

Water Mains: Clean, Pig, or Dig?



PNWS AWWA
Spokane, WA
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Presented By:

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Presentation Overview

- **Importance of Main Cleaning – Water Quality Perspective**
 - Reasons for concern
 - Regulatory aspects
 - Recent research findings
- **Overview of Selected Main Cleaning Strategies**
 - Approach
 - Effectiveness
 - Costs
- **Filling Industry Gaps with Upcoming Research**



Acknowledgments

- **Andrew Hill, Confluence**
- **AWWA**
- **Randy Moore and Kirt Ervin, Utility Services**
- **Brian Lakin, South Central Connecticut Regional Water Authority**



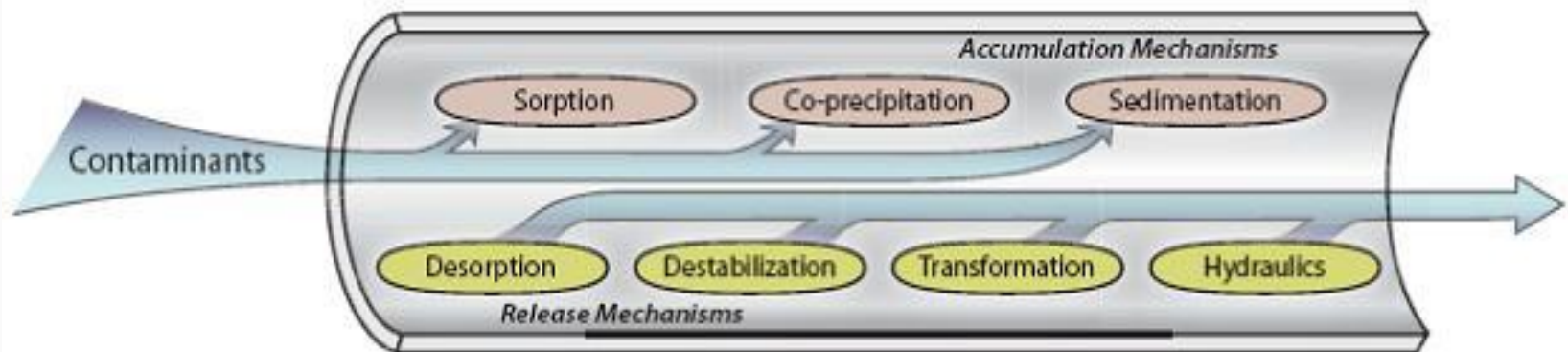
Why Clean Mains?

- **Pressure and flow impacts**
- **Rehabilitation/extend useful life**
- **Mitigate distribution system effects on water quality**
 - Water quality degradation from Point of Entry to tap



Context of Issue – Water Quality Impacts

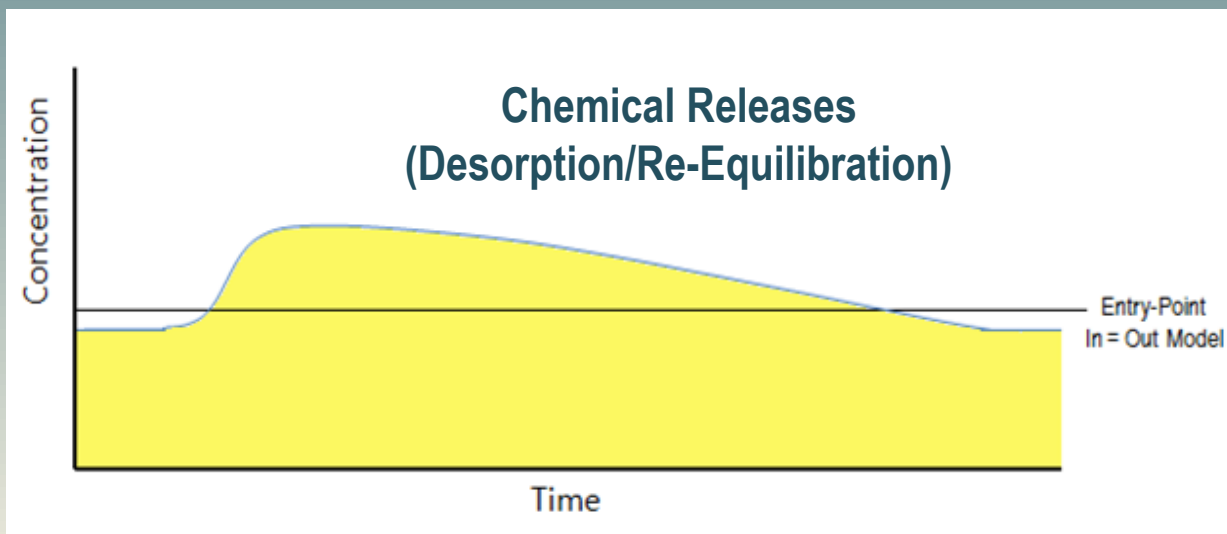
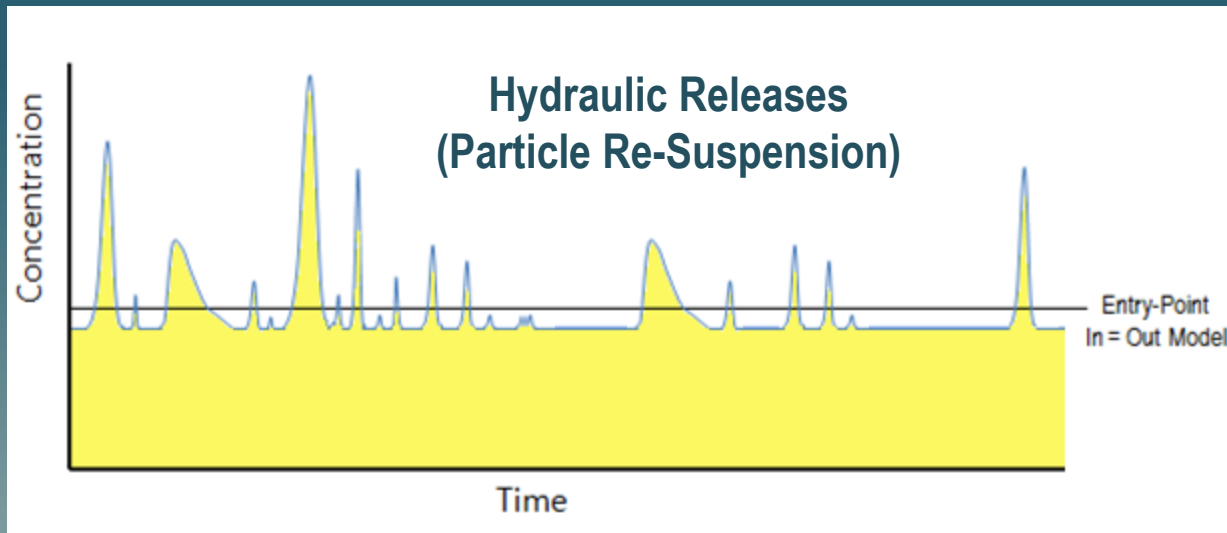
- **Distribution system isn't just a conduit – it's a reactor**
- **Water quality and hydraulics are dynamic**
- **Non-conservative water quality behavior: $in \neq out$**



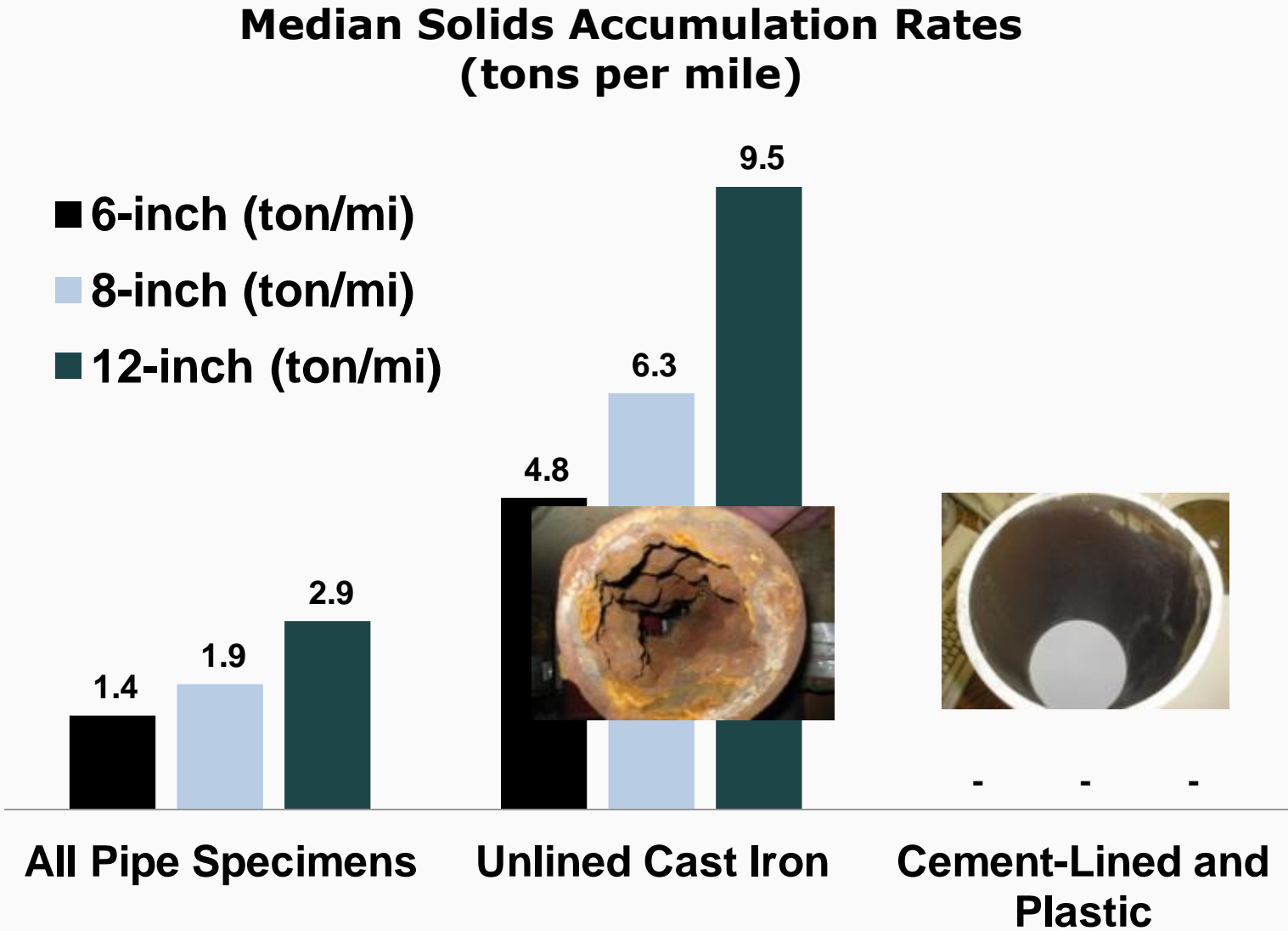
Source: Hill and Friedman et al., 2010 Journal AWWA



Conceptual Contaminant Release Profiles



Accumulation Can Be Quite Significant!!



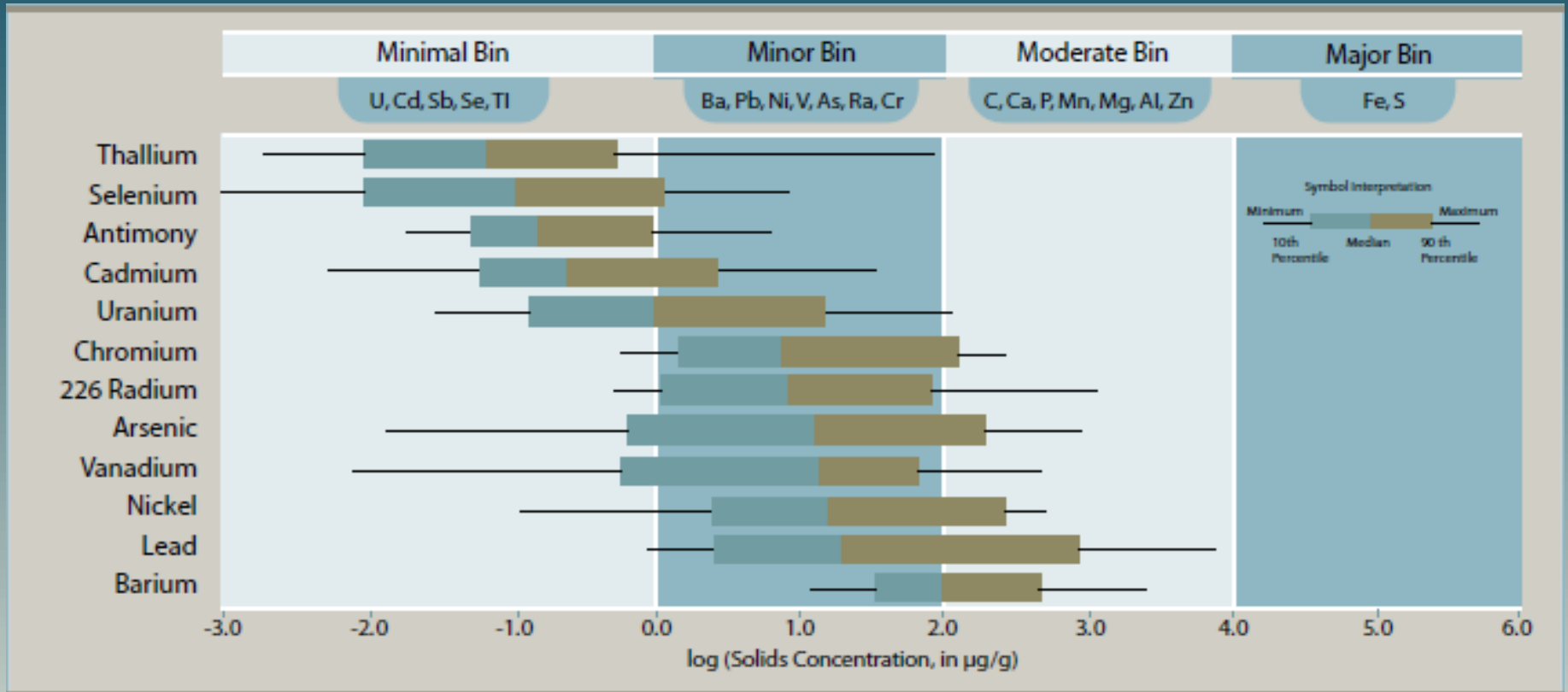
Source: Friedman and Hill et al., 2010, Water Research Foundation

Sinks – Corrosion Scales

- **Ubiquitous in distribution systems**
- **Substantial volume & surface area**
- **Very strong adsorptive properties**
 - Fe coagulant/media used for treatment



WaterRF 3118 – Occurrence Profiles



Source: Friedman and Hill et al., 2010, Water Research Foundation

Estimate of Scale Dissolution Needed to Equal MCL/AL

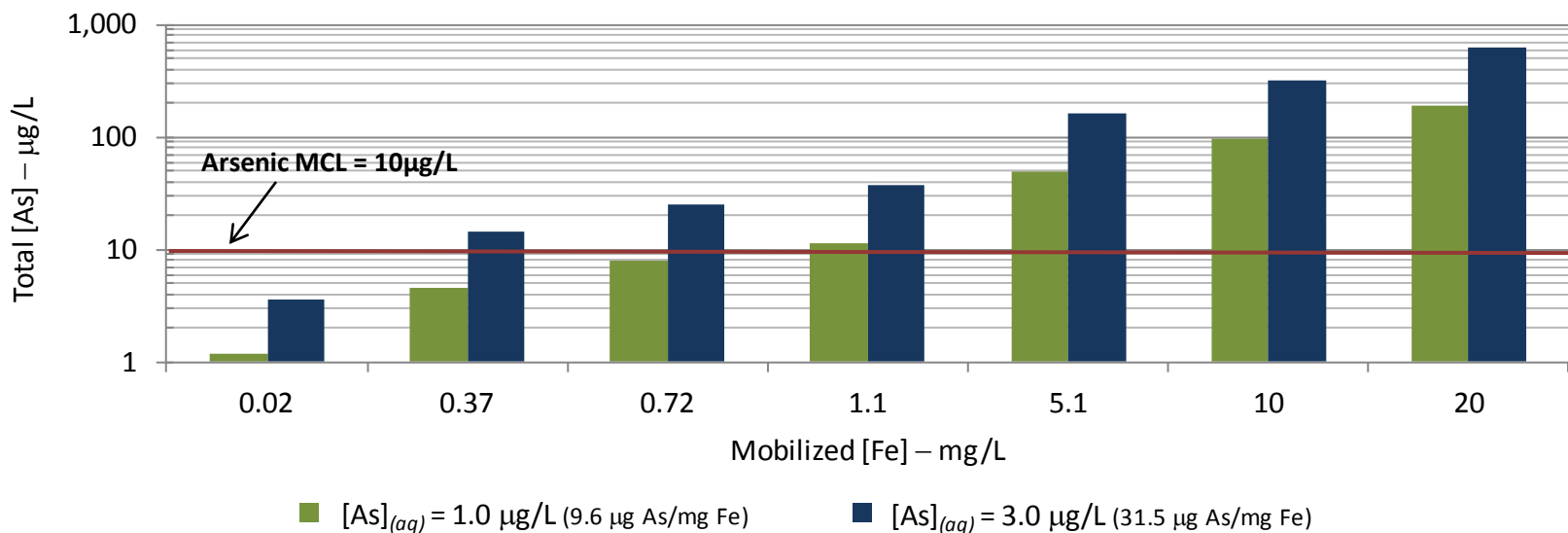
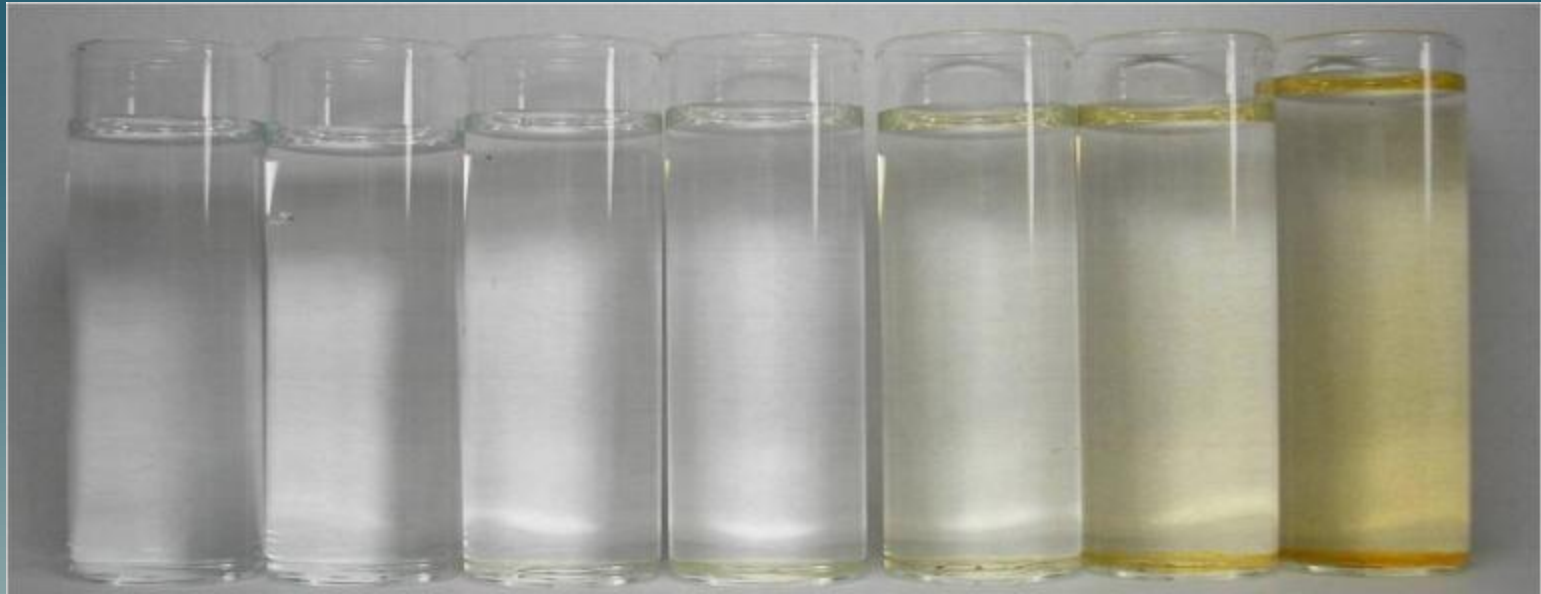
Trace Compound	% Scale Dissolution Needed to Equal MCL/AL
As (mg/L)	0.9
Ba (mg/L)	26.3
Cd (mg/L)	25.0
Cr (mg/L)	27.0
Ni (mg/L)	16.4
Pb (mg/L)	2.3
²²⁶Ra (pCi/L)	2.9
Sb (mg/L)	85.7
Se (mg/L)	555.6
Tl (mg/L)	66.7
U (mg/L)	60.0
V (mg/L)	5.3



Source: HDR Engineering

Can't Just Rely on Visual Clarity!!

Simulated Fe-As Particle Mobilization



Current Industry Initiatives

- **Limitations of current SDWA framework**
 - Monitoring/MCLs apply to system entry-points (POEs)
 - MCLs intended to protect against chronic health effects
- **To be addressed in future SDWA activity?**
 - Identified in RTCR Agreement-in-Principle as a “priority issue for additional research and information collection” (EPA, 2008)



Water Quality Drivers for Mains Cleaning

Water Quality Indicators

- Frequent water quality/discolored water customer complaints?
- Elevated levels of HPC? Positive coliform results?
- Difficulty maintaining disinfectant residual in parts of system?
- Sediment accumulation in reservoirs/dead-ends?

Water Quality Risk Factors

- Unfiltered supplies?
- Low-level loading of turbidity, sediment, Fe/Mn?
- Lots of old or corroded unlined iron pipe?
- Planning to implement a treatment change?
- Planning to introduce a new source?
- Planning piping changes that affect hydraulics?



Main Cleaning Options to be Discussed

- **Flushing**
- **Ice pigging**
- **Swabbing/pigging**
- **Mechanical scraping**



6 Essential Mains Cleaning Planning Elements

- 1) **Obtain up-to-date system maps**
- 2) **Coordinate stakeholders and define responsibilities**
- 3) **Obtain field equipment and necessary permits**
- 4) **Develop loops and establish feasibility of operation**
- 5) **Perform valve/hydrant pre-inspection and maintenance**
- 6) **Conduct public and customer notification**



Flushing



Why Flush?

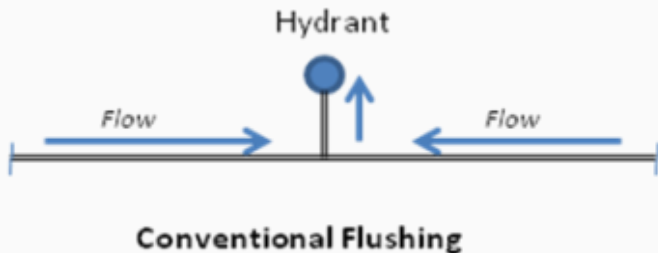
- **Key maintenance function in the “toolbox” for controlling water quality in distribution systems**
 - Pipe cleaning
 - Remove stagnant or degraded bulk water
- **Is “available” to everyone with a distribution system and hydrants**
- **Does not require outside party or vendor support**



Comparing Flushing Techniques

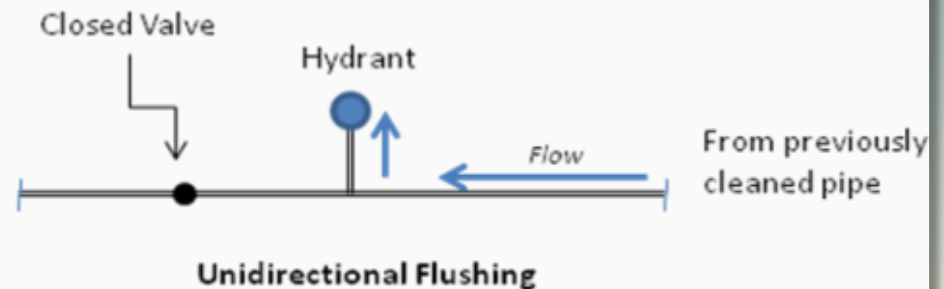
Conventional

- Hydrant draw without valving.
- Cannot control water source or velocity.
- Mainly to displace bulk water (scour usually not achieved)
- Typically reactive and localized



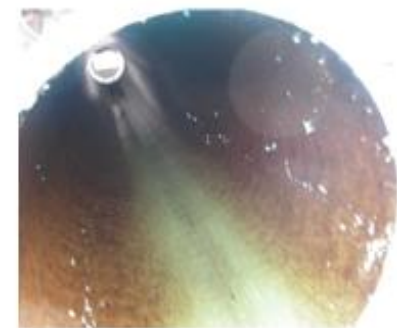
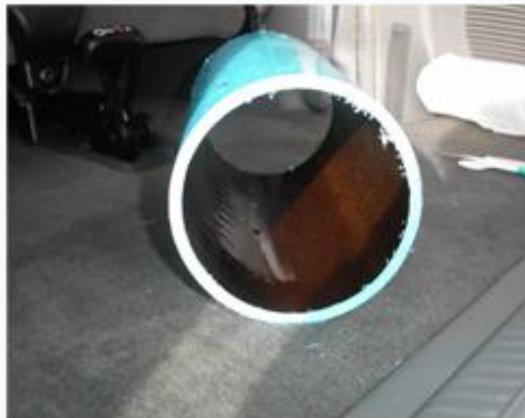
Unidirectional

- Organized, sequential valve and hydrant operation pulls water through a defined stretch of pipe.
- Start at clean water “fronts” and work towards system extremities.
- Control over the origin, direction, and velocity of water.
- Deposits are scoured and removed, and pipe is replaced with clean water.



Is Flushing the Best Solution?

- **Suited to mains $\leq 12''$ diameter**
 - Alternative strategies for larger mains
- **May not work well on some deposits**
 - Mn coatings, Adherent corrosion scale
- **More aggressive techniques may be warranted**



Mn coating on 6-inch PVC pipe before and after flushing at 10 fps



Role of Flushing Velocity

■ Flushing velocity determines scouring force

Velocity Range	Typical Objective/Benefits
2 – 4 fps	<ul style="list-style-type: none">• Bulk water turnover• Remove loose sediment
6 – 8 fps	<ul style="list-style-type: none">• Scour scale and tubercles• Thin biofilm layers• Remove portion of Mn coatings

Source: Friedman and Hill et al., 2003. WaterRF 2606



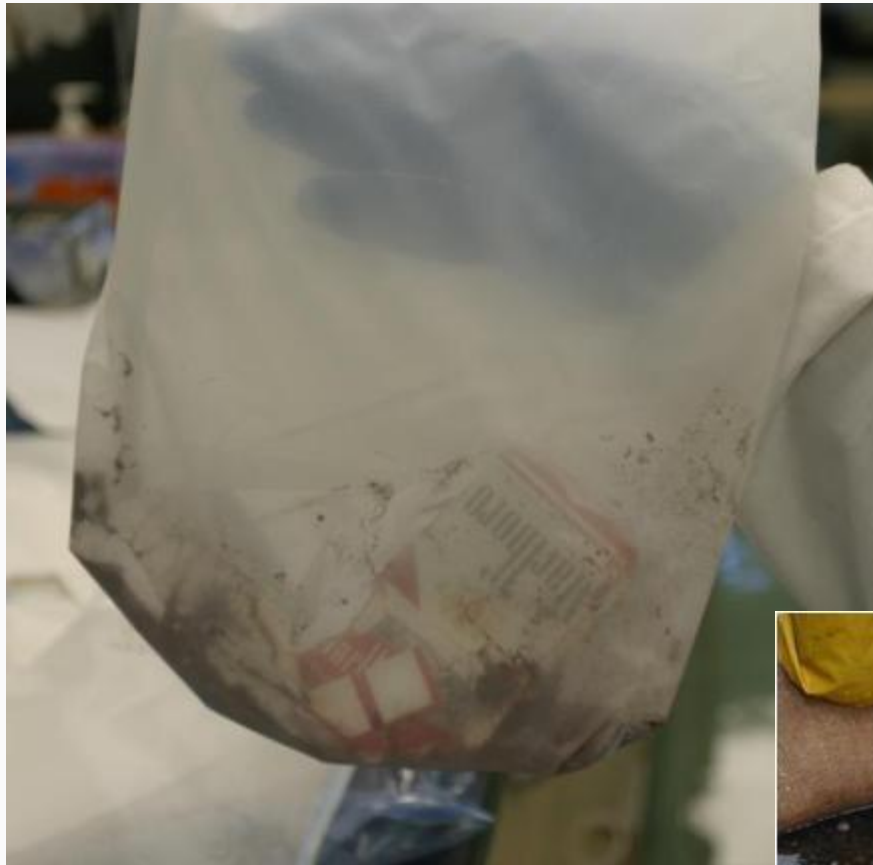
Flushing to Capture Deposits



Special socks can be used to capture solids from hydrant flushing events.



Other "Solids" from Flushing

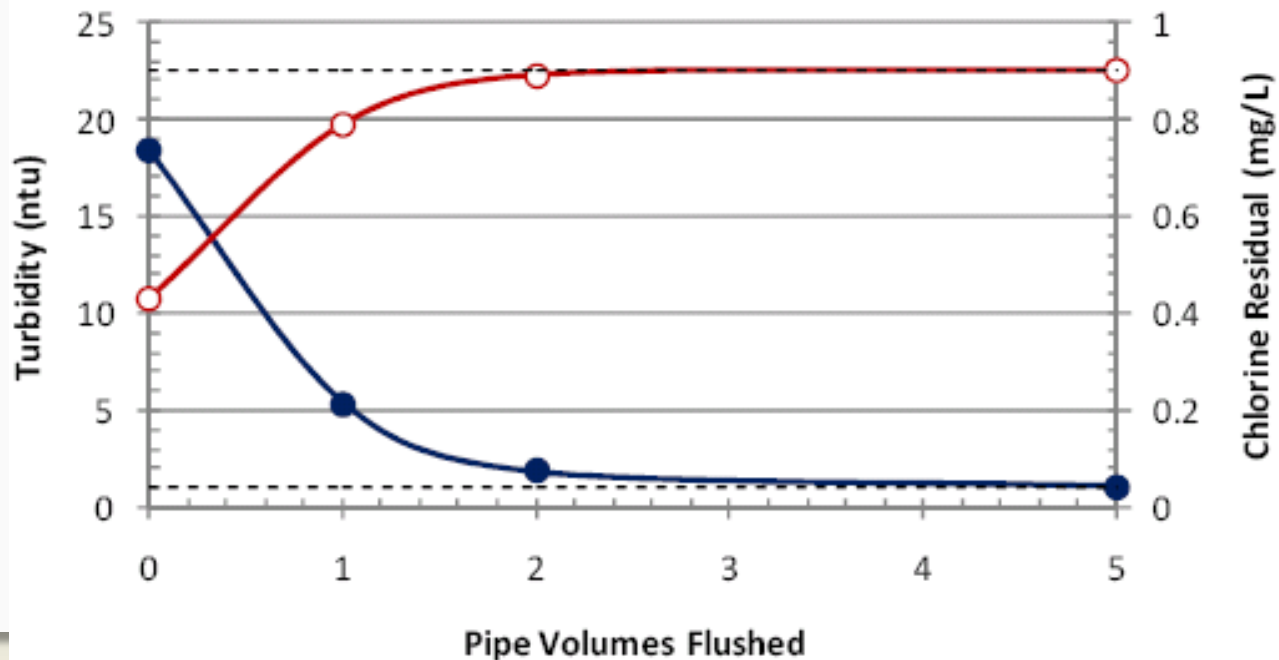


- Leaves, dirt and bark chips
- Rocks and pebbles
- Cat carcass



Duration of Flush

- Disposal constraints
- Use “flush-terminating” criteria
 - Monitor discharge water quality
 - Restore turbidity and disinfectant residual to clean water value
 - Turn-over at least 2 pipe volumes



Don't Rely Solely on Visual Appearance to Terminate Flush



#1 = 11% Pipe Volume
#2 = 33% Pipe Volume
#3 = 55% Pipe Volume

- **Flushed water looks relatively clear**
- **But compared to bulk water:**
 - Nearly 1 mg/L instantaneous total chlorine demand
 - Order-of-magnitude increase in iron
 - HPCs in the thousands
 - Flushed water was nitrified



Program Evaluation and Refinement

■ Address some basic questions

- ❑ Were water quality improvement objectives met?
- ❑ What was the level-of-effort and costs?
 - Consider one-time vs. repeat labor efforts
- ❑ Were there positive secondary aspects?
- ❑ Were there negative secondary aspects?

■ Assess pros/cons and costs/benefits and refine the program as appropriate



Ice Pigging

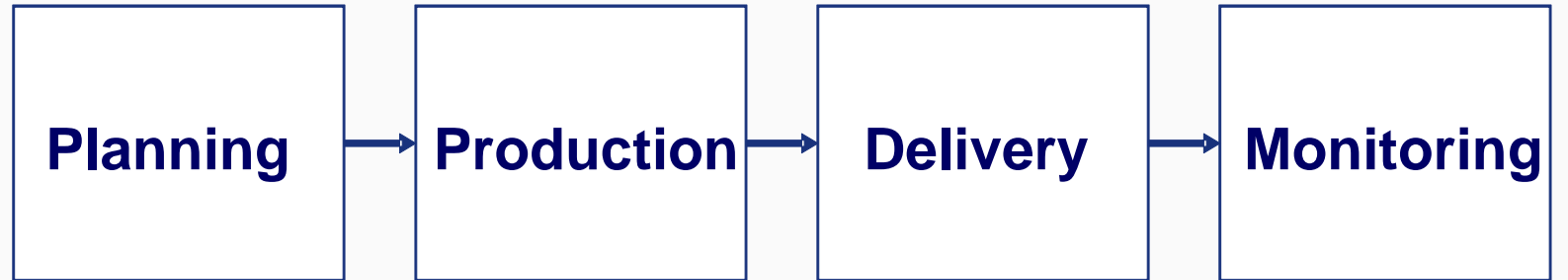


How Does Ice Pigging Work?



- An ice pig is a semi-solid material that can be pumped like a liquid
- But behaves like a solid once the pig is formed in the pipe
- National Sanitary Foundation (NSF) approved additive (NaCl) as freezing point depressant
- Additional chlorine maybe added

Overview of Ice Pigging



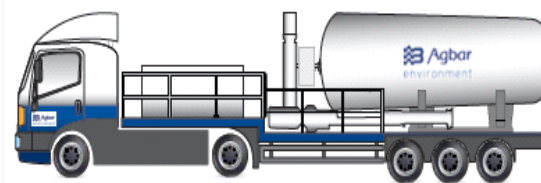
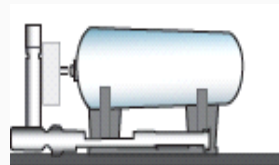
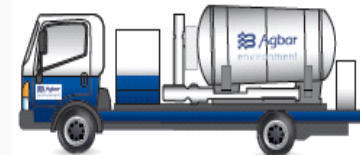
Pipes and fittings plans and operational requirements

Ice makers
Holding tanks

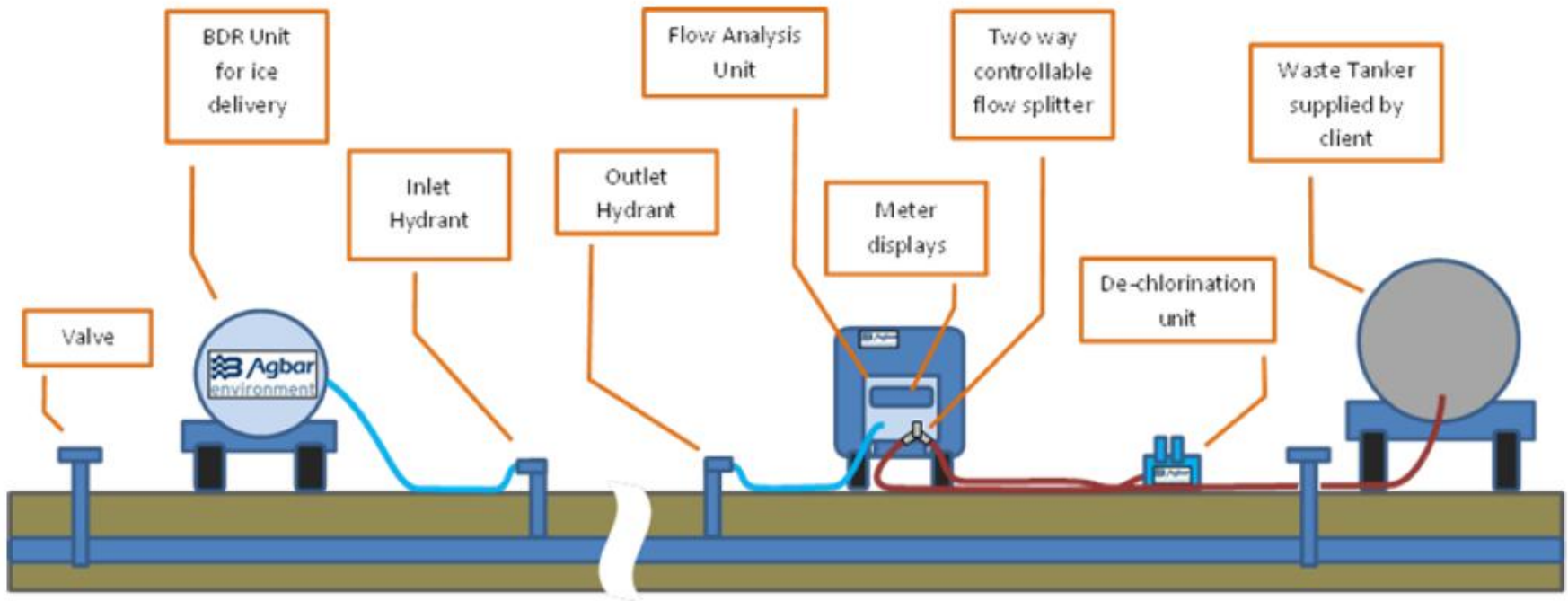
Delivery units
Support vehicles

Instrumentation

Use Utility Water to Make Ice



Overview of Ice Pigging Process



- Main is isolated
- Volume of ice slurry is pumped into water main (10-20% of pipe volume)
- Ice is carried downstream using upstream main pressure
- Debris is captured within the ice – not pushed ahead by the ice
- Conductivity and temperature monitors detect when pig is arriving
- Debris is removed with the ice pig
- Approximately one-half pipe volume is flushed
- Main is returned back to service according to local requirements

10T Rig in Spain



2 Ton Unit and Ice Maker



28

Checking the Density of the Ice



Ice Pigging Monitoring Equipment



What Comes Out

Samples from the Ice Pig

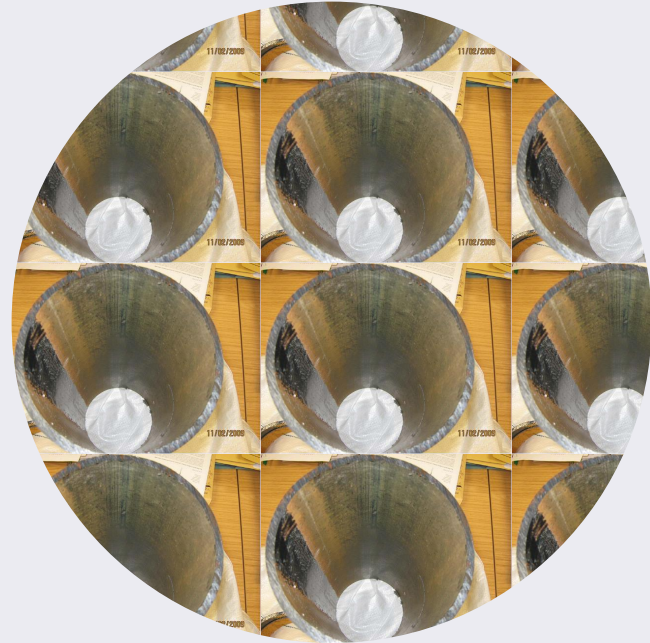
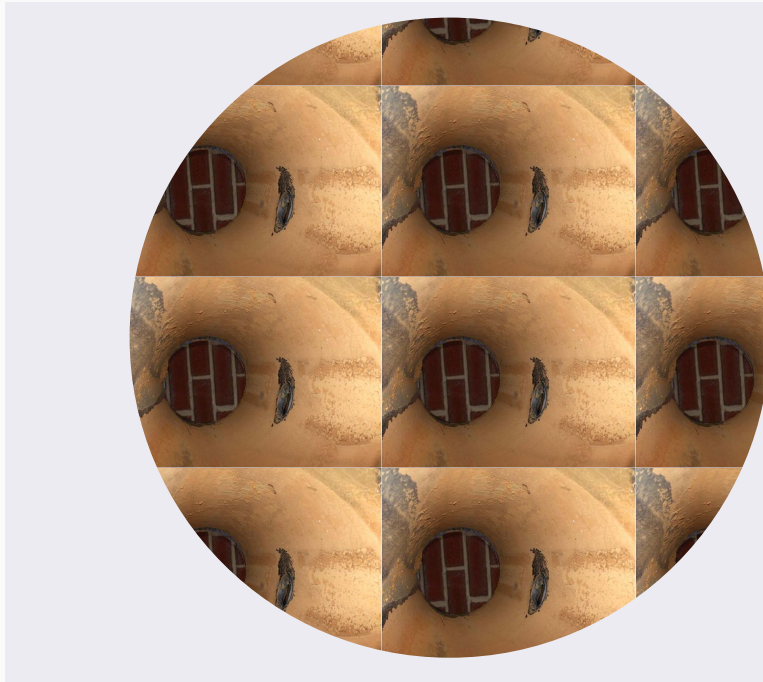


- ① Sample from front of pig
- ② Sample from middle of pig as it carries through sediment
- ③ Sample at end of pig where water is clean again

Results of the Process

Before

After



Comparing the interior of a 6 inch PVC pipe

Results of the Process

Before



After



Comparing the interior of a 6 inch cast iron pipe

Advantages of Ice Pigging

- Flow through changes in diameters, bends and valves
- Typically does not require excavation – insert ice slurry through existing hydrants/valves
- Low risk operation (compared to pigging/swabbing)
- Uses less water than traditional flushing to achieve same or better results
- Do not necessarily need to isolate services



Disadvantages of Ice Pigging

- Requires specialty equipment
- Requires third-party vendor support
- Extent of experience generally limited to pipe diameters \leq 18-inches
- Salt discharge requirements need to be determined for storm and sanitary sewer
- More expensive per mile of pipe compared to Unidirectional flushing (UDF) (but likely more effective)



Fluid Propelled Cleaning – Swabbing and Pigging



Distinction Between Swabbing and Pigging

Swabbing

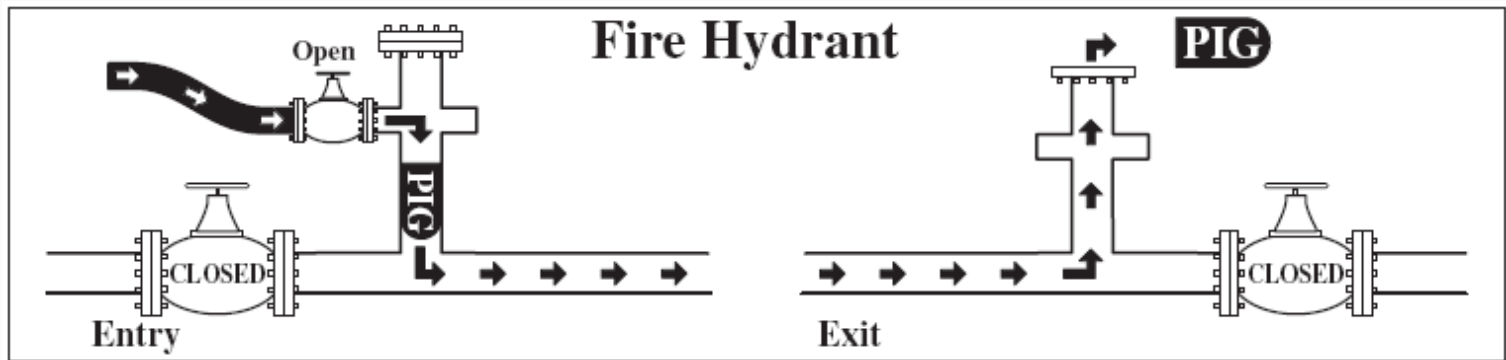
- Soft, compressible foam cylinders or cubes
- Launch/retrieval stations not needed for pipe <12-inch
- Gentler than pigging, more aggressive than flushing
- Can remove biofilm, Mn films
- Can navigate bends/pipe diameter changes
- Does not require relining

Pigging

- Rigid bullet-shaped pigs, with or without wire brushes
- Must be matched to pipe diameter
- Requires launch/retrieval stations
- Removes adherent corrosion and hard scales
- Relining of cast iron pipes and/or rehabilitation of weakened pipes often needed

Fluid Propelled Cleaning Procedure

- Perform cleaning
- Flush/Disinfect and return to service



Source: Pipeline Pigging Products, Houston, TX



Foam Swabbing



Fluid Propelled Cleaning Equipment and Labor

Pressurization tank used to force pig from launcher into water main



Pig launcher installed in street, on 'T' fitting



**Recovery point at end of main
(modified blow off)**



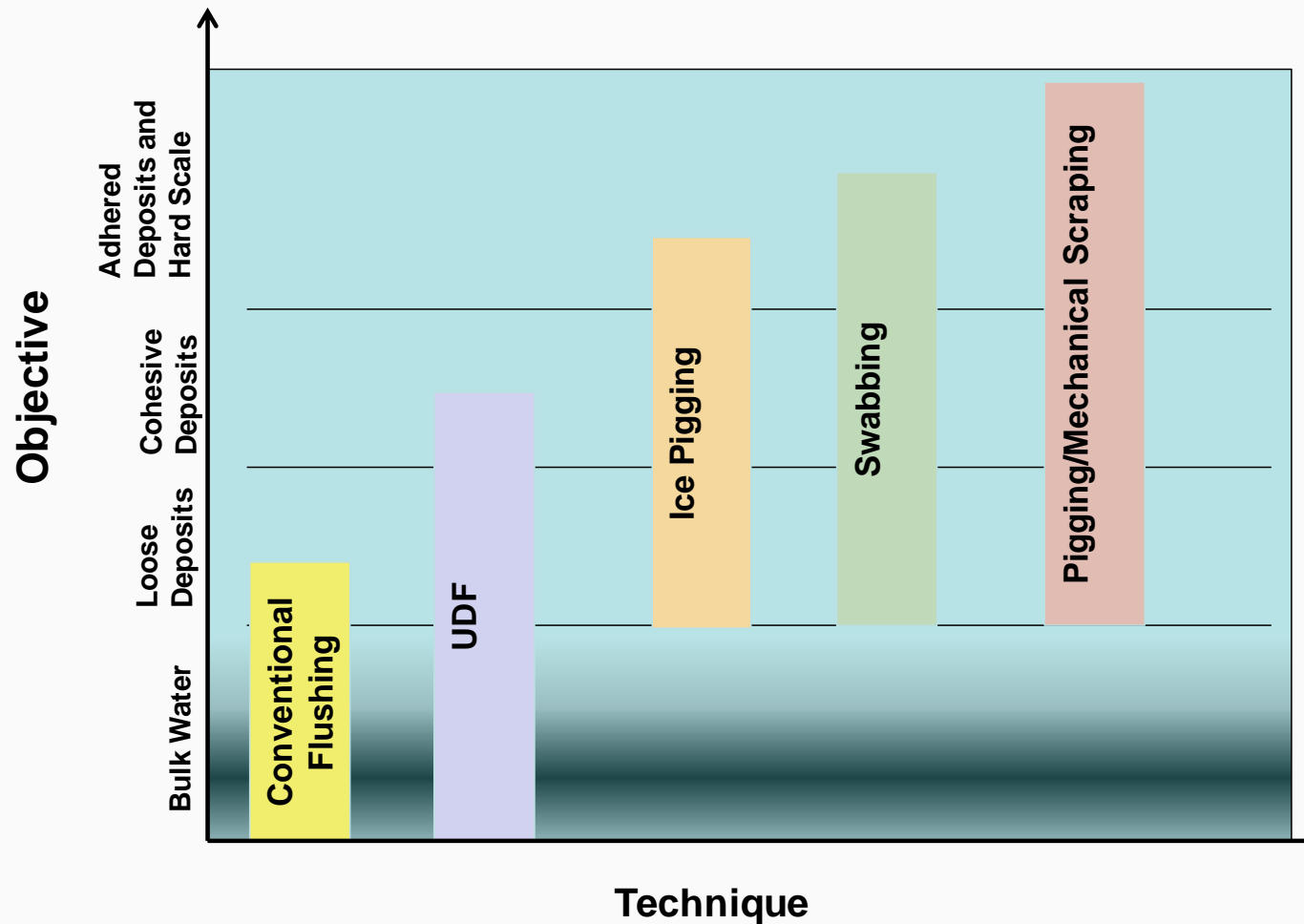
**Temporary catch basin and
disposal truck**

Mechanical Cleaning

Drag Cleaning



Comparison of Physical Mitigation Strategies



Source: Opflow, Friedman et al., August 2012.



Cost Considerations and Caveats

- **Very difficult to come up with “apples-to-apples” cost comparisons**
- **Costs per mile are extremely site-specific**
 - Pipe material/condition
 - Pipe diameter
 - Loop length
 - System modifications needed
 - Crew size
- **Cleaning frequency**
 - Primarily addressing legacy buildup?
 - Continuous loading?
 - Rehabilitation conducted?



Comparative Cost Approximations Site-Specific and Vendor Costs May Vary Significantly!

Technique	Planning Labor Costs* (\$/mi)	Field Activity Labor Costs* (\$/mi)	Estimated Vendor Support Cost (\$/mi)	Estimated Total Cost – O&M and Capital (\$/mi)**	Estimated Total Cost – O&M and Capital (\$/LF)**	Estimated Frequency (years)
UDF	\$3,000 1st time \$1,000 repeat	\$2000	\$0	\$5,000 1st time \$3,000 repeat	0.95	0.5 - 3
Ice Pigging	Similar to UDF	Similar to UDF	\$4,000 - \$24,000	\$9,000 - \$29,000	1.7 – 5.5	3 - 7
Swabbing	150% UDF	200-300% UDF	\$26,000-\$42,000	\$30,000 - \$48,000	5.7 – 9.1	3 - 7
Pigging	150-200% UDF	200-300% UDF	\$79,000-\$106,000	\$85,000 - \$111,000	16.1 – 21	≥10

Adapted from work conducted by Confluence Engineering Group, LLC and Kennedy/Jenks Consultants for San Francisco Public Utilities Commission (2011), information provided by Utility Service Group for ice pigging, and work conducted by members of Confluence Engineering Group for Woodinville Water District, WA (2008).

*Assumes labor rate of \$100/hr. Cost significantly impacted by # persons per crew, number of loops per mile, etc.

**Assumes no rehabilitation or major system modifications.

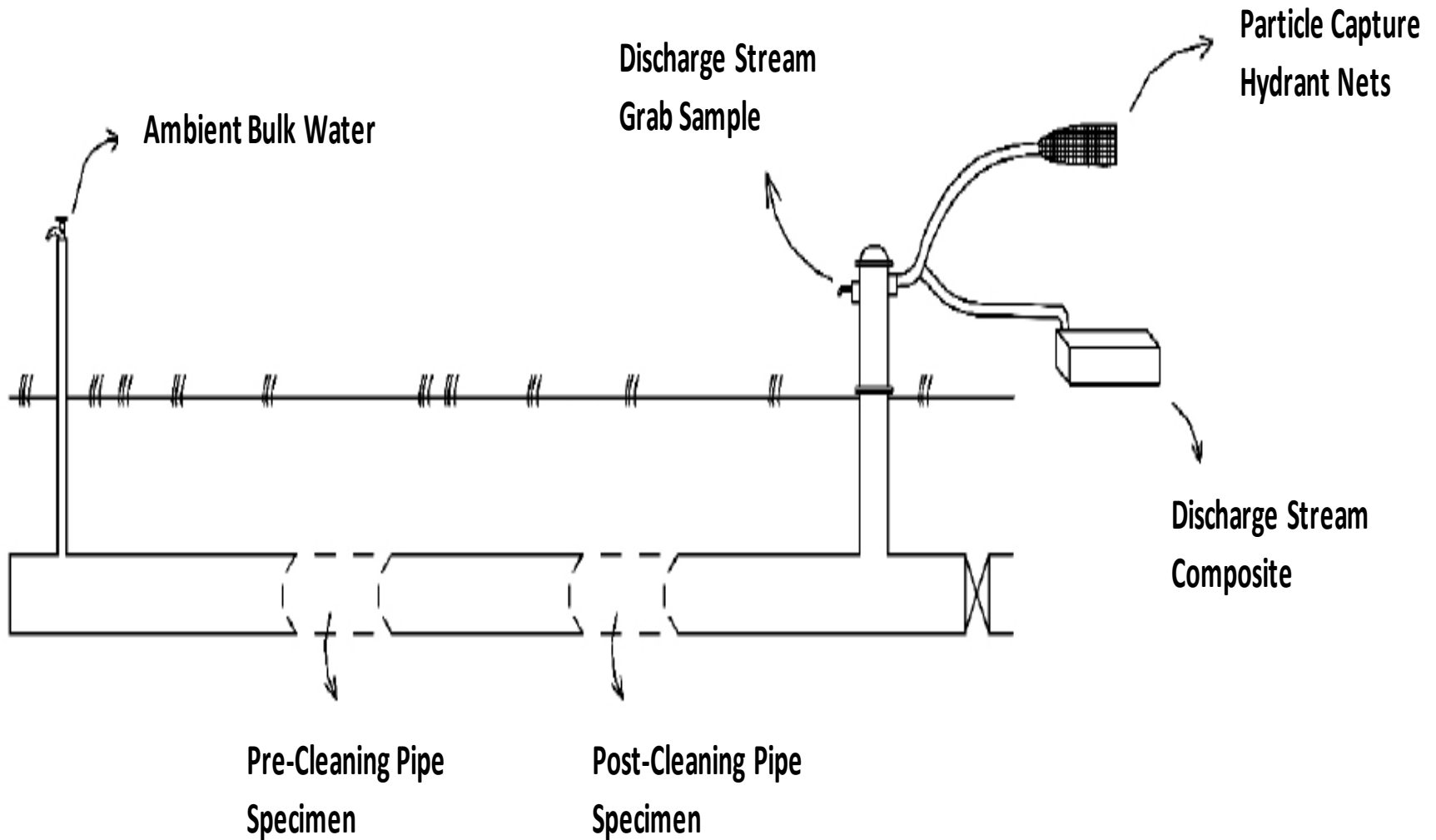
Overview of Park City Tailored Collaboration Proposal (WaterRF 4509)

■ Objectives

- ❑ Develop guidance for system-specific evaluation of vulnerability to metals accumulation and release
- ❑ Enhance understanding of accumulation/release mechanisms
- ❑ Evaluate effectiveness and costs of legacy deposit mitigation strategies for the PCMC system

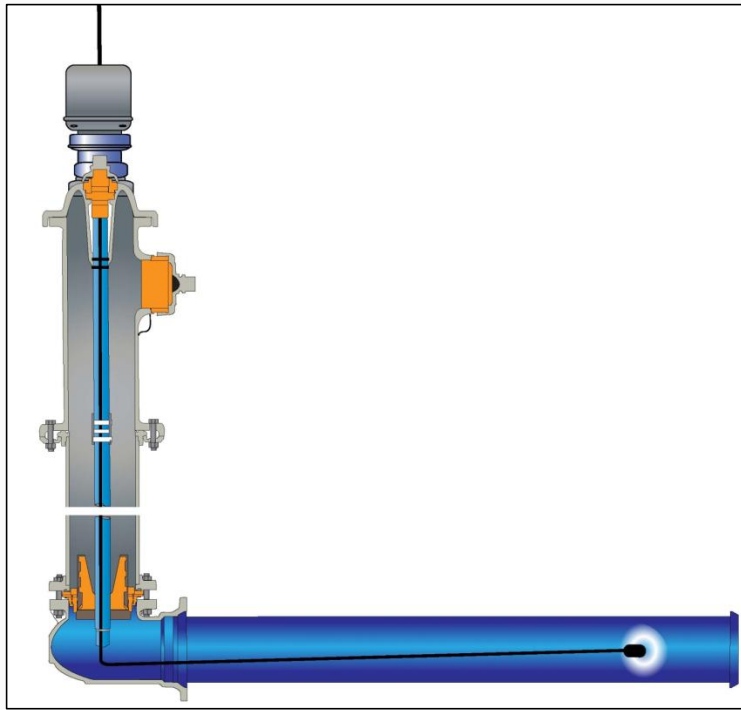


Potential Sample Origins from Pilot Demonstrations



Wachs Water Services – In-line Video Inspection

Investigator™



Example Investigator Images



Are Your Main Cleaning Practices Adequate, Optimized, and Sustainable?

- **Evaluate resource use vs. water quality objectives achieved**
- **Optimize where, when, how, how often for maximum benefits**
- **One size does not fit all**
 - Use the most efficient approach(es) for specific mains/water quality issues



Thank You!!



Questions?

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