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NUTRIENT REMOVAL FOR INDIRECT POTABLE REUSE

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INSIDE

REVERSING RISING WATER LOSS TREND USING SATELLITE GUIDED RECOVER PROGRAM

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BACKGROUND

The City of Garland is a municipality northeast of Dallas, Texas with a population of 234,585 residents. See Figure 1. It has 113,000 total service connections of which 92,700 are active or inactive retail metered connections. The City has 972 miles of pipe mains and delivers approximately 30 MGD to its customers. The City's system employs two pressure zones utilizing eight ground storage tanks and four elevated storage tanks comprising 49 million gallons of capacity.

In 1922, the City constructed its first groundwater well to serve drinking water to its residents. For over 25 years, this served as its sole source of supply. In 1951, the North Texas Municipal Water District (NTMWD) was formed to obtain water from various local sources and provide a reliable supply to surrounding participating communities. In 1954, Lavon Lake was constructed by the Army Corps of Engineers and in 1956, the City of Garland, one of the ten original members of the NTMWD, became the first to receive water from NTMWD.

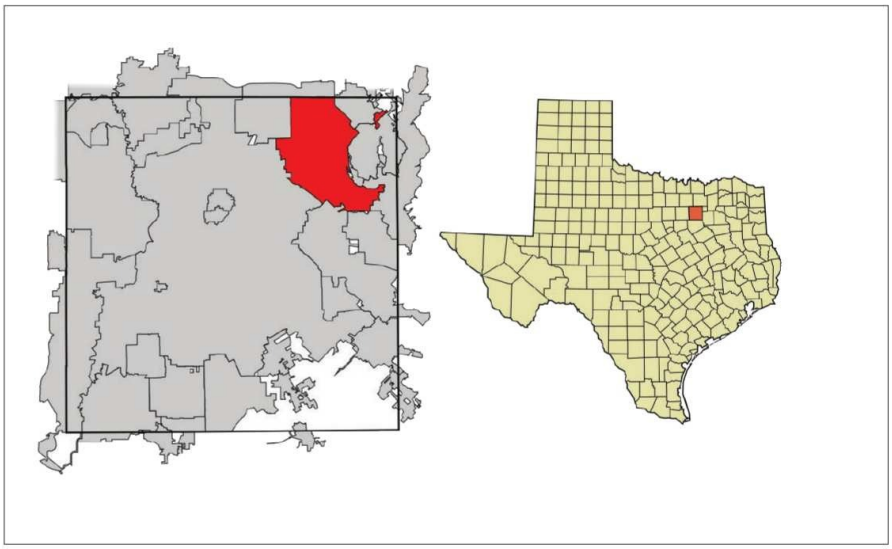

Figure 1

NON-REVENUE WATER

Over the course of the previous fifteen years, the City has experienced widely varying levels of non-revenue water (NRW). The NRW consists of real and apparent water losses. The losses range from less than 10% in 2006 to over 15% in 2011 to a low of 5.9% in 2015 to a high of 21.1% in 2020. See Figure 2.

The baseline billed water usage has been relatively consistent. It is dropping at a rate of less than 1% per year. In 2006, the average billed

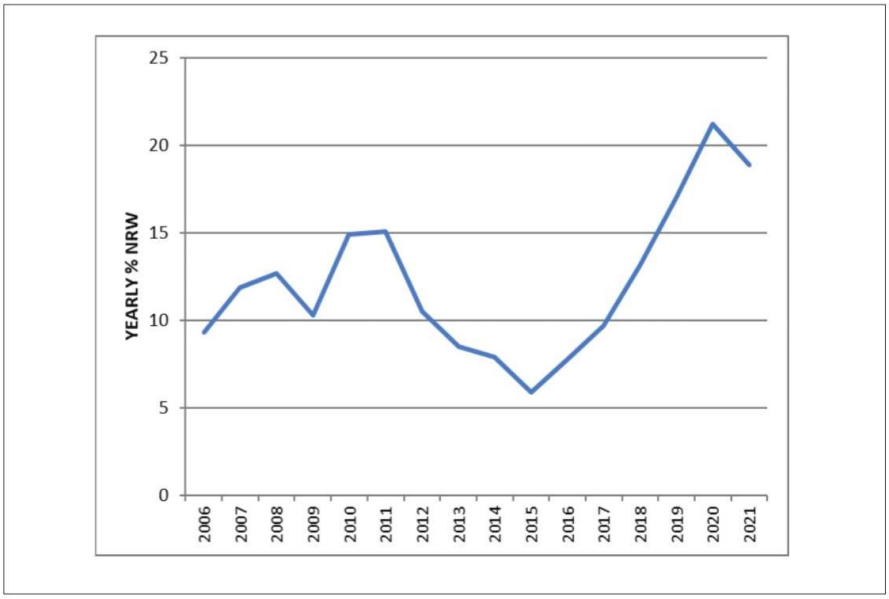

Figure 2

usage was approximately 890 MG per month, or 29.7 MGD and in 2021, the average billed usage was approximately 740 MG per month, or 24.7 MGD. See Figure 3. The graph shows a clear spike in water usage in the third quarter of the year throughout this time period, but the peak usage is dropping faster than the average usage. The baseline minimum usage is very stable at 600 MG per month.

PRO-ACTIVE LEAK DETECTION

For the City to have a more consistent, and lower, non-revenue water level, a pro-active leak detection program was instituted in 2021. This was the first time the City had employed such a program. In the past, there was only a reactive program, with crews investigating reported issues and repairing those leaks found.

In 2021, the City retained the services of ASTERRA to provide satellite surveys of the water system, to identify areas with leak probabilities. ASTERRA's technology utilizes specialized radar signals taken from a satellite to scan an area of interest and collect the resulting reflected signals. These signals are analyzed and processed to identify specific indicators of wet soil saturated with potable water, screening out the signal noise and other interferences. The result is a map showing Likely Leak Locations (LLLs), called ASTERRA Recover. Recover analysis typically highlights 5-10% of the entire system length, and only these locations where there is expected to be a leak are inspected by 'Boots on the Ground' (BOTG) leak detection teams. The time and resource cost of leak detection is much lower than traditional leak detection approaches (e.g. full-system, random, systematic, or block map). Additionally, the performance of the BOTG crews is much higher when utilizing the Recover leak pre-location technology, providing more value to the user.

In the spring of 2021, ASTERRA collected and analyzed the first satellite image of the Garland service area. Subsequently, a map of LLLs was provided to the City for field inspection. A combination of contract and City provided BOTG field inspection crews were used for this program. The field inspections occurred between July 19th and November 10th, 2021. All 311 POI/LLLs were inspected in 50 crew days. A total of 74.3 miles of pipeline were physically inspected. A total of 106 leaks were found. 75, or 71% were non-surfacing leaks.

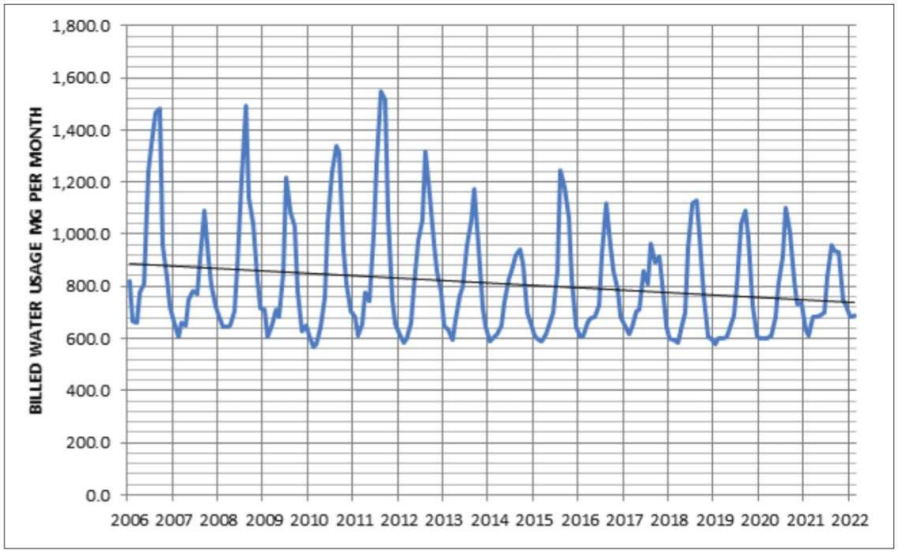

Figure 3

Table 1

Service	Leaks	Days	Miles Walked	Leaked/ Days	Leaks/Mile
1	106	50	74.3	2.1	1.4
2	80	28	41.8	2.9	1.9
Total	**186**	**78**	**116.1**	**2.4**	**1.6**

In 1922, the City constructed its first groundwater well to serve drinking water to its residents.

The second service began in the winter of 2021, when a satellite image was collected and analyzed. Field inspections began December 13th and are continuing. As of mid-March 2022, 182 of the 389 LLLs have been inspected. A total of 28 crew days have been spent physically inspecting 41.8 miles of pipeline. A total of 80 leaks were found. 66, or 82% were non-surfacing leaks.

Table 1 shows the results of the two Recover services. As can be seen from the table below the performance in the second service is better than from the first service. This is typical because the Recover algorithm can learn from multiple images and field results to refine the LLL delivery to be more precise. This results in more leaks found per day and more leaks found per mile inspected.

REDUCING REAL WATER LOSSES

The value proposition resulting from this work is identifying leaking pipes and reducing real water losses. The following analysis will focus on the real water losses identified by the satellite directed field leak inspection work. Only utility side leaks were used in calculating the real, non-revenue water, loss rate. Most of the leaks found pursuant to ASTERRA Recover program were non-surfacing leaks, those that are not visible and would not have been reported by work orders. 141 of the 186 leaks (76%) found by the ASTERRA-driven crew inspections were non-surfacing leaks. These leaks potentially can last for many months or

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even years before they are discovered without ASTERRA Recover. Locating these leaks earlier adds to the value proposition of the satellite program. An additional 143 leaks were found within the LLLs identified by ASTERRA Recover via customer reported issues. These were surfacing leaks and are not included in the analysis.

Real water losses found by the program so far are 0.636 million gallons per day, or 232.1 million gallons per year. This is calculated by multiplying the number of each type of leak (e.g. main, service, hydrant, valve, etc.) found by satellite directed field inspections by its estimated leak flow rate as defined in the *AWWA Manual of Water Supply Practices M36 Water Audits and Loss Control Programs, Fourth Edition*. The estimated size of potable water leaks contained in M36 are listed in Table 2. M36 is silent on meter and curb stop leaks. A meta-analysis of over 1800 North American projects performed over a period of 10 years was used to estimate those leak flow rates.

Table 3 shows the results from the work performed. A grand total of 186 leaks were found during this effort to date. Of the 186 leaks found by ASTERRA Recover, 119 were on the utility side of the meter, and thus are non-revenue water leaks; and 67 were on the customer side of the meter. The 186 leaks were found in 78 crew inspection days. A total of 116.1 miles of pipeline were physically inspected by the BOTG crews. This resulted in a performance metric of 2.4 leaks per day found and 1.6 leaks found per mile inspected. The Garland system is comprised of 32 % metal, ductile iron or cast iron, and 68 % PVC plastic pipe. It is much more difficult to acoustically identify a leak on plastic pipe than on metal pipe, as the sound travels less and has a lower pitch and intensity. In other projects using ASTERRA Recover, an average of 1.2 leaks per day and 0.8 leaks per mile have been found in systems comprised of mixed piping types. The results in the City of Garland exceeded the typical results in mixed pipe material systems.

The 119 utility side leaks found were categorized by subtype. This was done in order to calculate the real water loss identified by the program. Table 3 lists the leaks by subtype.

Table 4 calculates the real water loss identified by the satellite directed field work, using the utility side leaks in Table 3 and the leak flow rates in Table 2.

Table 2

Pipe Main	Service Pipe	Service Connection	Valve	Meter	Hydrant	Curb Stop
10.4	6.9	6.9	6.9	0.4	3.5	0.7

Table 3

Pipe Main	Service Pipe	Service Connection	Valve	Meter	Hydrant	Curb Stop
4	13	5	4	15	67	11

Table 4

Leak Type	Number	Flow Rate (GPM)	Total Flow (GPM
Main Pipe	4	10.4	41.6
Service Pipe	13	6.9	89.7
Service Connection	5	6.9	34.5
Valve	4	6.9	27.6
Hydrant	67	3.5	234.5
Meter	15	0.4	6
Curb Stop	11	0.7	7.7
Total	**119**		**441.6**

Based on the leak values contained in Manual M36, the total real water loss identified by the ASTERRA program is 441.6 GPM or 635,900 GPD. Many of these leaks were non-surfacing and would not have been noticed or repaired for many months or years. It is projected that the savings to the City of Garland is 232.1 MGY.

A total of 78 crew days were spent inspecting the LLLs, searching for leaks that contribute to the lost water. A total of 232.1 MGY of water loss was recovered based on the leaks identified in this manner. Thus, each day a crew spent searching for leaks generated 2.9 MGY of water loss reduction, or effectively new supply. This lost water can be used to meet additional demand in the system without the need for additional aquifer withdrawals, wholesale purchases from other entities or new capital improvements. The City of Garland obtains all of its water supply via treated water purchased from the North Texas Municipal Water District. These results show that crews spending days in the field searching for leaks using ASTERRA Recover generate valuable results.

CONFIRMING THE RESULTS

In order to confirm that Recover is having direct results, the above analysis must be compared to actual system data collected by the City of Garland. Figure 4 shows the rolling 12-month average of percent NRW. As can be seen from the graph, the NRW percent has begun to drop in 2021, due in part to ASTERRA Recover.

In order to evaluate the actual impact the Recover leak detection and repair intervention program had on non-revenue water levels, a critical look must be made at the post-intervention time period. The City began to repair leaks it found pursuant to the satellite program in August 2021, therefore, the full effect of the real water loss reduction would begin to be seen in September, 2021. A comparison of the six-month period September to February for the past three years was performed. The 2021 – 2022 period was post intervention, while the 2019 – 2020 and 2020 – 2021 periods were pre intervention. The results are shown in Table 5.

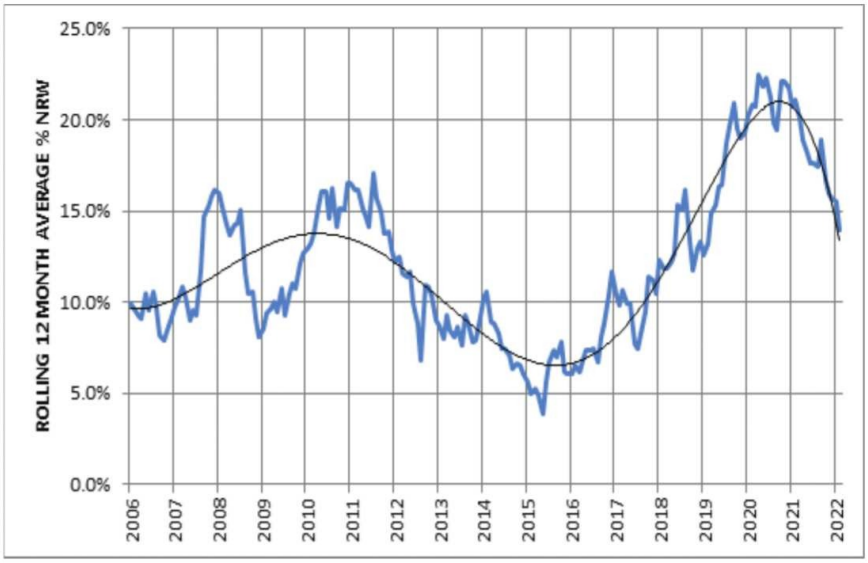

Figure 4

Table 5

Pre and Post Intervention Average NRW – MG/Month	
Septemeber 2019 – February 2020	92
Septemeber 2020 – February 2021	120
Septemeber 2021 – February 2022	50

Comparing multiple years during the same time period eliminates potential seasonal bias in the analysis as well as normalizes the data related to variations in rainfall and ambient temperature. The two years prior to the leak detection and repair intervention program the non-revenue water levels were over 100 MG per month for the six-month time period. Post intervention, the six-month non-revenue water average was 50 MG per month. This shows the effect that the ASTERRA Recover program has directly on NRW. The leaks found and repaired were mainly non-surfacing leaks that would not have been detected and fixed without the use of the satellite pre-location program. The elimination of the real water losses due to non-surfacing leaks resulted in a significant reduction in NRW.

RETURN ON INVESTMENT

The primary goal of this program was to reduce the level of Non-Revenue Water (NRW) in the City's system, which had sharply risen between 2015 and 2020. While the previous sections of this report have highlighted the program's success in addressing the primary issue, there is also a positive financial impact on the utility in reducing NRW, which must be evaluated to determine the value proposition of such a program. Under the City's current wholesale water contract with NTMWD, there is a minimum annual demand which Member Cities must pay (also known as "take-or-pay"). For Member Cities whose actual usage is below the "take-or-pay" amount, NTMWD has historically issued a rebate based on the unused annual requirement and a rate of rebate, which represents the cost of electric power and chemicals not spent due to the unused water. In the last 20 years, the City of Garland has used less than the minimum annual demand and received a rebate for all but one year. The rebate rate for FY 2020-21 was $0.49 per 1,000 gallons, or $490 per MG.

Under these conditions, which are specific to the City of Garland and other NTWMD Member Cities, water savings under the minimum annual demand do not lower the upfront

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cost of wholesale water, but rather increase the rebate amount. A simple payback evaluation can be conducted using the cost of service and the value of the recovered water. The cost of service is comprised of the ASTERRA Recover satellite services at $112,000 and the BOTG field leak inspection, which was $67,200 for 78 crew days of field inspection between contract and City crews, for a total cost of $179,200. The value of the recovered water can be calculated using the estimated volume at 232.1 MGY and the NTMWD rate of rebate for unused water below the "take-or-pay" amount. The value of this recovered water based on the most recent rebate is $113,729 per year. The simple payback period is just over one and a half years using these figures.

REFERENCES

AWWA Manual of Water Supply Practices M36 Water Audits and Loss Control Programs, Fourth Edition

ABOUT THE AUTHOR

Cynthia Baughman is a strategic technology leader with over 34 years' experience working in all aspects of IT. She has worked for the City of Garland, TX, for over 24 years, as an IT Network Services Manager, an IT Business Relationship Manager, and currently serves as the Water Utilities Technology Director. She oversees GIS, Asset Management, SCADA, Cybersecurity, and the utility's Water Operations call center. Cynthia earned her Bachelor of Science from San Jose State University in Business – Information Systems, and also holds several certifications, including NIMS, Business Continuity Planning, Project Management, and Business Relationship Management.

Paul Gagliardo has held leadership positions in the water and wastewater business for over 30 years. He spent 25 years at the City of San Diego, founded the AQUA 2000 Research Center to test new treatment technologies, performed health effects studies for the original "toilet to tap" project, developed two watershed master plans and a city-wide overall groundwater management program for the city. He was the Innovation Director at American Water from 2009 to 2017. Paul has been a judge for the Imagine H2O Accelerator since its inception in 2009. Currently he is an independent consultant assisting and advising innovative water sector startup companies. He is a registered engineer in the state of California and has a Master's Degree in Public Health. ●

Only utility side leaks were used in calculating the real, non-revenue water, loss rate.