CASE STUDY

Storm Drain Investigation

Uncovering an unknown underground asset through confined space manned entry.

Authors: Arno Leskinen, PE | Susanna Mabery

Introduction

Understanding the location of underground utilities is an important pre-design step on a project prior to excavation during construction. Obtaining accurate information on the utilities, in the form of as-builts, can save both time and money during the construction process. Unfortunately, accurate data is not always available, which can increase the risk to the project as well as cost and schedule overruns.

The City of Phoenix (City) is implementing a series of major infrastructure improvements located in Pressure Zones 3D and 4A to move water from the Salt River Project (SRP) system northward to the Central Arizona Project (CAP) service area. These improvements will help to reliably deliver water to the northern parts of the City during periods of drought and during times when the availability of CAP water is reduced.

The City selected Dibble to design these improvements, which include replacing approximately 2.5 miles of an existing 36-inch water transmission main (WTM) with a new 42-inch WTM along 35th Avenue from Thunderbird Road to Grovers Avenue, also known as Segment 3. The new WTM will provide increased capacity and eliminate flow restrictions caused by the existing 36-inch WTM.

35th Avenue excavation

During the utility evaluation for the alignment selection of the new pipeline, the Dibble team discovered that the preferred alignment would be in very close proximity to a large-diameter storm drain, for approximately one mile, between Acoma Drive and Paradise Lane. To minimize risk during construction, Dibble needed the dimensions and alignment of this storm drain to accurately detail the infrastructure on the construction documents.

Dibble and the City searched records for as-built documentation of the storm drain. The team found records for both the upstream and downstream locations, but unfortunately, the search for prior documentation of the one-mile segment was unsuccessful. Secondary sources indicated that the storm drain did not follow standard design practice and had multiple directional changes along the one-mile alignment.

Dibble explored options to determine the dimensions and alignment of the underground asset. Each option was considered based on the applicability to the project and cost:

- Ground Penetrating Radar (GPR) – Uses radar pulses to image the subsurface and is typically used on a small section. This method was not practical due to the length of pipe, high cost, and disruption to traffic, as the technician would have to move slowly along the length of the alignment.
- Sonde Float Balls – Uses magnetic locating balls inserted into a storm drain filled with water and a technician to follow the locating balls on the surface with a rod. This method was not practical for 2.5 miles of pipeline length with

traffic. It also requires a significant amount of water to fill a large-diameter drain and is not a sustainable use of scarce resources.

- 3D Scanning – Uses laser scanning technology to detect the storm drain. This method was most practical, but was too expensive and not realistic for the length of pipe.

After considering the options, Dibble proposed a manned entry field survey to the City as the most cost-effective solution to document the storm drain. Dibble's survey team would gather the information needed by entering the storm drain with a robotic total station. Dibble also proposed a concurrent manned entry, in conjunction with the survey, for a visual structural inspection to assess the condition of the storm drain. This was offered as a value-added service for the City to identify any needed maintenance or repairs, as the City was not aware of the storm drain's present condition.

Method

Dibble's survey team determined the horizontal and vertical alignment of the storm drain during the manned entry. They intended to locate the storm drain inverts every 100 feet for the approximate one-mile length of the storm drain pipe using the total robotic station. Control would be set at each manhole location.

For the manned entry visual condition assessment, Dibble's structural engineering team would mark field stationing on the pipe walls with white paint in 25-foot increments to use as a reference during the condition assessment. The structural team would perform the investigation using both visual and non-destructive physical probing to determine the integrity of the existing concrete. The team would document the observed defects using digital photographs and video recording. The defects would be noted based on a "clock position" for ease of future reference. The team would then provide a technical memorandum to the City identifying preliminary recommendations for repairs, as necessary.

Due to the complexity of performing a manned entry in a confined space, each team member associated with entry into the storm drain needed Occupational Safety and Health Administration (OSHA) compliance training for confined space entry. A subconsultant, American Rescue Concepts (ARC), was used during the survey and structural assessment to provide stand-by rescue and emergency extraction services while the Dibble team was working within the storm drain. It was assumed the manned entry of the storm drain would take three 10-hour days.

Plan of Action

Manned entry into confined spaces like manholes and storm drain is not an easy task to undertake. It is possible to encounter hazards once in the confined area, such as poor air quality, or in this case, flooding. During the planning of the entry, Dibble's flood control practice performed a study of possible sources of flow into the storm drain and determined that the flows, if any, would come from inlets in the roadway as opposed to any large-volume retention basins. Therefore, the risk of flash flooding during entry was minimized.

Survey team ready for storm drain entry

The team that entered the storm drain was kept to a minimum to reduce safety hazards. ARC was on site daily to assist the team with any safety concerns and conducted a routine safety meeting each morning prior to entering the storm drain. As a valued subconsultant, ARC provided peace of mind for the team, controlled the safety aspects, and allowed the survey and structural assessment teams the ability to focus on the task at hand.

The team wore air quality monitors to ensure there was no exposure to harmful gases once inside the storm drain.

The survey and structural assessment stations started at the manhole, located at the Hearn Road and 35th Avenue intersection, and became Sta. 0+00. The survey and assessment headed south of this station to Redfield Road and north of the station to Bell Road.

Structural team prepped for manned entry

Survey

The team initially thought only two manholes existed along the unknown alignment of the storm drain. Fortunately, this was not the case, and the survey team was able to locate manholes approximately every 500 to 600 feet. The survey team was concerned with the level of accuracy to maintain the survey data once inside the closed space, but a plan to establish a good control was crafted prior to entry.

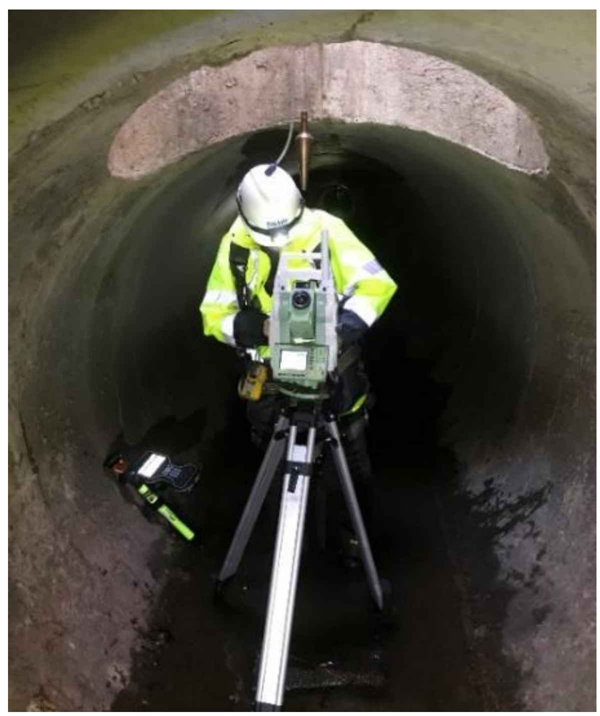
Establishing control for the survey was critical to the success of the project and crucial to obtaining accuracy for layout points of the storm drain. Setting the control inside the storm drain presented a challenge, as it is not possible to shoot straight down into a manhole to get the northing, easting, and elevation to set a control point. After brainstorming options, the survey team came up with the idea to take the northing, easting, and elevation of every manhole centerline and subtract the known invert elevation of the manhole to establish the control coordinates for the survey.

Once inside the storm drain, the robotic total station was set up and centered under a plumb bob, which was hung down from the ground-level manhole opening. This process was established at every manhole location along the alignment to provide checkpoints within the survey to verify accuracy. A hopscotch process between manholes was also used to overlap the data points for redundancy, and to increase the overall survey data accuracy.

Using the robotic total station enabled only a single member of the survey team to be inside the storm drain. After the total station positioning was established, distance and angle measurements were taken to the points the surveyor established with the prism on the field rod using Bluetooth technology on the robotic total station. The total number of miles traveled within the storm drain during the survey was significant, due to the repositioning of the total station and the field rod.

Structural

The structural team planned to document the existing conditions of the storm drain to provide the City with information about the remaining service life of the storm drain and required maintenance. During the manned entry, the team assigned the observed defects with deficiency rating similar to FHWA-NHI-16-039 and FHWA-NHI-130055 standards.



Robotic total station storm drain set-up

The team compiled defect location plans to document the layout of the pipe reach and provide color coding to link the defect coding to the station reports. These plans aided in the assessment, helped uncover why defects occurred at certain locations, and helped provide recommendations and repair costs for improvement. To provide a useful tool for the City to use for integration into their maintenance program, the team also created interactive diagrams.

Storm drain with reference stations and inlet pipes

Manned Entry Discoveries

The survey and structural team uncovered many interesting details within the storm drain. Most of the pipeline was straight, but at the Greenway Road intersection the pipeline varied greatly in direction. The data obtained at this location, due to the variance in the storm drain, added valuable details to the construction documentation.

The structural team did not discover a significant number of deficiencies within the pipeline. However, the storm drain revealed many interesting conditions; for example, the team found multiple protruding pipes into the storm drain, as well as a few sewer laterals running through. The structural assessment documented the location of these sewers to allow the City to track for future rehabilitation or maintenance efforts.


Sewer lateral spanning storm drain

Conclusion

This type of survey and condition assessment of the storm drain through manned entry is unique and is not often done due to the complexities of the confined space entry. After two grueling days immersed in the storm drain, the teams completed the survey and structural inspection.

The survey method proved to be very effective and helped to accurately locate the storm drain on the construction documents for the WTM replacement. Accuracy of the survey was very good, with data points only varying within 2 inches.

The structural assessment confirmed the location and condition of the storm drain and will allow the City to integrate the documented deficiencies into their maintenance program.

Exhausted survey team member, post manned entry

DIBBLE