

PART 1 SPECIFICATIONS

1.1 SYSTEM REQUIREMENTS

- A. A real-time level and flow monitoring system that operates in and around the sewer collection system shall be provided that is comprised of the following requirements.

1.2 SYSTEM SPECIFICATIONS

- A. The monitoring system type shall have active installations at more than 400 other public collection systems in the United States.
- B. The monitoring system type shall cumulatively have in excess of 150,000,000 operating hours of remote field unit operational experience.
- C. Multiple sensors shall be supported by the system.
- D. The system Remote Field Unit (RFU) shall monitor water levels at a rate of at least 12 times per hour with six (6) recorded measurements per hour, unless there is an alarm, and have the ability to remotely and wirelessly change this rate.
 - 1. Alarms shall be reported, when User-defined sensing thresholds are exceeded, in nominal conditions, within 20 seconds of detection.
 - 2. Thresholds may be set and changed remotely by system Users.
- E. The data shall be acquired from remote monitoring sites, via a low earth orbit satellite communication system, and delivered to redundant, secure servers with 2048-bit key encryption.
 - 1. Data from remote sites are accessed via the cloud on any web-enabled, desktop, smartphone, and smart device.
- F. The RFU shall meet IP-68 standards and capable of surviving immersion in sewage water at depth of six (6) feet for at least 24 hours.
- G. The RFU shall be designed to be easily mounted to manhole covers and may be installed completely outside the manhole to avoid confined space entry as defined by OSHA 1910.146.
- H. Remote field units shall provide periodic health messages a minimum of two (2) times per day indicating the proper operating parameters of the instrumentation including the health of the ultrasonic sensor, power pack, and satellite signal quality.
- I. RFU shall contain a micro-electromechanical system (MEMS) device capable of detecting acceleration and tilt and detect and immediately alarming for the opening or closing of the hatch or manhole cover.
- J. Remote data shall be accessible via a mobile app supported by Android and iOS.
- K. System will provide an application programming interface (API) for integration with customer data utilizing a JSON Web Token (JWT) for authentications and endpoints return data in JSON format.

1.3 REMOTE FIELD UNIT COMPONENTS

- A. The system shall be modular to provide application flexibility and have a remote field unit (RFU) containing the following components:
 - 1. Sensor or set of sensors

2. Two-way wireless, satellite communications
3. Data access, management and storage
4. System control box
5. Self-contained power source
6. Antenna
7. Mounting hardware

1.4 SENSOR SPECIFICATIONS

- A. The system remote field units (RFU) shall be capable of using one or more of the following sensors without any physical change in configuration of the system control box:
 1. Ultrasonic sensor;
 2. Dual pressure-level sensor that provides a means to measure water levels ABOVE the ultrasonic sensor with the following performance specifications:
 - a. Ultrasonic resolution shall be no more than 0.1"
 - b. Pressure resolution shall be no more than 0.5"
 - c. Built-in algorithm to minimize false distance readings
 - d. Total dynamic range of 0 inches to 30 feet
 - e. Fully potted and capable of withstanding 10G of force, and have an IP-68 rating
 - f. Does not require field calibration
 - g. Is temperature compensated
 - h. Small enough (less than 4" x 4" x 6") and independent physically of the system control box
 - i. Positioned easily anywhere in a manhole, CSO structure or similar structure with a connecting cable to the system control box up to 300 feet from the system control box
 3. Hydrogen sulfide (H₂S) sensor with the following performance:
 - a. Sensing ranges of 0 – 1000 ppm
 - b. Minimum calibration interval: 90 days
 - c. Constructed and operates to IP-68 standards

1.5 COMMUNICATION

- A. The system shall provide full two-way, satellite communication between the User and the RFU location.
 1. Monitoring data transmits from the RFU to the User dashboard.
 2. Commands can be sent from the User to the remote site to request data or change operational set points.
 3. The commands will be received by the RFU and executed within one (1) hour or less.
 4. Communications will remain in operations during short- or long-term electrical grid power loss, loss of local cellular networks, loss of local power.
 5. Communications to/from remotely monitored sites shall be enabled through a smartphone or smart device application.
- B. The system shall communicate using two-way, digital-radio signals directly to orbiting satellites for uninterrupted operations when there are

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local, regional, or massive power outages due to weather, forced blackouts or other extraordinary circumstances.

1. The orbiting satellite system shall have 66 active satellites and an additional six (6) back-up satellites in low earth, polar orbit and to assure communication redundancy.
2. No additional terrestrial communications systems shall be required to send or receive information to or from the installed RFU.
3. Satellite communication will be 'backward' compatible with the existing Iridium satellite network and 'forward' compatible with the recently launched Iridium Next satellite network for the next 20 years.

1.6 DATA ACCESS, MANAGEMENT & STORAGE

- A. The system shall have cloud storage, remote server, redundancy, and access to data via a standard web browser, smartphone, or smart device with 2048-bit key encryption security.
 1. There shall be no software required on any local computer to access and view data other than a standard web browser.
 2. There shall be access to data without restrictions or extra fees based on the number of Users.
 3. The data shall be stored for an unlimited period of time.
 4. There shall be no limits on the amount of data being stored.
 5. There shall be no limits to the messages sent from each site to the User.
- B. The User shall designate the persons who have access to data:
 1. The Users shall be designated as one of at least three levels of access whereby the lowest level is a view-only function and where the mid-level has access to selected controls and where the highest level has full access to all User-controls.
 2. The data shall be accessible via any device with a web browser using a Username and password for login.
- C. The system shall have access via certified iOS and Android applications for mobile devices.
- D. Ability to integrate Application Programming Interface (API) to communicate with the client's SCADA, GIS, ESRI, and CMM programs.

1.7 SYSTEM CONTROL

- A. The system control box shall be stand-alone and utilize an integrated control including circuitry for: power management; digital communications and data acquisition; on-board analysis of sensor data; storage of sensor and command data.
 1. Shall be fully potted to prevent intrusion of liquids or gases and be capable of withstanding 75G of shock.
 2. Capable of full submersion and be IP-68 rated.
 3. Shall have connectors for the antenna, the power source and the sensor.
 4. All connections to the system control box shall be water-tight to IP-68 standards.

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5. Will contain a MEMS sensor, which by virtue of the mounting of the sensing unit directly onto the manhole cover, shall detect the opening of the manhole cover immediately and send an alarm to the User of this opening.
6. Will be no larger than 4" x 3" x 2"

1.8 POWER SOURCE

- A. The system power source or 'power pack' shall be self-contained and have the following configurations to support off grid conditions.
 1. Minimum operating life of two (2) years.
 2. Utilize high power-density lithium thionyl chloride chemistry batteries, containing no heavy metals.
 3. A connector for simple and easy replacement.
 4. Potted and meet IP-68 standards.
 5. Contain electronics that provides isolation between cells and current limiting of the power pack to avoid:
 - a. Shortened life because of one cell's failure; and
 - b. High current draw from any one cell.

1.9 ANTENNA

- A. The traffic rated system antenna shall include two housing options:
 1. A reflective, raised pavement marker; and
 2. Recessed design for potential snowplow locations
- B. The antenna shall be mounted to the top of the manhole cover but may be mounted to other nearby structures within 15 feet.
- C. The mounting adhesive shall be a two-part acrylic adhesive suitable for structural bonding of metal parts.
- D. The antenna wire to connect to the system control box shall be fed through the manhole cover via a 3/8" drilled hole into the cover.

1.10 MOUNTING HARDWARE

- A. Depending on the application, the RFU with the system control box and the power source shall be housed and secured in place with one of two basic configurations:
 1. Two-part bracket system able to be mounted directly onto manhole covers for ease of installation and avoidance of confined space entry; or
 2. NEMA 4X enclosures containing the IP-68 system control box and power source.
- B. The bracket system shall be a heavy-gauge aluminum and have a hard-anodized, corrosion resistant coating to avoid corrosion in the sewer environment.
 1. Mounted to the underside of a manhole cover via either a flat mounting to the underside or secured to an underside vane via an adapter.
 2. Secured to the manhole cover with at least two stainless steel bolts
 3. Strain relief capable of securing the sensor cable.

4. Bracket constructed from at least two pieces, each able to be easily separated for parts service and replacement outside the plane of the manhole.
- C. The NEMA 4X enclosure shall be constructed of fiberglass, aluminum, or steel (stainless or otherwise).
 1. The NEMA 4X enclosure will contain the system control box, the power source, and supporting electronics.
 2. The NEMA 4X box will provide a means to connect external sensor(s) to the system control box and make measurements of the environment inside and outside of the enclosure.
 3. The NEMA 4X box shall be mountable on a variety of vertical and horizontal surfaces and include a helically polarized satellite antenna positioned to maximize exposure to the sky for satellite communications.

PART 2 USER DASHBOARD

2.1 DEDICATED WEBSITE

- A. The system shall have a dedicated, secure website, accessed and viewed upon login.
- A. The User interface or dashboard shall be map-oriented.
- B. The map page shall display all monitoring sites as indicated by symbols where specific site details and data are accessed.
- C. The map page shall have a dashboard feature to review the last 24-hour data on all sites.
- D. Access to any specific site's data is achieved by clicking the symbol on the map location page.
- E. When accessed, the specific site data is graphically displayed with a default time period (e.g. one week or one month) worth of level or flow data.
- F. The User may select any desired date range to inspect via a drop-down menu or through a date/time selection option.
- G. The system shall provide a specific symbol with a specific color on the dedicated User map display to graphically indicate the site or sites with an alarm, trend advisory or maintenance alert.
- H. The system shall provide a specific symbol with a specific color on the dedicated User map display to graphically indicate the site or sites with an alarm that has been activated because a cover or hatch has been removed or tilted.
- I. Users shall have the ability to download data using a .csv file format directly into an Excel spreadsheet with a single click.

2.2 ANALYTICS DASHBOARD

- A. The dashboard shall have data trend reports for all remote monitoring sites that are exhibiting unusual water level patterns suggestive of problems in pipes upstream and downstream and at the monitored site.
 1. Trend reports will be run automatically at least daily or can be accessed real time at any time by the User.

- B. This dashboard shall summarize the state of each site in terms of trend rise, trend fall, high-level advisory.
- C. The dashboard shall also characterize the flow type measured by the sensor, including the following types: diurnal flow, low amplitude flow, flat line flow and irregular flow.
- D. The system shall provide self-generated maintenance messages that include at least: battery voltage, sensor performance, communications status, and radio signal strength.
- E. The map view shall display a symbol with a specific color designating the site where a status had changed and therefore required maintenance.
- F. The system shall record and retain a complete history for all instances of maintenance messages, types, locations, times, and the staff members receiving these messages.
- G. The system shall, on the dashboard, calculate flow from water levels using Manning's equation and provide the ability on the website to adjust parameters as needed to calibrate these flow levels to local AV meters or other flow assumptions provided by the User.
 - 1. The dashboard shall be capable of allowing Users to switch between measurement units of level or flow.
 - 2. The dashboard shall provide four (4) different inputs for the flow calculation including pipe diameter, slope, Manning's co-efficient of roughness and level.
 - 3. Level shall be the dynamic portion of the calculation and remotely acquired data shall be used to calculate flow.
 - 4. The dashboard shall provide the capacity to change these four (4) input parameters of pipe diameter, slope, Mannings co-efficient of roughness, or level parameter in order to adjust for error or modeling purposes.
 - 5. This adjustment shall provide for adding/changing the data in designated fields and through a single mouse click, update the graph where both the original and updated graph are displayed in a single view.
 - 6. The flow may be calibrated using velocity meters or flow meters to set and fix the Manning's parameters of pipe diameter, slope, roughness coefficient and level.
 - 7. The system shall be capable of showing two graphs simultaneously of original data and modified data.

2.3 TREND REPORTING DASHBOARD

- A. The trend reporting dashboard shall include a daily auto scanning function of all remote sites using algorithms to detect day-over-day changes of level or flow.
 - 1. The changes shall be detectable in 0.1" increments.
 - 2. The dashboard shall have the ability to configure the detectable limits of trends.
 - 3. The User shall be able to configure each remote site setting through the dashboard for at each remote monitoring site.
 - 4. The dashboard shall report level or flow trend changes to the User via an email notification.

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5. Data provided from the dashboard will not require human intervention.
- B. Provided that a trend change is automatically detected the dashboard shall send an email notification, including a graph of the site of interest, to all designated recipients advising of that unusual trend at the remote site.
 1. The email shall provide the location, time, date and condition of the change including 'trend rise' or 'trend fall' designation.
 2. The dashboard shall provide a specific symbol on the map view (page) with a specific color display to graphically indicate the site or sites with trend changes.

2.4 NOTIFICATIONS

- A. Alarms related to flow or level settings shall be set and adjusted through the User dashboard and shall not require any adjustment at the RFU to change alarms settings.
- B. Alarms from the system shall be able to be acknowledged through a handheld wireless smart device or online. The system shall provide:
 1. **ALARMS** under conditions of high-water or low-level levels or intrusion;
 2. **ALERTS** indicating the need for service of the remote field unit;
 3. **ADVISORIES** for indications that the water level trends and patterns are not normal and require attention.
- C. Data updates from the RFU shall be no less frequent than once per hour.
- D. The system shall provide a real-time security 'intrusion' alarm that will transmit its signal within one minute, if the manhole cover or hatch is removed or tilted.
- E. The system shall record and archive a complete history for all instances of alarms, alarm types, location of the alarm, time of the alarm, the name of the person who acknowledged the alarm.

2.5 DATA FUSION

- A. The website shall integrate multiple real-time environmental data sets showing effects on the sewer system, including:
 1. Rain and weather data from NOAA
 2. Tidal data from NOAA
 3. Stream and river data from USGS
- B. A single, integrated graphical view showing the influence of these factors on sewer level and flow with the ability to pull an I&I inflow impact reporting feature
- C. A multi-graph view shall be capable of displaying up to five data sets of various types on a single graph.
- D. Provides a I&I inflow impact reporting feature

2.6 MOBILE APPLICATION

- A. Mobile access to the User interface will be available with a complimentary mobile application.
- B. The mobile app will be available for both iOS and Android Users, certified for download from the Apple Store and Google Play.
- C. Updates will be automatic at no cost without requiring software upgrades.

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- D. The mobile applications shall be accessible using the same secure login as the User website with unlimited Users.

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2.7 APPLICATION PROGRAMMING INTERFACE

- A. Application programming Interface (API) will be provided for programmatic access to system data.
- B. API will utilize a JSON Web Token (JWT) for API authentication and endpoints return data in JSON format.
- C. Access to the API will be provided by passing a JSON Web Token (JWT), an open, industry standard method for representing claims securely between two parties.
- D. Several API lists will be supplied, including:
 - 1. Location List API will be provided for access to customer's SmartCovers. This includes the location's coordinates, description and the latest status for all data types.
 - 2. Location Summary API provides a quick overview of an organization's locations. It provides a quick count of the number of locations, alarms, alerts, and advisories.
 - 3. Historical Data API provides access to data readings and the associated timestamps of a customer's SmartCovers.
 - 4. Alarm List API provides access to a list of a customer's locations that have active alarms.
 - 5. Latest Data API provides access to the latest status of a customer's SmartCovers. This endpoint is the predecessor to the Location List API.

PART 3 SAFETY

3.1 SAFETY

- A. Remote field units shall be licensed to mount directly onto the sewer manhole cover or vault hatch in order to minimize time and expense of confined space installation and service.
 - 1. Installation **shall not require confined space entry** of any type, whereas 'entry' into a manhole is defined by OSHA 1910.146 as 'any part of an installer's body, including hands, arms, fingers, crosses the plane of the manhole opening.'
 - 2. For installation or maintenance, no physical penetrations of any kind by any part of an installer's body shall be made to the manhole structure.
 - 3. The system shall not require any cutting or drilling into the street in order to mount the antenna.
 - 4. The system shall not require any drilling or cutting into the manhole or vault structure for mounting the bracket.
 - 5. RFU shall be capable of replacement in under 15 minutes of on-site labor and without any confined space entry as per OSHA 1910.146.

PART 4 ACCOUNT SUPPORT

4.1 INSTALLATION, TRAINING AND CUSTOMER SERVICE

- A. Manufacturer's representative will include a half-day of start-up service by a factory-trained technician, if requested.
- B. Internal crew resources or a certified contractor will install in strict accordance with the manufacturer's instructions and recommendations.

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- C. Contractor will include the manufacturer's services to perform start-up on instrument to include basic operational training and certification of performance of the instrument.
- D. Contractor will include a manufacturer's Service Agreement that covers all the manufacturer's recommended preventative maintenance, regularly scheduled calibration and any necessary repairs beginning from the time of equipment startup through to end User acceptance / plant turnover and the first 12 months of end-User operation post turnover.
- E. Items A and B are to be performed by manufacturer's factory-trained service personnel. Field service and factory repair by personnel not trained and certified by the manufacturer is not allowed.
- F. Use of manufacturer's service parts and agents is required. Third-party parts and agents are not approved for use.
- G. Agents will be assigned to the User for live customer support for the term of the service.
- H. Ongoing training will be supported during the term of the service.