# TCC - IMPROVING THE MANAGEMENT OF THE THREE WATERS NETWORKS

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## ABSTRACT

Tauranga City Council had contracted Downer to undertake their Three Waters GIS Enhancement project. This project transformed their existing GIS into a planning and analysis powerhouse.

While the existing TCC GIS system offered excellent access to spatial data, there were requirements relating to operational processes, planning and scenario analysis that were not easily addressed creating significant demand on the GIS team. Workarounds were unsustainable and a more robust solution was sought which would provide more timely and efficient accessibility for improved decision making.

The preferred solution was to leverage Out-of-the-Box tools as much as possible to deliver the required functionality, minimising customisation, development effort and cost. Solutions were integrated with Esri's ArcGIS Platform to be compatible with TCC's existing GIS system. This approach had a number of distinct advantages:

- Allowed full access to underlying features and data via ArcGIS mapping services
- Leveraged off TCC's existing Esri ELA licencing arrangements, no additional licencing costs
- Incorporates latest GIS and technologies
- Cost effective approach with greater financial flexibility
- Greater solution flexibility

All the time savings achieved by the delivered tools now free up technical staff to perform more advanced/specific analysis, instead of cleansing data or performing mundane and slow tasks manually.

## KEYWORDS

- **three waters**
- **GIS**
- **data management**
- **analysis**
- **data cleansing**

# 1 INTRODUCTION

Tauranga City Council City Waters division manages the three waters (water, wastewater and storm water) for the City. Whilst the existing Tauranga City Council GIS system offered excellent access to spatial data, there were requirements relating to operational processes, planning, data analysis, data cleansing, tracing, analytical reporting, scenario analysis and benchmarking that were not easily addressed. This resulted in significant demand on the GIS team due to processes such as tracing and analytical reporting.

Tauranga City Council identified five business requirements relating to operational processes, planning and analysis which were not adequately addressed using the existing manual and/or semi-automated special processes.

Accurate reporting relies on the accuracy of the data being entered into the system. As such, one of TCC's requirements was data verification using spatial tools to accurately identify errors with network connectivity and data attribution which were extremely difficult to achieve otherwise. The spatial tools also help ensure that any new data put into the system are accurate and correct.

Valve isolations play a critical role in operational management of emergency and planned shutdown, for example; pipe bursts which requires rapid identification of which valves to shut to isolate the network, number of impacted customers and if any of those customer are critical. With this information provided at the technicians fingertips on a map, appropriate actions can be taken and in the case of planned shutdowns, customers can be informed in advance.

The ability to define District Metered Areas and Pressure Zones which are discrete areas of the water network that are typically ring fenced by a combination of valves and flow meters and ring fenced by pressure control valves and pump stations respectively. By having these ring fences in a GIS, the council is able to manage their networks more efficiently. In the case of DMAs they can use the data to determine the amount of water supplied into each area and the amount of water consumed to determine the losses, which is the difference between the two. The DMAs can then be prioritised for leak detection activity.

Asset & Criticality ranking was deployed to determine how important a single asset is to the network as a whole. These spatial tools provide data valuable to the TCC Operations team such as understanding the impact of removing a single pipe from the reticulation network. Because the assessment is done via a GIS, spatially related information can be leveraged such as; how many customers are affected if the asset is isolated, does the asset cross any major infrastructure (roads, highways, and rail) and if it supports any critical customers. This information can then be used for prioritisation of renewals, operation and emergency planning.

Network planning/vulnerability scenarios allow TCC to easily create scenarios to test the vulnerability of the network and to assess the impact visually, something nigh-on unachievable with non-spatial methods. The information gleaned from this process can be used for planning and forward work activities.

Using ESRI's robust ArcGIS for Water Utilities solution as a base, Downer used their in-situ knowledge coupled with an Agile project methodology to deliver solutions that were "best-for-purpose" for the business as a whole, including; data maintenance teams, operational teams, decision makers and field crews.

# 2 METHODS

## 2.1 APPROACH

It was determined that the use of Out-of-the-Box tools to deliver the required functionality, where possible, minimising customisation, development effort and cost would be ideal to the council. The project took an Agile approach to development and delivery.

Using an Agile approach to system implementation reduced both the cost and time to deploy the system. At a high level, the framework for this implementation strategy was to understand and prioritise the business needs, deploy the components of the ArcGIS platform (ArcGIS for Desktop, ArcGIS for Server, and the enterprise

geodatabase), and then use an iterative approach in selecting and deploying applications to fulfil the prioritised needs.

An Agile approach to project management means that the council was informed and took part in all aspects of the deployment. Clearly identifying and monitoring goals and work allows the council to change requirements with the impacts for that change to be clearly seen. This approach also allowed for the requirements to be fleshed out as the solution is being developed with the close involvement of council during configuration and deployment (AltexSoft Inc. , 2016).

## 2.2 TECHNIQUES AND TOOLS

Application programming interfaces (APIs) and software development kits (SDKs) expose interfaces to ArcGIS capability and are used to construct the elements of subsequent tiers. Downer used these programing tools to extend ArcGIS and customise the OOTB tools for the council's needs.

The solutions tier is composed of configurations of the ArcGIS core technology provided by the tiers below it in Figure 1. ArcGIS for Water Utilities is a set of configurable solutions for water, wastewater, and storm water. These solutions provide focused applications supporting common water utility business needs and workflows (Esri Inc., 2014). The solutions tier consists of the content and capabilities of the platform that deliver their business value to the enterprise and are described in more detail in a later section.

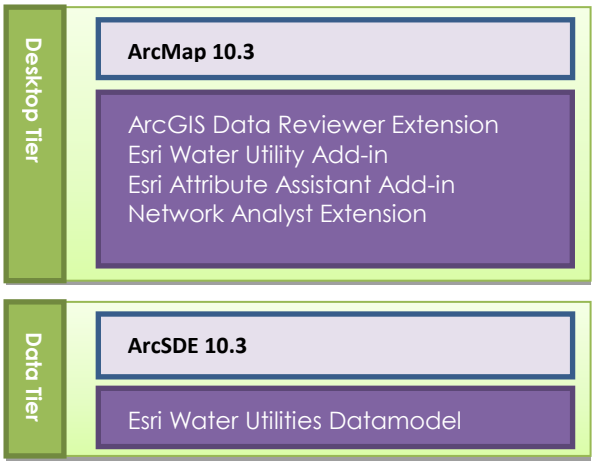


*Figure 1 Components used to enable to TCC Water Enablement solution*

The solution has been deployed as per the below, reusing existing hardware and licencing at the council;

- ArcGIS Data Reviewer Extension
- Esri Water Utility Solutions Add-Ins
- Esri Attribute Assistant Add-In
- Network Analyst Extension
- Esri Water Utilities Datamodel

## 2.3 ESRI WATER UTILITIES DATAMODEL

The Esri Water Utilities Datamodel was merged with the council's own data standards. One of the biggest benefits of a water utility adopting the Esri model is that it makes deploying the ArcGIS for Water Utilities maps and apps easier, faster and cheaper (Esri Inc., 2014). The Water Utilities Information Model incorporates many best practices for water utility GIS. This merger was performed by a simple comparison exercise and then the required changes made to the database schema.

### 2.3.1 GEOMETRIC NETWORKS

A geometric network is a set of connected edges and junctions, along with connectivity rules, that are used to represent and model the behaviour of a common network infrastructure in the real world (Esri Inc., 2016). Geodatabase feature classes were used as the data sources to define the geometric network, lines being edges along the network with point features creating the junctions.

The datamodel used three geometric networks; Water Supply, Waste Water and Storm Water.

## 2.4 ARCGIS WATER UTILITY NETWORK EDITING ADD-IN

This add-in provides the Water Utility Editing toolbar, Water Utility Network Reporting toolbar and a set of construction tools.

Included in the Water Utility Network Editing solution is the Water Utility Network Reporting toolbar. This toolbar is a series of reporting tools to improve a map technician's experience when working with infrastructure data. Included in the toolbar are tools to run isolation traces, calculate downstream and upstream flow accumulation for a main, and more.

Included in the Water Utility Network Editing solution is the Water Utility Construction tools, which improve the editing experience when adding new infrastructure data. These tools include four point construction tools and one line construction tool.

The Abandon Tools move features between an in-service dataset and an abandoned dataset. The provided Abandon dataset includes one layer for points and one layer for polylines. Each of these layers have some key characteristics of the in-service features, as well as a field to record the source of the features.

## 2.5 ARCGIS DATA REVIEWER EXTENSION

Data Reviewer for Water Utilities provides preconfigured ArcGIS Data Reviewer for Desktop batch jobs (.rbj) that can be used to validate, maintain, and improve the integrity of water, sewer, and storm water utility data. These batch jobs have been updated for the TCC datamodel.

## 2.6 ARCGIS ATTRIBUTE ASSISTANT ADD-IN

The Attribute Assistant Add-in uses a series of predefined methods to automatically populate attributes when updating or adding new features to the geodatabase. For example, one method populates a valve's size based on the water main feature it intersects. Other methods help you maintain the integrity of your infrastructure data by populating a unique identifier, last editor, and last update date on each feature.

The Water Utility Network Tools and Attribute Assistant Add-ins have been configured to perform common tasks with data stored in the TCC's existing model. The behaviour of these tools can be modified to work if the underlying model changes or to perform additional functions by modifying the configuration file shared by these Add-ins.

## 2.7 TOOLS AND SCRIPTS

The solution uses a number of OOTB and custom models and scripts. These are all encompassed within one toolbox grouped into categories. The image below shows the toolbox and how it is structured. Models used the ArcGIS for Desktop's model builder tools, scripts were created in Python leveraging the ArcGIS APIs. The table below outlines the main components of these tools.

*Table 1 Scripts and models that participate in the working of the solution.*

| | |
|---|---|
| Abandon Assets | Assets are selected and pushed through to the abandoned layers updating their abandoned date attribute to the current date and setting the status to abandoned. |
| DMA Planner | Generates a District Metered Areas based on selected mains by performing a trace from the Water Supply Main with the network |

| | |
|---|---|
| | configured with valves set to their base states and bulk meters disabled. |
| Pressure Zone Planner | Generate Planning Pressure Zones based on selected mains by performing a trace from a Water Supply Main with the network configured with valves set to their base states and pumps and reservoirs pumps disabled. |
| Pipe Criticality | Determines the criticality of a Water Supply Mains. The model considers number of meters and critical customers associated with the pipe as well as if the pipe intersects a major road or railroad. A criticality value is given from Very Low to Extreme. |

# 3 OUTCOME AND RESULTS

There is a significant positive difference between the before and after states.

## 3.1 DATA VERIFICATION

Data verification no longer relies on a treasure hunt or unexpected discovery. The council now have a tool that identifies the issues for them. The Data Reviewer for Water Utilities solution with the optimised ArcGIS Data Reviewer for Desktop batch jobs (.rbj) file are used to validate, maintain, and improve the integrity of water, sewer, and storm water utility data in an automated way, saving the council many manual man-hours. The reports that are created based on the automated analysis allow the council to view the check results based on different groupings or the total number of records in the table. You can also generate a report just for sampling results. This gives an accurate representation of the health of the dataset and can be used to plan accordingly to correct the discrepancies. These can be either quick or detailed. Figure 2 below is the example of the quick statistics that can be generated.

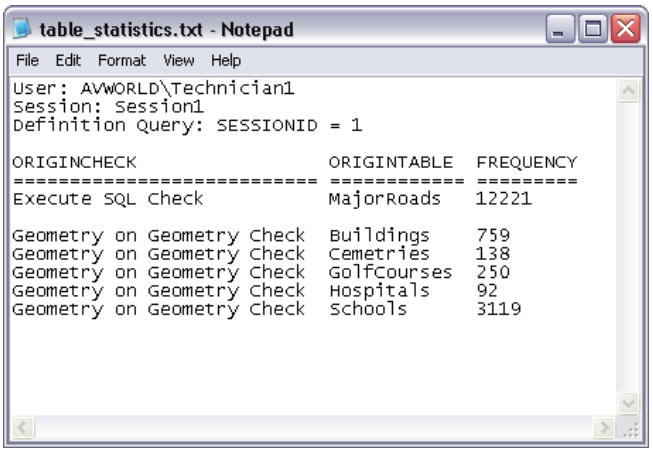


*Figure 2 Quick data health statistics generated from the Data Reviewer tool.*

With the use of the Attribute Assistant Addin and feature templates in conjunction with the Water Utility Network Tool Addin the accurate creation of water assets is greatly simplified by prepopulating many common features based on the design items being input, saving time and reducing errors during design.

The use of well-defined feature templates can significantly improve the task of creating features for the user. The Water Utility Network Tools also have some custom construction tools that enable features to be created automatically on the creation of another feature. For Example, when a water service connection is created, a connection line can also be created automatically connecting the connection to the nearest main. Figure 3 is an example of the Feature Templates Editing Window.

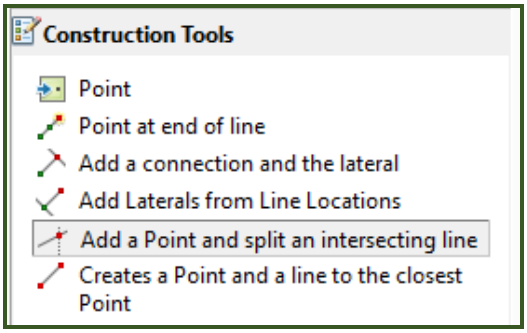


*Figure 3 Example feature template configuration that showcases the ability to automate and optimise the design process.*

## 3.2 ADVANCED NETWORK ANALYSIS

Valve isolations are completed efficiently and with the added benefit of immediate identification of critical customers. Prior to the delivery, this is something that was performed visually at best, by trial and error at worst. Valves required to isolate sections of mains are quickly identified by indicating the pipe(s) affected as shown in Figure 4.

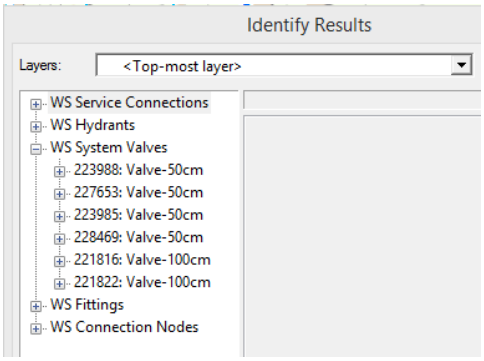


*Figure 4 List of valves required to isolate a section of main by indicating a break point geographically.*

In order to clearly identify critical customers when working with the water data, additions have been included to the map and database to showcase them. Figure 5 shows how this is represented in the solution.

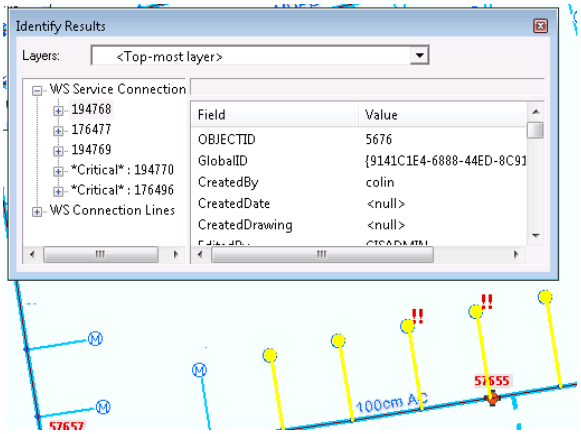


*Figure 5 If meter is assigned to a critical customer, It will display as *Critical* preceding its asset number.*

With the DMA/PZ tool, on demand updating of discrete zones is capable (Figure 6) which significantly improves TCC's ability to analyse the status of their water networks. A process that took months to perform manually can now be completed within a day.

*Figure 6 Result of running the DMA planning tools on a single section of the network.*

The creation of Water Pressure Zones (Figure 7) is very similar to the DMA creation. The only difference is the configuration of the network before performing the trace. As with DMA creation, being able to automate these process saves orders of magnitude of time.

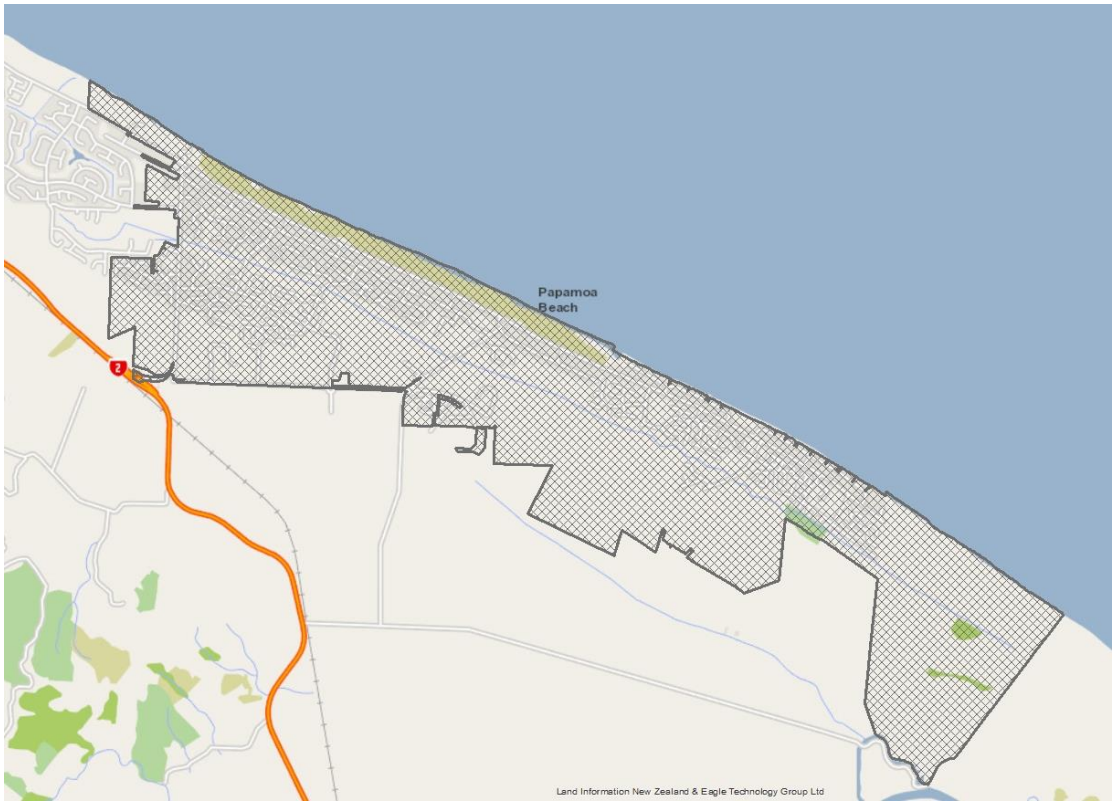


*Figure 7 A Planning Pressure Zone polygon which is aligned to parcel boundaries.*

TCC are also now able to accurately conduct criticality ranking of assets which was not previously feasible. This solution takes into account critical users such as hospitals, schools and dialysis patients. Because criticality can be identified quickly, scenarios can be created (such as including/removing a section of main) to identify how different scenarios affect the network more accurately and in a fraction of the time it used to take. This helps the council plan better networks going forward.

The criticality of a water pipe is determined by a number of factors. Criticality is important to identify assets within the network that may have a higher criticality score so that network infrastructure may be needed to reduce the risk assets may have. The model uses major roads, railroads, and critical customer meters to calculate a criticality score for water mains. This criticality score also takes into account the number of valves and

customers that would be affected if the main was isolated to make the resulting score as representative of real life as possible.

Reporting tools provide the capability to select all of or portions of the network and run an analysis to identify the infrastructure and customers they support. These tools can be run in bulk to have the information quickly at hand, or as needed on a version of the network that has been modified for a particular scenario.


*Figure 8 Visual representation of network critically.*

# 4 CONCLUSIONS

Using these tools, TCC now have a viable solution to their requirements which include data integrity, valve isolation, emergency shutdown, critical customer identification as well as DMA and pressure zone creation and reporting. All these are delivered using the existing TCC license agreement with Esri and using the already existing ArcGIS platform at the council, saving them money and the effort of supporting an additional software platform..

This project took the council's existing GIS, merged it with Esri best practice and Downer's decades of water maintenance experience to transform it from an asset viewer into a formidable spatial analysis and planning tool. Capabilities to immediately identify which valves to close to isolate the network, perform on the fly analysis on zoned areas of the network and interactively create and test vulnerability scenarios have quickly made the solution an indispensable tool to the council.

This solution helped TCC to leverage geographic information and the ArcGIS Platform to improve water operations and enhance customer services. It provides access to dynamic, authoritative content to create, collaborate, catalogue, and share maps, data, and applications with members of the organisation and the general public. The solution was conceived and deployed as per Esri best practice as much as possible, whilst incorporating the extensive domain expertise from maintenance experts within the Downer Water team who are intimately familiar with TCC's Three Waters infrastructure and operating procedures. This allows for the adoption of any future tools from the extensive Esri suite a matter of "plug and play".

On top of the delivery of the goals set out by the council for the project, additional benefits were achieved through the "out of the box wherever possible" approach, such as;

- full access to underlying features and data via ArcGIS mapping services
- Leveraged off TCC's existing Esri ELA licencing arrangements, no additional licencing costs
- Incorporating the latest GIS and service orientated architecture technologies
- Cost effective approach with greater financial flexibility

Using an Agile approach allowed the council to have input throughout the development and delivery of the solution. The result was a heavily reduced cost and effort for an in-depth requirements gathering phase before the onset of the project. In turn, it also lends to an ongoing release schedule. This means that the project has the capacity to evolve indefinitely by adding new functionality and upgrades on an ad-hoc basis throughout the future, either by internal staff at the council or a hired contractor. Not only were the water teams able to use and receive benefit from the tools early in the project cycle, they were inherently and continually testing the solution so that bugs could be identified and ironed out. The modular nature of the ArcGIS for Water tools made the adoption of an Agile approach easy for both Downer and TCC.

The solution described here and implemented at TCC has had significant benefit to the daily working of the water asset team, making them to be much more efficient, freeing up time to focus more on performing high-level tasks, and to help the rest to the council be more informed to make better decisions. The overall benefits are numerous, with respect to time, resources and additional flow on effect to projects reliant on these functions.

# 5 GLOSSARY

| | |
|---|---|
| Agile | Project management approach that breaks down tasks into discreet phases of work, allowing for multiple releases |
| API | Set of functions and procedures available to a developer to extend a specific software product |
| ArcGIS | GIS product suite developed by Esri Inc. |
| Batch Job | A group of common tasks that can be put together and run as one. |
| Customisation | The usage of available settings and configurations to provide a custom experience to the end user |
| District Metered Area | A discrete area of the water network identified by the configuration of valves on its boundaries |
| ELA | Enterprise License Agreement |
| Esri | Environmental Systems Research Institute |
| Geodatabase | Database schema that is used to house spatial and tabular data together |
| Geometric Network | A geometric network is a set of connected edges and junctions, along with connectivity rules, that are used to represent and model the behaviour of a common network infrastructure in the real world. |
| GIS | Geographic Information System |
| Out-of-the-Box | Ready to use tools without the need for development or heavy customisations |
| Pressure Zone | A discrete area of the water network identified by value configuration and pressure requirements |
| SDK | A set of programs that can be used to develop software |
| TCC | Tauranga City Council |
| Tracing | Identifying the related asses upstream or downstream from a point on the network |
| Valve isolation | Selecting a point on the network and identifying which valves would need to be shut to isolate it |

# 6 ACKNOWLEDGEMENTS

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