

**Exhibit A**

**Scope of Services**  
**for**  
**Flow Monitoring Program**  
**2016 Flow Monitoring**  
**City of Lawrence, Kansas**

**Intent and Purpose**

*The City of Lawrence has adopted a Rapid Inflow and Infiltration (I/I) Reduction Program. The objective of the Rapid I/I Program is an overall 35% reduction of I/I within the project area.*

*This flow and rainfall monitoring and related data analysis project will be conducted to supplement the Rapid I/I Program. Temporary (90 days), long term (167 days), and permanent (366 days) flow monitoring surveillance will be conducted. Temporary flow monitoring will be conducted at 24 locations for 90 days (Approximately from 3/15/2016 to 6/15/2016) at the following locations:*

- *Fourteen locations within the I/I reduction area will isolate specific sub areas*
- *Seven locations within the I/I reduction area will quantify flows from the University of Kansas*
- *Three locations within the total project area surveillance basins will analyze the capacity of a particular area initially designed for ultimate development on the West side of town*

*Permanent flow monitoring will be conducted at one locations for 366 days (Approximately from 1/1/2016 to 12/31/2016) and four locations for 167 days (Approximately from 1/1/2016 to 6/15/2016) at the following locations:*

- *One location within the I/I reduction area will monitor a pump station overflow (366 days)*
- *Four locations within the I/I reduction area will provide total project area surveillance (167 days)*

*Permanent rainfall monitoring will be conducted at five rain gauge locations for 366 days (Approximately from 1/1/2016 to 12/31/2016) at the following locations:*

- *Kaw Water Treatment Plant, Stratford Water Tower, Pump Station #44, Pump Station #9, and Pump Station #5*

*The data will be manually downloaded bi-weekly during the 90 day period for all meters, including the four long term flow meters, one permanent flow meter and five permanent rain gauges. Outside of this period, the long term and permanent meters and rain gauges will be downloaded monthly for the remainder of their respective monitoring periods. Letter reporting will be conducted on a quarterly basis as a Quality Control report which will include equipment servicing records, performance summaries, and adjustments made. In addition, the characteristics of storm events that occurred during the reporting period will be described and a comparison to 2015 and 2014 data sets will be evaluated.*

*Two final data reports will be developed following the culmination of the temporary and permanent flow monitoring sessions that will summarize the data collected. Each report will include yearly comparisons, site descriptions, site maps, surcharge summaries, overflow summaries, rainfall summaries, scattergraphs, hydrographs, and site setup sheets.*

## **Task A – Project Management**

1. **Administration.** Administration will include scheduling, invoicing and resource allocation of personnel and equipment.
2. **Kickoff Meeting.** A kickoff meeting will be held with CITY personnel to discuss the scope, flow monitoring sites, schedule, and coordination of the project.
3. **Project Status Meetings (2 Meetings).** Project status meetings will be held with City personnel to discuss the progress of data collection and other project items. The meetings will include site data reviews, quality control report reviews, data analysis reviews and general progress of the project.

## **Task B – 2016 Flow Monitoring Site Plan (7 Metering Sites)**

1. **Preliminary Site Visits and Planning.** It is anticipated that monitoring will occur at all of the same I/I reduction area isolation locations and most previously monitored KU flow quantification sites. However, seven new monitoring sites will be added to the monitoring plan in order to break up one of the I/I reduction basins further (4 sites) and to perform a capacity analysis of an area designed for ultimate expansion in West Lawrence (3 sites). Preliminary site visits will be conducted to develop a metering plan and to determine the appropriate monitoring equipment and setup for each site. If a proposed location is not considered suitable, CONSULTANT will investigate and recommend alternate locations. At sites determined to be candidates for flow monitoring, site data will be collected. This will include manhole depth and pipe diameter measurements, notations of manhole surcharge evidence and a measurement of depth and velocity of the flow stream. In addition, schematics and pictures of the manholes' "in" and "out" piping will be made.
2. **Flow Monitoring Plan Report.** Following the site investigations, CONSULTANT will prepare a monitoring plan report for the spring 2016 Flow Monitoring. The monitoring plan will include a discussion about each site that includes site issues and/or concerns and includes the recommended monitoring equipment for the site. The monitoring plan will be discussed and reviewed with the CITY prior to installation.

## **Task C – Permanent Flow Monitoring**

Permanent flow monitoring will include servicing and if necessary, removal or replacement of the flow meter. Field servicing visits will be done on a bi-weekly basis during the 90 day temporary monitoring period and on a monthly basis throughout the rest of the 366 day monitoring period. Unplanned site visits to address meter malfunctions will be performed within two days of the identification of failure. During each site visit, sensors will be cleaned to ensure proper accuracy of measurement and manual level and velocity readings will be collected to confirm calibration of the flow meter. If it is found that velocity readings are not recorded between services, then velocity profiling will be done using the Manning's "n" calculations. All services will include confined space entry to conduct the service. Throughout the monitoring period, battery voltage levels and meter desiccant conditions will be monitored and replaced as needed to ensure proper function of the flow meters.

1. **Pump Station Overflow Bypass Reporting – One Site for 366 Days.** Flow monitoring will be conducted at one pump station overflow site. The flow monitoring will be

conducted with an AV flow meter set to log data at 5-minute intervals. The site will be monitored for 366 days (1/1/2016 – 12/31/2016). Site service visits will be monthly.

- 2. Total Project Area Surveillance – Four Sites for 167 Days.** Flow monitoring will be conducted at four flow monitoring sites. The permanent flow monitoring will conclude at these sites at the end of the temporary 90 day session. The flow monitoring will be conducted with Area Velocity (AV) flow meters set to log data at 5-minute intervals. Each location will be monitored for 167 days (Approximately 1/1/2016 – 6/15/2016). Services will be made on a bi-weekly basis during the 90 day temporary monitoring period and monthly for the remaining 77 days.

#### **Task D – Temporary Flow Monitoring**

Temporary flow monitoring will include installation, servicing and removal of flow meters. Field servicing visits will be done on a bi-weekly basis for the 90 day monitoring period. Unplanned site visits to address meter malfunctions will be performed within two days of the identification of failure. During each site visit, sensors will be cleaned to ensure proper accuracy of measurement and manual level and velocity readings will be collected to confirm calibration of each flow meter. If it is found that velocity readings are not recorded between services, then velocity profiling will be done using the Manning's "n" calculations. All services will include confined space entry to conduct the service. Throughout the monitoring period, battery voltage levels and meter desiccant conditions will be monitored and replaced as needed to ensure proper function of the flow meters.

- 1. Spring 2016 – 24 Sites for 90 Days.** Temporary flow monitoring will be conducted at 24 sites for a 90 day period. Flow monitoring will provide isolation of sub-basins within the I/I reduction area at 14 locations, quantification of flows from the University of Kansas at seven locations, and capacity analysis of a particular area within the total project area surveillance basins at three locations. The flow monitoring will be conducted with Area Velocity (AV) flow meters set to log data at 5-minute intervals. Adjustments to the data will be made prior to analysis to account for level drifts and missing velocity data.

#### **Task E – Permanent Rainfall Monitoring**

Permanent rainfall monitoring will include servicing of the previously installed rain gauges. Field servicing visits will be done on a bi-weekly basis for the first 90 days and then on a monthly basis throughout the rest of the 366 day monitoring period. Unplanned site visits to address meter malfunctions will be performed within two days of the identification of failure. During each site visit, sensors will be cleaned to ensure proper accuracy of measurement. All services will include an inspection of the equipment and a manual download of the rainfall data. Throughout the monitoring period, battery voltage levels and meter desiccant conditions will be monitored and replaced as needed to ensure proper function of the rain gauges. During the initial service, CONSULTANT will be accompanied by CITY personnel in order to install CONSULTANT owned padlocks in order to gain access to the restricted sites in the services to follow.

- 1. Total Project Area Rainfall Surveillance – 5 Sites for 366 Days.** Permanent rainfall monitoring will be conducted at 5 sites for a 366 day period. The rainfall monitoring will provide rainfall monitoring coverage for the entire project area. The monitoring will be conducted with Teledyne Isco Tipping Bucket Rain Gauges that were previously installed in 2014 and 2015 set to log data at 5-minute intervals. Each location

will be monitored for 366 days (Approximately 1/1/2016 – 12/31/2016). Services will be made on a bi-weekly basis during the 90 day temporary monitoring period and monthly for the remaining 276 days.

#### **Task F – Online Data Access and Alarming**

Based on the web-based telemetry requirements established during the monitoring planning stage, telemetry equipment and software will be installed for remote data collection and provide meter alarming. This will be achieved through remote access to the CONSULTANT'S FlowLink Pro telemetry website that will enable on-site modems and Teledyne Isco 2150 meters to call in. Online data access will enable the CONSULTANT and CITY to monitor data between services and monitor reactions to rainfall events without having to service the meter.

- 1. Permanent Cell Based Telemetry and Alarming (Total Project Area Surveillance, 167 days).** Permanent cell based telemetry will be conducted for 4 sites using Teledyne Isco 2105ci remote telemetry units.
- 2. Permanent Cell Based Telemetry and Alarming (Pump Station Overflow, 366 Days).** Permanent cell based telemetry and alarming will be conducted for 1 site using a Teledyne Isco 2105ci remote telemetry unit.
- 3. Permanent Cell Based Telemetry (Rain Gauge, 366 days).** Rainfall gauges were installed by CONSULTANT field crews in 2014 and it was intended that these would call into and be hosted by the CITY's web-based telemetry site. The data was hosted by the CONSULTANT in 2015 and 2014 and in order to continue this permanent cell based telemetry hosting will be conducted for 5 rain gauge locations using Teledyne Isco 2105ci remote telemetry units.

#### **Task G - Data Adjustments.**

- 1. Data Adjustments.** Flow meter data will be adjusted based on the specific site's manual measurements review and overall data review. Adjustments will be made to correct level and velocity drift. If velocity readings are not recorded between services then a Manning's curve will be used to estimate the velocities. Flow data will be adjusted on a monthly basis and included with data submittals. Adjusted and raw flow data will be included in flow data submittals.
- 2. Mass Flow Balance.** A mass flow balance will be conducted at selected sites at the end of flow monitoring sessions. The flow balance is used to further determine the accuracy of the flow data by comparing flow site data of interconnected sites. The flow balance compares daily flows recorded. Adjustments to flow data for networks that do not balance will be weighted on the confidence level for each site.

#### **Task H – QA/QC Reporting and Data Submittals**

- 1. Quarterly Reporting.** The quarterly QA/QC report is important to verify that quality monitoring data is being collected. The QA/QC report will summarize the flow and rainfall data and discuss each site individually if applicable. The last two quarterly submittals will only contain data from the one permanent monitoring site, the pump station overflow. In which case, an overflow summary will be provided with the rainfall data similar to the first two quarterly submittals.

Site issues experienced will be noted and an evaluation of the quality of data collected will be made. The number of storm events and whether each site reacted to wet weather events will be summarized. This is important information to determine if flow monitoring data can be used to evaluate I/I reduction and beginning to establish yearly comparisons. The QA/QC report will be prepared and reviewed by an experienced engineer prior to submittal.

A summary table of the manual measurements taken in the field and the corresponding monthly level and velocity graphs will be developed and continued throughout the project. The manual measurement table will be included in all formal data submittals. This table will provide confirmation of meter accuracy and a record of meter malfunctions or down-time.

A total of four QA/QC Reports with corresponding data will be submitted during the course of the project. Each report will build upon the previously submitted report and include a running total and new totals for number of metered days. The approximate schedule of QA/QC submittals is presented below:

QA/QC Report	Data Period		Approximate Submittal
	Start	Stop	
1	1/1/2016	3/31/2016	4/20/2016
2	4/1/2016	6/30/2016	7/20/2016
3	7/1/2016	9/30/2016	10/20/2016
4	10/1/2016	12/31/2016	1/20/2016

The final QA/QC Report covering data collected during December 2016 will take the place of the Permanent Flow Monitoring Summary Report that was provided at the end of the year in 2014 and 2015.

2. **Data Submittals.** The raw and the adjusted data for the level, velocity, and flow rate will be included in all QA/QC reports provided to the CITY. The QA/QC reports and data submittals will be uploaded to the FTP site for the CITY to download.

### Task I – Data Analysis

1. **Data Analysis.** Analysis of the flow data will be conducted using methods and procedures proven to be accurate and commonly used in the industry. These methods include determination of base flow (ADDF) and infiltration, peak I/I flow calculation and I/I volumetric calculation for each significant storm event. A correlation will be established for multiple storm events that can be used to project I/I for specific storm return intervals. A correlation factor will also be calculated to provide a confidence level for the established relationship. Daily and monthly totals will be determined at each site to provide further data analysis. These totals will be used to ultimately determine the success of the repairs that have been completed in order to reduce peak flows at the wastewater treatment plant.
2. **Pre and Post-Rehabilitation Flow Data Summary.** For monitoring sites that will be evaluated for I/I reduction levels after improvements, a method for comparison will be established through meetings with the CITY. Once the method is established, pre-

rehabilitation data will be processed using this methodology. A summary of the comparison between pre and post-rehabilitation data will be provided with estimates of I/I removal levels.

3. **Capacity Analysis.** For the three monitoring sites that will be installed in West Lawrence, two meters will be placed upstream of the third; one of which is sized for ultimate development of its tributary area (42" Hobas-composite pipe). However, the other upstream and downstream meters are not designed for ultimate development. Thus, the need to perform a capacity analysis between these three meters in order to determine how much development can occur before the downstream portion of the interceptor is overloaded and when a parallel interceptor will need to be installed.

The capacity analysis will be performed by calculating ten-year design flows for each location and then performing a hydraulic grade line (HGL) analysis investigating ten pipes upstream and downstream of the meter locations down through the 24" connection point. The analysis will include a sensitivity analysis of the pipes to determine storm protection before surcharging.

#### **Task J – Flow Monitoring Reports**

Project data reports will be submitted along with corresponding flow data. The front end summary of the report will include but is not limited to:

- A listing of meter locations
- A monitoring plan figure
- A basin flow schematic with tributary acres
- General monitoring procedures and discussion of issues experienced
- Tabulation of rainfall events
- Flow adjustments resulting from mass balance checks
- A summary of sub-basin flow parameters and the evaluation of excessive I/I in each sub-basin (*optional*)
- A comparison of 2016 flow data to the 2015 and 2014 flow data results to determine reduction in I/I levels

The appendices of each report will include but are not limited to:

- Site sections with information on each site including estimated pipe capacities, evidence of downstream conditions, and the flow curve used to supplement data points with missing velocity or depth measurements
- Site sheets for each site with dimensions, pictures, and a site map accompanied by monthly flow hydrographs, depth and velocity graphs, and an overall scatter plot
- A tabulated summary of manual and recorded measurements from each site visit

1. **Draft Temporary Flow Monitoring Summary Report.** A draft temporary flow monitoring summary report will be developed for the temporary flow monitoring. The report will summarize work completed and present flow monitoring results. A review meeting will be held following the submittal of the temporary draft report in order to discuss comments from the CITY.
2. **Final Temporary Flow Monitoring Summary Report.** The final temporary flow monitoring summary report will be updated based on comments and direction provided in the review meeting. The final report and data will be submitted digitally with 2 hard copies and digital data included.

## **Task K – Optional Services**

- 1. Extend Temporary Flow Monitoring for 30 Days - Field.** Flow monitoring will be conducted at the same 24 temporary flow monitoring sites for an additional 30 days.
- 2. Extend Permanent Flow Monitoring for 30 Days - Field.** Flow monitoring will be conducted at the same 4 permanent flow monitoring sites for an additional 30 days. This will include extending cell based telemetry and alarming at these four sites.
- 3. Extend Temporary Flow Monitoring for 30 Days - Office.** Additional flow monitoring will require additional data review, adjustments, and analyses not accounted for in the initial 90 day flow monitoring data review. This will all be performed if flow monitoring is to be extended 30 days.