Executive Summary

The focus on condition assessment of gravity wastewater collection systems (sewers) continues to broaden. Traditionally, the main focus of condition assessment of sewers has been directed at operational issues related to the collection and conveyance of flows to a facility for treatment and disposal. To address operational issues, attention has tended to concentrate on maintenance activities associated with the cleaning and removal of debris and foreign materials from collection system pipes. The combination of debris and extraneous wet-weather induced flows can result in less than desired levels of customer service and possibly cause raw sewage to overflow from the collection system or to result in basement backups.

Cleaning and inspecting sewer pipes is essential for utilities to operate and maintain a properly functioning system and minimize SSOs. The routine maintenance of a sewer system often includes sewer system cleaning, root removal/treatment, and cleaning/clearing of sewer mainline blockages. However, understanding where and when to perform cleaning activities in the most effective manner is not necessarily a straight forward task. In an attempt to direct maintenance staff and cleaning equipment to those pipes in a sewer system that require attention, some agencies identify cleaning needs by conducting inspection of the sewers prior to cleaning. Rapid assessment approaches and tools provide an avenue to significant pre-cleaning inspection cost savings that could be achieved through reduced inspection and non-productive cleaning costs.

The overall objective of this EPA funded study was to demonstrate a recently developed innovative acoustic-based sewer line assessment technology that is designed for rapid deployment using portable equipment. This technology can provide a rapid assessment of the need for pipe cleaning and an overall pipe-condition assessment. Acoustic technologies require a minimal amount of equipment when compared to closed-circuit television (CCTV) inspection systems. These acoustic based technologies have the potential to provide information in a matter of minutes to assist a utility in determining whether a sewer pipe might be partially or fully blocked and require cleaning or renewal.

Innovative inspection approaches are now emerging that take advantage of the advances in newly available observation and detection technologies and deployment strategies, such as acoustic- (sonic, ultrasonic) and light- (laser, infrared) based devices that have not traditionally been applied to sewer system investigation. These technologies are designed for rapid deployment using portable equipment and do not necessarily require a robotic transporter in order to capture data for the entire length of the pipe. The deployment of these non-traditional technologies, supported by emerging digital, modular, and robotics technologies has the potential to greatly expand the “reach” of sewer system inspection techniques, while reducing the overall cost of sewer inspections.

One commercially available line of emerging technology for the rapid assessment of gravity sewer lines is acoustic-based technology for sewer inspection. Acoustic energy naturally follows a pipe’s curvature. Obstructions within the pipe will cause a portion of the acoustic energy to be reflected and absorbed. In addition, unless the obstruction is significantly dense, a portion of the acoustic energy also passes through. These inherent physical properties of acoustics within pipes

provide the mechanisms for evaluating a pipe's condition. Based on these mechanisms, acoustic inspection technology may be capable of quickly evaluating the presence of blockages, features, and defects in the interior of sewer pipes and provide informed decisions relating to the need for cleaning or further inspection using other available technologies.

The SewerBatt is a portable, battery-operated, acoustic sewer inspection tool that consists of an acoustic sensor head that is mounted on a pole (similar to a pole-mounted camera device) which is lowered into the manhole and inserted into the pipe being inspected. The sensor head contains a sound source (speaker) that transmits an acoustic excitation signal into the pipe. Simultaneously, the acoustic signal response from the pip is captured by an array of microphones that are also contained in the sensor head. The captured signal responses, along with the user inputs related to the pipe section being inspected, are used to assess the pipe condition.

After the device is inserted into the pipe and the user inputs are completed, the user can click on the "run" button to run an inspection test. Typically, the signal transmission and response recording process is completed in less than a minute. Features (such as lateral connections and the pipe end) and defects (such as broken pipes and sedimentation) affect the acoustic excitation signal either by reflecting a part of it back to the SewerBatt sensor, or by absorbing the sound energy. These pipe segment features (or defects) are presented as "bumps" in the acoustic signal response plots. By comparing these response bumps recorded with a library of known signal responses, the system provides an assessment. For rapid assessment, an automated condition assessment module that reviews the acoustic signal response, makes allowance for the energy loss from the pipe-ends and lateral connections, and then grades the pipe. The final pipe condition or grading is simply in the form of a colored traffic light indicator providing a red, amber (yellow), or green (RAG) grade. A red grade assessment indicates the need for further inspection or cleaning. An amber grade assessment is cautionary, indicating that there may be some blockage issues, but not sufficient to block the flow. A green assessment indicates the pipe is free of any significant blockages and no further evaluations are necessary.

MSDGC is responsible for the operation and maintenance of over 3,000 miles of sewer, with approximately 600 miles of those sewers being "off-road." These off-road sewers are typically inspected every 8 – 10 years and are difficult to access, and expensive to inspect. In addition to these "off-road" sewers, MSDGC also inspects and cleans on-road sewers on a proactive basis. For the purposes of this study, the following three Greater Cincinnati-area locations were identified and selected for this demonstration:

- Hunt Road – off-road sewers (see Appendix B for a detailed figure)
- Galia Drive – off-road sewers (see Appendix B for a detailed figure)
- Greenhills – on-road sewers (see Appendix B for a detailed figure)

These locations include a range of pipe sizes and a variety of pipe materials and were scheduled for cleaning and inspection during the study year. The selected study areas have sewer pipes ranging from 6- to 12-inch diameters. The SewerBatt system deployed in this evaluation is designed to work optimally in this pipe size range. For optimal evaluation of larger diameter pipes, the acoustic unit would require retrofitting with larger sized and more powerful electronic hardware coupled with adjustments to the algorithm software.

A project-specific EPA required Quality Assurance Project Plan (QAPP) was developed and implemented by the project team. Each sewer pipe-segment was to be examined and assessed using selected acoustic methods, pole mounted camera, and CCTV prior to cleaning. If cleaning was considered necessary based on the inspections, the sewer segments were to be cleaned, examined, and assessed again after cleaning. Per the project's QAPP, the following strategy was specified for conducting the inspections. Sewer line branches were to be inspected by starting at the furthest downstream pipe segment, with the inspection regime systematically conducted to the furthest upstream pipe segment. This procedure was specified to ensure that if any material (or debris) was dislodged during testing, the material would flow downstream and not impact subsequent testing in the upstream pipe segments.

Besides providing a pipe condition and blockage assessment, the key advantage of implementing technologies such as SewerBatt is the rapid deployment feature using portable equipment that can result in significant cost savings to utilities. As mentioned previously, the Greenhills area within MSDGC was selected to evaluate the time it takes to conduct an acoustic assessment campaign using SewerBatt. As the goal of this study area was to evaluate the time required to perform the acoustic inspections, advanced planning and preparation was conducted to help mitigate issues associated with traffic control and location of manholes. This sub-study involved sixty-two (62) SewerBatt measurements at pipe-segments covering approximately 10,000 linear feet of pipe in the Greenhills study area with pipe sizes of 8" and 10" diameters.

The emergence of acoustic sewer inspection technologies (e.g., SewerBatt) as rapid deployment, low-cost, reliable, pre-cleaning assessment tools is focusing growing attention on the potential for more cost-effective sewer cleaning programs. Through the ease of deployment, reduction of cost, increases in reliability of these inspection approaches, combined with the potential for reducing the "cleaning of clean pipes," significant cost savings are attainable. As utilities apply these new inspection technologies, they can move towards implementing sewer cleaning programs that consist of planned directed and quick response cleaning. Also, these cost savings can be realized while improving collection system performance and achieving the protection of public health and water quality.

The results of this demonstration project reveal the potential for more cost-effective sewer cleaning programs. The site specific pre-cleaning assessment inspection costs resulting from this project and MSDGC's historic practices for CCTV (on-road), CCTV (off-road), and SewerBatt (on- and off-road) are $1.68/ft., $2.03/ft., and $0.13/ft., respectively. Thus, for pre-cleaning assessment, the application of the SewerBatt can reduce MSDGC's costs by $1.55/ft. for on-road sewers and $1.90/ft. for off-road sewers. In addition, by moving to a sewer cleaning program predominated by planned directed cleaning, MSDGC can save $2.00/ft. by reducing its "cleaning of clean pipe." In total, when costs of conventional CCTV inspection and cleaning are combined, for each pipe segment that is deemed "clean" using the SewerBatt, MSDGC can save $3.55/ft. for on-road sewers and $3.90/ft. for off-road sewers.

The results of this demonstration of the SewerBatt show promise for its application as a tool for cost-effective, pre-cleaning assessment, post-cleaning quality assurance and quick condition assessment screening. The application of the SewerBatt in an overall collection system O&M program should enable wastewater utilities to optimize their sewer cleaning efforts and free up valuable resources to more effectively implement critical CMOM and asset management programs. Also, with further development, SewerBatt has the potential to provide a very useful sewer defect identification and location capability.