Subject: **Tucson Water & Arizona Department of Water Resources (ADWR)**
Leak Detection Program – 2023 Final Monitoring Report Deliverable

2023

Final Report

WATER MANAGEMENT

ASSISTANCE PROGRAM

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REQUIREMENT:

Task 1: review existing system documents

The initial program was setup in order of tasks. Task 1 consisted of reviewing Tucson Water existing documents that included pipeline original as built design and shop drawings which identified pipe diameter and material. Pipe material is valuable information for the condition assessment program providing a prioritized workflow method which included non-metallic pipelines and metallic. Metallic pipelines traditionally are a priority over non-metallic pipelines due to the susceptibility to corrosion attack. The evaluation process for corrosion control is driven by data collection and monitoring of the asset over time. The uptick in the corrosion potential enables a placement on the prioritization list to address corrosion, possibility of cathodic protection (cp) application, and an option to perform leak detection.

Through the data analysis process, two sites were identified as suspect with a need to perform a direct assessment. The primary reason for selecting the two sites was the possibility of stray current interference from two foreign gas pipeline crossings. To add, "the Federal Pipeline Safety Act of 1968 required that cathodic protection be applied to underground gas lines subject to active corrosion which might pose a hazard to the public safety." By law, the gas industry maintains high levels of cp (typically impressed cp) on their line to combat corrosion. A cp system is beneficial for the gas line. However, water pipelines experience stray current interference from the gas industry's cp systems and the effect is electrical Direct Current (DC) collecting on the water line and discharges at the point of least resistance. At this point the corrosion process begins for the water pipelines.

The amount of metal that will be removed is directly proportional to the amount of current flow. "One ampere of direct current discharging into the usual soil electrolyte can remove approximately twenty pounds of steel in one year." Note: typically, we seldom encounter

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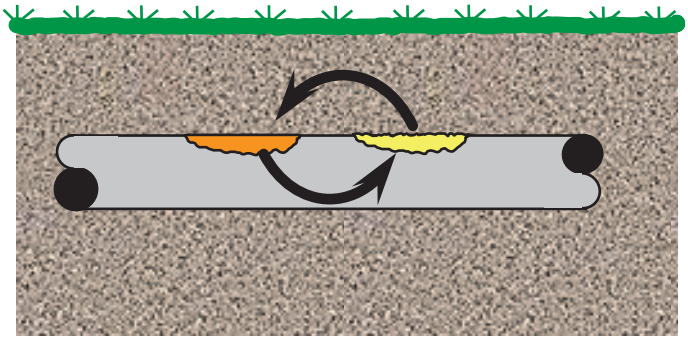
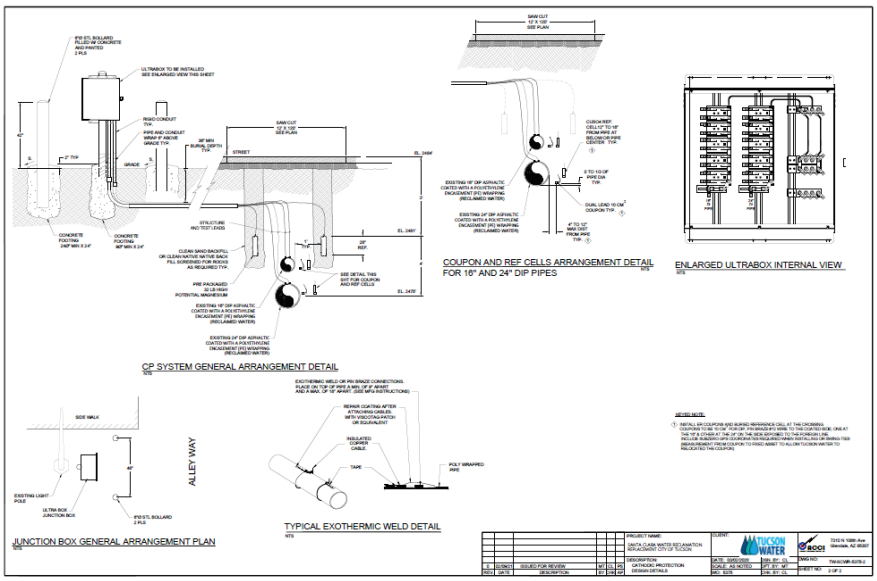
currents of this magnitude on pipeline. It is generally in the thousandths of an ampere (milliamps or ma).



Our program identified two locations experiencing stray current interference. Site one – two ductile iron pipelines (16" & 24") parallel to each other on our city southwest location. Site two – one 30" welded steel pipeline suction side to a booster pump on the city far east side location. This location had active corrosion cells with through wall pitting and experiencing a leak.

Site one – remedial measure: a new sacrificial cathodic protection (cp) system was designed and both parallel pipelines were excavated, electrically wired for the cp system, new 32lb. high potential magnesium anodes were installed and wired into an above ground junction box with new corrosion test stations, and a new loose bonded polyethylene encasement installed.



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Site two – remedial measure: existing 30" welded steel pipeline was excavated, and forensics identified severe pitting on the pipeline from outside in and one through wall penetration causing a severe leak. The pipe was repaired by new welded collar straps, a new coating installed, and a new sacrificial cathodic protection system was designed, and electrically wired for the cp system, new 32lb. high potential magnesium anodes were installed and wired into an above ground junction box with a new corrosion test station.

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Task 2: Project Kickoff Information Gathering

First – For Tucson Water's project kickoff it was excitingly easy to assemble a team of employees eager to assist with our director's direction and goal to reduce non-revenue water loss to 4%. It was evident our challenges were tough. The team consisted of the business management office, operations, maintenance, GIS, hydraulic modeling, and engineering.

Second – The Water Service Area (WSA) is large, and a decision was made to focus the efforts on the water conveyance system consisting of distribution and transmission mains, this included all waterline features (assets) to complete the infrastructure. I.e., pipe material, and most critical

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assets. Additionally, the roadway intersection of Broadway and Stone was identified as project point "zero" (Cardinal direction). This location is relevant being located in the area with the oldest infrastructure. Once the first area (Area 1) was completed, a second area (Area 2) was created for the field teams to address for leak detection and condition assessment and delineated on a GIS map.

City of Tucson Water Department Service Area (with total survey points, leaks, discrepancies, and defects)

Task 3: Pipeline Inspections

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Tucson Water's condition assessment program (formerly known as the pipeline protection program) has a very strict standard as it pertains to performing internal pipeline inspections. Each contractor must provide a cost proposal, identify each employee assigned to the project and their roles, specific planning document that addresses the requirement to disinfect all tools or equipment inserted into the pipeline. Depicted below is an itemized snapshot of a Transmission main project:

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2. Roles and Responsibilities

Table 2.1 provides a brief description of the organizations involved in the inspection and their required duties for a successful inspection.

Table 2.1: Role and Responsibilities

Company / Organization	Description	Roles and Responsibilities

City of Mesa/ Garney Construction	Preparation and Inspection	• Isolate and dewater pipeline as per MOPOs
		• Tools required to disassemble blind flanges/access manholes.
		• Tools required to complete Lockout/Tagout procedures (Lock Box).
		• Keys for gates/vault access.
		• Determine if required:
		  ○ Pumps to remove water that collects overnight in pipe low points and manholes.
		  ○ Traffic Control and Permit(s).
		• Provide:
		  ○ Rescue support team
		  ○ Two (2) or more personnel for topside support and provide access to each open manhole.
		  ○ Two (2) Tripods, Davit arms, and self-retracting lifelines (SRLs) (one for each topside supervisor).
		  ○ Ladders at each open manhole for Entry/Egress.
		  ○ OSHA compliant permit required for confined space entry support and pipe rescue.
		  ○ Entry documentation, atmospheric monitoring, ventilation, communications, access, rescue/first aid w/AED.
		  ○ Provide onsite Bump test and/or calibration.
		  ○ Tripod and winch/rope system at each entry/exit point.
		  ○ Positive/Negative pressure ventilation.

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Table 2.1: Role and Responsibilities

Company / Organization	Description	Roles and Responsibilities

Pure Technologies	Pipeline Inspection	• One (1) to two (2) rental SUVs or Minivans
		• PureEM Electromagnetics Inspection Tool/Cart
		• Pathmaker Radios
		• Personal Protective Equipment (PPE) for each entrant, including:
		  ○ High-Vis vest and durable pants
		  ○ Full Body Harness with back D-ring
		  ○ Air Monitor (bump-tested each morning)
		  ○ Safety/Steel Toe Boots
		  ○ Hard hat with headlamp
		  ○ Flashlight
		  ○ Gloves (Nitrile Coated or Rubber)
		  ○ Safety Glasses
		  ○ Whistle
		• Other
		  ○ Ear protection
		  ○ Rope and bucket
		  ○ GPS
		  ○ Record drawings
		  ○ Confined Space Entry Form
		  ○ Measuring Tape and Various Hand Tools
		  ○ Crayons for pipe numbering
		  ○ Bump-It Compressed Air Can
		  ○ Tool Disinfectant Solution / Boot Dip
		  ○ Waders and or Boot Spikes

Fee Schedule (15.35 Miles - 42in BWP)

Description	Unit Rate	Unit of Measure	Qty	Total
SmartBall Mobilization: Includes Travel, Equipment Shipping, Site Reconnaissance and Project Planning Document	$26,250	Lump Sum	1	$26,250
Smartball Inspection:	$15,750 – First 5 miles $11,500 – Miles 6 - 20	Per Mile	15.35	$197,775
SmartBall Report: Inspection Results Analysis and Reporting	$10,500	Lump Sum	1	$10,500
TOTAL				**$234,525**
Additional Services:				
PipeDiver Mobilization: Includes Travel, Equipment Shipping, Site Reconnaissance and Project Planning Document	$78,750	Lump Sum	1	$78,750
PipeDiver Launch Tubes: For pressurized insertion and extraction	$65,000	Lump Sum	1	$65,000
PipeDiver BWP Inspection:	$84,000 – First 10 miles $78,750 – Miles 11-20	Per Mile	15.35	$1,261,312
CCTV Inspection (With PipeDiver) - Optional	$3,150	Per Mile	15.35	$48,352
PipeDiver Report: Inspection Results Analysis and Reporting	$10,500	Lump Sum	1	$10,500

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Tasks 4: Distribution System Field Work

Distribution system field work was the primary and most important task for Tucson Water to perform leak detection considering most water loss is within the distribution network. A systematic phased approach was designed for the areas to be tested and accounted for. The test method chosen was traditional boots on the ground equipped with acoustic ground microphones. The most important information to convey was that the contractor physically visited each pipeline feature and tested for leaks, GPS verified, and documented within the contractors Project Tracker program. The end results of the ADWR grant field work is a huge success! The contractor performed leak detection in 5 areas, on a total of 658 miles of pipeline with locating 192 total leaks, equating to 120.65 GPM. Tucson Water has an Asset Management System (ASM) documenting the asset registry and identified leaks. Each leak was visited by a Tucson Water condition assessment team member to identify the leak location, decide if it was a Tucson Water leak or Customer leak then was entered into the ASM program. A work order was created, and the leak was repaired. A service request was created for Customer leaks and each customer was notified in person or by a door posted informational card (if the owner was not home). Each table below identifies area leak information with a summary.

Area 1					
MILES SURVEYED	**HYDRANT POINTS**	**VALVE POINTS**	**SERVICE POINTS**	**OTHER**	**TOTAL SURVEY POINTS**
200	1,130	5,094	10,036	4	16,237
TOTAL LEAKS	**GALLONS PER MINUTE**	**GALLONS PER DAY**	**GALLONS PER WEEK**	**GALLONS PER MONTH**	**GALLONS PER YEAR (365)**
63	35.75	51,480	360,360	1,544,400	18,790,200

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Area 2					
MILES SURVEYED	**HYDRANT POINTS**	**VALVE POINTS**	**SERVICE POINTS**	**OTHER**	**TOTAL SURVEY POINTS**
200	1,051	4,113	10,456	2	15,622
TOTAL LEAKS	**GALLONS PER MINUTE**	**GALLONS PER DAY**	**GALLONS PER WEEK**	**GALLONS PER MONTH**	**GALLONS PER YEAR (365)**
47	33.30	47,952	335,664	1,438,560	17,502,480

Area 3					
MILES SURVEYED	**HYDRANT POINTS**	**VALVE POINTS**	**SERVICE POINTS**	**OTHER**	**TOTAL SURVEY POINTS**
93.5	610	2,450	6,376	0	9,436
TOTAL LEAKS	**GALLONS PER MINUTE**	**GALLONS PER DAY**	**GALLONS PER WEEK**	**GALLONS PER MONTH**	**GALLONS PER YEAR (365)**
28	22.55	32,472	227,304	974,160	11,852,280

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Area 4					
MILES SURVEYED	**HYDRANT POINTS**	**VALVE POINTS**	**SERVICE POINTS**	**OTHER**	**TOTAL SURVEY POINTS**
93.5	452	1,803	6,187	1	8,443
TOTAL LEAKS	**GALLONS PER MINUTE**	**GALLONS PER DAY**	**GALLONS PER WEEK**	**GALLONS PER MONTH**	**GALLONS PER YEAR (365)**
34	16	23,040	161,280	691,200	8,409,600

Area 4b					
MILES SURVEYED	**HYDRANT POINTS**	**VALVE POINTS**	**SERVICE POINTS**	**OTHER**	**TOTAL SURVEY POINTS**
71	336	1,473	,553	0	5,362
TOTAL LEAKS	**GALLONS PER MINUTE**	**GALLONS PER DAY**	**GALLONS PER WEEK**	**GALLONS PER MONTH**	**GALLONS PER YEAR (365)**
20	13.05	18,792	131,544	563,760	6,859,080

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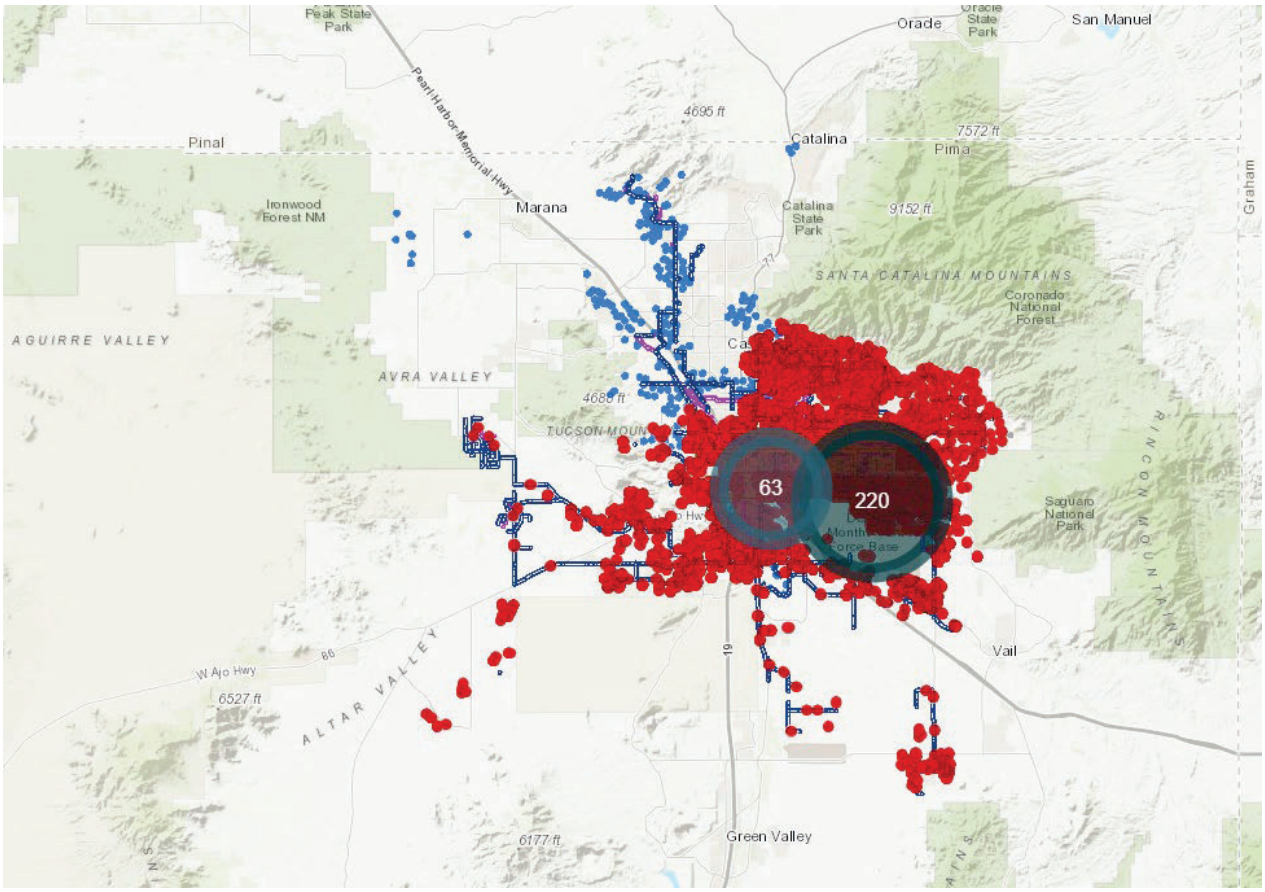

Overview – City of Tucson Water Infrastructure (Project Tracker).

Tasks 5: Transmission Main Field Work

Initially with the transmission main field work priority list it was difficult to identify one specific main within the Tucson Water infrastructure network. Multiple transmission mains are equally critical due to the ranking of criticality by consequence of failure and likelihood of failure. A simplified selection process was based on the lack of redundancy connected to or around the main. The condition assessment team selected the Avra Valley Transmission Main. The pipe material is 42" C-303, Concrete Cylinder Pipe (CCP), approximately 57 years old and represents 30.5 million gallons per day of water supply into the heart of Tucson. We selected the Smartball technology for leak detection because it is the simplest least intrusive leak

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detection tool to insert into a large diameter pipeline because of the use of existing ports on the pipeline and tracking capabilities. Additionally, a detailed GPS map was created to add to the Tucson Water GIS system.

Transmission Main					
Age of Pipe	**Pipe Size**	**Pipe Material**	**Miles of Pipe**	**Pipe Anomalies**	**Total Leaks**
57	42	C-303 CCP	8.9	2	0
Notes:	The two anomalies were excavated & inspected, a direct assessment performed, the acoustic event was noise located on the pipe lateral at a noisy valve. No leaks were found.				

The portion of the pipeline inspected for this assessment began at Station 42+41 near the intersection of Sandario Road and Ajo Highway in the West and ended at Station 860+06 near the Martin Reservoir in the East. An approximate aerial view of the inspection limits is provided in Figure 2.1.

Figure 2.1: Approximate aerial view of the inspection limits of the 42-inch Avra Valley Transmission Main

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Tasks 6: Monitoring

Tucson Water completed the contractual obligation by providing ADWR with annual progress reports and individual reports outlined in Tasks 1-5. *Note: all annual reports were submitted and approved by ADWR*. Each task identified the number of miles of pipe tested, number of leaks identified with estimated water loss, and a copy of the asset management work order numbers. To date all work orders (leaks) have been completed.

Tasks 7: Final Report

During the initial ADWR Grant application and deciding on a scope of work, Tucson Water proactively and systematically identified opportunities to reduce non-revenue water and improve our return on investment. Our goal was to reduce system loss from 9% to 4% annually. Quantifying all the data for this project was a huge success! The data reveals the following information:

- 192 Leaks detected, if left unresolved, the amount of water lost equates to 63,413,640 gallons annually.
- One-acre feet of water contains 325,851 gallons of water.
- 63,413,640 gallons of water equates to 194.6-acre feet of water.

Unfortunately, at the current state of water loss, we have not reached the desired 4% water loss goal. Our water loss analysis is 8.25%. However, due to this grant and years of building a foundation for managing our losses, Tucson Water is in a better position to capture losses with the adjusted procedures.

Project successes, lessons learned, and challenges for future leak detection projects.

Tucson Water encountered numerous successes during the leak detection process that included the total number of leaks identified which in turn equaled the same number of repairs or replacements. Within our standard operating guidelines, we used the AWWA M36 industry standard for addressing water loss. We were in a reactive state of addressing water loss to a now proactive approach. We utilize acoustic monitoring technology that is non-invasive and

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provides real-time data on pipelines. While performing leak detection testing, water losses are documented and calculated each day and added to overall losses. The leak detection data is aiding our Artificial Intelligence (AI) VODA and Asset Management (or Maintenance Management) programs by adding the data into the system. For example, an AI analysis was performed within the distribution system and areas of criticality were identified. Those areas were relayed to the Condition Assessment Program (CAP) team for review. The CAP team was able to add to these areas and rearrange criticality based on the current leak activity.

The Condition Assessment Program team continues to perform leak detection on our entire network of water infrastructure with an emphasis on the distribution mains. Tucson Water is proud to share the success of the annual water loss program by progressing forward in a positive direction. Ensuring consistency with data is an active challenge and we will continue to use technology as a tool for data driven analysis by using companies with new proven testing methods of performing leak detection or infrastructure renewal.

Thank you for your continued support and patience as we perfect our program.

If you have any questions, please contact me at [redacted]

Sincerely,

Jose Pico

Jose Pico,
Tucson Water
Condition Assessment Program (CAP)

cc: John Van Winkle, P.E. Chief Engineer Rev 03/29/2024

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