A Data-Focused Approach to a Water Utility's In-house Survey Program

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Key words: Utilities; Reality Capture; Surveying; Assets; Field-to-Finish

SUMMARY

Water utilities face ongoing fiscal challenges due to ageing infrastructure, rising costs, and the need to respond to climate change. TasWater provides water and wastewater services across the state of Tasmania, Australia. The TasWater Survey Program was designed with consideration for data democratisation and discoverability concepts and uses a data-focused paradigm to increase financial sustainability and efficiency.

The TasWater surveying system combines reality capture, conventional surveying, field-to-finish workflows, and 3D printed tools and accessories to efficiently survey complicated water and wastewater assets. Integration of the reality capture and conventional surveying data, combined with a field-to-finish system is used to generate CAD deliverables, including 3D modelled underground services. The CAD deliverables contain data structures and attributes to enable translation into GIS native formats.

A library of reality capture survey data is made available company wide, allowing users to virtually visit sites across Tasmania and inspect assets, take measurements, and collaborate on projects. This library of accessible data saves on travel costs, as well as reducing requests of the Survey Program. Efficiency is increased further by operating with a data-focused paradigm. Requested survey projects are still undertaken, but surveyors also identify other assets with inadequate spatial data in the vicinity and survey those as well, reducing future travel costs for both the surveyors and all other users of that data.

This approach has been very effective, with many examples identified where the opportunistic surveying of assets has removed the need for site visits, improved project scoping, or enabled projects to move to design more rapidly by using the existing survey data. The development of a library of reality capture data, currently containing over 550 sites, also places TasWater in a good position to take advantage of future technology, such as the use of LiDAR in mobile devices, as such data can be georeferenced against the existing reality capture data.

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1. INTRODUCTION

Utilities and other asset owners operate in a fiscally challenging environment due to ageing infrastructure, rising costs, and the need to respond to climate change (Means III et al. 2005, Hughes et al. 2010, GHD 2015, Dickson 2010, Diaz et al. 2014, Bloetscher et al. 2010). Therefore, it is an imperative for utilities to seek out methods to improve efficiency and financial sustainability. This paper describes an operating model used by the survey program at TasWater. TasWater is a local council-owned entity providing water and wastewater services across the state of Tasmania, Australia, and has a large, geographically diverse asset base. The TasWater Survey Program is designed to leverage reality capture techniques (e.g., laser scanning, photogrammetry) integrated with conventional survey methods (e.g., GNSS, total stations) to efficiently provide future proof, multipurpose, spatial data products to a wide variety of users, e.g., Gawronek et al. (2024), Fascia et al. (2024). An additional concept used to increase efficiency, and a key point of differentiation relative to surveying industry norms, is that the TasWater Survey Program operates within a data-focused paradigm, in contrast to the more common project-focused paradigm. This approach has yielded many benefits including increased understanding and usage of reality capture data products across the company, a high level of efficiency, and decreased logistics costs.

2. BACKGROUND

This paper will discuss common surveying requirements encountered at TasWater such as detail, boundary, topographic, and engineering surveying, site plans, surveying for construction of assets, as-constructed surveys, condition assessments, and data acquisition and validation for the geographical information systems (GIS). The specialist monitoring of dams is not within the Survey Program's purview and is not considered within this paper.

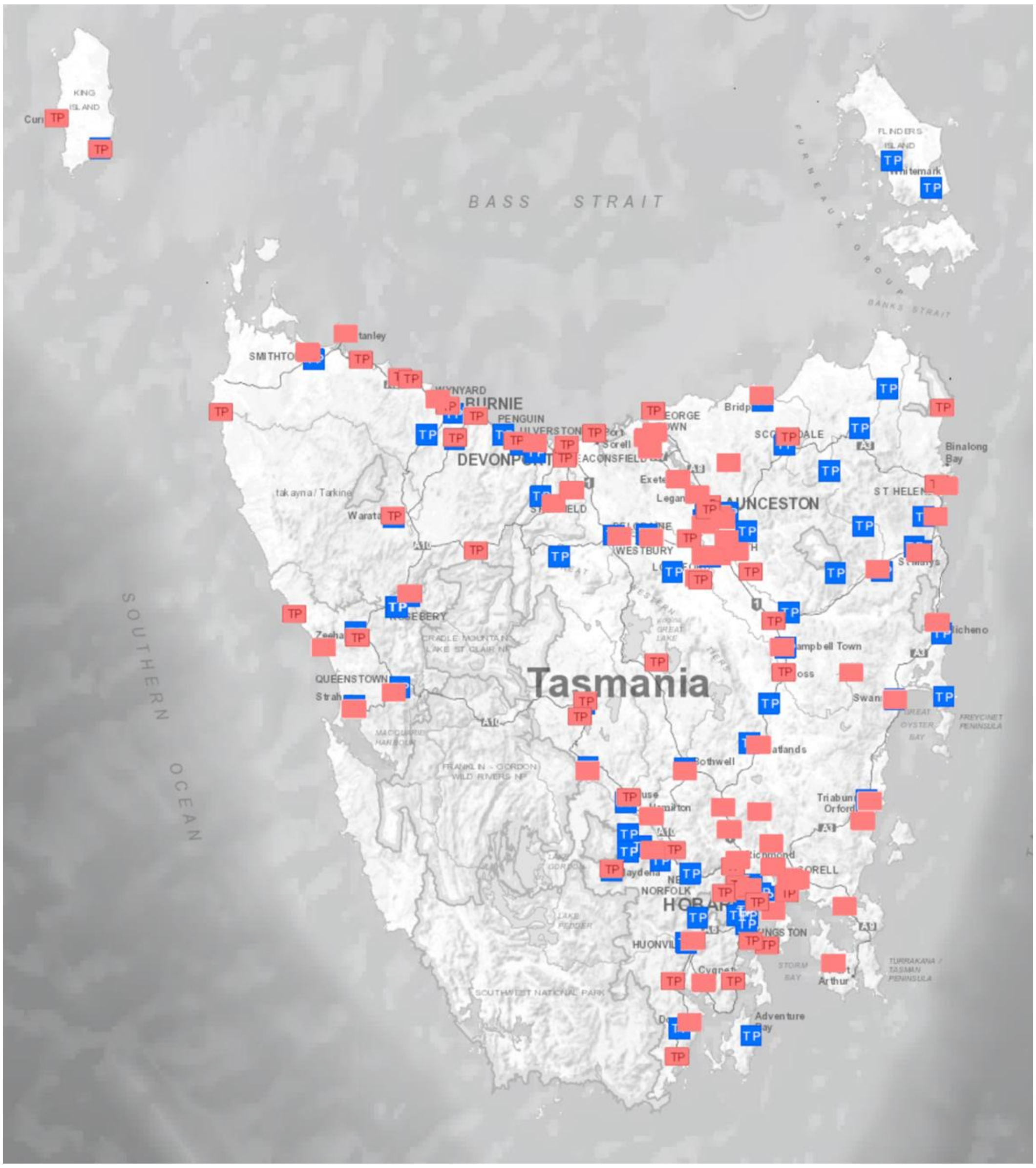

Figure 1. Map of Tasmania showing TasWater's sewage (red) and water (blue) treatment sites.

TasWater has a geographically diverse infrastructure base covering the state of Tasmania (Figure 1), serving ~471,700 customers via ~6600 km of water mains and ~4960 km of sewer mains. Assets include 59 water treatment sites, 110 sewage treatment sites, ~950 pump stations, ~290 reservoirs, and ~350 dams (TasWater 2024a). TasWater formed in July 2013 from three regional water utilities, Cradle Mountain Water, Southern Water, Ben Lomond Water, and their shared services company, Onstream. These water corporations were established in 2008 from an amalgamation of 29 councils, 3 bulk water corporations and some state government agencies (TasWater 2024b). This heritage has resulted in a wide variety of asset designs and data quality.

Surveying at TasWater has similarly evolved over time. Between 2013 and 2021 most surveying for construction or renewal projects at TasWater was achieved through outsourcing. At the same time, several programs were undertaken to improve data quality of network assets in the GIS such as the Asset Data Quality Improvement Program (ADQIP), which ran from 2015 to 2018 and Asset Condition Assessment Program (ACAP) from 2019 to 2021. Typical data products were spatial data and attributes of maintenance holes, power poles, and similar assets, usually on a town/suburb scale, delivered predominantly via outsourcing.

Several key learnings were identified from these programs. A lack of in-house surveying systems, standards, and knowledge hampered collaboration with contractors and stakeholders, particularly on projects that required working alongside TasWater personnel. Deliverables often had insufficient data or metadata which hindered good spatial data management practices such as the development of data catalogues and archives, as well as opportunities for future data reuse. Insufficient internal capability limited the ability of the program team to perform adequate quality assurance on deliverables. While the programs delivered bulk data for network assets, more challenging sites such as pump stations, treatment sites, underground services, and similarly difficult-to-measure assets were rarely surveyed.

In 2020, following the completion of the ADQIP/ACAP programs, changes in funding models and staff movements, the roles were repurposed, and a new surveying operating model was developed, establishing the current Survey Program. The Survey Program consists of two surveyor roles in the Data and Analytics team in the Digital and Technology Department, reflecting the rapid technological change and data products of the surveying industry. Several factors combined to make this the ideal time for an overhaul of the Survey Program. The existing equipment consisted of several older GNSS units all of which were due for replacement, particularly with the impending sunset of the 3G mobile network. There were no surveying software packages, systems or standards. Essentially the survey program was able to begin with a clean slate, without any need to maintain compatibility with legacy equipment or systems. The Data and Analytics team had also spent considerable effort advocating for concepts like data discovery, data democratisation, drones and virtual tours to the business. The previous ADQIP and ACAP programs had established a yearly budget for outsourcing which simplified the development of the business cases for acquiring the instruments necessary to build in-house surveying capability. Lastly, developments in laser scanning technology meant that there were small and economical laser scanners available, such as the Leica BLK series, well suited to the types of surveying commonly encountered at TasWater.

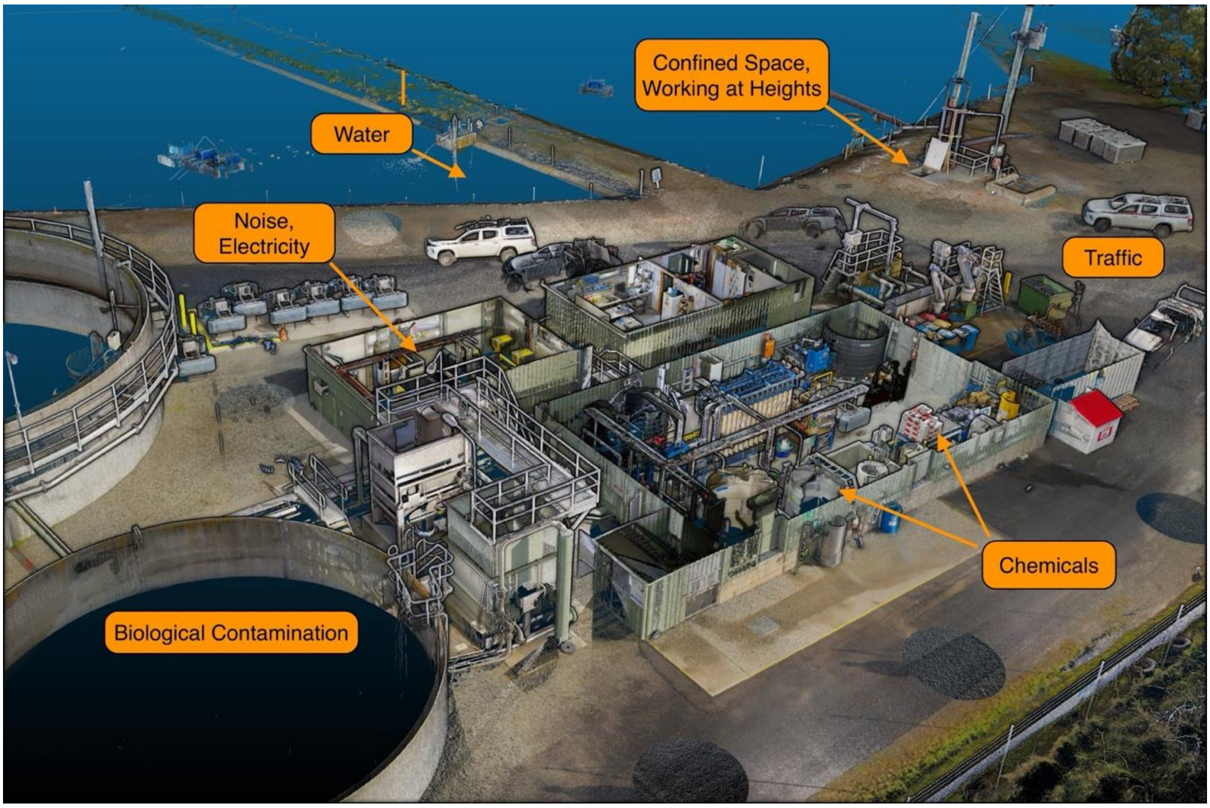

Figure 2. Example laser scan, showing some of the hazards at a sewage treatment plant (roofs removed from laser scan).

Surveying of water and wastewater infrastructure presents numerous challenges. Many assets have confined space and heights risks associated with them. Depending on location there may also be hazards such as remote areas, dangerous atmospheres, traffic, water, chemicals, electricity, wildlife, and biological contamination (Figure 2). Survey complexity is also highly variable, ranging from simple sites like wastewater lagoons through to very complex sites such as water treatment sites, many of which have undergone multiple, and often poorly documented, upgrades throughout their life. TasWater also faces significant logistical costs, with thousands of assets spread over an area of around 55,000 km^2.

TasWater has challenging spatial data requirements. While both GIS and CAD deliverables can consist of coded linework and points, there are often fundamental differences between the two types of data (Sadoun and Fukara 2012, Rawashdeh 2014, Boria et al. 2020). Mainstream surveying systems use coded points, sometimes with attributes. Codes are used to categorise features, and can define layers, breaklines, symbols, and other characteristics in CAD and most surveying software packages. Linework is typically defined by the point code and adopts the attributes of the point used to begin the line. However, there are limited capabilities for use of attributes in most CAD software and attributes are rarely associated with linework and features. Due to this limitation, attributes collected in the field are typically converted to annotations or used to define symbology (e.g., an attribute may be used to define the size of a tree symbol). Information such as slopes, grades, volumes, etc. are derived from the geometry of the points and linework.

In contrast, attributes are foundational to GIS, can be associated with any feature type, and often contain important spatial information. TasWater uses attributes for key spatial information in the GIS. For example, while TasWater's GIS uses coordinates to define the horizontal coordinates of surveyed points and survey codes generally align to the GIS feature classes, heights for pipe surface and invert levels, valve heights, and other features are defined by attributes. In particular, sewer mains use upstream and downstream invert and surface levels (USIL, DSIL, USSL & DSSL) to define heights at each end of the pipe, with the upstream and downstream end of the pipe defined by the direction of the linework.

This represents a very different data structure to most surveying systems and breaks a common assumption – that each point in a survey has a single coordinate. In TasWater's GIS data, a single point – the end of a pipe – may have two coordinates with shared, identical, horizontal coordinates, but two heights (USIL and USSL) defined in the attributes. The preservation of data integrity, including attributes, is therefore an important constraint on the development of TasWater's surveying systems. It is necessary that survey deliverables include suitable data structures to allow downstream translation from CAD to GIS compatible data with full preservation of attributes.

3. METHODS

Considering the challenges, data requirements and TasWater's long term strategy, the following principles were identified.

- The Survey Program had to be able to safely survey sites and assets ranging from simple to very complicated.
- Survey deliverables had to be suitable for many users, compatible with both CAD and GIS as well as any necessary standards, and future proof.
- The Survey Program had to achieve high levels of efficiency.

These principles were used to guide development of the Survey Program including instrument selection, field-to-finish workflows, and the deployment of tools and software to make survey and laser scan data discoverable, accessible, and usable by end users. A roadmap document (TasWater 2023) was also developed that explains how these principles guide the Survey Program. The roadmap describes challenges, desired outcomes, and the benefits that flow from these principles when applied within TasWater and with consideration for concepts drawn from the larger data industry such as data democratisation and discoverability.

3.1. Data-Focused Paradigm

Most surveying operates within a project-focused paradigm. A project is initiated, survey specifications established and surveyor selected, survey is performed, deliverables produced, and the project is closed out. This is a common process across the industry. Each project is usually an individual piece of work, and it is not common to be able to combine projects to save on travel, administration, and effort. In contrast, the TasWater Survey Program operates using a data-focused paradigm. This means that incoming survey requests are still treated as projects and are used to prioritise work. However, rather than trying to combine projects to achieve efficiency, instead each project is assessed against all TasWater assets in the vicinity of the project to identify any nearby assets that also warrant surveying. This means that many assets will potentially be surveyed before planning for an asset improvement has commenced.

3.2. Equipment Selection

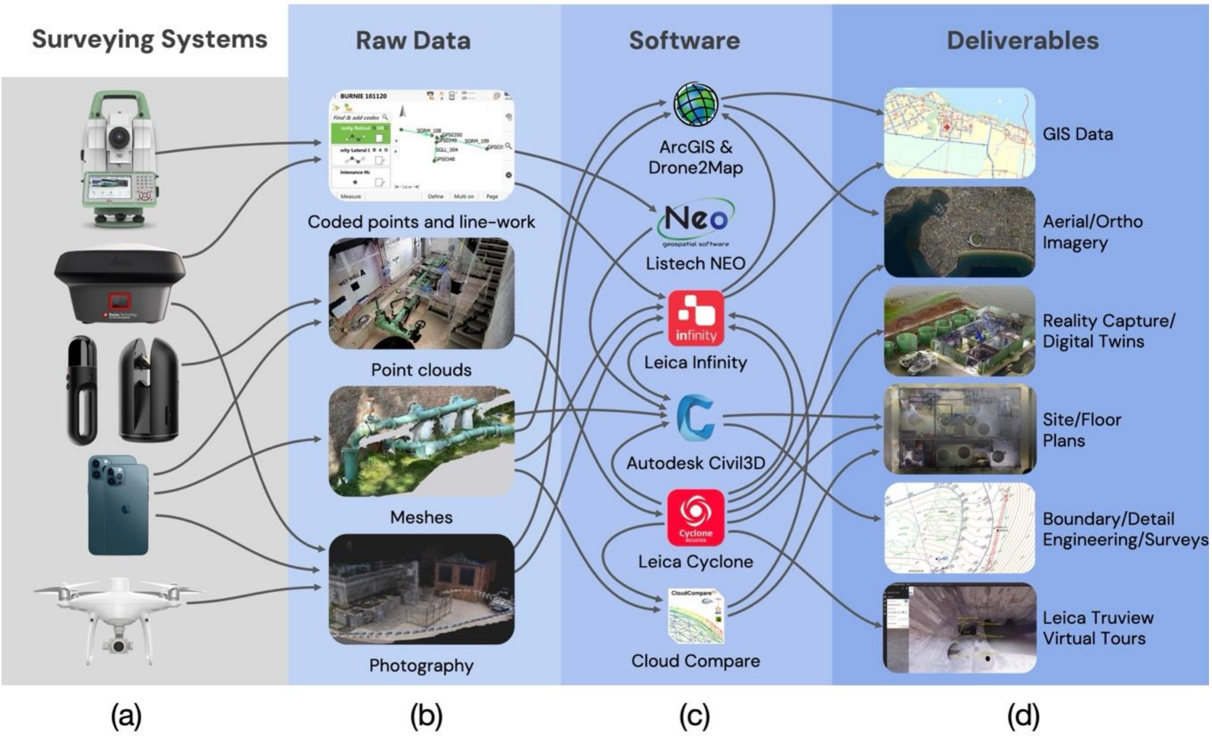

Figure 3. TasWater's surveying system showing (a) instruments, (b) data types, (c) software suite, and (d) common deliverables and typical flows of data through the system.

Each surveyor is equipped with conventional survey instruments consisting of a high-end GNSS unit and a mid-range robotic total station, as well as reality capture instruments, consisting of a laser scanner and a photography drone (Fig.3). The Leica GS18i GNSS system with an integrated camera for ad-hoc photogrammetry was chosen due to the large volume of asset and GIS work anticipated. The camera feature was selected to enable capture of assets under cover such as trees and verandahs. A total station was determined to be necessary for establishing control, for conditions unsuitable for GNSS, and for precision work, however, it was not anticipated to be heavily used and therefore the mid-range Leica TS13 was chosen. A laser scanner was an obvious requirement, enabling the rapid and safe survey of complex sites and virtual tours. Laser scanning also minimises the need for multiple visits to a site as field checks are rarely required, thereby mitigating some of the logistical challenges associated with surveying at TasWater. Considering the intended usage included inverted scanning of maintenance holes, pump stations, and similar assets the Leica BLK360 scanner was selected. It is small enough to fit through most pump station safety grates and inspection openings, light enough to be used inverted with just a photography tripod, and relatively economical.

The GNSS, laser scanner and total station fulfil the bulk of surveying requirements at TasWater, but some sites, such as lagoons, are not well suited to these instruments. For these large sites with sparse features each surveyor has a DJI Phantom RTK drone, providing semi-autonomous photogrammetric data capabilities. Alongside these primary instruments, each surveyor also has a variety of tools and accessories including a Leica Disto S910, traverse kit, magnetic locator, hydraulic lid lifter, and a large invertible tripod. The Survey Program also has a Leica BLK2Go SLAM (simultaneous location and mapping) LiDAR unit commonly used for tasks such as rapid surveys of offices, depots and tanks, and for environments too tight to use tripod mounted scanners.

Some of the key factors that drove this selection of instruments were size, integration, and batteries. With the exception of the TS13 and DJI Phantom, the instruments are stored in very compact cases. Integration between the instruments means that all scanners can be controlled by a single iPad, and both the TS13 and GS18i share a CS20 controller. Likewise, shared batteries mean that only one or two chargers are required on field trips. This means that it is feasible to take the entire instrument suite on any field trip so surveyors do not have to compromise the work or make a second trip.

3.3. Software and Systems

The Survey Program has many different clients within the business, with widely varying data requirements. It was identified early in the development of the Survey Program that the surveyors would need to be able to generate both CAD and GIS compatible deliverables with efficiency achieved through automation of workflows. Manual workflows, based on surveyor's field notes, and uncoded or unstructured surveying data do not scale efficiently, particularly as survey complexity increases (Kamel et al. 2020). Instead, a field-to-finish surveying system, capable of rapidly recording all commonly surveyed features and their attributes in a structured fashion was required. By collecting structured data, with predefined codes and attributes, field-to-finish systems facilitate the development of automated workflows with prescribed symbols, linetypes, and breaklines in CAD and GIS feature classes, layers, and attributes. Field-to-finish systems also typically produce higher quality data as they tend to remove subjectivity from field data collection, and enable real time validation of codes and attributes (Kamel et al. 2020, Paiva and Raymer 1990).

The TasWater Survey Program's field-to-finish system enables the transfer of survey data from field acquisition through to a CAD deliverable, compatible with TasWater's Asset Spatial Data Standard (TasWater 2022), which defines the specifications for as-constructed surveys of gifted assets. The CAD deliverable includes all attribute information recorded in Autocad compatible blocks to allow for translation and transfer into the GIS. The field-to-finish system is used by the Survey Program but is also made available to external surveyors to assist them to meet the spatial data specifications of TasWater.

The field-to-finish system begins with a code table similar to those used by many of Australia's state transport authorities, including Tasmania's Department of State Growth. It is anticipated that, in the future, tools to translate CAD deliverables between the TasWater and State Growth standards will be developed. The TasWater code table has been extended to include additional codes required to describe features unique to water utilities, as well as attributes to fulfil the requirements of TasWater's GIS system and associated Asset Spatial Data Standard and includes quality levels from the Australian Standard of Subsurface Utility Information (AS5488).

Initial processing of the data is done in Leica Infinity, where the conventional surveying data is augmented with virtually surveyed features from reality capture data if required, then exported to an ASCII text file. This file is then processed through Microsoft Excel to generate a points import file and a script that inserts blocks with attributes for Civil3D or similar CAD packages. The use of ASCII text files and Microsoft Excel in preference to more advanced formats such as LandXML is an intentional effort to maintain compatibility between the Survey Program's systems and the larger surveying industry.

A single workflow, from field to CAD to GIS, instead of two parallel workflows, was developed for two reasons. Firstly, it meant that external surveyors who could deliver CAD files but may not have the ability to deliver suitable GIS files would be able to supply data to TasWater. This is a requirement for as-constructed surveys of gifted assets as well as some other outsourced work. Secondly, it allowed for the development of a single processing tool written in Microsoft Excel that sits upstream of the CAD deliverable. This tool processes the survey data to calculate many of the GIS attributes, place underground services at the right depths, and automatically generate CAD blocks with attributes. Attributed blocks for points, such as valves, hydrants, trees, etc, are inserted at the point location, whereas blocks that are linked to linework are inserted at the midpoint of the line. This CAD data structure is easily interpreted by Extract Transformation and Load (ETL) tools such as FME (Feature Manipulation Engine) by Safe Software, to generate GIS compatible deliverables.

Excel was chosen because it is used at most survey companies. By using a single workflow instead of two separate pipelines for GIS and CAD data, the processed data is identical in both CAD and GIS deliverables. This is particularly relevant when it comes to underground services. Spatial information for underground services is difficult to acquire and valuable for design and safety. As 3D GIS capabilities are developed, the best source of 3D spatial data to update the GIS will likely be new and previously supplied CAD deliverables. New technologies such as the visualisation of underground services using augmented reality also require accurate 3D spatial data (Stylianidis et al. 2020).

The other half of the surveying systems are the reality capture workflows, mostly using Leica BLK laser scanners. This data is used for a wide range of tasks including virtual surveying, design, spatial analysis, orthoimagery, and virtual site visits. Laser scan data is processed through Leica Cyclone Register to generate Recap and structured E57 point cloud files for design, analysis, and further processing, and Leica TruView files for virtual site visits. The TruView files are then uploaded to TruView Enterprise, providing company wide access to laser scan data via a web browser. Drone data is processed through Drone2Map to generate point clouds, as well as orthoimagery for the GIS. Drone derived point clouds and meshes are then made available as scenes in ArcGIS Portal. Additional point cloud processing, analysis, and creation of derived products are typically done using the E57 files in CloudCompare while virtual surveying is usually undertaken in Infinity.

3.4. Data Discoverability and Self Service

The emphasis on data democratisation and discoverability in the data industry (Maynard-Atem 2019, Awasthi and George 2020, Wu et al. 2019) has also been applied within the Survey Program as a way to achieve high levels of efficiency. The Survey Program’s systems include tools and workflows that generate a library of consistent survey data that users can easily access. Almost all Survey Program deliverables are on state datum coordinates so that spatial information can be compared freely across different projects as well as for compatibility with the GIS. Almost all reality capture data is made available company-wide via TruView. Metadata for reality capture projects is stored in a feature layer of the GIS, with a polygon denoting the surveyed area and relevant attributes. Likewise, an FME automation has been developed to automatically publish survey control to a GIS feature layer. Using the GIS to record these details means that all the reality capture data and survey control data are discoverable by users across TasWater. It also means that dashboards showing sites surveyed, which instruments are used most heavily, which coordinate systems are in use, etc. are easy to create. Conventional survey plans are stored in Autodesk Vault, catalogued under the water or sewer system. The project database, Survey Program website, and conventional survey files are all developed or stored in Microsoft Sharepoint. Training materials have been developed and made accessible through the Survey Program website. These tools enable users to find and identify relevant survey data without the need to consult with the Survey Program, freeing up valuable time for both the users and the surveyors.

3.5. Data Products and Deliverables

The TasWater survey program generates a variety of deliverables (Figure 3). Most deliverables are a subset, combination, or derivation of two main data products. The reality capture data product consists of structured E57, Recap and TruView point cloud files and associated metadata. Derived products such as 3D models, triangulated meshes, orthoimagery, or virtual surveys are usually done on demand and only when necessary. Point clouds are very rapid to generate and update, whereas derived products can often take significant time. Given the small footprint of the Survey Program, the intent has been to improve knowledge, understanding, and tools across the business so that users consider point clouds as a desirable dataset and are happy to use them directly via software like Autodesk Recap and Leica TruView. The conventional survey data product consists of a 3D CAD plan, with underground services and surface features with attributes, a triangulation surface, orthoimagery from the laser scans or drone, and associated metadata.

3.6. 3D printing of Tools and Accessories

The need to survey a range of sites efficiently has resulted in the development of numerous tools and accessories. To rapidly deploy a laser scanner for surveying maintenance holes, ground level spherical targets were developed. Traditionally, linking laser scanning data to site control relies on flat targets, which are usually placed on near-vertical surfaces so they are normal to the laser scanner, or spherical targets, which are usually mounted with a 5/8” thread or magnet to tripods or brackets. When scanning maintenance holes, there is no guarantee that there will be nearby surfaces for mounting of flat targets, and setting up spheres on multiple tripods is inefficient.

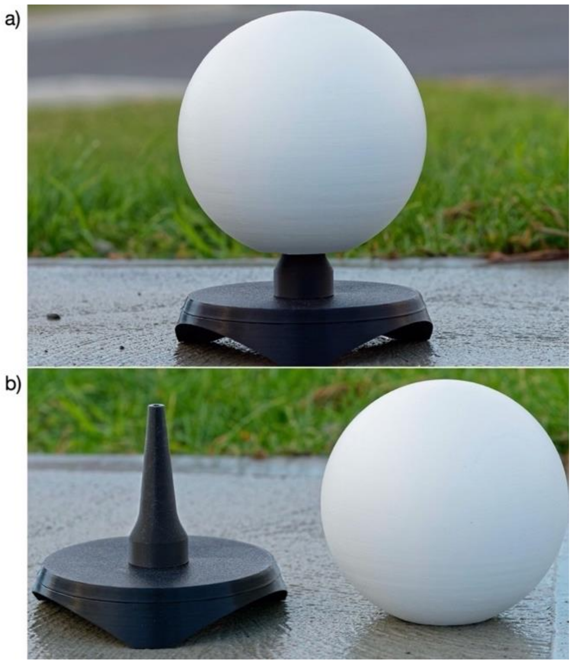

Figure 4. A 3D printed target sphere, (a) assembled, and (b) separated showing the spike for establishing the control point.

TasWater's laser scan targets are 150mm spheres, 3D printed using nylon infused with carbon fibre and painted in matte white (Figure 4). Each sphere has a baseplate with a spike. The tip of the spike is located with a conventional instrument and then the sphere is placed over the spike. The centre of each sphere corresponds with the tip of the spike, thereby removing any requirements to record target offsets or level the base plate. To use, the surveyor drops 3-4 baseplates around the maintenance hole, locates each baseplate with GNSS or total station, places the spheres on top of each baseplate and starts scanning.

For conventional surveying of maintenance holes, a brace was developed that mounts the Leica Disto S910 in the centre of a maintenance hole opening. This allows a surveyor to gather all dimensions and depths of the maintenance hole and associated pipes from a single position and accounts for slope distance and the issue of sloping maintenance hole rims. The brace was fabricated using 3D printed carbon fibre infused nylon and an aluminium extrusion.

3D printing has also been used to design custom cases for equipment, tool mounts for vehicles, and other accessories, such as a 3D printed iPad stand. The stand holds an iPad and a large power-bank to enable all-day scanning and minimises contamination of the iPad when working on sites with potential biological contamination such as sewage treatment sites and pump stations. 3D printing is often significantly less expensive than purchasing off the shelf accessories.

3.7. Other Responsibilities

Alongside the survey work, the Survey Program provides advice about surveying and spatial data across the business. Surveyors collaborate with other teams on development of project specifications and have developed tools to guide users as to whether work should be outsourced or done by the Survey Program. With a small footprint, it is necessary for the Survey Program to concentrate on high value work that is difficult to outsource. The Survey Program also contributes to governance initiatives such as the development of the Asset Spatial Data Standard. In addition, the Survey Program manages aerial drones across TasWater through documentation of pilot certifications and drones, as well as CORS (continuously operating reference stations) located on TasWater infrastructure.

4. RESULTS

To determine the effectiveness of the Survey Program an assessment of survey projects was made to identify the variety of work performed, whether any benefits were identifiable from the integrated and data-focused approach, and the level of engagement across the business. As of November 2024, the Survey Program had completed around 400 projects, ranging in scale from minor surveys of assets, through to large statewide surveys, such as the laser scanning of 173 sewer pump stations.

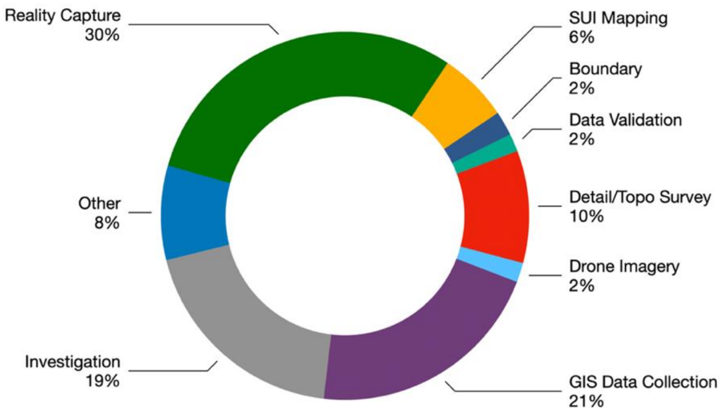

Figure 5. Categorisation of projects completed by the TasWater Survey Program.

Each survey project was categorised by a series of tags, providing some insight into the types of surveys performed by the Survey Program (Figure 5). "Reality Capture” represented the bulk of the work with 30% of tags, closely followed by “GIS Data Collection” at 21% and “Investigations” at 19%. “Investigations” refers to projects where an issue is identified with the data in the GIS or older plans and the Survey Program is tasked to resolve the issue. “Investigations” will often have a lot of overlap with other categories. “Detail/Topo Surveys” represented around 10% of the Survey Program’s work, followed by the “Other” category at

8%. The "Other" category includes work that does not fall under the typical data products created by the Survey Program and includes tasks like aerial LiDAR processing and analysis, 3D modelling, and advanced processing of the Survey Program's reality capture products, specialised drafting such as long sections, data procurement from external sources, and survey of features and points that are not destined for the GIS or CAD deliverables. SUI (sub-surface utility information) mapping was required for around 6% of projects, with "Boundaries", "Data Validation", and "Drone Imagery" each being required for around 2% of projects. Some drone projects are categorized as reality capture depending on what the primary deliverables are for the project.

Note that the above represents projects by categorisation but does not necessarily represent the effort (hours per surveyor) spent on each of those categories. In particular, the "Investigations", "Other", "Boundary", and "Data Validation" categories are often minor surveys looking at a handful of assets in a small region. In contrast, requests for "Reality Capture", Detail/Topo Surveys", "GIS Data Collection", and "SUI Mapping" range from individual sites, to tens or hundreds of sites across the state. While the Survey Program does track field and office hours spent across all projects there has not yet been an attempt to calculate total effort spent on various survey types. The project categorisation has been sufficient to demonstrate the wide range of work requested.

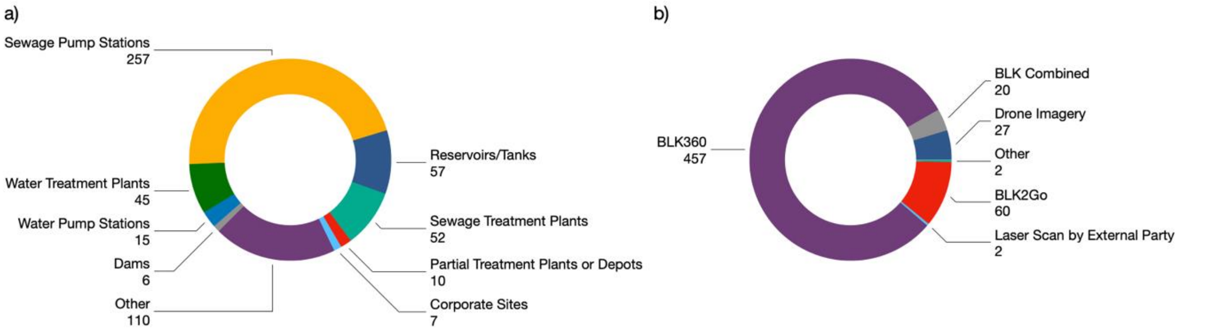

Figure 6. Breakdown of (a) reality capture data for sites, and (b) instrument types used.

As of November 2024, The Survey Program had completed reality capture of 568 sites (Figure 6). Of those, nine sites had been revisited and updated, with the older scan data marked as non-current, leaving 559 active sites. The 559 active sites consisted of 52 sewage treatment plants, 45 water treatment plants, 272 pump stations, 57 tanks/reservoirs, 6 dams, and 110 "other", which includes maintenance holes, minor network assets, civil works, etc. Seven corporate sites had been scanned, including all the main offices and several major depots. The remaining 10 sites consisted of partial scans of treatment and corporate sites. These values are undercounted to some degree as many treatment sites include pump stations and tanks which are not counted. Only the primary asset within each scan extent polygon is used to categorise the reality capture data. In the future this may be resolved by GIS analysis that identifies all relevant assets within each laser scan extents polygon, but it is not a high priority.

The BLK360 series instruments form the backbone of TasWater's reality capture capabilities with 477 sites scanned. The BLK2Go had been used to survey 80 sites, primarily tanks, offices, and depots, where speed was a higher priority than data consistency and panoramic image quality. There is an overlap between the BLK360 and BLK2Go scanners as they are occasionally both used on a project. The Phantom RTK drones had been used on 27 sites, mostly lagoon sites in rural areas. Two sites had been surveyed with the "Other" instrument type, which was entirely represented by the onboard photogrammetry of the GS18i, and two dam sites had been surveyed by external parties.

Adopting reality capture techniques as a primary survey system has been successful. These systems have enabled the laser scan survey, complete with total station control, of a typical sized treatment plant for a town to be completed in only a few hours. Even the larger treatment plants around Hobart or Launceston can usually be surveyed within a few days. Likewise, pump stations can often be scanned in less than an hour. Reservoir sites and depots can also be surveyed in one to two hours when using the BLK2Go mobile scanner. Providing access and simple tools for users to interrogate and inspect the laser scan data has resulted in high levels of acceptance for reality capture deliverables across the company. Requests for point cloud deliverables accounted for almost 40% of all survey requests. An example demonstrating the benefits of this capability was the laser scan survey of all sites on King Island in just one week, consisting of a water treatment site, two sewage treatment sites, two reservoirs, two pump stations, a dam, and some topography to check overflow levels. Access to those sites requires airline travel and therefore the ability to visit, inspect and do design work on these sites from the desktop has reduced costs and effort considerably.

Combining laser scan data with conventional surveying has also enabled high levels of efficiency. On many sites, features are inaccessible with conventional equipment without considerable compromise or effort. For example, features inside confined spaces such as wet wells, features near live edges, and features inside buildings. By capturing laser scan data as standard practice and utilising virtual surveying, surveyors are able to fill in gaps in the data with high accuracy for little effort. The effectiveness of integrating reality capture and conventional surveying systems was determined by assessing the projects tagged with "Detail/Topo" as they typically represent surveys for engineering design. If integration of reality capture and conventional survey data was less efficient than purely conventional surveying techniques, then it is likely that only a small percentage of these surveys would use combined data. Instead, 81% of these surveys combined reality capture and conventional survey data, with only a handful of simple surveys, such as corridors through rural land, using just conventional data. In addition, by having a virtual representation of the site available, the requirement for field checks is reduced, representing a large saving in time and costs, particularly for more remote sites.

The benefits of a data-focused approach, where surveys of assets are undertaken as opportunities arise, are inherently hard to quantify. Assuming that survey data is discoverable, then the main indication that a data-focused approach is working would be a decrease in survey requests as the library of surveyed sites increases. If there was an up-to-date library of all sites, then it would be expected that there would be almost no requests for reality capture of sites. Unfortunately, there is no complete library, and the demand for surveying services, prioritisation of assets for survey, and understanding of reality capture across TasWater has undergone rapid change over the last 4 years as the Survey Program has been developed, making it difficult to establish a baseline.

There are a few examples that give some insight into the effectiveness of the data-focused approach. In 2022 a project was established to update treatment site plans. Site features were digitised into the GIS from orthoimagery derived from the laser scans of sites, with other relevant features identified and added from virtual site inspections using TruView. The initial tranche of treatment sites identified for the project consisted of 31 sites. Of those, over half consisted of sites that had been surveyed without a survey request, many of them using contingency time left over from other projects. To survey these sites as part of the project would require approximately 50 hours of additional travel and two to three nights accommodation. Combined with the time taken to survey those sites, this would add approximately four weeks of effort to the project.

There have also been numerous requests for surveys made for sites that have been previously surveyed without a survey request. At least thirty sites were identified, typically treatment sites, tanks, reservoirs, and pump stations. Each survey request that is able to be fulfilled using opportunistically collected data saves time and travel costs. This is especially important where the round trip for many sites may involve up to a day of travel and overnight accommodation.

Engagement with the larger business through the use of the Survey Program website, data discovery tools, word of mouth, and direct communication has been very effective. As of November 2024, more than 170 users from teams across the business had generated projects for the Survey Program. This is also reflected in the wide variety of work shown in the project categorisation above. In particular, the high percentage of "Other" projects which often require creative combinations and analyses of spatial datasets, both from the Survey Program's data products and elsewhere, to solve problems.

5. DISCUSSION

TasWater's Survey Program has demonstrated significant benefits by establishing reality capture systems as a primary surveying methodology and through integration and automation of surveying systems. Laser scanning has enabled rapid surveying of sites, and the field-to-finish process, particularly when combined with virtual surveying of reality capture data and the ability to field check plans from the desktop has led to the efficient production of CAD and GIS deliverables. These technologies and workflows make projects more efficient with less effort spent on data capture and processing. Further benefits are found by applying those surveying systems within a data-focused paradigm. This paradigm means that rather than just completing the survey projects requested by end users, surveyors also identify any nearby assets that are missing survey data and, if time and circumstances permit, survey those assets as well. This approach is not often feasible in the larger surveying industry but is very applicable within utilities where assets are built and then undergo little change besides wear and tear until the asset is upgraded or mothballed. This means many sites may be surveyed prior to a survey request, which raises the concern as to whether an asset's survey data is still up to date when an asset requires an upgrade.

Several capabilities inherent to TasWater help to mitigate this concern. The data discovery tools deployed by the Survey Program, such as TruView, allow users to view and collaborate on sites virtually, making it easy to communicate any relevant changes made to a site since the survey. More importantly, while the Survey Program has a very small footprint with only two full time surveyors, almost half of TasWater's personnel are devoted to field operations. The field operators are responsible for network and treatment site operations and maintenance and have access to TruView, providing many opportunities for site updates to be identified and communicated.

The data-focused paradigm also turns the traditional project-focused value of data upside down. Under a project-focused paradigm, survey data is often perceived as just a necessary component needed to achieve the project's outcomes. Once the project is completed, it is common for survey data to be stashed in a desk drawer or archived away in the project files. However, across TasWater there are many different users with many different spatial data requirements, which means that survey data has value whether it is required for a project or not. It is commonplace to find users relying on decades-old plans for a wide variety of purposes. By developing a library of survey data that is discoverable by users it can minimise the reliance on old, uncertain, information and be applied to solve many problems, such as determining whether an asset upgrade is necessary. With access to good quality spatial data, it is often possible for a project's survey scope to be developed entirely from the office or, potentially, not even require surveying and move straight into design.

The opportunistic capture of survey data is also very economical. As it may only take a few hours to laser scan a treatment site, in many cases it is faster to perform the survey than it would be to establish a project, design a survey scope, and request a survey. This is especially the case for any sites away from the major cities, where the logistics required to determine the project's survey scope and specifications can account for more effort than the surveying. Most surveying projects also include some time set aside for contingencies, such as bad weather or other difficulties. By opportunistically surveying other assets in the vicinity of the project, any unused contingency is repurposed into useful survey data. A demonstration of the effectiveness of opportunistic surveying were some recent projects at Zeehan and Strahan, around 4 hours drive from Hobart. The survey projects were to survey the fire hydrants of Zeehan and some minor GIS pickup in Strahan. Zeehan is on the West Coast in a high rainfall area. Two and a half days were set aside for the survey and travel, with an additional one and a half days of contingency. The contingency was not required and was used for opportunistic surveying. In addition to the Zeehan and Strahan surveys, the water treatment plant laser scan survey at Zeehan was updated, and laser scanning or drone surveys were completed at the Zeehan sewage treatment plant, the Zeehan depot, the Trial Harbour sewage treatment plant, the Trial Harbour pump station, the Queenstown water treatment plant, and three tanks at Zeehan and Queenstown.

The reality capture data generated by the Survey Program also enables future innovations and capabilities. Point cloud data, in particular, can be considered as a general purpose spatial data framework. Point clouds can be used for derived products, such as 3D models, virtual surveying, and spatial analysis, but one area that has huge potential is that point clouds can be easily used to georeference other point clouds. This means that once a laser scan of a site has been completed, anyone with a laser scanner can scan areas of interest, and their scans can be georeferenced and potentially incorporated into the existing site point cloud framework via cloud-to-cloud registration, as long as there is sufficient overlap. This has a lot of potential as the presence of LiDAR capabilities becomes more common, such as in mobile devices like the Apple iPhone Pro. Reality capture data also forms the basis for digital twins. While there is still a lot of development required to build digital twins of assets and sites, having a large library of sites ready for use is an important first step.

6. CONCLUSION

The TasWater Survey Program combines conventional surveying, reality capture, and field-to-finish surveying systems and works within a data-focused paradigm to safely and efficiently survey water and wastewater infrastructure across the state of Tasmania. With a small footprint of two full time roles, and 169 treatment sites spread over ~55,000 km^2, there is a need for highly efficient surveying systems and the minimisation of travel. The use of reality capture systems such as laser scanners and photogrammetry drones enables the rapid survey of sites, including hazardous areas such as confined spaces and, more importantly, minimizes the requirement for field checks and travel. By combining reality capture with conventional surveying, virtual surveying can be used to augment gaps in the conventional survey data and provide context for CAD data through orthoimagery or point clouds. Likewise, 3D modelled underground services from conventional surveying can augment reality capture data. Logistics across the business are minimised by incorporating data democratisation and discoverability concepts in the survey program. All reality capture data is made available company-wide through TruView Enterprise, enabling users to virtually visit sites and inspect assets, take measurements, and collaborate. Logistics are streamlined further through the adoption of a data-focused approach. In contrast to the conventional project-driven operating model, a data-focused approach means surveyors still carry out surveying projects on request, but also identify any other assets that have inadequate spatial data in the vicinity and survey them at the same time. For example, a survey request may be for a water treatment site at a remote town, but the surveyor may also survey the sewage treatment site and water storage tanks at the same time. That extra data, while not immediately required for an upgrade project, is valuable for other people in the business, and can save on significant travel in the future. Combining reality capture, conventional surveying, field-to-finish, data democratisation, and a data-focused approach has enabled the TasWater Survey Program to deliver efficient, future-proof, generalised spatial data products providing the business more data, better data, and contextual data.

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