Sewer Flow Monitoring & Threshold Analysis

The capacity evaluation method involves the following process:

1. Collect 15-minute interval depth and velocity data points at each site over the entire monitoring period and determine the depth vs. velocity relationship or pipe curve based on Manning's equation.

2. Determine statistically the minimum, maximum and average depths and flow rates at each site during the monitoring period.

3. Calculate the maximum theoretical unobstructed flow rate at each site.

4. Determine remaining capacity under peak flow conditions at each site, using the ratios of actual daily flow depths to pipe diameter.

5. Calculations from this sewer flow monitoring study are based on steady uniform flow with steady flow defined as the discharge being constant with time, and uniform flow defined as the slope of the water surface and cross-sectional flow area being constant in the length of pipe analyzed. Using velocities from this study in conjunction with the associated cross-sectional areas depicted by the monitored levels, the flow was calculated using the Continuity Equation, and then the slope was derived using Manning's Equation.

The pattern of velocity and depth data points for a sewer operating in free-flow conditions over an extended period of time should conform to the depth-velocity relationship of the Manning Equation, which is the basis for evaluating flow monitoring data. This equation (shown below) defines a commonly used theoretical relationship between depth and velocity in pipes operating under free flow conditions:

\[ v = 1.486/n \times R^{2/3} \times S^{1/2} \]

Where,

- \( v \) = velocity (fps)
- \( n \) = pipe roughness, defined as the Manning's Roughness Coefficient
- \( R \) = hydraulic radius,
  - defined as wetted area (ft\(^2\)) divided by wetted perimeter (ft)
- \( S \) = hydraulic slope

According to common sewer design, the velocity shall not be less than 2.0 fps a minimum of once per day to provide sufficient scouring action for self-cleaning.

- The maximum velocity at the Site 1 Beechwood MH was 2.54 fps with an average velocity of 0.49 fps. Since velocities only exceeded 2.0 fps on three days during this
nine-day study, this site is expected to have issues with regard to settlement of normal system solids. In addition, normal system solids were noted in the trough during installation and removal of flow monitoring equipment.

- The maximum velocity at the Site 2 State & Beechwood MH was 3.84 fps with an average velocity of 3.26 fps. Since velocities exceeded 2.0 fps every day during this nine-day study, this site is not expected to have issues with regard to settlement of normal system solids.

- The maximum velocity at the Site 3 State & Imperial MH was 1.34 fps with an average velocity of 0.67 fps. Since velocities never exceeded 2.0 fps during this nine-day study, this site is expected to have issues with regard to settlement of normal system solids. In addition, debris had to be removed from the trough prior to flow monitoring, and two-inches of sediment was in the trough, which could not be removed without a vacuum truck.

- The maximum velocity at the Site 4 Imperial MH was 1.49 fps with an average velocity of 0.53 fps. Since velocities never exceeded 2.0 fps during this nine-day study, this site is expected to have issues with regard to settlement of normal system solids. In addition, normal system solids were noted in the trough during installation and removal of flow monitoring equipment.

According to common sewer design, the depth versus diameter (d/D) ratio for gravity drains of 12 inches in diameter or less should be no greater than 0.50 for the ultimate peak flow condition.

- The maximum d/D ratio for the Site 1 Beechwood MH during this study was ~0.14. Therefore, this site has capacity available at peak flow.

- The maximum d/D ratio for the Site 3 State & Imperial MH during this study was ~0.66. Therefore, this site exceeds the d/D ratio limitation of 0.50 under peak flow conditions, but this was due to the two-inches of sediment in the line. If the sediment were removed, the levels observed during this study should be below the d/D ratio limitation of 0.50 under peak flow conditions.

- The maximum d/D ratio for the Site 4 Imperial MH during this study was ~0.27. Therefore, this site has capacity available at peak flow.

According to common sewer design, the depth versus diameter (d/D) ratio for gravity drains of greater than 12 inches in diameter should be no greater than 0.67 for the ultimate peak flow condition.

- The maximum d/D ratio for the Site 2 State & Beechwood MH during this study was ~0.42. Therefore, this site has capacity available at peak flow.
Whether or not the available capacity is sufficient in the monitored pipes is dependent upon the mean loading per unit of usage of the proposed project and the point or points of connection to the existing sewer system. Since the capacitance of a system is contingent upon its most limited segment, the Site 3 State & Imperial MH is the limiting factor, but with the sediment removed, all four sites have good capacitance available. In addition, the increase in flow should increase the velocities, improving the scouring action and the capacitance within the monitored lines.

**Methods & Procedures & Equipment**

*Methedns and Procedures*

Utility Systems Science & Software provided M+D Properties with an off the shelf, non-proprietary flow monitoring solution that included four state of the art Hach Flo-Dar® AV Sensor systems. The project course of action is listed below. The US³ team:

- Prepared the traffic control plans and obtained a City Encroachment Permit for the sites on Beechwood Av, Imperial Hwy and State St in Lynwood, CA.
- Validated the sites for suitability for flow monitoring.
- Installed and calibrated the flow monitoring equipment per manufacturer recommendations.
- Modified each system to further support the monitoring requirements.
- Removed the equipment, validated the data and prepared the data reports.

*Equipment*

![Equipment](image)

**Figure above:** Equipment installed as part of the sewer flow monitoring study

Utility Systems Science & Software
Figure above: Web-Enabled Flo-Dar® AV Sensor, Radar-Based Velocity/Area Flow Meter

SPECIFICATIONS

- **Enclosure**
  - IP68 Waterproof rating, Polystyrene

- **Dimensions**
  - 160.5 W x 432.2 L x 297 D mm (6.32 x 16.66 x 11.7 in.),
  - With SVS, D = 387 mm (15.2 in.)

- **Weight**
  - 4.8 kg (10.5 lbs.)

- **Operating Temperature**
  - -10 to 50°C (14 to 122°F)

- **Storage Temperature**
  - -40 to 60°C (-40 to 140°F)

- **Power Requirements**
  - Supplied by FL900 Flow Logger, Flo-Logger, or Flo-Station
• **Interconnecting Cable**
  o Disconnect available at both sensor and logger or Flo-Station
  o Polyurethane, 0.400 (±0.015) in. diameter; IP68
  o Standard length 9 m (30 ft), maximum 305 m (1000 ft)

• **Cables — available in two styles:**
  o connectors at both ends
  o connector from sensor with open leads to desiccant hub, desiccant hub with connector to logger. A potting/sealant kit will be included. This can be used to run the cable through conduit.

• **Certification**
  o Certified to: FCC Part 15.245: FCC ID: VIC-FLODAR24
  o Industry Canada Spec. RSS210. v7: IC No.: 6149A-FLODAR24

**SURCHARGE DEPTH MEASUREMENT**
  o Auto zero function maintains zero error below 0.5 cm (0.2 in.)

• **Method**
  o Piezo-resistive pressure transducer with stainless steel diaphragm

• **Range**
  o 3.5 m (138 in.), overpressure rating 2.5 x full scale

**VELOCITY MEASUREMENT**

• **Method**
  o Radar

• **Range**
  o 0.23 to 6.10 m/s (0.75 to 20 ft/s)

• **Frequency Range**
  o 24.075 to 24.175 GHz, 15.2 mW (max.)

• **Accuracy**
  o ±0.5%; ±0.03 m/s (±0.1 ft/s)

**DEPTH MEASUREMENT**

• **Method**
  o Ultrasonic

• **Standard Operating Range from Flo-Dar® Housing to Liquid**
  o 0 to 152.4 cm (0 to 60 in.)

• **Optional Extended Level Operating Range from Transducer Face to Liquid**
  o 0 to 6.1 m (0 to 20 ft.) with 43.18 cm (17 in.) dead band, temperature compensated.

• **Accuracy**
  o ±1%; ±0.25 cm (±0.1 in.)

**FLOW MEASUREMENT**

• **Method**
  o Based on Continuity Equation

• **Accuracy**
o ±5% of reading typical where flow is in a channel with uniform flow conditions and is not surcharged, ±1% full scale max.

SURCHARGE CONDITIONS DEPTH/VELOCITY DEPTH (Std with Flo-Dar® Sensor)
• Surcharge depth supplied by Flo-Dar® sensor.

VELOCITY (Optional Surcharge Velocity Sensor)
• Method
  o Electromagnetic
• Range
  o ±4.8 m/s (±16 ft/s)
• Accuracy
  o ±0.15 ft/s or 4% of reading, whichever is greater.
• Zero Stability
  o ±0.05 ft/s

The Flo-Dar® Open Channel Flow Meters provide an innovative approach to open channel flow monitoring. Combining digital Doppler radar velocity sensing with ultrasonic pulse echo level sensing Flo-Dar® provides accurate open channel flow monitoring without the fouling problems associated with submerged sensors.

Perfect solution for Difficult Flow Conditions:
• Flows with High Solids Content
• High Temperature Flows
• Caustic Flows
• Large Man-Made Channel
• High Velocities
• Shallow Flows
Benefits

1. Personnel have no contact with the flow during installation.
2. Maintenance caused by sensor fouling is eliminated
3. Field Replaceable/Interchangeable Sensors and Monitors

How It Works

Flo-Dar® transmits a digital Doppler radar beam that interacts with the fluid and reflects back signals at a different frequency than that which was transmitted. These reflected signals are compared with the transmitted frequency. The resulting frequency shift provides an accurate measure of the velocity and the direction of the flow. Level is detected by ultrasonic pulse echo. Flow is then calculated based on the Continuity Equation:

\[ Q = V \times A, \text{ Where } Q = \text{Flow, } V = \text{Average Velocity and } A = \text{Area} \]

Accurate Flow Measurements

Flo-Dar® provides the user with highly accurate flow measurements under a wide range of flows and site conditions. By measuring the velocity of the fluid from above, Flo-Dar® eliminates accuracy problems inherent with submerged sensors including sensor disturbances, high solids content and distribution of reflectors.
US³ Company Information

US³ is a California Corporation Federal ID No. 33-0729605 and qualifies as a Minority Business Enterprise. US³ has certified as an MBE with the California Public Utility Commission's authorized clearinghouse, Verification Number: 97ES0008.

US³ is a specialty service company for the Water & Waste Water industry, providing monitoring and control for Utilities since 1996. US³ is in the forefront of this industry by taking the proven technological approaches developed in other high tech industries and applying them to protect one of our most precious natural resources - our water.

US³ engineers and technical personnel have applied advanced instrumentation system technology to water/wastewater open channel flow monitoring, pipeline evaluation, engineering, and data analysis, all coupled to the power of the Internet. This unique integrated systems approach allows the company to bring greater insight and intelligence to gathering information about water/wastewater system performance of our clients, and in turn, to support the fulfillment of their commitments to manage and cost effectively design, operate, and maintain these systems.

Figure: US³ utilizes exclusively Hach March-McBirney Flo-Dar® Meters

Utility Systems Science & Software
Moreover, US³ supports Municipalities, Consulting Engineering firms and other water/waste water systems integrators by providing temporary technical services for engineering, software programming and technical site maintenance and calibration site support work, primarily in the Water and Waste Water industries.

![Image of technician working](image)

**Figure:** All technicians are certified for Confined Space Entry.

**Name, Title, Address and Telephone numbers of persons to contact concerning this report.**

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