Main Cleaning and Control Strategies for Legacy Mn

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American Water Works Association
Pacific Northwest Section

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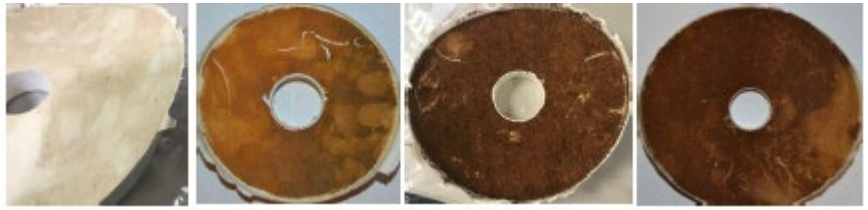
confluence
ENGINEERING GROUP LLC

Agenda

- Overview of distribution system strategies to control legacy Mn
- Main cleaning methods
- Evaluation of flushing for removal of legacy Mn
- Utility guidance to assess and mitigate legacy Mn risks

Preventive, Source-to-Tap Approach

- Treatment (or source control) to reduce Mn loading into the distribution system is vital
- However, source control/treatment does not …
  - Address legacy Mn
  - Eliminate on-going Mn accumulation
- Accumulation $\propto$ Loading (lb/yr) $\times$ Time
  - Even low Mn loading can be problematic over long timeframes
  - Reduce Mn loading to as low level as feasible (at least to < 0.02 mg/L)



Utilities need to sustainably manage Mn accumulation in their distribution systems

Legacy Mn Control Strategies

Legacy Mn Control Strategies

Stabilize System Chemistry

- Maintain robust disinfectant residual throughout the distribution system
  - Free chlorine ≥ 0.4 mg/L as Cl_2
  - Monochloramine ≥ 1 mg/L as Cl_2
- Keep pH variations to ≤ 0.5 units
- Try to avoid alternating between dissimilar sources (pH, DIC, SO4)
  - Match, blend, or keep separate

Will not prevent hydraulic releases

Remove with Main Cleaning

- Select appropriate method(s)
  - Light cleaning
  - Aggressive cleaning
- Develop appropriate frequencies

May not prevent chemical releases

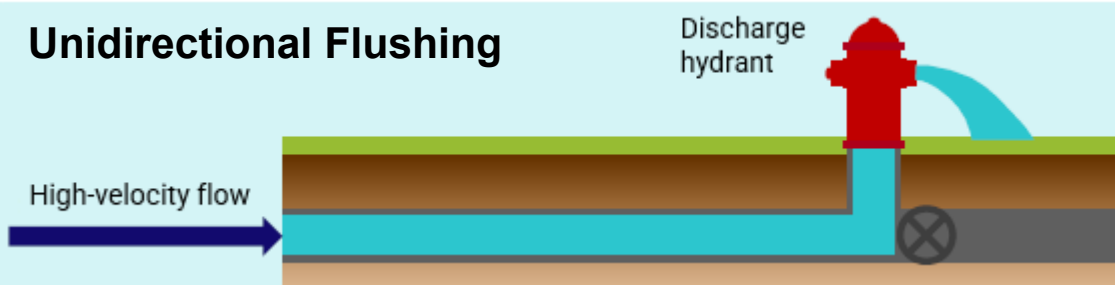
Main Cleaning Methods

- Unidirectional Flushing
- “Others”

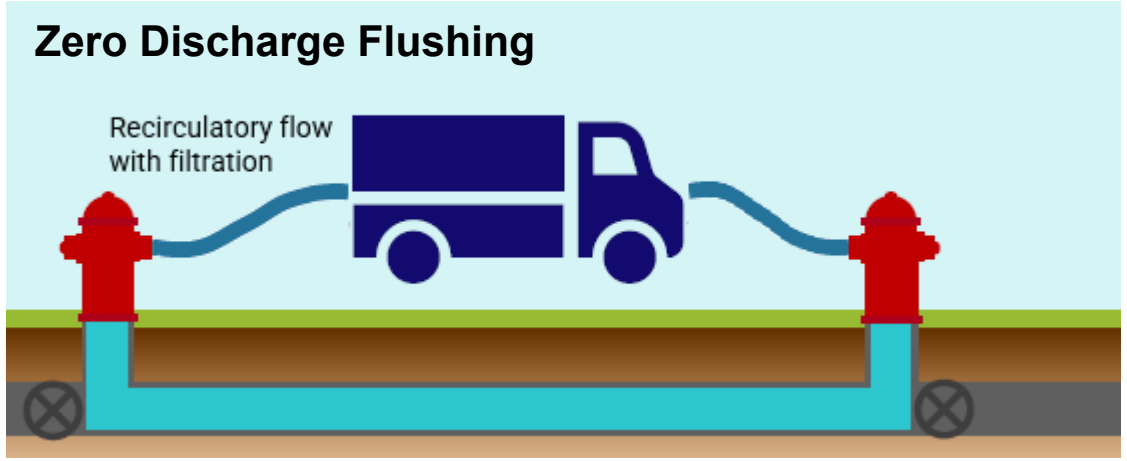
Main Cleaning “Toolbox”

Flushing Options

Unidirectional Flushing

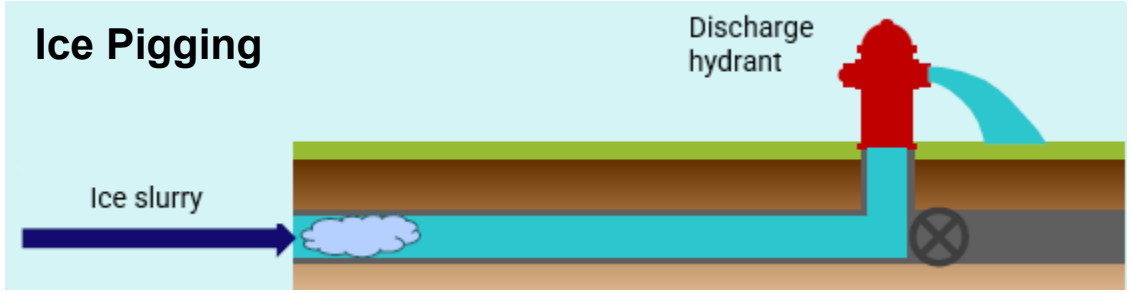


Zero Discharge Flushing

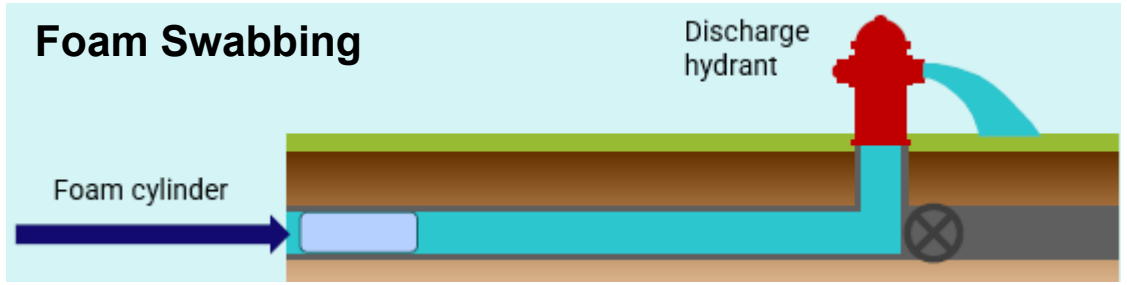


Pigging Options

Ice Pigging



Foam Swabbing



Zero Discharge Flushing (ZDF)

Zero Discharge Flushing

- ➕ Conserves water
- ➕ Avoids discharge issues and constraints
- ➕ Can “spot UDF” and “spot booster chlorinate”

- ➖ Flushing truck = $$$
- ➖ Filter replacement costs
- ➖ Loops can span multiple pipe diameters, resulting in different velocities and impaired performance

Ice Pigging

Ice Pigging

- High shear forces; removes cohesive deposits (50-100%)
- Low risk operation: ice pig is highly navigable

- Vendor requirement; high cost ($12K per pipe-mile + mobilization)
- TDS > 10,000 mg/L can present disposal challenges

Foam Swabbing

Foam Swabbing

- ≈100% cleaning
- Can perform in-house
- Significant planning; slow, resource-intensive operation (cost is 5-10x UDF)
- Risks (swabs can get stuck, hydrant issues)
- Not suitable for unlined iron or asbestos cement pipe

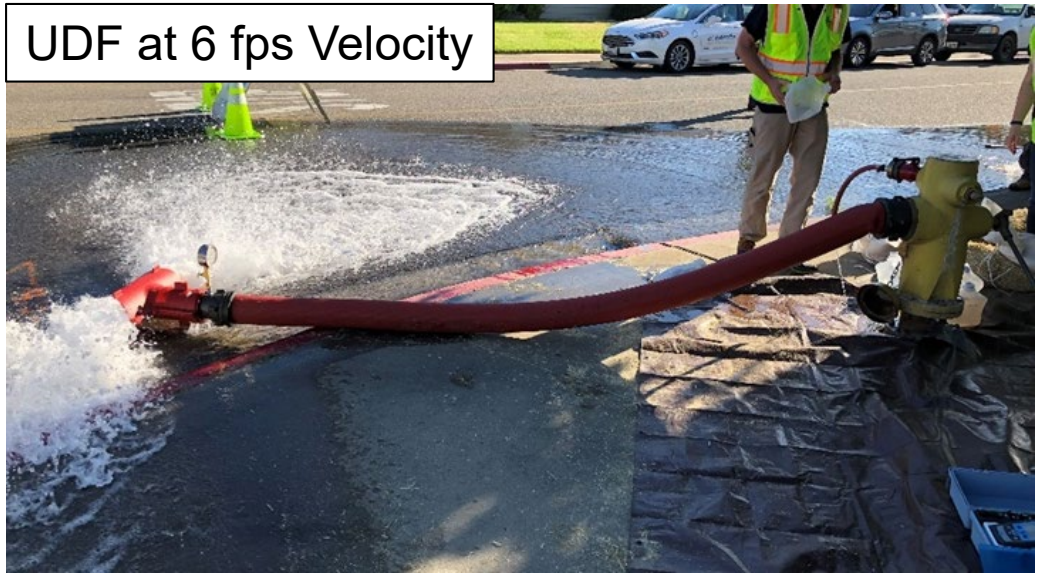
Evaluation of UDF Cleaning Efficacy for Legacy Mn

- Motivated by utility experiences
- Evaluated through controlled main cleaning trials
  - UDF at 6 ft/s followed by foam swabbing on the same pipe
  - Discharge stream sampled to assess Mn removed
- Several participating systems
  - Different pipe types and ages
  - Entry-point Mn ≤ 0.05 mg/L in each system

Main Cleaning Trials

- California system
- Undisinfected
- Mn < 0.01 mg/L
- C900 plastic pipe

UDF at 6 fps Velocity



Swabbing (Launch 1 of 4)

Discharge Sample Profiles

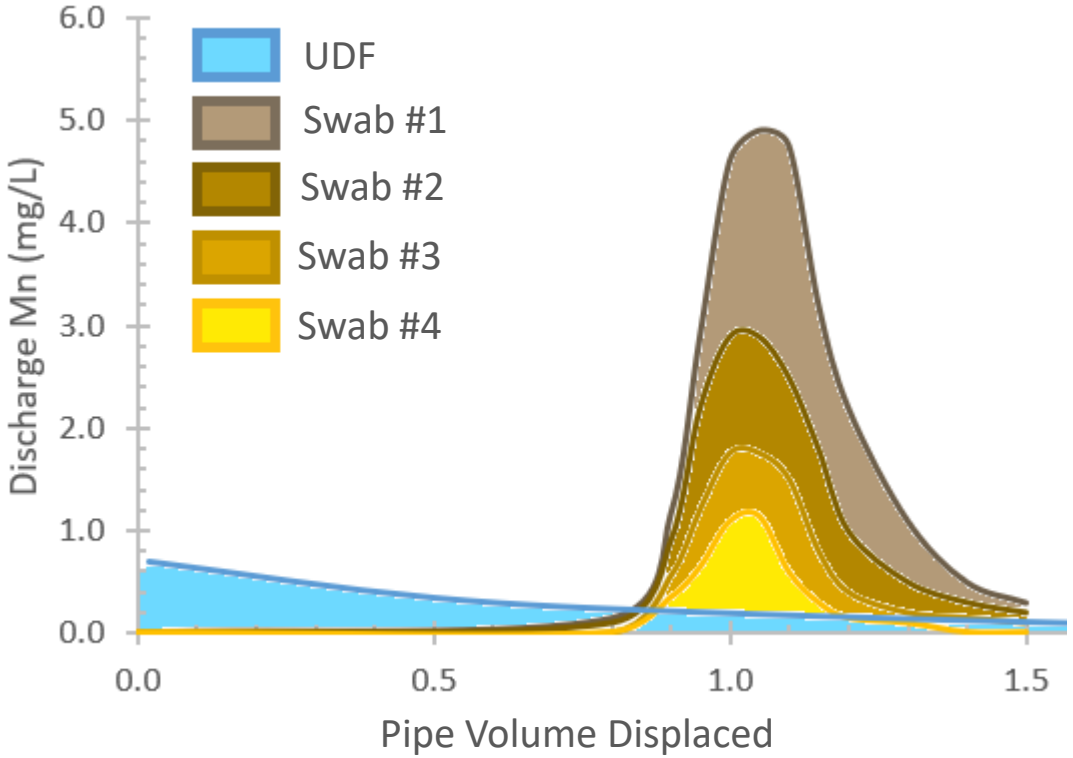
UDF Profile

Swab Composites

Manganese Mass Removal

Mass balance on profile samples

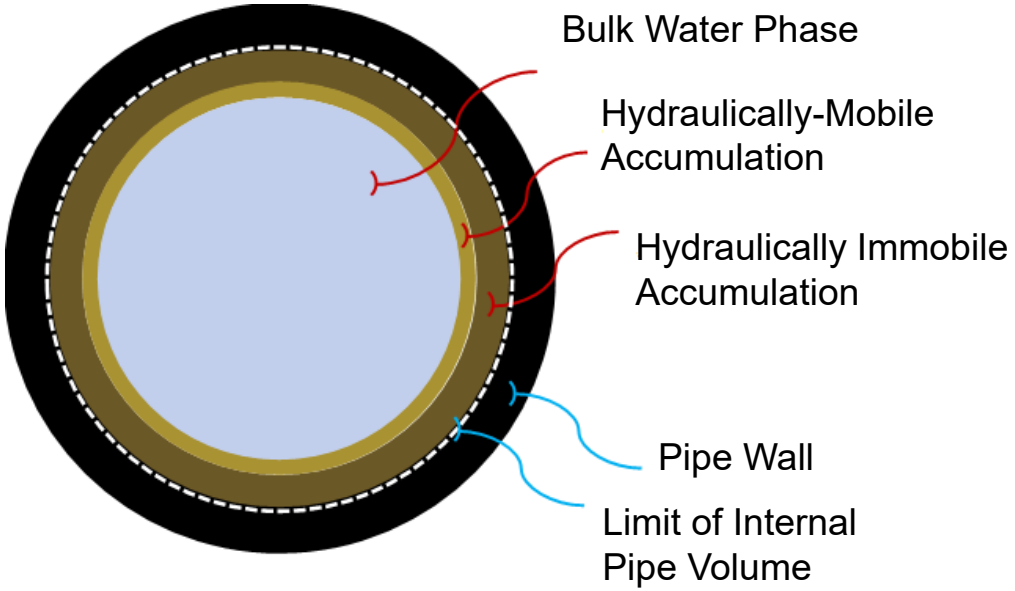
- UDF = hydraulically mobile Mn (HMM)
- Swabbing = residual Mn left on pipe
- Total Mn Inventory = UDF + Swabbing
- UDF Efficacy = HMM ÷ Total Mn [=] %



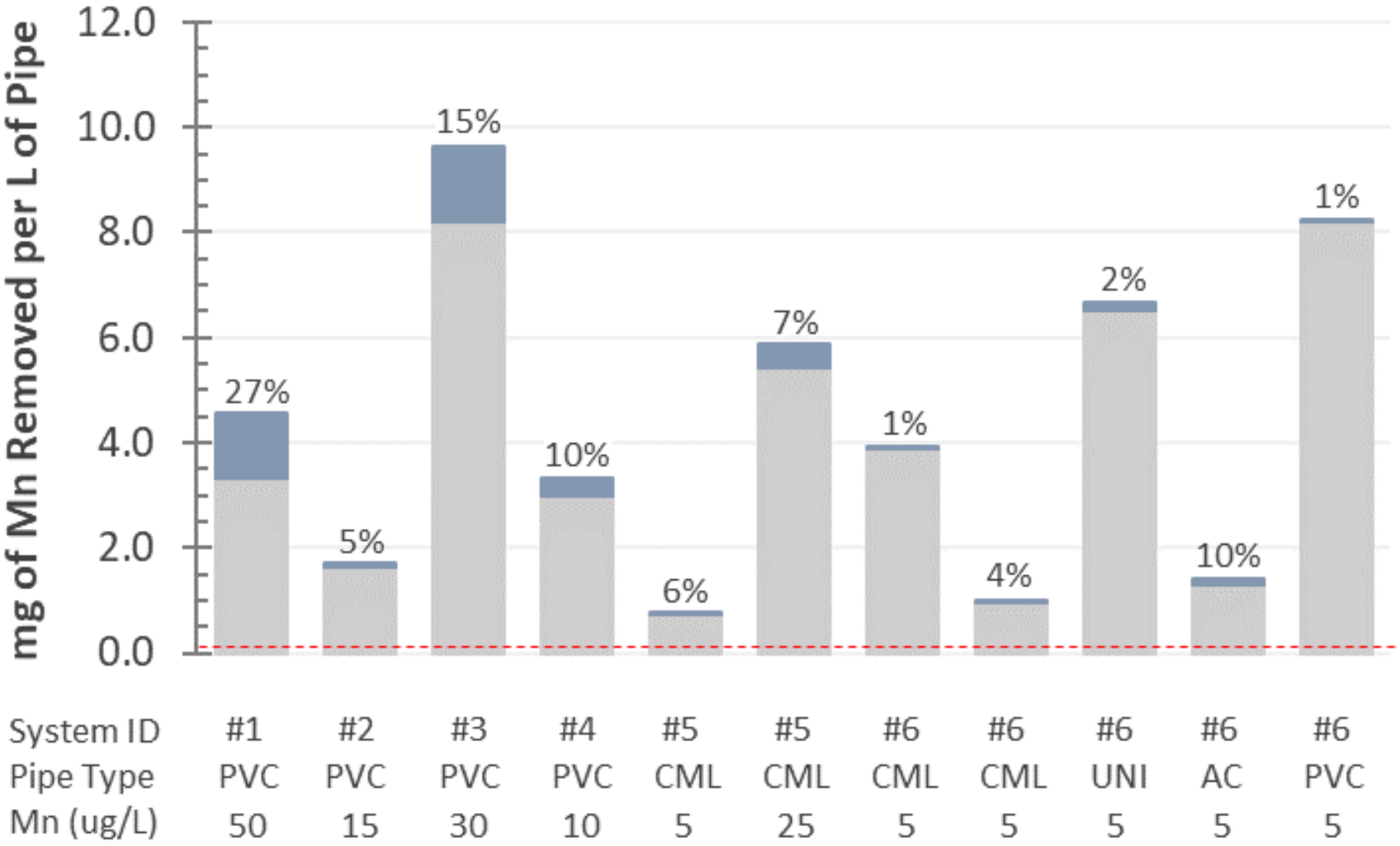
Manganese Mass Removal

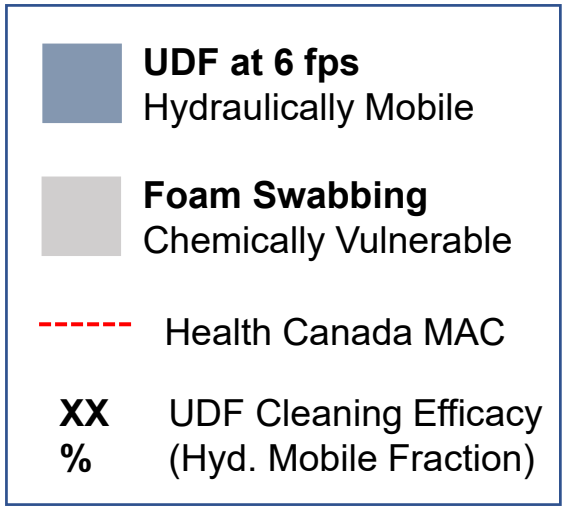
Mass removed normalized to volume of pipe (units of mg/L)

- Supports comparison across sites with different pipe sizes & lengths
- “Accumulated Mn Concentration”
- Reflects potential increase in bulk water Mn concentration if released



Challenges Flushing Legacy Mn





Implications for Utilities

1. UDF by itself cannot reliably prevent chemical releases of legacy Mn since it doesn't effectively remove it
2. There is a limit to flushing's cleaning capability for legacy Mn – repeat or frequent UDF cannot substitute for a more aggressive cleaning method

UDF – What is it Good For?

- Removes the Mn that is most mobile
  - Prevents hydraulic releases of Mn (and other loose deposits)
  - Removes Mn destabilized by source changes/chemistry shifts
- Reduces the rate of Mn accumulation
  - May slow conversion from loose to cohesive
  - Extends out the frequency for aggressive cleaning
- Other benefits
  - Water quality
  - Enforced asset inspection, exercising, and operation

Control Strategies for Legacy Mn

Strategy	Recommended Best Use
Unidirectional Flushing	• **Routine practice:** to prevent hydraulic releases, remove destabilized Mn, and slow the rate of accumulation (frequency dependent on risk factors) • **Special practice:** prior to significant hydraulic changes; after source/blend changes and water chemistry shifts
Aggressive Cleaning	• **Special or infrequent practice:** to restore pipe to a clean condition, prevent or halt chemical release events, and to address problem areas where UDF has been inadequate
Stabilize Water Chemistry	• **Where feasible** • Especially important in Mn-laden areas where aggressive cleaning cannot easily be performed • Benefits extend into premise plumbing

Utility Assessment Activities

Mn control strategies should be tailored to system conditions and risk factors for accumulation/release

- Risk screening based on existing data and institutional knowledge
  - Past/present Mn loading
  - Pipe types/ages
  - Field observations by crews
  - Customer complaint trends
- Collect and analyze pipe deposits
  - Pipe taps
  - Opportunity pipe samples from repair/replacement projects
- Conduct main cleaning demonstration tests
  - In conjunction with source/chemistry changes to assess destabilization
- Perform distribution system water quality monitoring (don't rely only on customer complaints)
  - "Event-based" = focused, risk-based
  - Especially important to capture soluble release events (no visual alert)

Special Situations

Before introducing a new source or making treatment or disinfection changes, conduct pipe loop tests with native pipes to assess scale re-equilibration response

Thank You!

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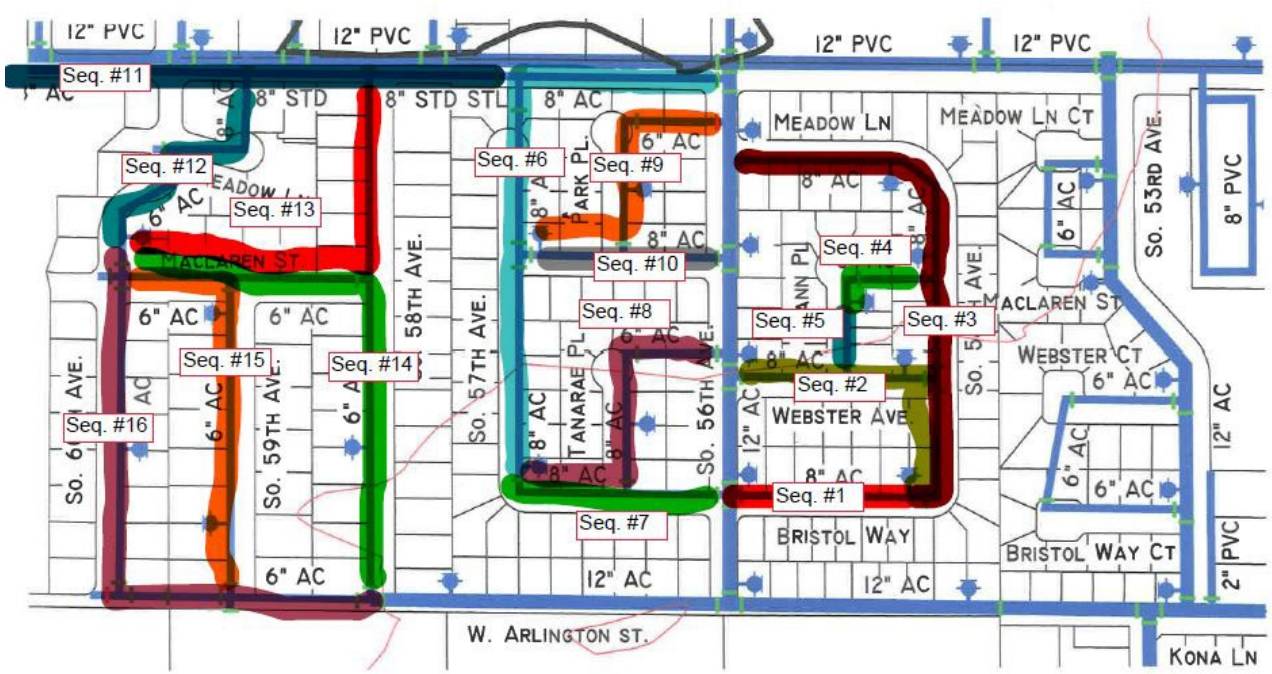
Reference Slides

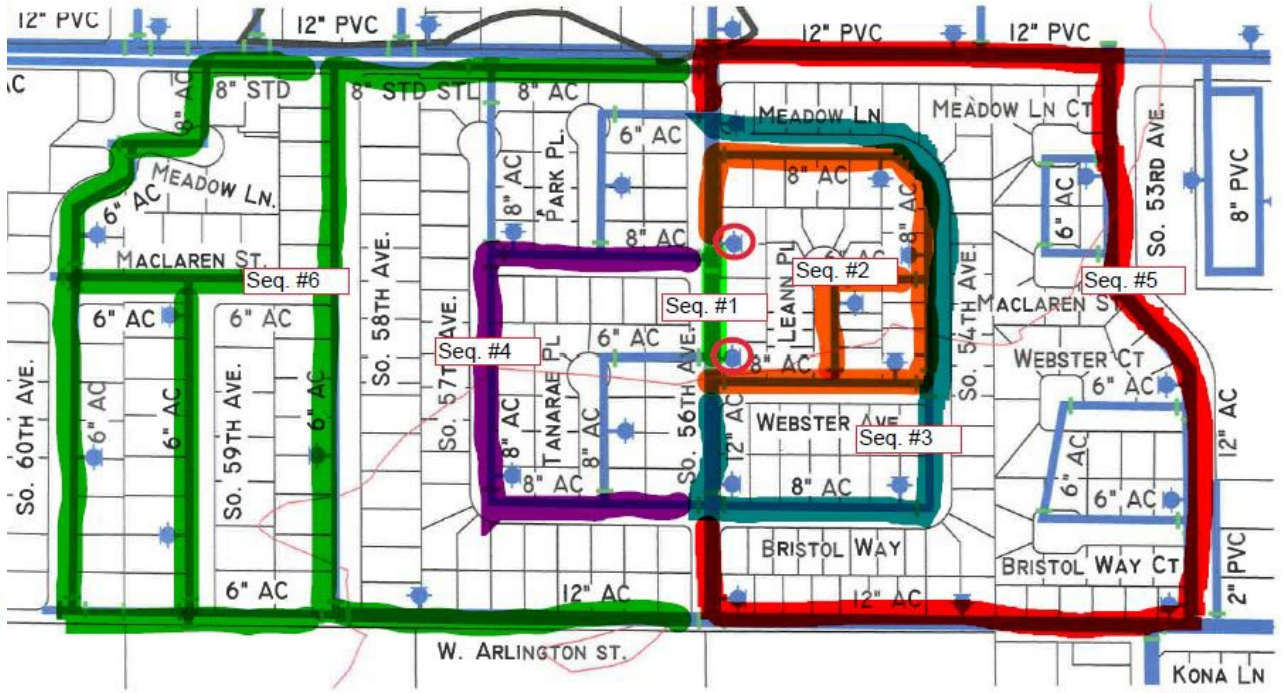
UDF

- Pipe Diameters conserved with sequence
- Valving and direction of flow from large to small
- Work from CWI out to smaller mains; very sequential
- Flowrates are set to meet velocity goals (depend on pipe diameter)

NO-DES

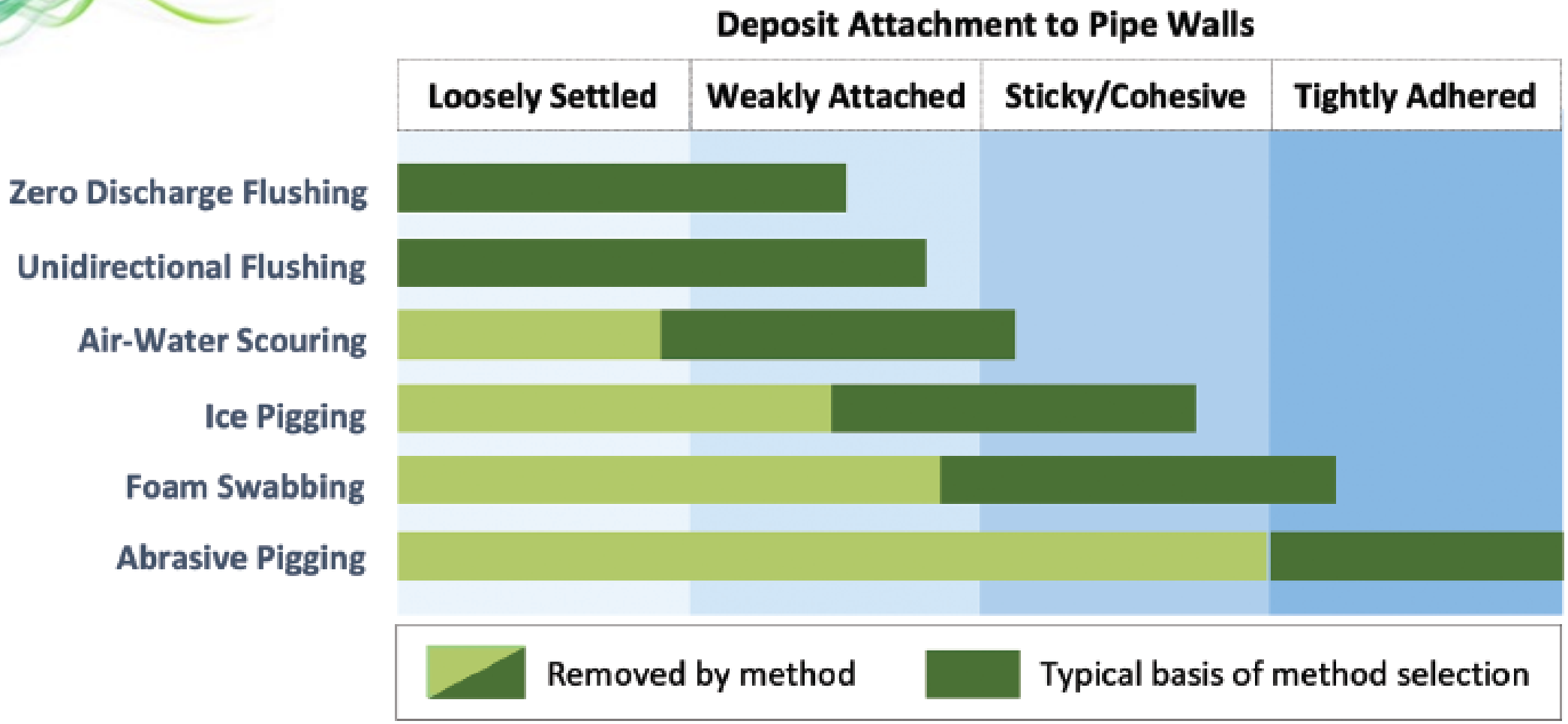
- Potential for several pipe diameters per “loop”
- One set flowrate through multiple pipe diameters leads to variable velocities and cleaning performance
- No CWI necessary
- Less mob./demob. time; can cover more pipe-miles per day than UDF





Source: Confluence Engineering Group LLC

Main Cleaning Application Niches



Flushing Visuals ≠ Pipe Cleaning Efficacy