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LOOKING IN HARD TO REACH PLACES – SAN JOSE-SANTA CLARA REGIONAL WASTEWATER FACILITY YARD PIPING CONDITION ASSESSMENTS

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ABSTRACT: The San Jose-Santa Clara Regional Wastewater Facility (RWF) has 67,000 linear feet of wastewater process piping that carry raw sewage, liquids, and sludge between the various unit treatment process areas. Much of the process piping at the RWF has remained in service continuously over the years without interruption, with 70 percent being over 25 years old and greater than 10 percent over 50 years old. In June of 2015, Black & Veatch collaborated with the City of San Jose to develop a risk-based framework that prioritized various process piping condition assessment work and developed guidelines for conducting the condition assessments. Since then, V&A Consulting Engineers has evaluated 25 percent of the wastewater process piping, obtaining physical condition data to support Black & Veatch's rehabilitation prioritization and design efforts. This paper will present lessons learned to date, which include:

1. Benefits of adopted condition assessment protocols for prioritization and design
2. Benefits of a pipe specific inspection approach – various materials of construction and ranging in diameter up to 144 inches
3. Benefits of leveraging operational/shutdown conditions of other projects

INTRODUCTION

The San Jose-Santa Clara Regional Wastewater Facility (RWF) has approximately 67,000 linear feet of process pipes that carry gas, liquids, sludge, air, steam, and other process streams to and from the various treatment areas of the 200 million gallon per day facility. Much of this process piping has remained in service continuously without interruption since installation, with 70 percent over 25 years old and greater than 10 percent over 50 years old. Based on a 2015 desktop study of RWF process pipes, 16 pipe systems, totaling 21,000 linear feet, were identified as high priority or at high risk of failure.

In 2018, the City of San Jose retained Black & Veatch for the Yard Piping Improvements Project (Project), with V&A Consulting Engineers (V&A) as a sub-contractor to systematically assess all buried process pipes 8 inches to 144 inches at the RWF, which equates to approximately 60,000 linear feet of piping. The RWF yard piping is shown in Figure 1. Pipes at the RWF are comprised of many materials, but are primarily made of either reinforced concrete, ductile iron, or welded steel. The focus of the multi-year Project is to repair, rehabilitate, or replace (R/R/R) pipes, or portions of pipes, that are highest priority based upon criticality and/or observed physical condition. Buried process piping installed in the 1950s and 1960s have exceeded their design life and due to the potential for failure, through this project the City is increasing operational reliability and mitigating the likelihood of failure of their existing buried linear assets.

Figure 1: RWF Yard Piping Map

CONDITION ASSESSMENT PLANNING

In June 2015, Black & Veatch collaborated with the City of San Jose to develop a risk-based framework that prioritized condition assessments and developed guidelines for conducting them based on the various materials of construction and diameter range. Black & Veatch developed a condition assessment plan that provided a prioritized list of critical pipes for inspection, inspection protocol recommendations, and end of life estimates. The plan used weighted risk factors to determine the likelihood of failure and consequence of failure for each assessed pipe. Depending upon identified pipe risk, inspection protocols and desired levels of inspection detail were determined for each pipeline. The final report produced in 2015 has served as the technical basis for the current Yard Piping Improvements project, and the recommendations provided in that initial report have largely been followed. Pipelines assessed to date are presented in Figure 2.

Following each inspection, Black & Veatch reviews the resultant condition data and makes R/R/R recommendations based on the findings. The Project follows an annual cyclical schedule in which pipes are 1) inspected during the regional dry-weather season; 2) design work based upon these inspections occurs during the wet weather season; and 3) R/R/R construction proceeds in the next dry-weather season. There is a separate service order for each year's pipe rehabilitation design, and a design-bid-build (DBB) project model is followed for each service order. Approximately 1,700 linear feet of the 36,000 linear feet inspected to date was identified during inspections to have severe deficiencies requiring R/R/R. These identified pipe segments have since been rehabilitated.

Figure 2: Yard Piping Assessed to Date

V&A prepared and submitted a condition assessment plan to the City for review prior to the field work. The condition assessment plan described the roles and responsibilities of key team members, safety procedures, schedule, required access, level of City's participation, and approach for conducting the work. Plans were developed to collect the highest resolution data while executing field work in the safest manner possible and with the least impact to operations. Black & Veatch completed the City's Process Shutdown Requests (PSRs) according to the City's forms and protocols. The PSRs had details regarding the purpose of condition assessment, areas of work, and activities necessary to accommodate the condition assessment. Shutdowns require collaboration with all facility stakeholders and each inspection had a PSR submitted for City review, allowing solicitation of critical feedback to successfully execute the inspection. Planned RWF shutdowns for repair and maintenance activities and already installed temporary bypass piping were leveraged to execute onsite activities, most effectively utilizing City resources. Adequate rescue services, confined space access, and all confined space equipment needed were available for onsite activities and debriefing sessions were held with the RWF's Industrial Safety Officer. An example excerpt from a condition assessment plan is shown in Figure 3.

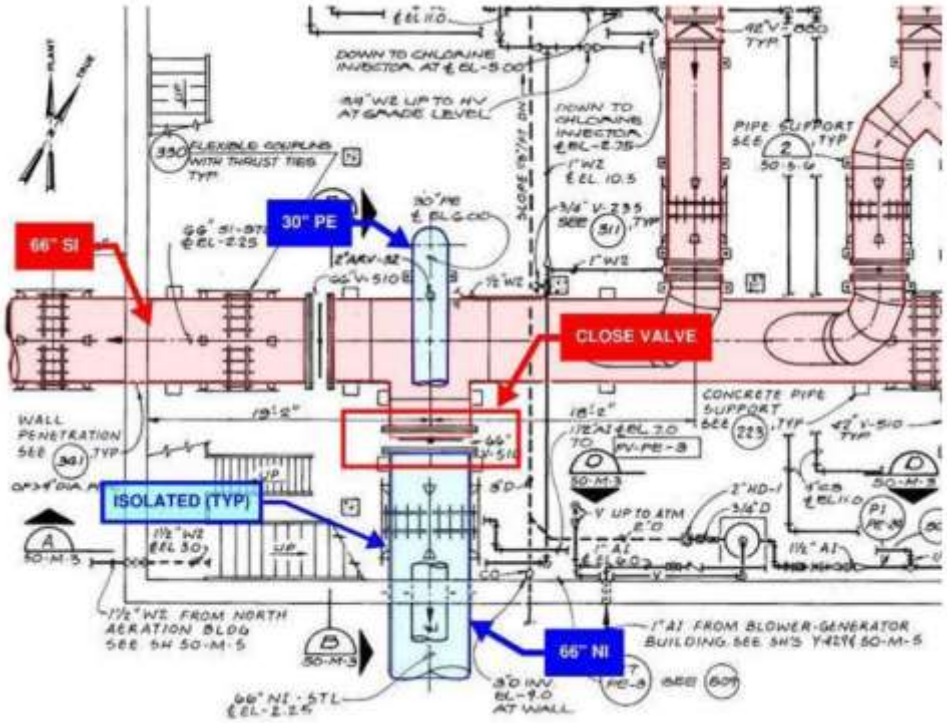

Figure 3: Example Isolation Plan

FIELD INVESTIGATIONS

The objective of the process piping condition assessments for this project was to obtain comprehensive, yet direct condition data to support rehabilitation design decisions. This can be a challenging task for buried process pipelines at a wastewater treatment plant. Since process pipes at the RWF are generally buried and cannot be taken out of service without disruptions to treatment operations, it is inherently difficult to assess their condition. These assessments typically involve a process shut-down, pipeline isolation, pipeline draining and dewatering, flow bypassing, potholing or excavation.

In order to achieve this, the team reviewed the existing as-builts to determine pipe material, size, alignment characteristics, and access. Then the team discussed operational constraints with the RWF. Armed with this background information, the team was able to plan for process shut-downs, where possible, as well as take advantage of opportunities, where certain pipelines or processes were planned to be taken out of service for maintenance or rehabilitation, either directly or indirectly (part of entire another process shut-down, etc.).

Physical entry, which allowed a comprehensive set of data to be obtained was usually a first choice, but major considerations for personnel safety and operational constraints also had to be considered. Performing a physical entry assessment typically allows a thorough visual investigation to be performed along with the ability to obtain complementary data such as concrete surface testing, reinforcing steel scans, concrete core sampling, ultrasonic or broadband electromagnetic metal wall thickness testing, and dimensional measurements.

Where the pipelines could not be taken out of service or dewatered, the team considered multi-sensor inspection (MSI) platforms outfitted with various sensors and a high-definition camera for condition assessment. For pipes less than 24 inches in diameter, options are more limited. Traditional closed-circuit television video (CCTV) and potholing was used to obtain condition data on these smaller pipes. Metal wall thickness testing was performed in the potholes. From a programmatic standpoint, attempts were made to try and capture consistent data per pipe type, if possible. Table 1 shows the methods that were used to assess the pipes at the RWF from the last three years (2018 – 2020).

Table 1: Yard Piping Assessment Methods

Process Pipe	Yard Piping Assessment Completed from 2018 – 2020						
	Pipe Material	Year Assessed	Confined Space Entry (1)	Potholing (2)	MSI: Crawler (3)	MSI: Sub (4)	Traditional CCTV (5)
87” x 136” SES	RCP	2018	X				
96” SES	RCP	2018	X				
24” RAS (A-Side)	DIP	2018					X
78” PE	RCP	2018	X				
96” PE	RCP	2018	X				
84” PE	RCP	2018	X				
60” EBSR	RCP	2018	X				
66” & 84” SE	RCP	2019	X				
54” RAS	CMLS	2019	X				
24” RAS (B-Side)	DIP	2019					X
42” ML	CMLS	2019					X
77” x 121” PLE	RCP	2019				X	
84” PLE	RCP	2019				X	
8” & 10” BS	CIP	2020		X			X
42” ML	Varies	2020	X				
11’x11’ NE	RCP	2020				X	
84” & 102” NI	RCP	2020	X		X		
77” x 121” SE	RCP	2020				X	
87” x 136” SES	RCP	2018	X				X
96” SES	RCP	2018	X				

(1) Confined space entry allowed visual investigation, concrete surface testing, reinforcing steel scanning, concrete core sampling, ultrasonic testing, and dimensional measurements to be performed.

(2) Potholing allowed visual investigation of pipe exterior and metal wall thickness testing using ultrasonic testing and broadband electromagnetic scanning. CCTV and hydro-flushing was also performed on the interior.

(3) MSI crawler platform was outfitted with video camera and LIDAR and sonar sensors, which allowed video and dimensional measurements.

(4) MSI submersible platform was outfitted with video camera and sonar sensors, which allowed limited video and dimensional measurements.

(5) Traditional CCTV crawler camera. Hydro-flushing was performed prior to remove loose material from pipe surface.

LESSONS LEARNED FROM FIELD INVESTIGATIONS

It was critical that RWF O&M was involved early and often. This allowed the team to communicate the shut-down, flow control, and access requirements, and adjust plans as necessary. The process was iterative to ensure that the best opportunity to obtain direct data could be achieved.

In one instance, the assessment plan for the 11x11-foot nitrification effluent (NE) pipeline had to be revised from using a floating platform MSI inspection to a submersible platform MSI inspection. This was due to the realization, after considerable deliberation, that the water levels in the NE pipeline could not be drawn down enough to allow clearance in the headspace of the pipeline for the floating platform throughout most of the 3,200 feet alignment. The original intent was to draw down the wet well levels at FIPS and use a floating MSI platform equipped with a high-definition camera, sonar, and Lidar. This method was preferred because the targeted condition data was crown corrosion, which has been the most prevalent and detrimental form of corrosion on reinforced concrete pipe (actually reinforced concrete box structure) observed at the RWF thus far.

The fall back plan was to use a submersible ROV with video and sonar sensors. While the submersible platform's video camera can be somewhat limited in an immersed environment, the water clarity was not a complete hindrance to obtaining visual data along the crown of the pipeline. The imaging and profiling sonar sensors provided additional condition information that allowed the team to discern that the pipeline was generally in good condition with no apparent major defects and evidence of crown corrosion.

Working closely with O&M also allowed the team to assess the 84-inch diameter RCP nitrification influent (NI) pipeline. This pipeline, which conveys primary effluent 2,800 feet from the Primary Effluent Pump Station to the nitrification clarifiers, has never been dewatered or assessed during its 40 years of service. Challenges for assessing this pipeline included a limited shut-down window and the need to dewater approximately 1 million gallons of primary effluent remaining in the pipeline. The shut-down window was limited to 48 hours to keep the biological components of the treatment process alive. Given this window, the team put together a dewatering and assessment plan including an hour-by-hour breakdown of tasks from the start of the shut-down. This allowed the team to employ the full suite of assessment methods including physical entry, concrete surface testing, concrete core sampling, and an MSI crawler equipped with video, sonar, and lidar on to obtain condition data on the majority of this critical pipeline.

Since physical entry was only able to be performed on 1,400 feet of the alignment, it was helpful to be able to capture MSI inspection data on the remainder of the alignment. Data from the physical entry assessment allowed the team to validate the MSI results and confidently extrapolate conditions to the rest of the alignment.

DATA DRIVEN SCHEDULE AND DESIGN FOR SUCCESSFUL CONSTRUCTION

Condition assessment data to support Black & Veatch's design and quantified the rehabilitation scope. Each inspection uses a pipeline specific approach to obtain physical condition data to support Black & Veatch's rehabilitation prioritization and design efforts. Cured-in-place pipe (CIPP), partial depth concrete crown repair (PDCCR), and concrete crown repair were selected to repair identified damage. Condition assessment results also helped Black & Veatch to reprioritize pipe rehabilitation. The 84-inch and 102-inch concrete pipelines were reassigned from moderate to severe risk due to severe condition based on condition assessment results.

The condition assessment in 2018 discovered the 96-inch and 87x136-inch concrete pipelines were in severe condition due to crown corrosion, as seen in Photo 1 and Photo 2. Pipe failure would have disrupted facility operation, so the project team split the two pipelines into a separate project for early construction, which repairs were completed in 2020. The initial design for a corroded 96-inch concrete pipeline was CIPP yet condition data determined that the last few feet of the pipeline was corroded and CIPP would not reach the end of the pipeline. The design was revised to include PDCCR for the last ten feet of the pipeline.

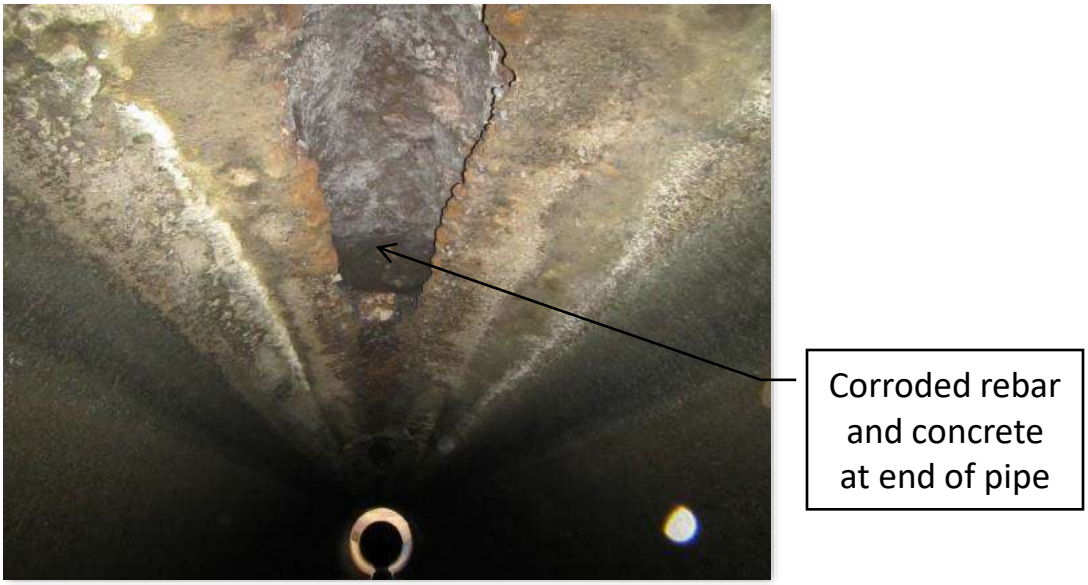

Photo 1: Severe crown corrosion at 96-inch PE pipe

Photo 2: Concrete and rebars exhibited severe corrosion for 96-inch and 87x136-inch pipelines

Condition assessment is essential to a project's success. Often project schedules and costs are affected because condition assessment did not occur prior to construction. For instance, the City upgraded an existing pipe junction structure connecting the 78-inch and 96-inch concrete pipelines at the RWF and assumed existing pipelines were still functioning; however, when the structure was accessed for construction, the City found the 78-inch pipeline had severe corrosion which resulted in project delay to design and rehabilitate the pipeline. Uncertainties can be avoided if condition assessment can be conducted before construction activities.

DATA TRENDS AND NEXT STEPS

Assessed pipelines were primarily in good condition with localized damage identified. Figure 4 shows the condition scored to date. Trends were not identified between pipe material type and documented damage. Primarily concrete type pipe has been inspected yet was primarily in good condition indicating minimal headspaces within the lines. The Settled Sewage piplines exhibited progressive damage compared to the other pipelines assessed which can be attributed to identified headspaces and the corrosive internal atmosphere. Trends were not identified between pipeline age and documented damage. Some of the oldest pipelines installed within the facility were evaluated and found to be in similar condition to pipelines installed during the 1980s and earlier. Process stream appeared to be the main correlator for potential damage.

To date, approximately 36,000 linear feet of process piping has been inspected and 1,700 linear feet was found to be defective and required rehabilitation. Continued inspections are planned for 2021 to evaluate more critical pipelines such as the Raw Sewage pipelines into the RWF. Other project shutdowns will again be leveraged to effectively investigate the yard piping.

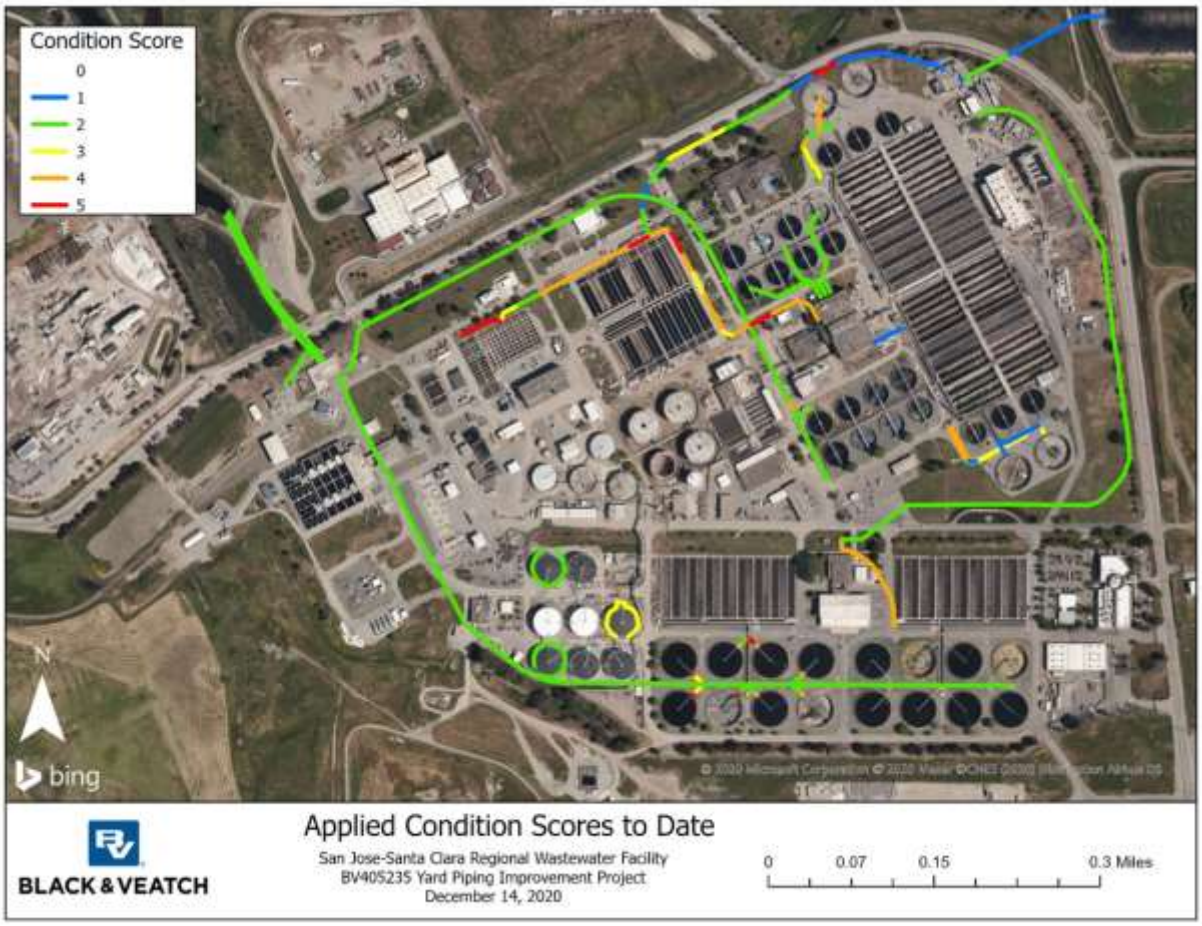

Figure 4: Assessed Condition to Date

REFERENCES (in alphabetical order)

Original work; no references to list.