RH BORDEN
DELIVERING DATA TO SMART CITIES

White Paper: BASINiQ™ – Revolutionizing Inflow and Infiltration (I&I) Detection in Wastewater Collection Systems

Introduction: The Pervasive Challenge of Inflow and Infiltration

Inflow and Infiltration (I&I) refers to extraneous, unused water that enters sewer systems from sources such as rainfall or groundwater. This unwanted water can account for a significant portion, typically between **35% and 50%, of all treated wastewater**. The presence of I&I creates numerous problems for municipalities and utility districts, including collection system overflows, increased flow to treatment plants, negative environmental impacts, escalated operating costs, and potential threats to public health. Common sources of I&I include downspouts connected to sewer laterals, leaks and breaks in pipes, holes in manholes, and illegal connections. The primary challenge for utilities is not in fixing I&I, but in **effectively finding its source**.

Limitations of Traditional I&I Assessment Methods

Traditional methods for detecting I&I are often inefficient, time-consuming, and costly, providing limited data and sometimes missing subsurface issues. These methods include:

- **Smoke Testing**: While useful for identifying surface-level defects like broken cleanouts or illegal storm drain connections, smoke testing has significant limitations. It is **weather-dependent** (less effective in wet or cold conditions), **limited to surface-level leaks** (missing subsurface defects), requires **favorable soil conditions**, and **does not quantify flow volume**. It also provides only a snapshot in time, can result in false negatives due to blockages or improper pressurization, and requires extensive coordination and public notification due to potential health and safety concerns or false alarms. Deep pipe leaks or those below the water table often go undetected.
- **Manhole Inspection**: This method requires active conditions (i.e., water flowing) to detect infiltration; a dry period might lead to a false negative.
- **CCTV (Closed-Circuit Television) Camera Inspection**: Similar to manhole inspection, CCTV cameras are effective in identifying visible defects within pipes but struggle to find

I&I if it's not actively flowing or if the defect is small or submerged. CCTV studies are also costly and target single pipe segments.

- **Flow Monitoring Systems**: While effective for locating and quantifying flows in suspect basins, traditional flow meters are **very expensive** and require **confined space entry for installation**, limiting their deployment to perhaps one or two per day. This makes it impractical to implement a high density of flow meters needed for pinpointing specific I&I sources within a basin.
- **Flow Isolation Studies**: These involve physically entering manholes and taking measurements, which is labor-intensive and cannot be scaled easily.

Collectively, these traditional methods are often **less effective** in finding I&I sources.

Introducing BASINiQ™: A Data-Driven, Scalable Solution

BASINiQ™, delivered by RH Borden Smart Solutions, LLC, is a new, highly cost-effective, and rapid method for detecting and pinpointing I&I sources in wastewater collection systems. It leverages a combination of cutting-edge technologies to provide a **data-driven, scaled way** to identify I&I. BASINiQ™ is significantly faster than traditional methods, often yielding results in as little as **60 to 90 days**, a 10-20 times improvement in speed.

The core components of the BASINiQ™ methodology include:

1. **Manhole Virtual Models (MVMs) / Digital Twins**: BASINiQ™ creates a high-resolution **digital twin** of each manhole or designated structure through a full 360-degree video and LIDAR scan. This digital twin precisely captures the geometry at the base of the manhole, including diameter, slope, and material. This crucial dimensional information is then used in conjunction with Manning's equation (an industry standard) to **accurately translate water level readings into flow data**. This is a critical breakthrough, as the ability to reliably convert level to flow at scale has historically been a significant challenge.

2. **Sensor-Dense Level Monitoring Networks**: The system uses a large network of **lightweight, radar-based level sensors** placed strategically in manholes. These sensors are highly accurate, fast, and easy to deploy, requiring no confined space entry for installation. Unlike older ultrasonic sensors, radar-based sensors are less susceptible to

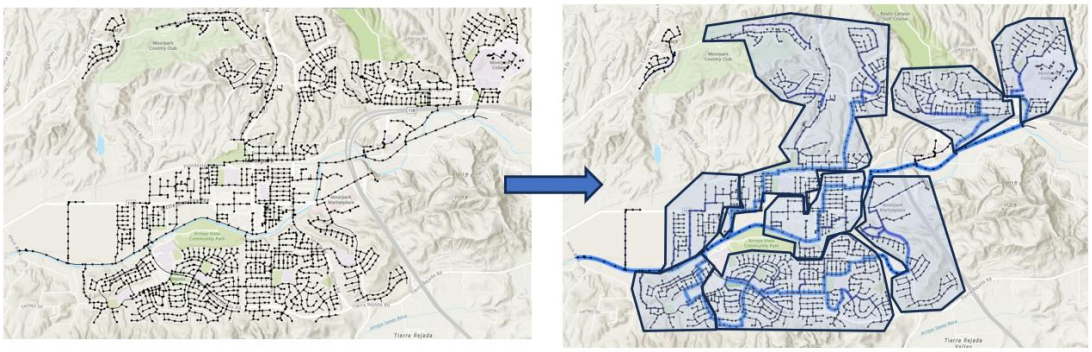
environmental factors like humidity and temperature, providing more accurate measurements and cleaner signals. The sensors maintain reliable **connection rates** and a **five-year battery life**, enabling 24/7 monitoring and real-time data flow for weeks or even months (up to 5 months). This high reliability and ease of deployment allow for **dense and wide-scale sensor deployment**, with hundreds of monitors installed concurrently.

3. **Precision Weather Tracking**: BASINiQ™ integrates with the **Baron Weather Network**, a high-resolution network of thousands of surface gauges and satellites used by organizations like NASA, Garmin, Ezri, and Verizon. This network provides weather updates every half-mile across the country every four minutes, offering highly precise weather data that traditional single-point rain gauges cannot match. This weather data is crucial for correlating precipitation events with observed flow anomalies.

The BASINiQ™ Methodology: A Two-Phase Assessment

The BASINiQ™ approach systematically identifies I&I through a phased process, starting with a broad system understanding and then drilling down to specific problem areas.

1. **Understanding Basins**: The first step involves decomposing a collection system into its natural **basins**, defined as a collection of pipes with a common outfall, typically ranging from two to ten miles in size. This basin-centric view, often established through a free shape file consultation, allows for effective prioritization.

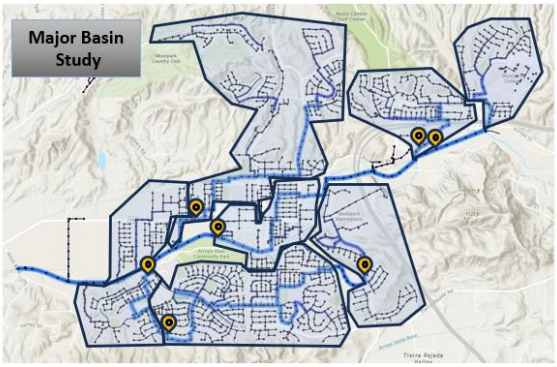


Traditional System View

Basin View

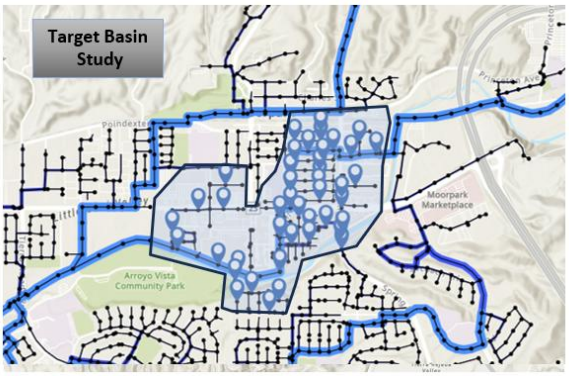
2. **Major Basin Study**:
    - **Purpose**: To identify and prioritize which basins are the largest contributors of I&I within an entire collection system.

- **Deployment**: A sensor is placed at the outfall (downstream end) of each major basin.



- **Process**: When it rains, all sensors simultaneously detect flow changes. This allows for a direct comparison of additional flow across different basins, revealing which ones are the primary contributors.
- **Outcome**: Provides a clear prioritization for where to invest capital dollars for I&I mitigation.

3. **Target Basin Study**:
    - **Purpose**: Once a problematic basin is identified, a Target Basin Study is conducted to pinpoint the **precise pipe segments or manholes** where I&I is entering the system.
    - **Deployment**: A high-density network of sensors (typically **7 sensors per mile**, or one every 300-800 feet) is deployed throughout the targeted basin, often involving 30, 50, or even 100 sensors. A 100-sensor installation can be completed within 1-2 weeks.

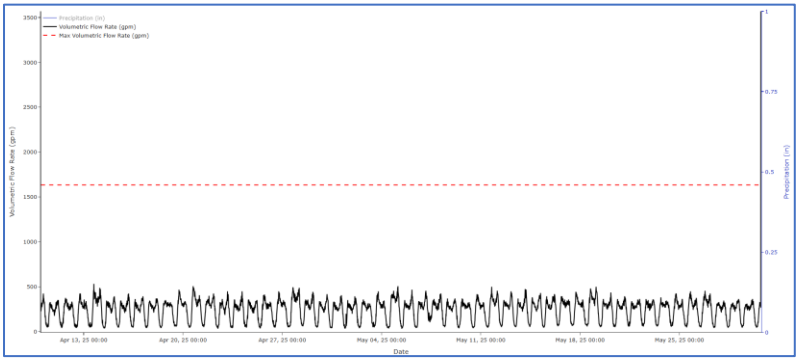


- **Process**: This dense network captures granular flow data during rain events, allowing for the precise localization of I&I sources. Flow stacking analysis can show increased flow rates as water moves downstream, indicating points of I&I entry.
- **Outcome**: Identifies exact points for remedial action, such as lining, grouting, or replacing specific pipe segments or manholes, ensuring capital resources are applied with high assurance of successful remediation.

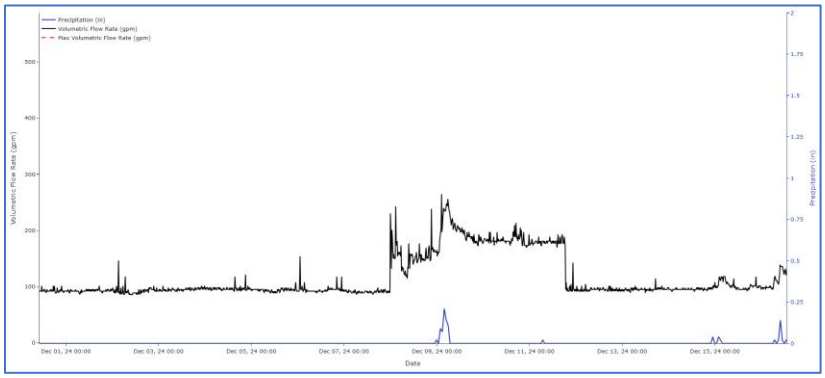
Identifying I&I Signatures: Decoding Flow Patterns

BASINiQ™ analyzes four distinct flow signatures to identify I&I and other anomalies:

1. **Daily Diurnal (DAL) Pattern (Regular Flow)**: This is the baseline, representing the typical daily fluctuation of water usage within a system, reflecting human activity (e.g., morning peaks, nighttime troughs).

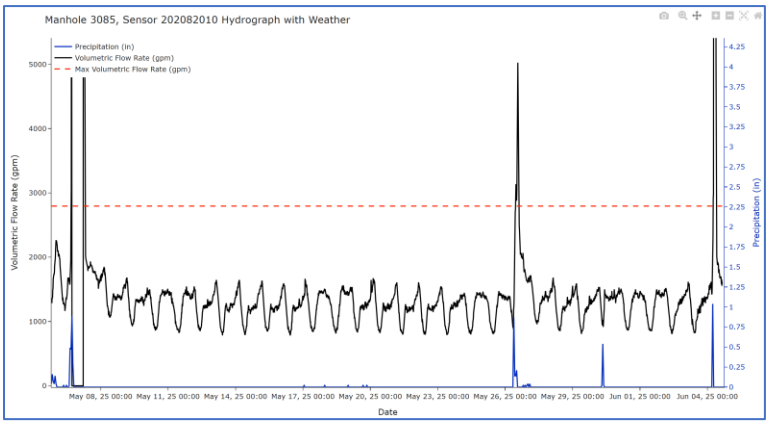


2. **Blockage**: Characterized by a **sharp increase or decrease** in water level, often unrelated to weather events. This indicates a partial obstruction that elevates the water level, which then dislodges and returns to baseline. The DAL pattern may still be superimposed on the elevated level.

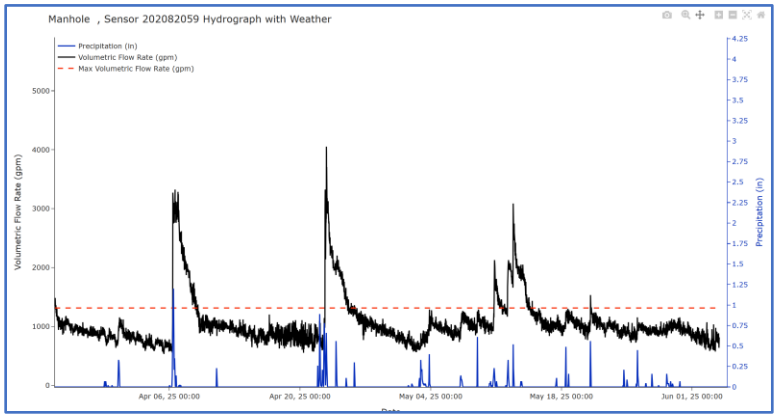


3. **Inflow (Open to Sky)**: Appears as a **sudden, rapid spike in water level directly associated with a rain event**, followed by a sudden drop once the rain stops. This

typically occurs from direct connections to the sewer system, like downspouts or open manhole caps, that quickly channel rainwater. Inflow is often less expensive to fix as it frequently involves surface-level issues.



4. **Infiltration (Underground)**: Indicated by a **more gradual rise or slow decrease** in water level during a rain event, often persistent over time. This is commonly due to breaks in underground pipes or holes in manholes where surface saturation leads to water slowly seeping into the system. Often, a combination of rapid spike (inflow) and slow decrease (infiltration) is observed, representing the "worst of both worlds".



By analyzing these distinct signatures in relation to precision weather data, BASINiQ™ can differentiate between types of I&I and other flow anomalies, providing crucial information for remediation strategies.

Proven Efficacy: Case Studies

BASINiQ™ has successfully identified I&I in numerous studies across the country, with over 40-50 studies conducted so far.

- **San Rafael, California**: A 14-basin (or 16-basin) assessment quickly ranked basins by their I&I contribution levels. Analysis of hydrographs clearly showed certain basins with significantly higher and more persistent I&I spikes during rain events compared to others, guiding the municipality on where to prioritize investments.
- **North Logan, Utah**: A Target Basin Assessment across 68,000 linear feet of pipe using 80 sensors pinpointed the exact manhole and pipe needing remediation. Video confirmation later validated the I&I source, demonstrating the methodology's reliability.
- **Mansfield, Kentucky**: In a target basin study, BASINiQ™ identified a **large hole in a manhole** that was the source of I&I, contributing **over a million gallons per day** from that single hole during a rainstorm. This significant contribution highlighted the impact of a single source on the entire treatment plant. The visualization allowed walking the line to pinpoint the exact street where the I&I was occurring.

These case studies underscore the ability of BASINiQ™ to effectively locate I&I, leading to targeted and impactful repairs.

Key Benefits and Advantages of BASINiQ™

- **Speed and Efficiency**: BASINiQ™ is 10 to 20 times faster than traditional methods, compressing I&I detection from years to a matter of months (60-90 days being typical). This allows utilities to identify reduction points in one rainstorm, achieving results that previously took years.
- **Cost-Effectiveness**: Studies are **significantly less costly** than traditional flow metering or other inspection methods. For example, a major basin study with 10 data points can be less than half the cost of a traditional 4-sensor flow meter study. A target basin study with up to 100 sensors can still be less expensive than a traditional 4-sensor flow meter study.
- **Scalability and Density**: The lightweight, inexpensive sensors enable dense deployment of hundreds of monitors concurrently across entire collection systems without significant impact on staff resources. This is a "paradigm shifter" compared to limited, expensive flow meter installations.
- **Precision and Accuracy**: The combination of radar-based level monitors and manhole digital twins (MVMs) allows for the precise identification of I&I sources down to the

exact pipe or manhole. While not designed for highly accurate flow quantification for billing or engineering modeling, it is precise enough to detect the "extreme signal" of I&I.

- **Non-Confined Space Entry**: Sensor installation does not require hazardous confined space entry, improving safety and reducing labor intensity.
- **Pre-Rain Event Deployment**: Sensors can be installed and left for weeks or months, allowing for data collection before rain events and capturing comprehensive signals from multiple storms.
- **Consistent Assessment and Post-Remediation Monitoring**: BASINiQ™ provides a more consistent assessment of I&I impacts. Sensors can be left in place after identifying I&I to monitor the effectiveness of repairs and track reduction over time.
- **Data-Driven Insights**: The system provides real-time data, analytics, and data visualization through an interactive GIS dashboard, offering valuable insights into basin flow changes and I&I detection.

Implementation Process

The typical BASINiQ™ engagement begins with a simple request: clients provide a **shape file** of their collection system. RH Borden then performs a free initial consultation to decompose the system into basins and provide cost estimates based on the selected study type (Major or Target Basin). The service model covers sensor installation, 24/7 monitoring, data collection, and ongoing maintenance. The studies typically last up to five months or until sufficient rain events (usually 1-inch or more, though as little as 0.25 inches can be effective) are captured to confirm I&I results.

Conclusion: A Game-Changer for Wastewater Management

BASINiQ™ represents a significant advancement in wastewater infrastructure maintenance and management. By providing a data-centric, sensor-intensive approach that leverages digital twins and high-resolution weather data, it addresses the long-standing challenge of finding I&I effectively and cost-efficiently. The ability to rapidly pinpoint I&I sources at scale, coupled with competitive pricing and a comprehensive service model, makes BASINiQ™ a **game-changing solution** for municipalities seeking to reduce overflows, lower treatment costs, and improve environmental outcomes.