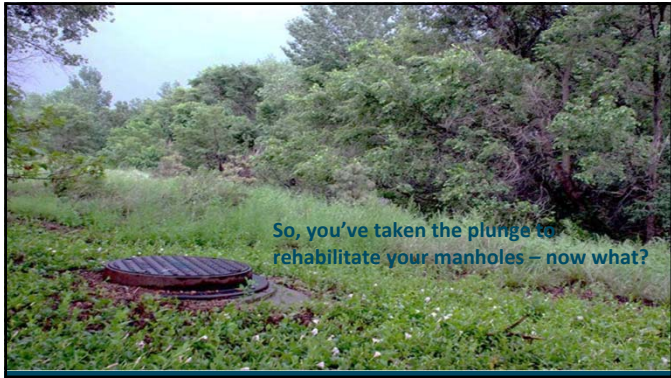
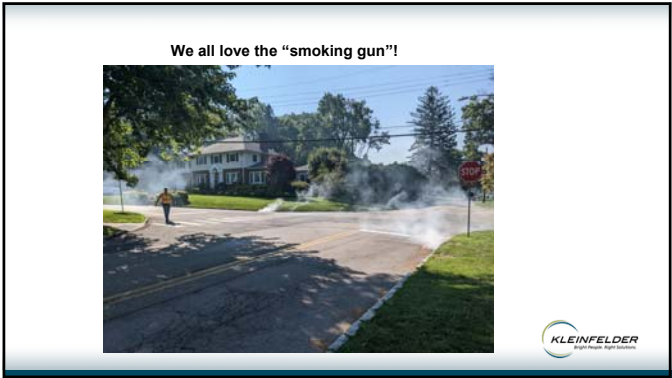


NJWEA - Winter Tech Transfer 2025 Trenchless Technologies



1



4

So, you've taken the plunge to rehabilitate your manholes – now what?

Presentation Outline:

- Importance of Manholes
- Health & Safety Preparation
- Typical Manhole Infiltration/Inflow Sources
- Decision Making
- Common Manhole Rehabilitation Methods

2

Importance of Manholes

- Manholes identified as 30-50% source of sewer system extraneous flows
- Manholes are the most important structure used in a sewerage system:
 - Manholes are “windows” into buried infrastructure that would otherwise be inaccessible
 - On average, occur every 300-400 ft in a gravity sewer system
 - Provides many access points for monitoring conditions and quantifying extraneous flows
 - Necessary for gravity system venting
 - Generally placed at pipeline junctions, slope transitions, horizontal alignments and system terminal points
 - Primary access to pipelines for maintenance, inspection, and renovation.

5

About the Presenter

- Over 25 years experience primarily with Sanitary Sewer Evaluation Surveys (SSES); Infiltration/Inflow (I/I) Investigations; and asperutenance rehabilitation
- Infrastructure Evaluation and Rehabilitation
 - Sanitary and storm sewer condition assessments
 - “Find it, fix it” sewer investigations
 - Rehabilitation projects to correct identified deficiencies
 - Projects range from small, private systems to large-scale Authorities
- NASSCO PACP/MACP/LACP Certified
 - Industry standard for sewer asperutenance condition assessment
 - NASSCO I/ICP Inspector for CIPP

3

Importance of Manholes

- Knowing your system is important - Infrastructure is deteriorating!
 - Collected data most important to have solid baseline
 - One of the largest capital assets a municipality owns/operates
 - Infrastructure approaching/beyond intended life design
 - Predominately made of Portland-cement precast concrete
 - Masonry manholes: made of brick or concrete block
 - Concrete components susceptible to deterioration
 - Stresses on concrete cause cracks and joint separation
- Manholes: Less attention than pipelines
 - Placed in high traffic roadways; heavily vegetated areas; adjacent to waterways
 - Groundwater migration to manhole
 - Water enters through manhole defects due to hydrostatic pressure:
 - Concrete erosion weakens structural integrity
 - Minerals accelerates corrosion of metal components
 - “Dutch Boy with Finger in Dike” situation

Cost of reactive repairs are typically much greater than proactive repairs!

- “A stitch in time saves nine”

6

Health & Safety Preparation

What is a Confined Space?

- Any space not designed for continuous occupancy
- Large enough for workers to **bodily enter** and perform tasks
- Limited or restricted entry or exit (egress)
 - Ability to escape in an emergency would be hindered!


Hazards: Asphyxiation, drowning, engulfment (liquids and solids), toxic chemicals, respirable dust, dangerous machinery, noise and falls





7

Typical Manhole Infiltration/Inflow Sources





10

Health & Safety Preparation

Worker Requirements

- Certification & training**
 - Confined Space Certified
 - Hazard recognition (perform appropriate testing)
 - Proper use of all PPE
 - Trained in self-rescue (to the degree possible)
 - Trained to perform necessary work!
- Occupational health monitoring protocols focus on:**
 - Behavior: claustrophobia, stress
 - Cardiac conditions, epilepsy, Type 1 diabetes, immunocompromised
 - These can put not only you but others at risk!







8

Typical Manhole Infiltration/Inflow Sources

- Frame and Cover
- Cone/Chimney/Ring
- Walls (barrel)
- Non-Watertight Joints
- Non-Watertight Piping Connection Points
- Channel and Benching
- External Drop Connection Piping






11

Health & Safety Preparation

- CSE Policy & Certification**
 - Company/Client procedures
 - CSC Permit
 - Identifies and documents hazards
 - Employer authorization to enter permit-required space
 - Completed and approved by Supervisor
 - Must be displayed near the entrance
- Have a qualified attendant**
 - ENTRY CAN NEVER BE MADE ALONE!
 - Trained individual
 - Outside the space to monitor safety conditions
 - Be ready to notify rescue teams in an emergency
- Emergency Contact Numbers (911, local contacts)**

KLEINFELDER CONFINED SPACE ENTRY PERMIT									
Job Information		Permit Information		Safety Information		Equipment Information		Signatures	
Job No.	Job Name	Permit No.	Permit Date	Permit Type	Permit Status	Equipment Type	Equipment Status	Authorized Person	Rescue Team
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue
123456	Manhole Repair	789012	12/15/2024	Standard	Active	Manhole Cover	Good	John Doe	ABC Rescue





9

Typical Manhole Infiltration/Inflow Sources

Frame and Cover

- Buried/paved-over covers**
 - Condition mostly unknown
- Vent/pick hole inflow**
 - Surface water enters left through cover ventilation and/or pick holes
 - No inflow didn't "balled down" to capture residual water
 - Covers in low lying areas subject to frequent ponding of stormwater
 - Covers located near curb and/or gutter highly susceptible
- Cracked/loose frame and cover**
 - Cover is shifting (wrong size or has become bent or bowed)
- Offset frames from concrete**
 - Frame is not properly aligned with structure
- Beneath frame**
 - Freeze/thaw cycles, heavy vehicle loading, paving, traffic vibration: promote openings
 - Surface water which penetrates road cracks and enters voids underneath frames
 - Leaking adjusting ring joints (pushed apart)
 - Improper installation or poor materials (non-waterproof cement)
 - Properly installed rubber seals around rings deform and decay over time
- Vandalism**
 - Manhole covers stolen when scrap metal prices are high





12

Typical Manhole Infiltration/Inflow Sources

Frame and Cover



View of void at precast slab junction, inset shows location near waterbody



View of inflow through cover from ponding water (no inflow insert)



View of heavy inflow through cover



View of tree obstruction



Arrow points to broken casting



Unsealed from top of cone section



13

Typical Manhole Infiltration/Inflow Sources

Cone/Chimney/Ring

- Infiltration from chimney/ring**
 - Soil expansion & contraction (freeze-thaw)
 - Causes structural movement, cracking, mortar displacement
 - Chemical attack concrete deterioration (cracks & spalling)
 - Poor construction materials & methods
 - Watertight gasket not installed or defective
- Ring section with missing or shifted bricks/blocks**
 - Poor construction materials & methods
- Root protrusion through annular voids**
 - Seek out the moisture and constant supply of air inside







16

Typical Manhole Infiltration/Inflow Sources

Frame and Cover






14

Typical Manhole Infiltration/Inflow Sources

Walls & Non-Watertight Joints

- Cracks/fractures**
 - Commonly caused by vibrations, shifting and expanding soil
 - Damaged during installation/transportation
- Infiltration from barrel joints**
 - Gasket degradation; movement and settlement; poor installation
- Infiltration from loose or missing mortar**
 - Typical with brick and block manholes
- Hydrogen Sulfide Corrosion, Microbial Induced Corrosion**
 - Erodes concrete surface; further lessens the structural integrity
 - Abrasion
- Missing or broken/corroded rungs (steps)**
- Infiltration from wall/bench interface**
- Unsealed lift holes or lateral connections**

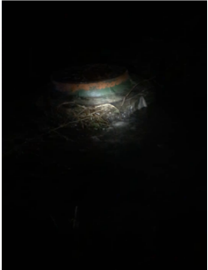





17

Typical Manhole Infiltration/Inflow Sources

Frame and Cover




Infiltration AND Exfiltration!




15

Typical Manhole Infiltration/Inflow Sources


Walls & Non-Watertight Joints




View of exposed wall aggregate due to H₂S corrosion, inset shows measured wall loss




Arrows point to wall joint leaks




View of wall joint leak




Arrow points to wall leak



View of shifted wall bricks



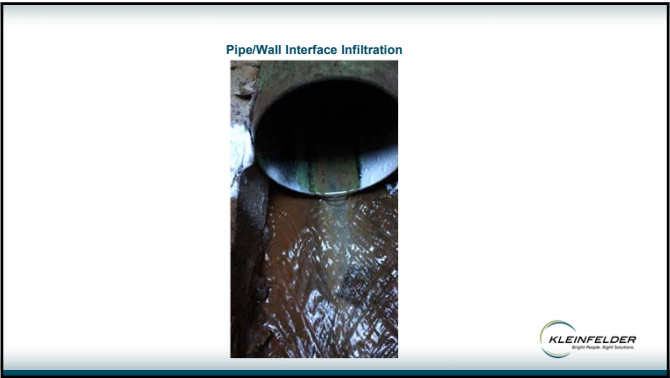
View of mineral deposit buildup from wall defect



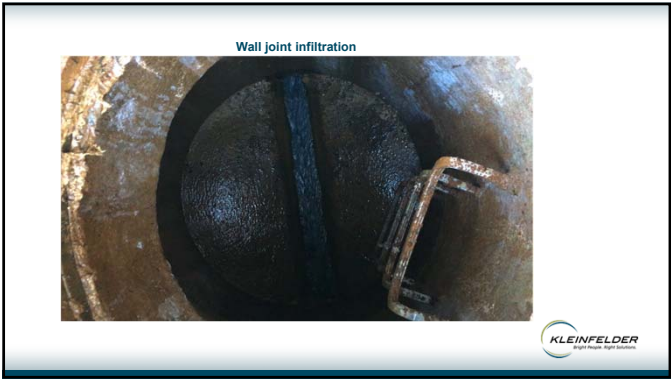
18



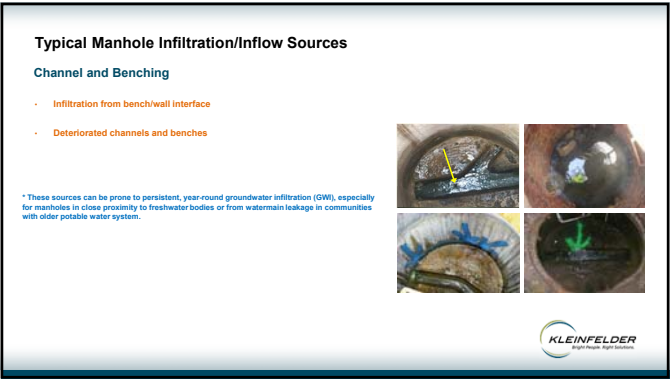
19



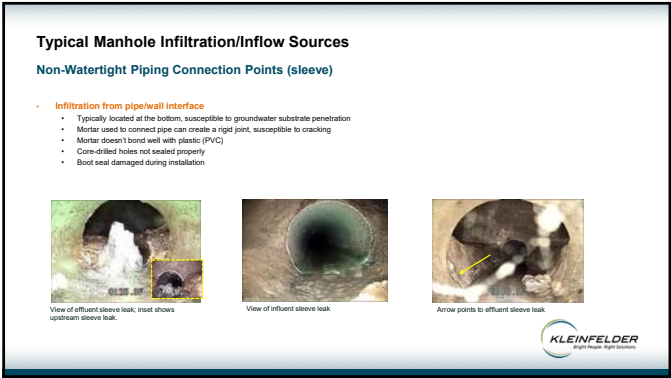
22



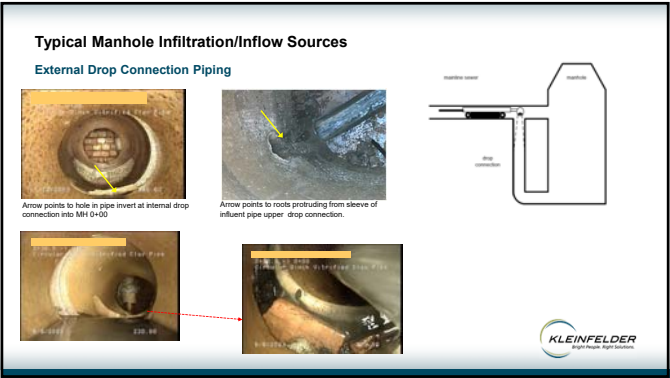
20



23









21



24

Typical Manhole Infiltration/Inflow Sources

Root Intrusions



Root bed mass in channel


Root bed mass in channel

Roots along bench and walls

Root mass

Root mass going downstream of pipe

Roots under frame of manhole and along bench




25

Decision Making

Selecting Appropriate Corrective Measure for Rehabilitation

- Investigator Training:
 - An untrained investigator will look for leaks and major structural damage
- Trained investigators will recognize obvious and subtle clues:
 - Void areas under the manhole frame
 - Evidence of surcharging
 - Evidence of overflows
 - Depth of flow in the sewer—provides clues about sewer capacity
 - Flow velocity—clues about partial obstructions & adequate velocity
 - Flow clarity
 - Evidence of vandalism
 - Intruding roots
 - Infiltrating groundwater
 - Sewer suitability as a flow measurement site
 - Cover location with regards to storm water runoff
 - Evidence of hydrogen sulfide deterioration
 - Atmospheric conditions—ability of personnel to safely enter manhole
- Weather: A manhole may have no leaks during dry and most wet weather conditions but during a few hours when rainfall-induced infiltration (RDI) occurs, the manhole may leak at very high rates (10,000-50,000 gpd).



28

Decision Making

Selecting Appropriate Corrective Measure for Rehabilitation





26

Decision Making

Selecting Appropriate Corrective Measure for Rehabilitation

- Understanding Possible Risks:
 - At what point to intervene to avoid a failed condition?
 - Avoid an unacceptable cost and/or consequence
 - Emergency repairs are always the most expensive kind
 - Crucial to know your system; high-risk locations
- In addition to inspection data, supplemental data on long-term asset performance is required to aid in the decision-making process:
 - What are the consequences of failure?
 - What is the likelihood of failure?
 - What are the costs to replace over rehabilitation?
 - What alternatives exist, given the assessment results? (e.g., replacement, trenchless rehabilitation, deferment/delay?)
- Engineering Calculations: physical measurement of wall deterioration; size of voids; manhole depth; or calculated I/I rates (orifice)
- Remaining Life Estimation: Duration of time until an unacceptable condition exists, or an asset no longer meets its primary function (NASSCO's MACP ratings)






29

Decision Making

Selecting Appropriate Corrective Measure for Rehabilitation

- Key factors to consider:
 - Existing manhole condition
 - Severity of damage
 - Intended purpose
 - Potential I/I Reduction
 - Location/accessibility
 - Traffic disruption and effects on other public utilities
 - Soil type
 - Groundwater level
 - Desired lifespan (long-term effectiveness)
 - Budget
- The purpose of a condition assessment is to detect manhole defects and/or extraneous flow sources!
- Defects must be defined and main failure mode must be determined in order to select the appropriate rehabilitation method
- This aspect of the project is essential to the ultimate success of the project





27

Decision Making

Selecting Appropriate Corrective Measure for Rehabilitation

- Consequence of Failure:
 - Refers to the potential impact the failure would have related to:
 - Environmental
 - System Reliability
 - Public Health
 - Proximity to water
 - Proximity to school or park boundaries
 - Proximity to critical infrastructure
 - Location to transportation (crosses roadway)
 - Number of tributary pipe connections
- Likelihood of Failure:
 - Refers to the probability of failure based physical condition:
 - Manhole age
 - Structural Defects of Interest
 - NASSCO MACP Ratings (Structural and O&M)
 - Location to Floodplain
 - Potential for Runoff
 - Evidence of Surcharges
- Follow-up decision making process:
 - Defect prioritization ranking and rehabilitation ranking to fix/upgrade the system leads to risk reduction!







30

Decision Making

Extraneous Flow Removal Efficiency

- Removal efficiency is primarily influenced by:
 - Success of diagnosis and prioritizing manhole extraneous flow sources
 - Ability of recommended rehabilitation work to eliminate extraneous flows
 - Quality of contractor rehabilitation work or ineffective inspection of this work
- Cannot be accomplished by one (1) investigation project followed by rehabilitation work only in the municipal sector of the sewer system
- Private property manholes are susceptible to non-watertight rehabilitation work
 - Willingness of municipality or sewer authority to enforce rehabilitation of private property manhole defects
- Ongoing evaluation programs necessary as the potential for new extraneous flow sources problems to be creates exists every day





31

Common Manhole Rehabilitation Methods

Frame and Cover

- Buried/paved covers**
 - Uncover manhole cover and assess condition
 - Raise frame to grade
 - Install rubber ring beneath frame
- Vent/pick hole inflow**
 - Install inflow-prevention insert "sated bowl" (steel or HDPE)
 - Install hole cover plugs or stainless-steel bolts with caulk
 - Replace with waterproof cover and frame
- Cracked/loose frame and cover**
 - Replace cracked frame and cover
 - Reset and seal loose frame
- Beneath Frame**
 - Chemical grout injection
 - Hydraulic cement (parging) to fill voids
 - Bitumastic sealant or replace rubber gaskets (watertight seal)
 - Polymer (polyurethane) coating to seal mounting rings and adjusting rings
 - Replace frame with polyurethane frames or adjusting rings




Source: <https://sewersentry.com>



34

Common Manhole Rehabilitation Methods

Focused on I/I Reduction or Elimination





32

Common Manhole Rehabilitation Methods

Cone/Chimney/Ring

- Infiltration from chimney/ring**
 - Inject a sealant or chemical grout into cracks
 - Install rubber sleeves (internal and external)
 - Cementitious coating
 - Flexible epoxy and urethane applied sealants
 - Polymer concrete inserts
 - Cured-in-place liners
- Cracked; missing; shifted bricks/blocks**
 - Replace bricks/blocks
 - Hydraulic cement to fill cracks and repair voids in damaged brick
 - Chemical grouts to fill voids
- Root protrusion through annular voids**
 - Chemical grout injection
 - Chemical root inhibitors: Metam-Sodium and Dichlobenil






35

Common Manhole Rehabilitation Methods

Focused on I/I Reduction or Elimination

- Chemical Grout Injection (gels and foams)**
 - Non-structural repair; primarily used for infiltration control and soil stabilization
 - May be needed to stop infiltration prior to application of linings and coatings
- Liners and Coatings**
 - Fiberglass liners used to restore surface and renew structural integrity
 - Coatings insulate surfaces from corrosion, chemical attacks, wear & tearing
 - Provides a barrier preventing entry of surface water and groundwater
 - Cement Liners: Mortarless Mortars - Fiber Reinforced Epoxies
 - Cement Liners: Calcium Aluminate Mortars - Epoxy Mortars
 - Epoxy Liners - Polyurethane and Hybrid Polyurea Liners
 - Epoxy Resin - Pure Polyurea Liners
- Structural Repairs**
 - Replacement of damaged component
 - Replace entire manhole

* Note: Multiple repair methods may be required.





33

Common Manhole Rehabilitation Methods

Walls/Joints

- Cracks/fractures**
 - Removal and replacement of damaged component
 - Full Depth Lining: Cementitious; Polymer; Epoxy; Fiberglass; Cured-in-place manhole (CIPM)
 - Polyurea protective coatings
 - Chemical grout injection
- Infiltration from joints/unsealed lift holes**
 - Chemical grout injection
 - Install rubber joint seals (compressed with expansion bands)
 - Hydraulic cement coated with a waterproofing epoxy
 - Fill lift holes with repair mortar
- Infiltration from wall/bench**
 - Repair/replace if too deteriorated allowing significant infiltration or affects hydraulics
 - Repair with hydraulic cement and/or chemical grout injection
- Hydrogen sulfide corrosion**
 - Full Depth Lining: Cementitious; Polymer; Epoxy; Cured-in-place manhole (CIPM)
- Missing or broken/corroded rungs (steps)**
 - Install/replace rungs with polypropylene rungs (tough, weather resistant)







36

Common Manhole Rehabilitation Methods

Bench/Invert


- **Infiltration from pipe/wall interface (sleeve)**
 - Cementitious mortar lining
 - Polymer cement coating
 - Chemical grout injection
 - Rubber boot
- **Infiltration from bench/wall interface**
 - High-quality cement mortar
 - Epoxy resin injections
 - Chemical grout injection
- **Deteriorated channels and benches**
 - High-quality cement mortar
 - Epoxy Coating
 - Precast concrete inserts
 - Reconstruct






37

“A sewer worker is like
a brain surgeon
... We're both
specialists”



Ed Norton (*The Honeymooners*)



38

Thank you!



Michael Whalen
mwhalen@kleinfelder.com
609.924.8821

www.kleinfelder.com





39