The Ten Types of Sewer Hydraulics
Using Scattergaphs to Identify Hydraulic Performance and Capacity Robbers

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THREE-MONTH OUTLOOK PREDICTION PROBABILITY 0.5 MONTH LEAD
VALID NDJ 2010
MADE 21 OCT 2010

EC MEANS EQUAL CHANCES FOR A, N, B
A MEANS ABOVE
N MEANS NORMAL
B MEANS BELOW
Three Types of Sewer Capacity

• As-Designed Capacity
• As-Built Capacity
• Operational Capacity

Operational Capacity = As-Built Capacity - Hydraulic Losses.
Top Ten Hydraulic Conditions

1. Normal open channel flow.
2. Open channel in backwater
3. *Silt, Obstacles or “Dead Dogs”*
4. *Surcharged flow*
5. *Bottlenecks*
6. *Temporary blockage*
7. SSO downstream
8. SSO upstream
9. Downstream pump station
10. Hydraulic Jumps/ waves
Typical Metering Installation
Properly Deployed, a Flow Meter will see Upstream and Downstream
(Double the information by looking at Scattergraphs)
Scattergraphs

- A display of paired depth and velocity readings.
- The pattern should look like a pipe curve.
- A pattern that doesn’t look like a pipe curve means that one of two things is occurring:
  1. Normal open channel flow is not occurring
  2. The meter is not working correctly.
High Precision
High Bias
Inaccurate

Low Precision
High Bias
Inaccurate

High Precision
Low Bias
Accurate

Low Precision
Low Bias
Inaccurate

From Standard Methods
The target for a meter is a line not a bulls eye. Low precision meters produce wide scatter.
Normal Dry Weather flow

Depth - Velocity
Flowmeter
The combination of a Pipe Curve, meter data and confirmations reveal a meter’s accuracy.
Silt and Obstacles result in backwater at a meter.
Dead Dog

Flow Depth (in)

Flow Velocity (ft/s)

Dead Dog = 6.45 in.

d_{HO} = 6.45-in
C_{SS} = 3.3102
R^2 = 0.9483
Manning Design Equation and Lanfear-Coll Equation both Miss the Mark.
High Technology proves the existence of the Dead Dog in sewers
Iso-Q Lines
In an ideal pipe, the pipe can surcharge and the Hydraulic Grade Line will be parallel to the pipe. In this situation the pipe should be carrying full capacity.
Surcharge “By the Book”
Bottleneck Downstream of Flowmeter
HGL is Nearly Flat for Several MHs Upstream
Bottleneck & Capacity Loss
Shifting Debris

Pipe Flow
ZN-01

Rainfall (in) | Flow (MGD) | Depth (in) | Velocity (ft/s) | Date
---|---|---|---|---
0.0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 4 | 6 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 | 5.5 | 6.0

Apr 1997
Shifting Debris
Upstream SSO

SSO Upstream of Flowmeter

Depth - Velocity
Flowmeter

ROOTS
Upstream
SSO
SSO and Bottleneck Downstream of Flowmeter

Depth - Velocity
Flowmeter

ROOTS
Downstream SSO
Downstream SSO
In backwater, the meter measures pumping rate.

In free flow the meter measures actual flow.
Pump Stations
Waves (unstable hydraulics)

Hydraulic Jumps

A hydraulic jump moving back and forth, upstream and downstream of the sensors.

High Flow

Low Flow

Flow Meter

Flow Depth (in)

Flow Depth (in)

Flow Velocity (ft/s)

Flow Velocity (ft/s)

Subcritical (Fr < 1)

Supercritical (Fr > 1)

Standing Waves

Undular Waves
Spotting Bad Velocity and Bad Depth
The End

• For more scattergraph information and to request a poster visit:
  
  http://www.adsenv.com/scattergraphs
The Pain of Subtraction

8.5 mgd ± 5%
1.5 mgd ± 0.1 (7%)
1.5 mgd ± 0.6 (44%)

10 mgd ± 5%
0.20 mgd ± 10%
0.23 mgd ± 10%
0.22 mgd ± 15%
0.20 mgd ± 15%
0.20 mgd ± 15%
0.25 mgd ± 20%
0.20 mgd ± 20%
The Pain of Subtraction

Avoid Subtracting More Than 66% from Upstream to Define a Basin.