USING DATA SCIENCE TO DRIVE WATER UTILITY DECISIONS: A CASE STUDY IN A MEDIUM-SIZED UTILITY

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ABSTRACT

A common dilemma faced by water utilities interested in proactive apparent water loss control is (a) how to manage the overwhelming volume of data and (b) how to glean value-added insight in a timely manner from the data? Valor Water Analytics partnered with Clayton County Water Authority in Georgia to answer these two questions. The project covered 2 phases and a total of fourteen months from May 2016-August 2017. It leveraged 5 years of historical billing, meter, and customer information data, ongoing data updates, and Valor's Hidden Revenue Locator apparent loss technology, built off data science methodologies, to identify apparent loss issues on a monthly basis. Utility staff from IT, Meter Services, and Customer Services were instrumental in investigating the flags prioritized and presented by Valor, and resolving issues. This presentation will show that data science can be used to efficiently locate apparent loss issues, and also share how Clayton County Water Authority have been able to operationalize these outputs and tackle their meter under-registration issues in a proactive manner to meet revenue assurance and business process efficiency goals.

KEYWORDS

Proactive apparent water loss control, Data science, Issue prioritization, Meter under-registration, Meter asset management, Revenue enhancement, Process improvement

INTRODUCTION

Apparent water losses are revenue losses due to inaccurately measured or unauthorized consumption. Common causes for apparent losses include metering inaccuracies, billing errors, customer leaks, and illegal connections (Naik 2017). Apparent water loss control is steadily becoming an area of interest for utility managers across the USA, especially managers in states like Georgia and California where there are regulations around water loss and efficiency measures (SB-370; SB-555). Savvy managers also recognize that proactive water loss control can yield benefits like revenue recovery, more accurate water demand quantification, improved planning of capital-intensive water supply projects, and better customer care.

Currently, many water loss control programs are restricted to 'top down' annual water audits, and operational focus on a small subset of high revenue accounts. While these static spreadsheet assessments are useful for reporting purposes, it does not empower utility field and customer services teams to identify, prioritize, investigate and resolve apparent loss issues across their meter base as they occur. This capability is provided by Software-as-a-Service (SaaS) technologies like Valor Water Analytics Hidden Revenue Locator (Figure 1; Valor Water Analytics 2018). Large data volume challenges are mitigated through the use of data application programming interface (API) for automated data extraction and ingestion from client meter and billing systems to Valor systems. Apparent loss issues/anomalies/flags are presented on user-friendly online dashboards, with guidance on actions, and quantification of benefits. In addition to these advantages, the uniqueness of this product is the data engine built of multiple apparent loss detection models. By incorporating established engineering principles, advanced data science methodologies, and machine learning, the models are trained to produce high precision of issue detection. Valor has deployed the product at 10+ clients across the USA, and have achieved precision results that are at least 30X greater than that obtained by current utility operations through a random sampling approach (e.g. replacing meters based on age because they could be under-registering). The models are refined with additional datasets and feedback received from field investigations, and set up to yield steadily higher rates of precision, and increased value for utilities.

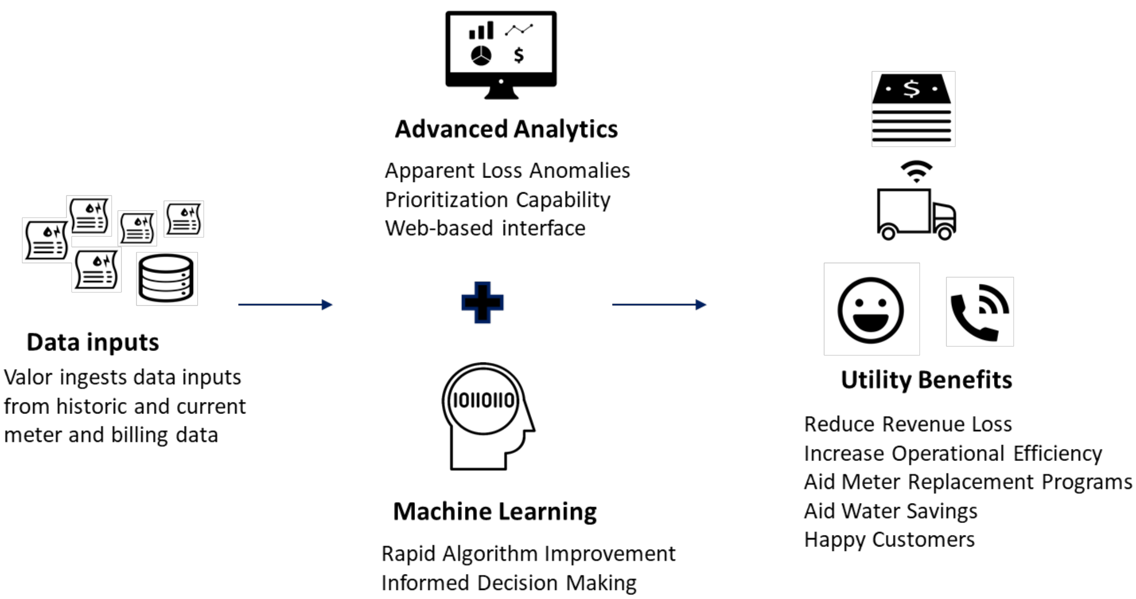

Figure 1

Valor's Hidden Revenue Locator Product Overview

Clayton County Water Authority (CCWA) in Georgia (CCWA 2018) was one of the early adopters of proactive apparent loss management and Valor's Hidden Revenue Locator. CCWA is an award-winning private water, wastewater, and stormwater utility, with an annual revenue in excess of $100 million, and around 80,000 customer accounts. They are known amongst Georgia water utilities as having a culture of continuous improvement. This is partly due to their geography at the top end of the watershed, where water is scarce and expensive, and also due to intrinsic motivation amongst their employees to be excellent water stewards. CCWA tested Valor's Hidden Revenue Locator as part of a 2-phase program that covered fourteen months from May 2016-August 2017. The goals of the program were (a) identify revenue enhancement opportunities through ongoing apparent loss detection technology (b) identify business process improvement opportunities.

METHODOLOGY

CCWA Metering and Billing Overview

CCWA has automated meter reading (AMR) technology, with monthly meter reading and billing across 25 cycles (reading routes). The approximately 80,000 meters are predominantly mechanical (>95%) and sourced from a single meter manufacturer. CCWA undertook an extensive meter replacement program from 2008-2013. There is no scheduled meter replacement program and testing per se; however, the top 2000 revenue accounts are regularly monitored and 700 meters annually tested. CCWA's service area is predominantly residential (94%). The utility regularly contends with customer affordability challenges, and a growing transient population base.

Project Phases 1 and 2: Hidden Revenue Locator Deployment

Figure 2 presents a schematic of Valor's Hidden Revenue Locator SaaS deployment process in Phases 1 and 2. Phase 1 occurred from May 2016-Oct 2016. As part of the Planning phase, CCWA IT leveraged Valor's standard data solicitation process to transfer monthly billing data, customer information data, and meter data for all meters. Historical data was provided upfront from January 2012 through April 2016, and an automated data feed was established to share ongoing monthly updates. Valor reviewed and transformed the data per their standard data transformation process and performed necessary health checks. 75,911 meters were determined as available for apparent loss issue detection, across eight indicator categories (Table 1).

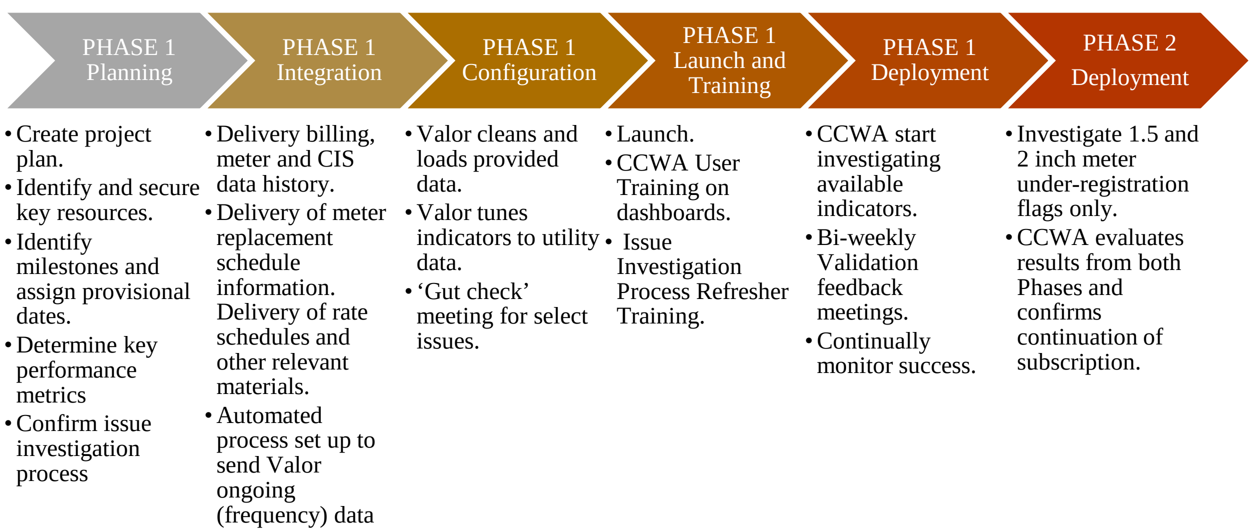

Figure 2

Valor's Hidden Revenue Locator Deployment Process for CCWA

Table 1

Apparent Loss Indicators for CCWA

Indicators	Description	Active in Phase
Meter Under- Registration	Detects meters whose accuracy is decreasing over time, causing the meters to register less water than is flowing through them.	1 and 2
Leaks – Monthly	Tracks water use and detects water loss due to leaks by analyzing monthly consumption data.	1
Meter Read Errors	Detects negative and implausible meter reads.	1
Missing Base Charge	Detects if the base/service charge is missing from a bill.	1
Customer Misclassification	Identifies meters that have been incorrectly classified with regards to their customer type.	1
Meter Right Sizing	Detects if the customer has a water meter sized differently than their demand	1
Non-Reporting Meters	Detects meters that are not reporting any reads.	1
Meter Tampering	Detects potential residential water meter tampering or instances of wire error that may be tampering.	1

All eight indicators were launched in Phase 1. Flags were identified in six categories - Meter Under-registration, Leaks- Monthly, Meter Right Sizing, Meter Read Errors, Customer Misclassification and Meter Tampering. The Phase 1 report was used by CCWA to gain a high-level understanding of key problem areas. However, they did not have the resources to investigate all flags produced by Valor. After an office review of 196 flags, CCWA Meter Services tested 22 meter under-registration flags in the field (data not included), per the procedure shared in Table 2. They gained sufficient confidence in the technology to proceed with a more thorough evaluation i.e. Phase 2.

Phase 2 occurred from Mar 2017-Aug 2017, and focused on meter under-registration flags for 1.5 and 2 inch meter sizes only. The top 100 meter under-registration flags determined by Valor were reviewed by CCWA, and 72 flags were tested in the field over 2 months, per the procedure shared in Table 2.

Table 2

Meter Under-registration Field Investigation Procedure

Indicator	Field Testing Procedure established by Valor and CCWA
Meter Under- Registration	1. Confirm meter location and number. 2. Take picture of meter in setting. 3. Confirm meter is horizontally installed. 4. Confirm no error codes (wiring issue etc. that may have caused reductions in meter reads) 5. Conduct visual inspection for leaks and note if present 6. Conduct visual inspection for tampering and note if present 7. Confirm meter movement 8. Use meter test port to record reads at a minimum of 3 flows (low, medium, high) per AWWA M6 guidelines for that meter 9. Share investigation results with Valor

Meter Under-registration Revenue Sum determination

Valor's Meter under-registration model incorporates features like meter age, throughput, consumption correlations, water quality, customer move in/out, etc. The model is trained on investigation feedback results, and any additional knowledge gleaned from new client datasets. Under-registration flags are generated at the meter level once scores pass established thresholds, and are presented on the Hidden Revenue Locator online dashboard. Each flag includes a confidence rating (HIGH, MEDIUM), total volume loss (gallons), and total revenue loss (US $). Utilities use these fields to prioritize and manage issues.

The total water volume loss associated with meter under-registration is calculated for each meter from the date of detected decline (flag start) to the date of the last billing update prior to meter testing. It is calculated on a per month basis as the difference between actual and expected volumes in that month, and summed across months from flag start to the last billing update. The total revenue loss is the revenue associated with the meter under-registration volume calculation, and is based off client volumetric rates. It is worth mentioning that the flag start date may not be the date when the meter first started under-registering; it is the date when there is sufficient data for Valor to have confidence that the meter is indeed under-registering.

RESULTS

Table 3 presents Phase 1 meter under-registration results for residential meters, as determined by Valor. About 3% of residential meters were flagged as under-registering. This averaged to about $6 per meter. The meter under-registration results for non-residential meters are presented in Table 4. Interestingly, 15% of non-residential meters were flagged as under-registering. This averaged to about $67 per meter. A total revenue loss of $754,424 was estimated for meter under-registration, over a four-year time period.

Table 3

Phase 1 – Residential meter under-registration summary

Customer class	Meter Size (inches)	Number of Unique Flags (6 month total)	Total Revenue Loss Identified ($)
Residential	5/8	2,000	446,341
	3/4	208	3,085
	1	107	5,853
	4	20	107
TOTAL		2,335	455,386

Table 4

Phase 1 – Non-residential meter under-registration summary

Customer class	Meter Size (inches)	Number of Unique Flags (6 month total)	Total Revenue Loss Identified ($)
Non-residential	5/8	148	7,484
	3/4	74	2,590

1	83	5,908
1.5	111	45,000
2	101	141,000
3	30	3,524
4	23	2,114
6	46	86,023
8	35	4,374
10	5	622
TOTAL	657	299,038

In Phase 2, 28 flags out of 72 tested flags were confirmed as under-registering. This yielded a 39% precision rate for Valor's data-science meter under-registration approach. CCWA Meter Services had previously tested meters randomly, while undertaking their meter replacement program, and found only 6-10% of meters had been under-registering. Valor therefore provided a 4X improvement in identifying under-registering meters.

All 28 flags start dates were in the 2012, 2013, 2014 timeframe, revealing that these meters had been under-registering for many months, prior to investigation by CCWA. Table 5 summarizes the meter failure rates, as identified during meter testing.

Table 5

Phase 2 – Meter Failure Rates for 28 Correct Flags

Meter Testing Results – Failure rates	**Number of Unique Flags**
Low flow (90-95% registration)	21
Low flow (80-90% registration)	1
Low flow (70-80% registration)	1
Low flow (60-70% registration)	1
Low flow (<80% registration) and Medium flow (<95% registration)	2
High flow (<95% registration)	1
Meter Stopped	1

Of the 28 flags, there were 3 flags for which Valor did not have rate structures. These 3 flags were omitted, and total revenue loss calculations done on the 25 flags for which rate structure information was available. Total revenue loss estimates of $207,214 over a five-year time period was determined. Figure 3 presents the distribution of the total revenue loss for these 25 under-registering meters, sliced by Customer Class and Meter Size (inch), and Meter Installation Year.

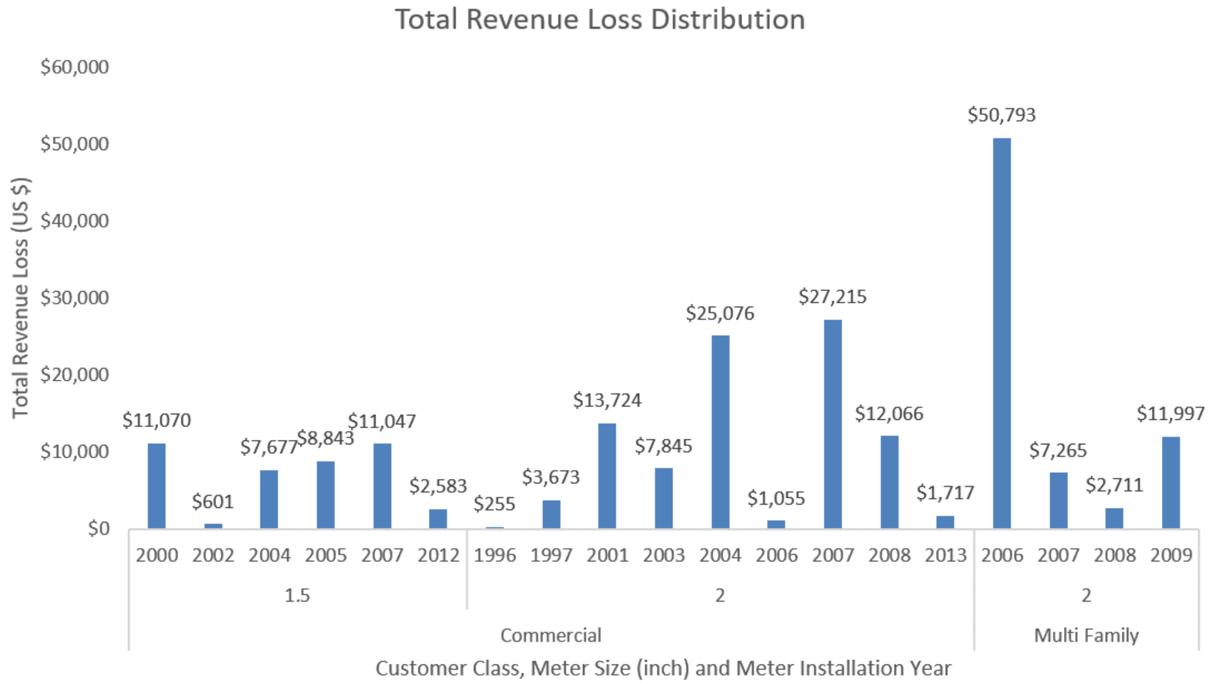

Figure 3

Phase 2 – Total Revenue Loss Distribution for 25 Meter Under-registration by Customer Class, Meter Size, and Installation Year

DISCUSSION AND CONCLUSIONS

Undertaking system-wide apparent loss analysis in Phase 1 revealed not only which issues are present, but the magnitude of the issues. With data that meter under-registration was the largest issue faced by CCWA (a staggering total revenue loss estimate of $754,424 over four years), CCWA were empowered to subsequently focus their efforts on this indicator. In addition, the data suggested greater short-term gains were possible by focusing on non-residential meters, and within this, the 1.5 and 2 inch meter sizes (Table 4). It is reasonable to conclude other utilities facing similar resource constraints to CCWA would want to consider focusing first on non-residential meters, and then work their way through residential meters. The one caveat here is that there could be some additional challenges to overcome around non-residential meter access and/or availability of meter testing equipment; that might lead to operational delays.

Table 5 reveals that a majority of the under-registering meters, identified by Valor, failed at low flow. Hannah et al. (2017) studied residential water use patterns in several utilities in North America in 2016, including at CCWA, and compared the flow data results to that of 1999. They determined that usage profiles across regions have changed considerably, with more volume observed at low flows (less than 2 gallons per minute). This suggests that low flow under-registration can be more significant to utilities, than may have been anticipated from previous understanding.

Valor's data-science approach to detection of under-registration yielded a 39% precision rate at CCWA in Phase 2. This was 4x higher than what CCWA Meter Services teams had obtained through their own random sampling and testing approach. It is clear that a data-science approach allows for creation of improved models and enhances the quality of outcomes. This allows utilities to obtain more value for the same operational effort and meter testing costs.

Figure 3 shows that meter age is not the only determinant of under-registration, nor is there any strong correlation between meter age and total revenue loss. This is interesting because it signals that a change is needed in the ways utilities consider and prioritize meter replacement. While most utilities have different residential and non-residential meter schedules, data suggests that there are greater revenue advantages to locate and resolve under-registering meters as part of normal operational workflow, rather than to wait for the next meter replacement program based of length of service. More studies are needed to quantify the per-meter cost benefit and to guide utility managers on the optimal time for each meter replacement to occur. It would be in utilities' best interests to use these findings and insights from their own data, to design future state meter replacement schedules that will achieve maximum effectiveness and avoid unnecessary costs.

In conclusion, a proactive approach to apparent water loss control is highly advantageous to utilities, as it allows them to tackle these issues as part of normal operations and allows them to maximize on revenue enhancement opportunities and business process efficiency goals. CCWA have been one of the early adopters of proactive apparent water loss control, and through partnership with Valor and use of Valor's data-science and machine learning models, are receiving the right detail of insight on issues to prioritize action and capitalize on revenue enhancement and business process efficiency opportunities.

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