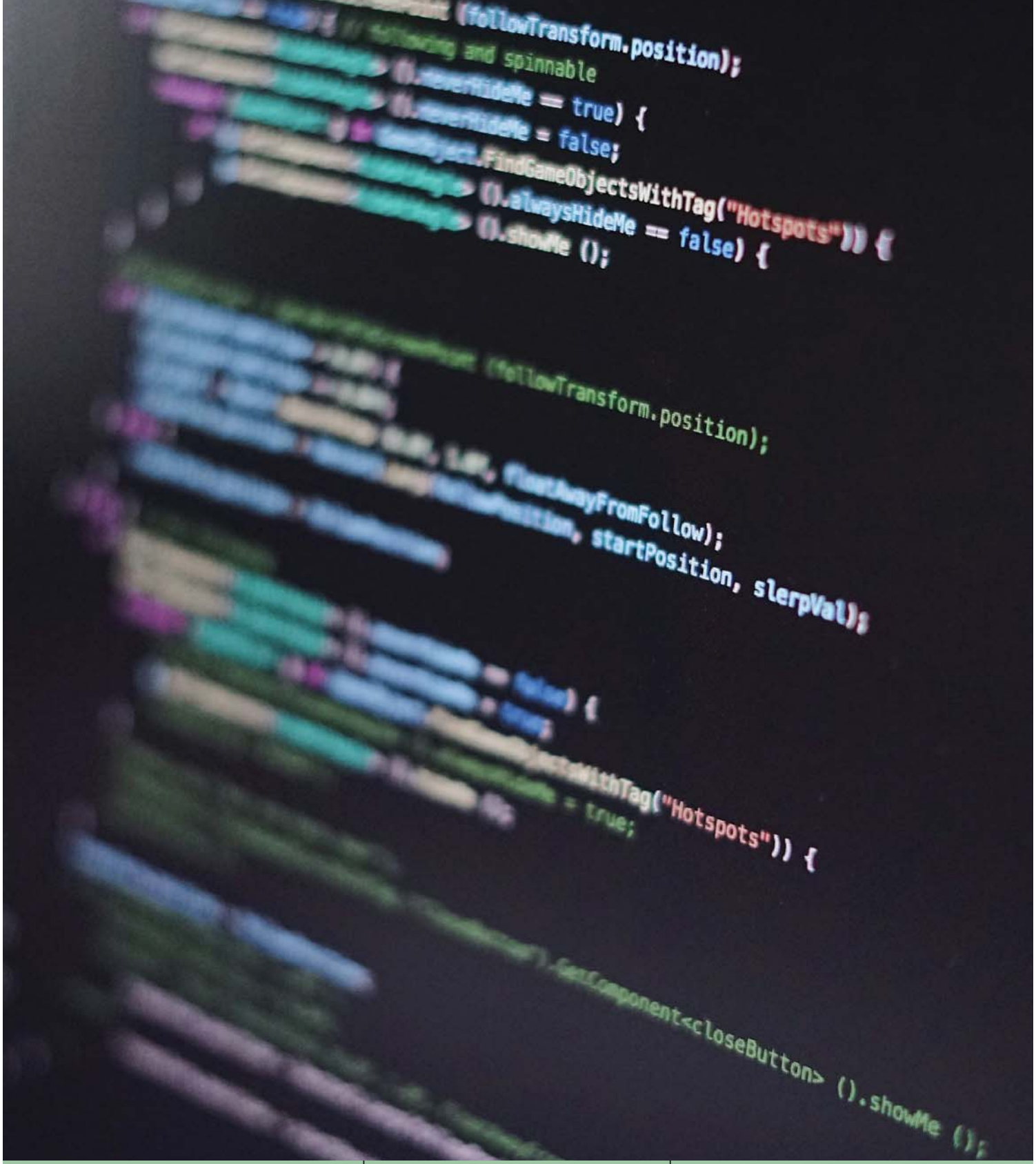

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