

Perspectives on Private Sector Infiltration/Inflow Identification and Rehabilitation



Prepared by
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RJN Group, Inc.

2012 – Original 1980's ICAP “Revisited”

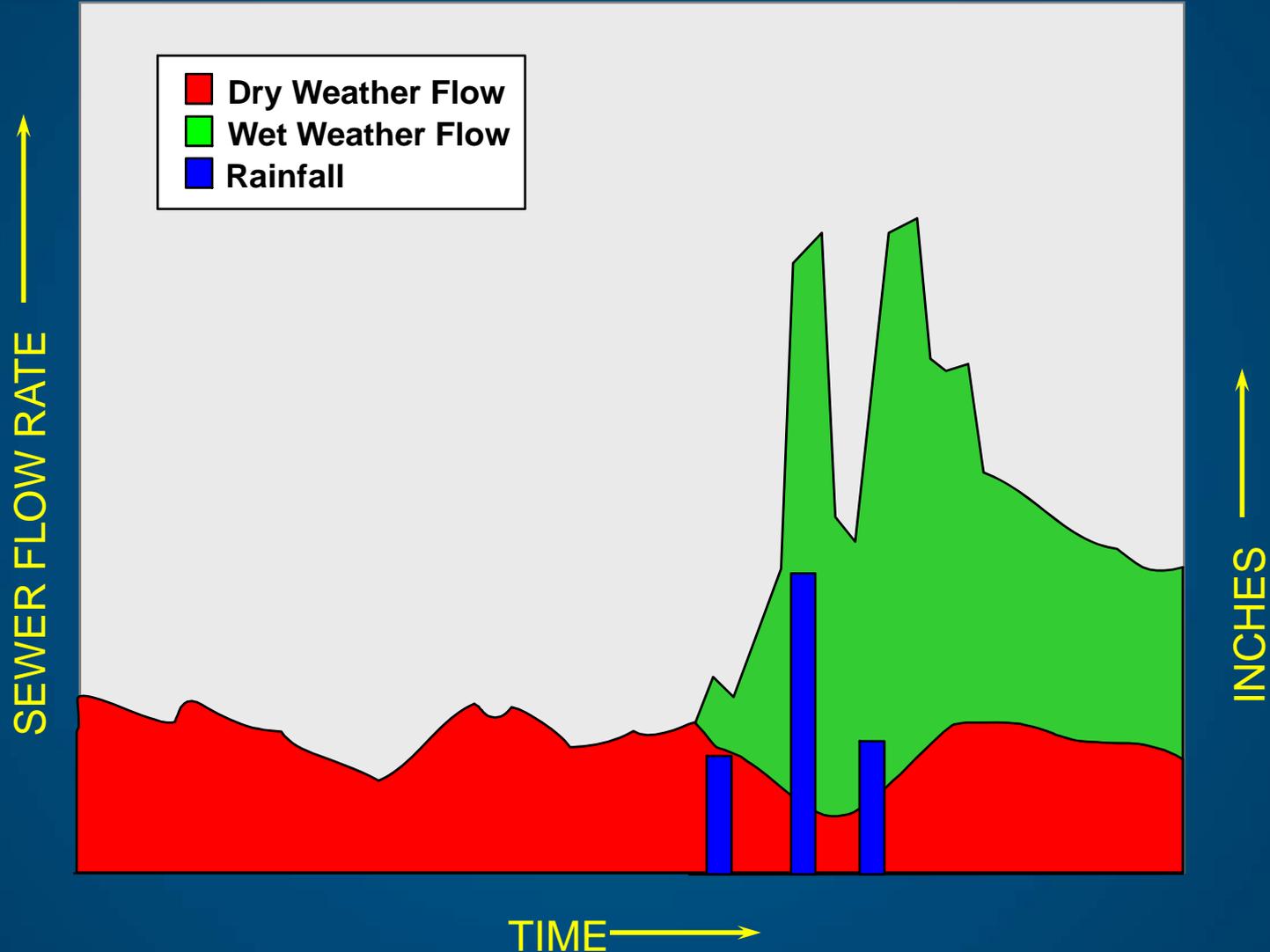
- Over 20 Years Since Original ICAP Rehabilitation
- SSO's at MWRD Pump Stations
- Increased Wet-Weather Flows at MWRD WRP's
- Recent Increase in Frequency of Very Intense Storms
- Impact of USEPA/IEPA and NPDES Permit Renewal - TBD?
- NPDES Permits for Satellite Sewer Systems - TBD?
- Public Sector Sewers Have Deteriorated Over 20 Years
- Higher Concentration on Private Sector in ICAP “Revisited”

Where Does the Rainfall Go?

- Stormwater Runoff – 40%
- Soil Absorption / Groundwater Recharge – 40%
- Evaporation – 15%
- Sanitary Sewer System – 5%



Typical Sewer Flow Hydrograph



Rainfall/Inflow Correlation

BASIN 04

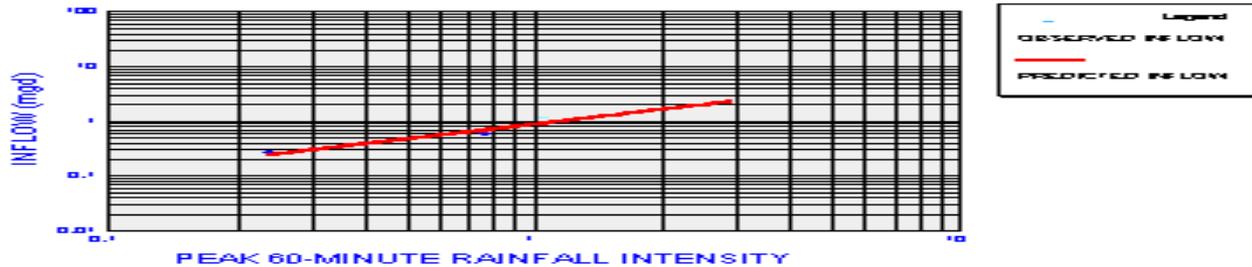
Q vs i Regression Analysis --

OBSERVED INFLOW (mgd)	i60 Rain (in/hr)	LOG Q	LOG i	PREDICTED INFLOW (mgd)	
1.093	1.070	0.039	0.029	-0.026	0.941
0.588	0.770	-0.231	-0.114	-0.155	0.700
0.326	0.350	-0.487	-0.456	-0.463	0.344
0.265	0.240	-0.577	-0.620	-0.611	0.245
1 Year Storm @	1.600		0.204	0.131	1.352
5 Year Storm @	2.550		0.407	0.313	2.058
10 Year Storm @	2.900		0.462	0.364	2.310

Regression Output:

Constant		-0.053	
Std Err of Y Est		0.076	
R Squared		0.949	0.974
No. of Observations		4.000	
Degrees of Freedom		2.000	
X Coefficient(s)	0.901		
Std Err of Coef.	0.147		

Rainfall Intensity & Inflow Relationship
Basin 02



RJN Group, Inc.
Consulting Engineers

City of Grand Prairie
9.5M, MC3 & MC4 Drainage
Areas
Exhibit

% Capture of Rainfall in Sanitary Sewer

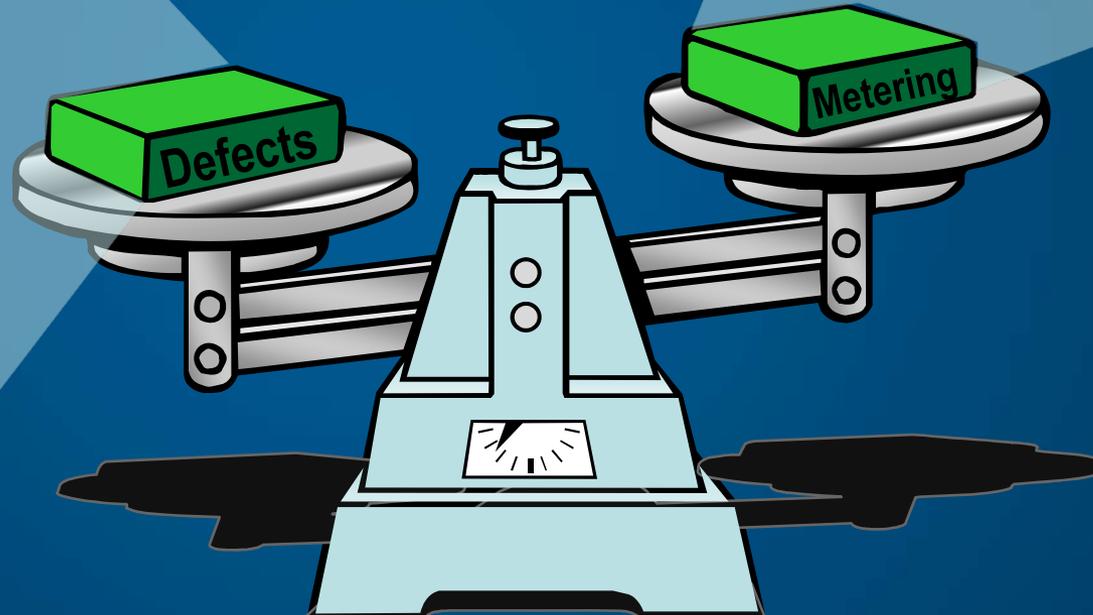
Rainfall / Inflow Relationship

Percentage Rainfall Captured

Basin 21 – Elmhurst, Illinois

Storm Date	Rainfall Intensity (inches / hour)	Percentage Peak Rainfall Runoff Captured	Percentage Rainfall Volume Captured
March 15, 1999	0.19	5.3	4.6
March 18, 1999	1.00	4.6	4.1
March 22, 1999	0.60	5.1	5.0
April 1, 1999	0.55	5.2	5.2
April 7, 1999	0.91	4.8	4.6
April 9, 1999	0.40	5.8	5.5
Average		5.1	4.9

Flow Balancing – Wet-Weather Inflow



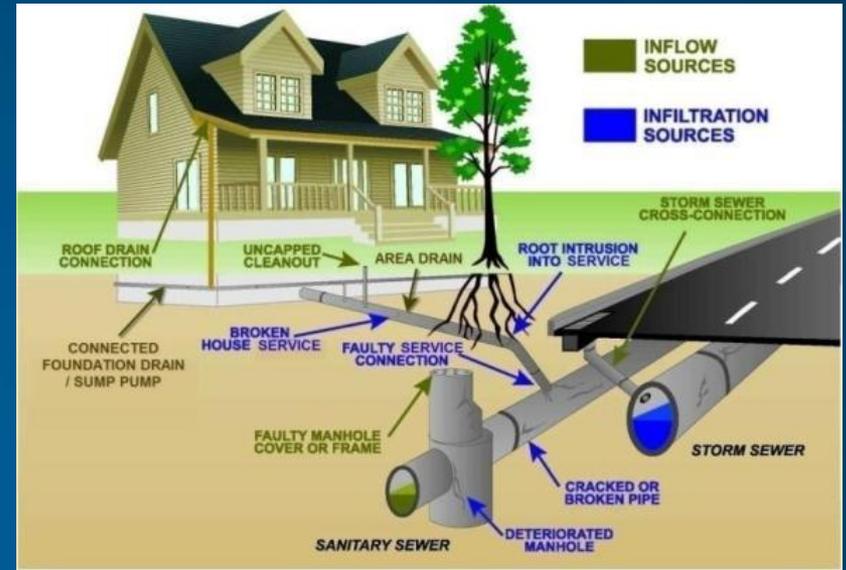
Clearwater Inflow Sources Into Sanitary Sewer

■ Public Sector

- Manholes
- Main sewers
- Storm sewer cross connections

■ Private Sector

- Interior sources - sump pumps and foundation drains
- Exterior sources - driveway, stairwell, patio, area drains, cleanouts
- Service laterals and service lateral connection to main sewer

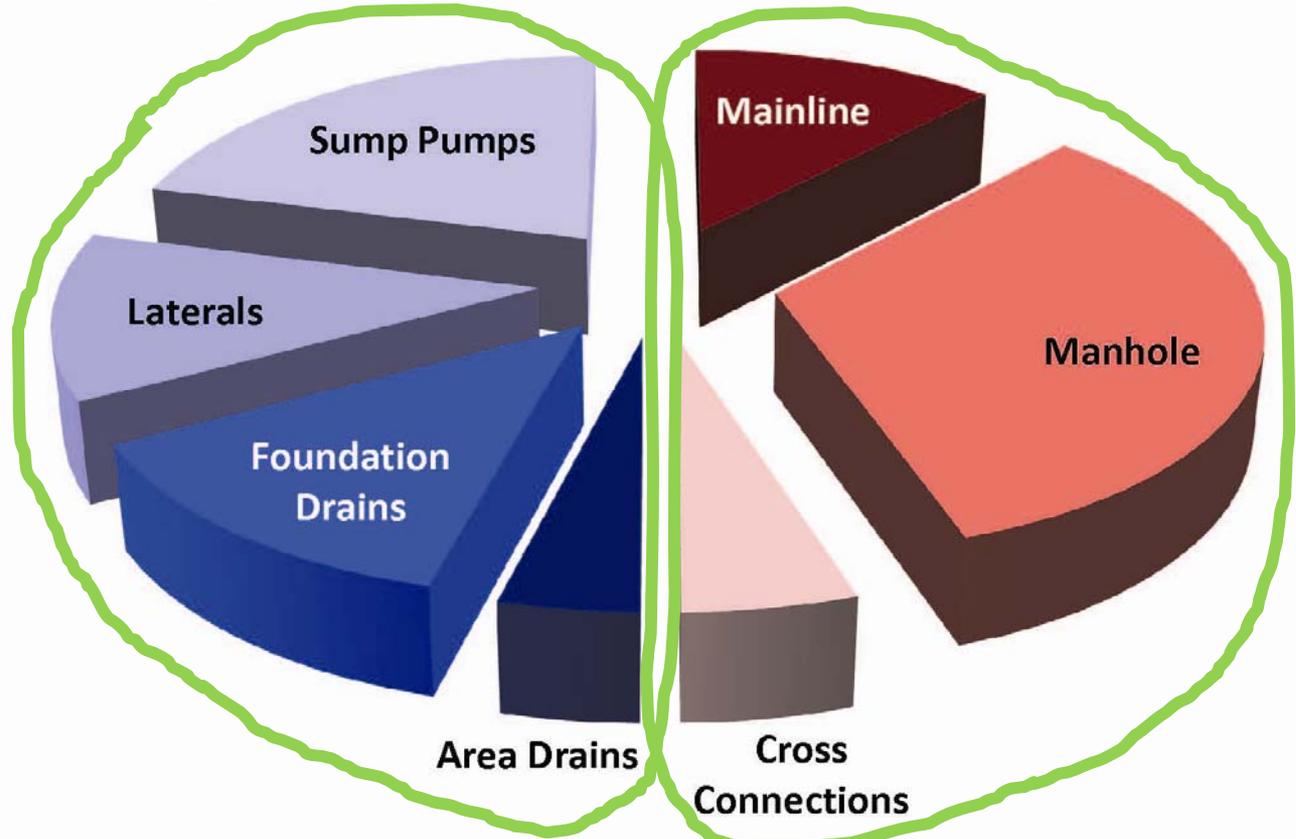


Pre-ICAP 1985 - Typical Inflow Distribution in Chicago Area

Typical Inflow Source Distribution - Illinois

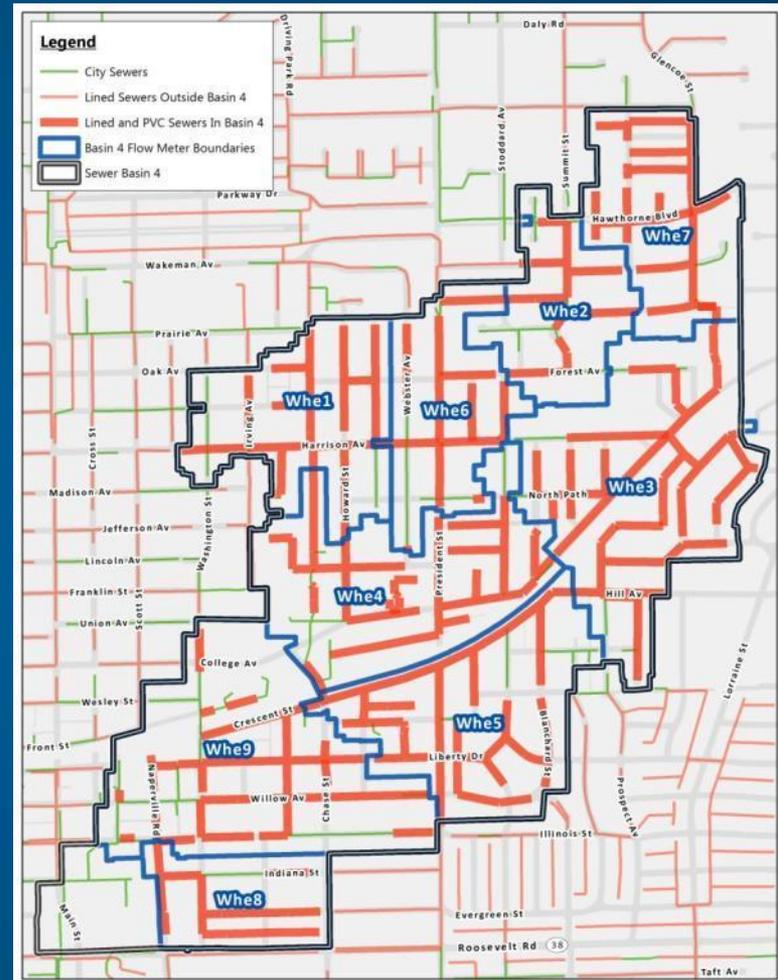
 Private Sector = 50%

 Public Sector = 50%

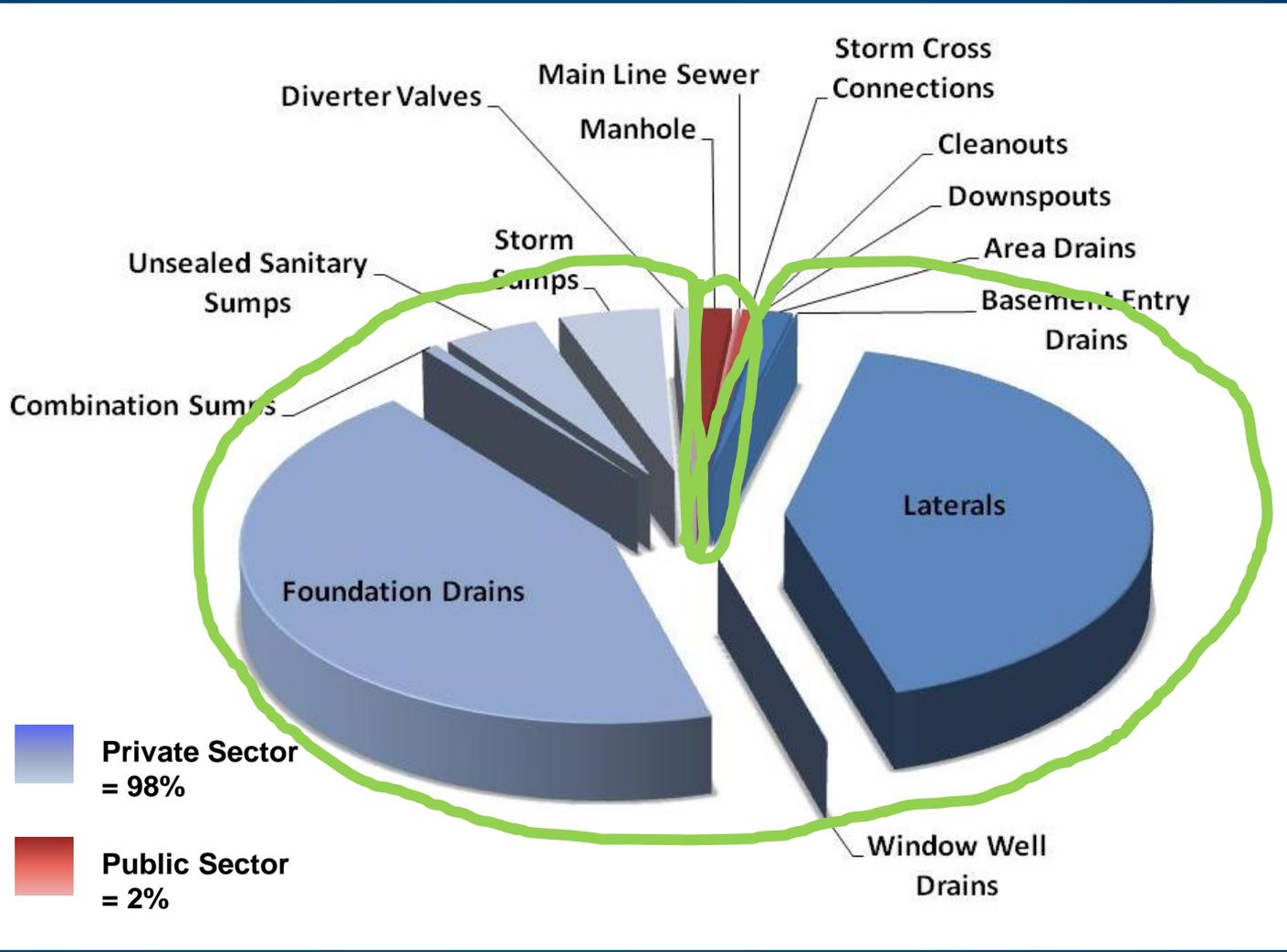


City of Wheaton Basin 4

- 90% of Manholes Rehabilitated
- 95% of Main Line Sewers Rehabilitated with CIPP
- Peak Flows Still Exceed Seven Times Dry-Weather Flow for One-Year Storm



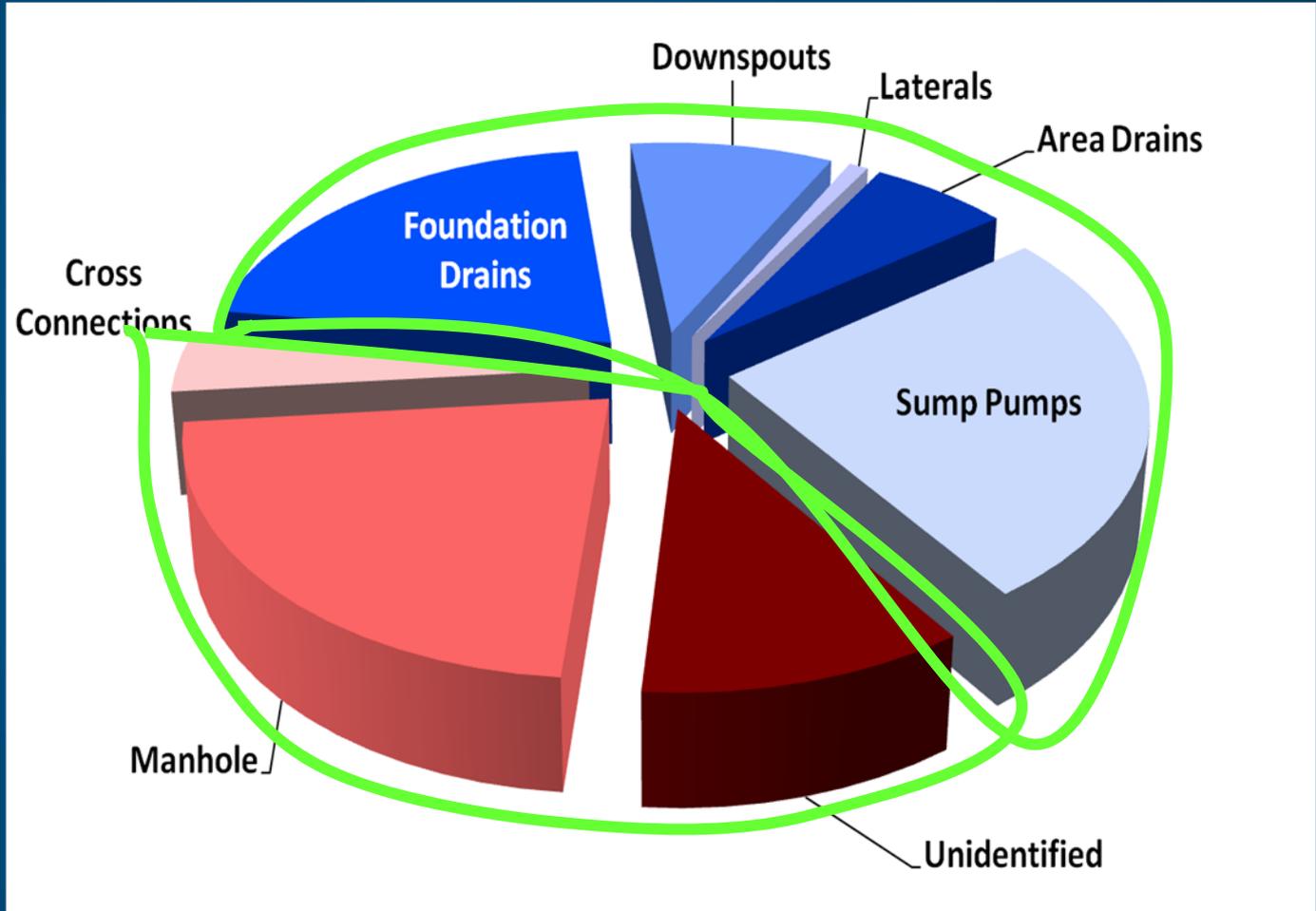
Inflow Source Distribution - Basin 4



Elmhurst Inflow Distribution in 1987

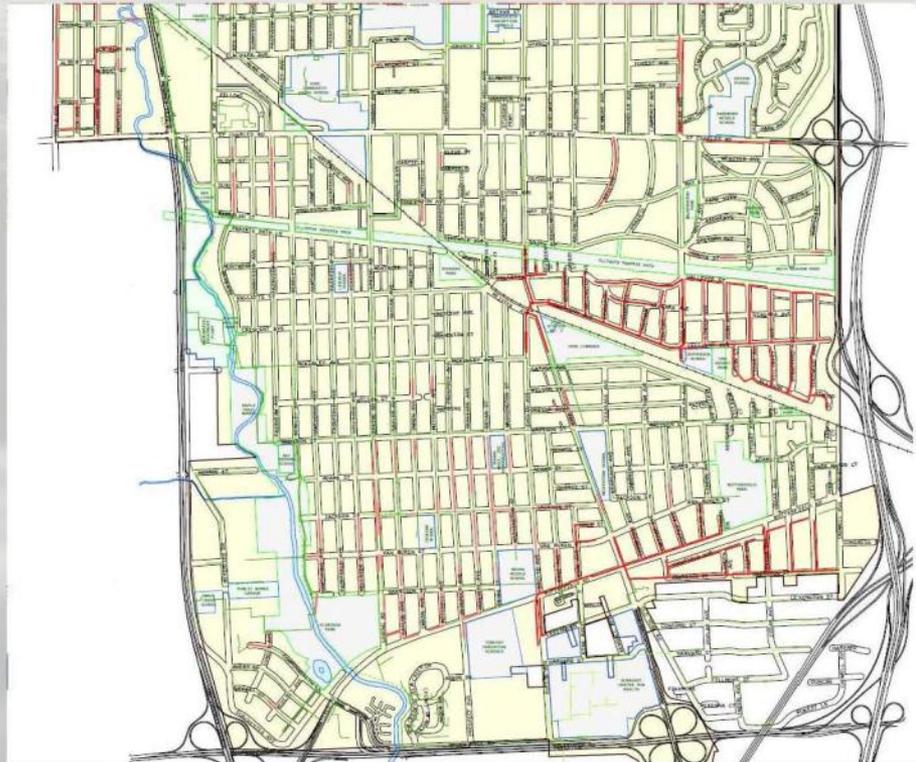
Private Sector = 63%

Public Sector = 37%



CIPP Lining Program- South Elmhurst

Sanitary Sewer Lining Projects South Elmhurst (since 1993)

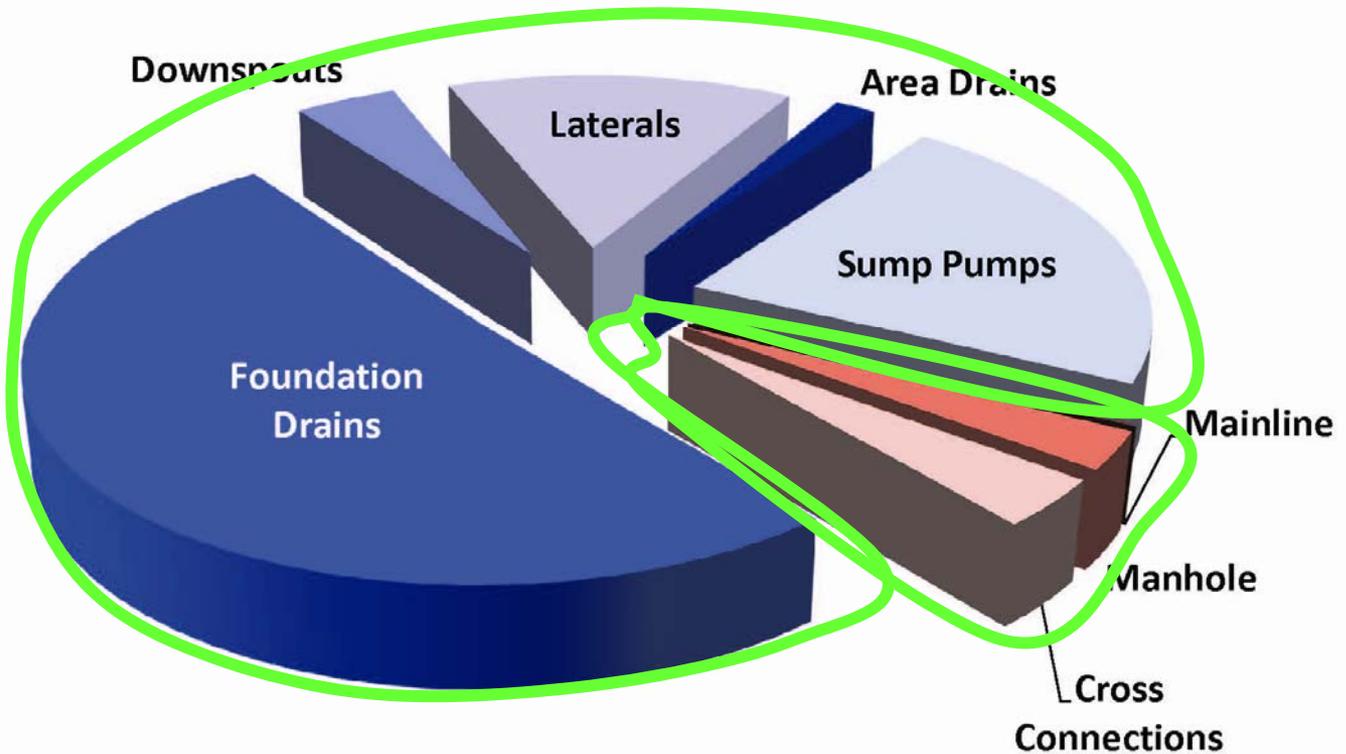


Elmhurst Citywide Distribution in 2011

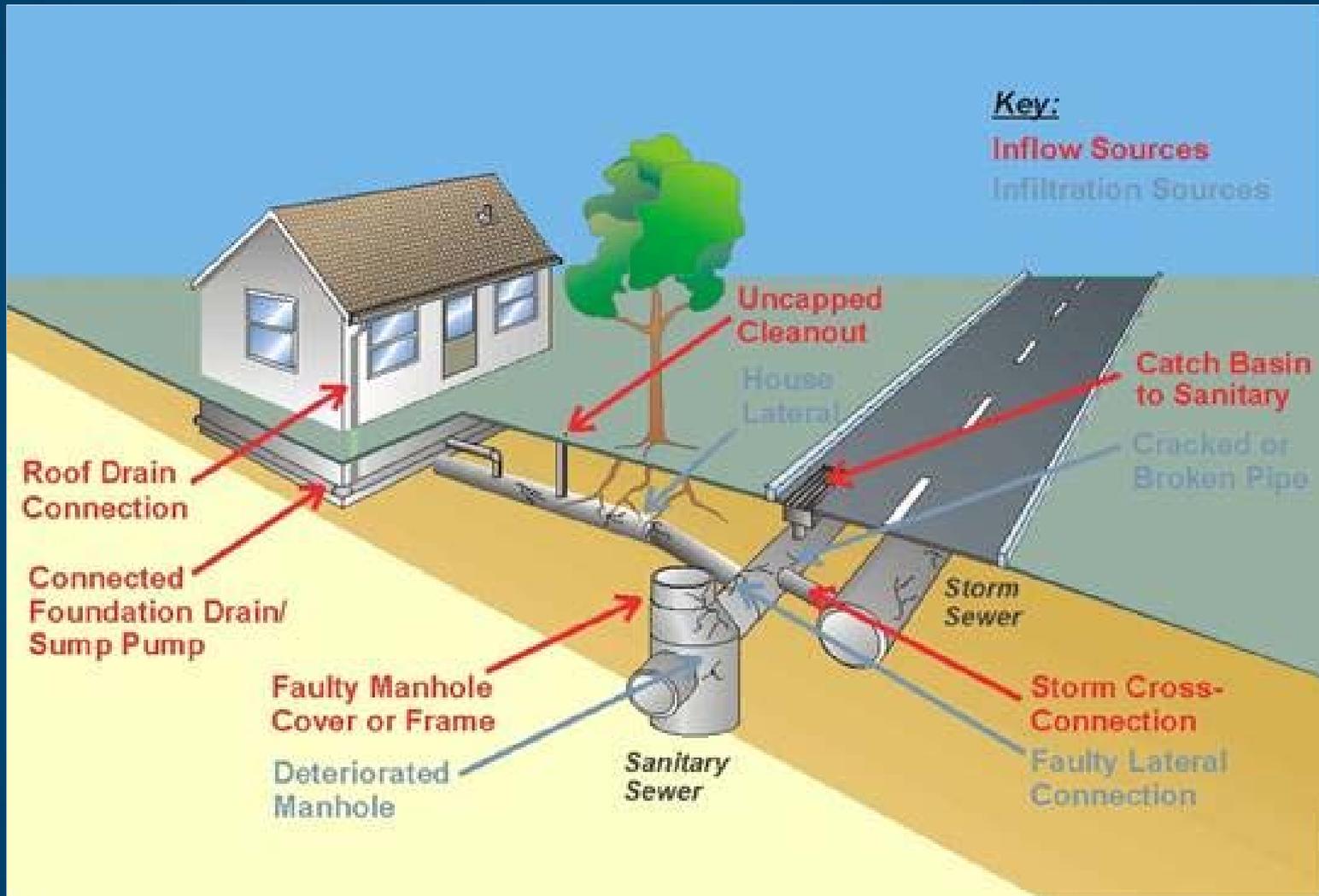
City-Wide Inflow Distribution

 Private Sector = 93%

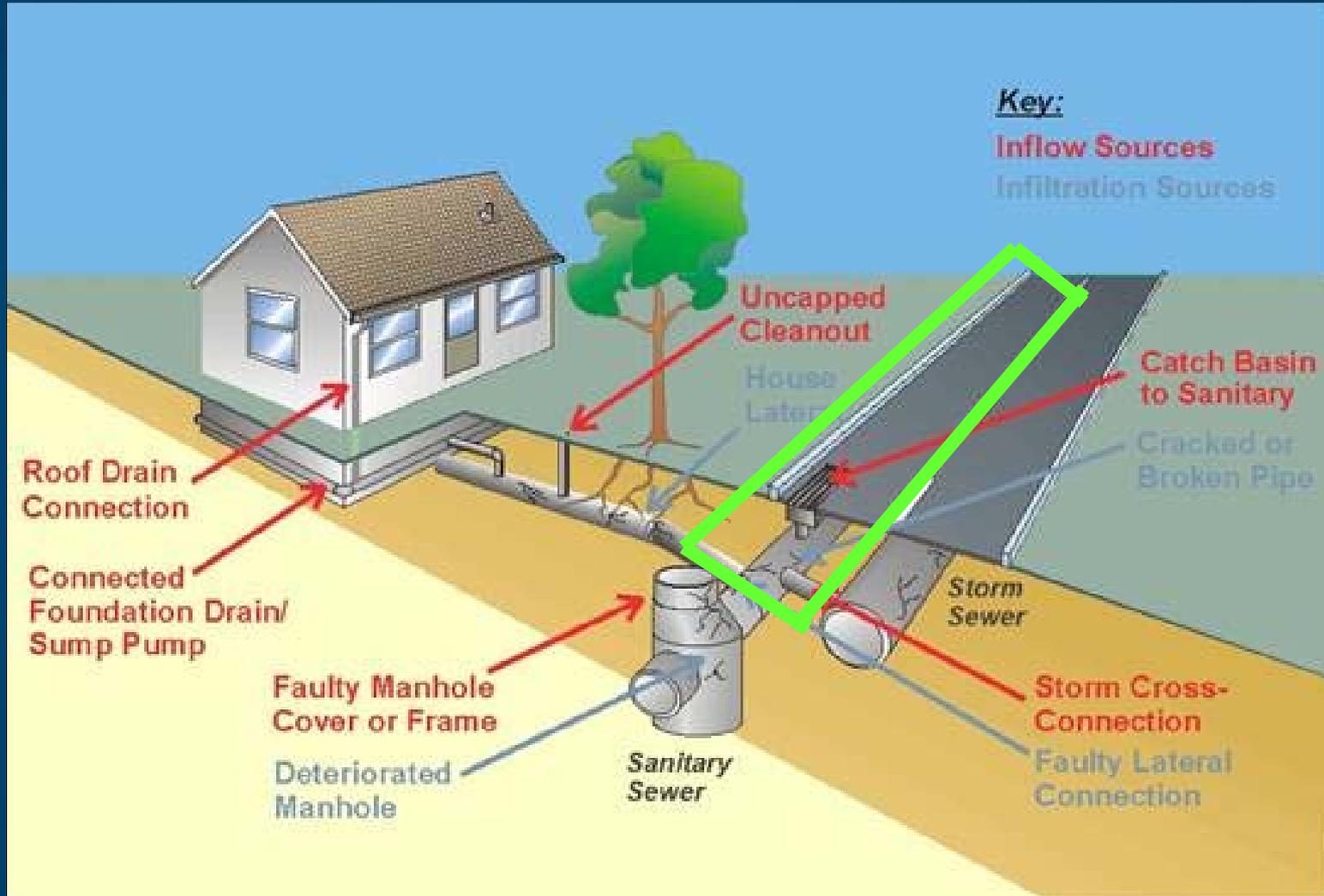
 Public Sector = 7%



Public Sector Infiltration/Inflow – Main Line



Public Sector Infiltration/Inflow – Main Line



Main Sewer Defects



Indirect Cross Connections

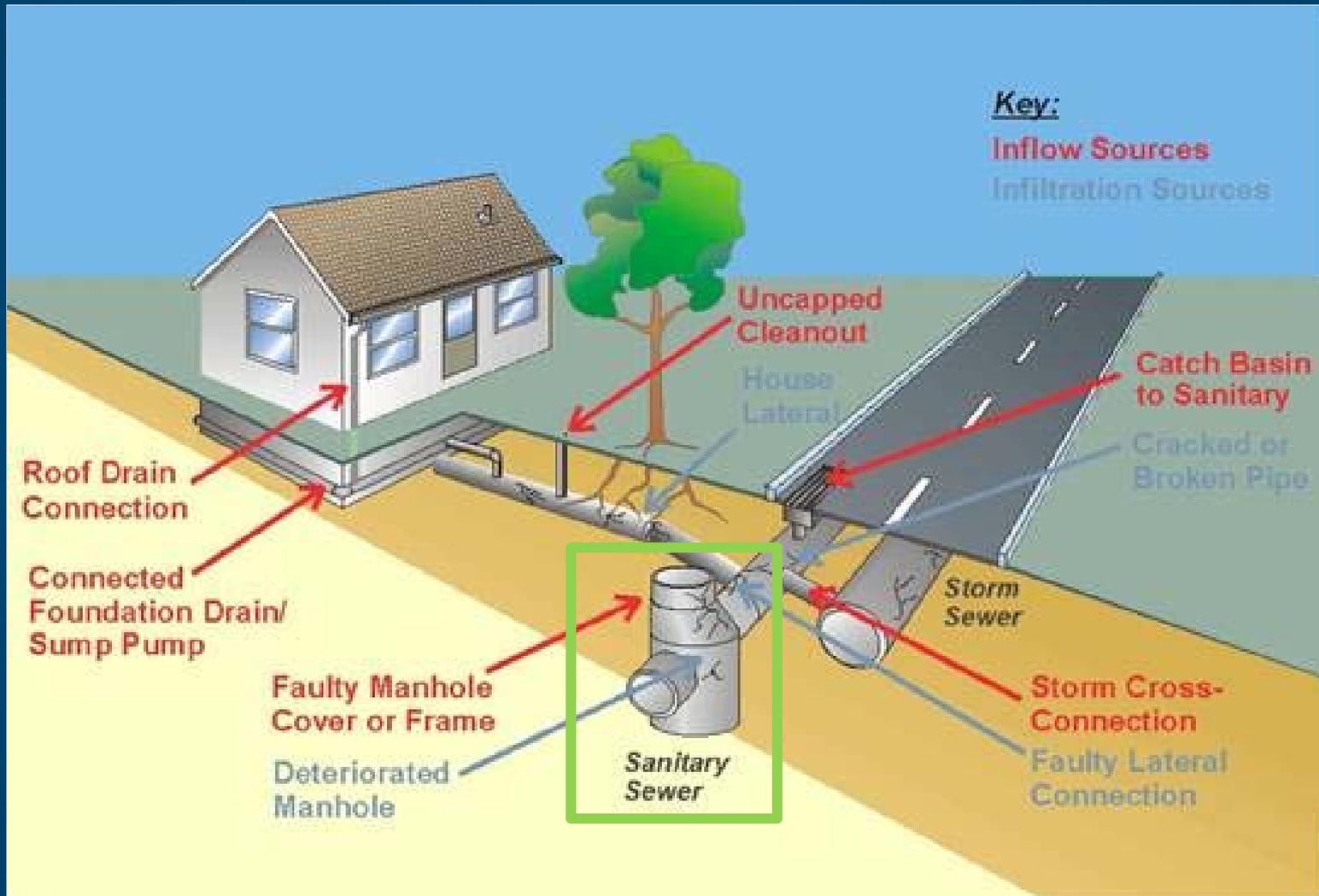


Main Line Sewer Rehabilitation

- Rehabilitate from Manhole to Manhole
- Excavation Not Required Using “Trenchless Technology”
- Most Common in Illinois - Cured In Place Pipe (CIPP)



Public Sector Infiltration/Inflow - Manholes



Manhole Infiltration/Inflow Defects



Manhole Rehabilitation

Cover Defects

- frame & lid
- MH Insert

Bench/Trough & Pipe Seal

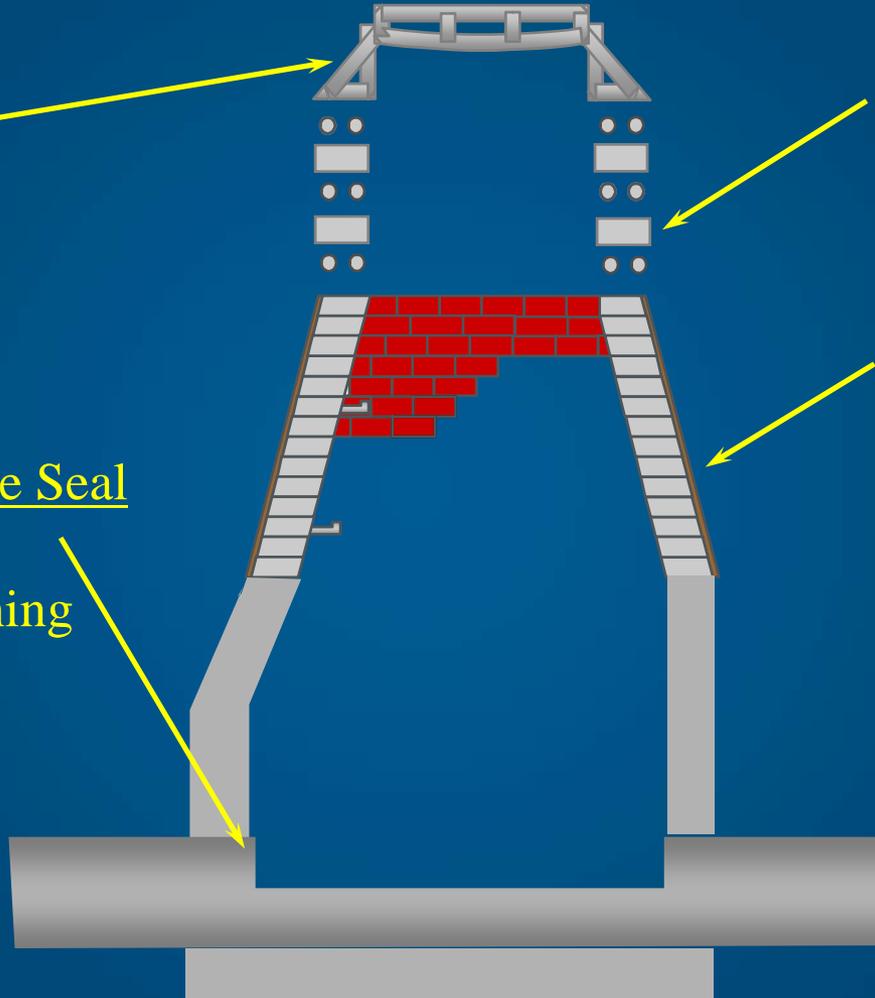
- chemical grouting
- hydro cement patching
- rubber gaskets

Adjustment

- new adjustment rings
- chimney seals
- polyethylene sheeting

Manhole Walls

- chemical grouting
- cement linings
- epoxy coatings
- CIP systems
- oakum rope



Manhole Rehabilitation



“Permacast”



“Raven 405”

Manhole Rehabilitation



Sample Manhole Inspection – Spring 2011

- Inspected 76 Manholes Rehabilitated in 1987
- Locations Near Creek, with Main Sewer Lining, Various Ages
- Result – Limited Defects
1987 Rehabilitation Work Still Generally Sound

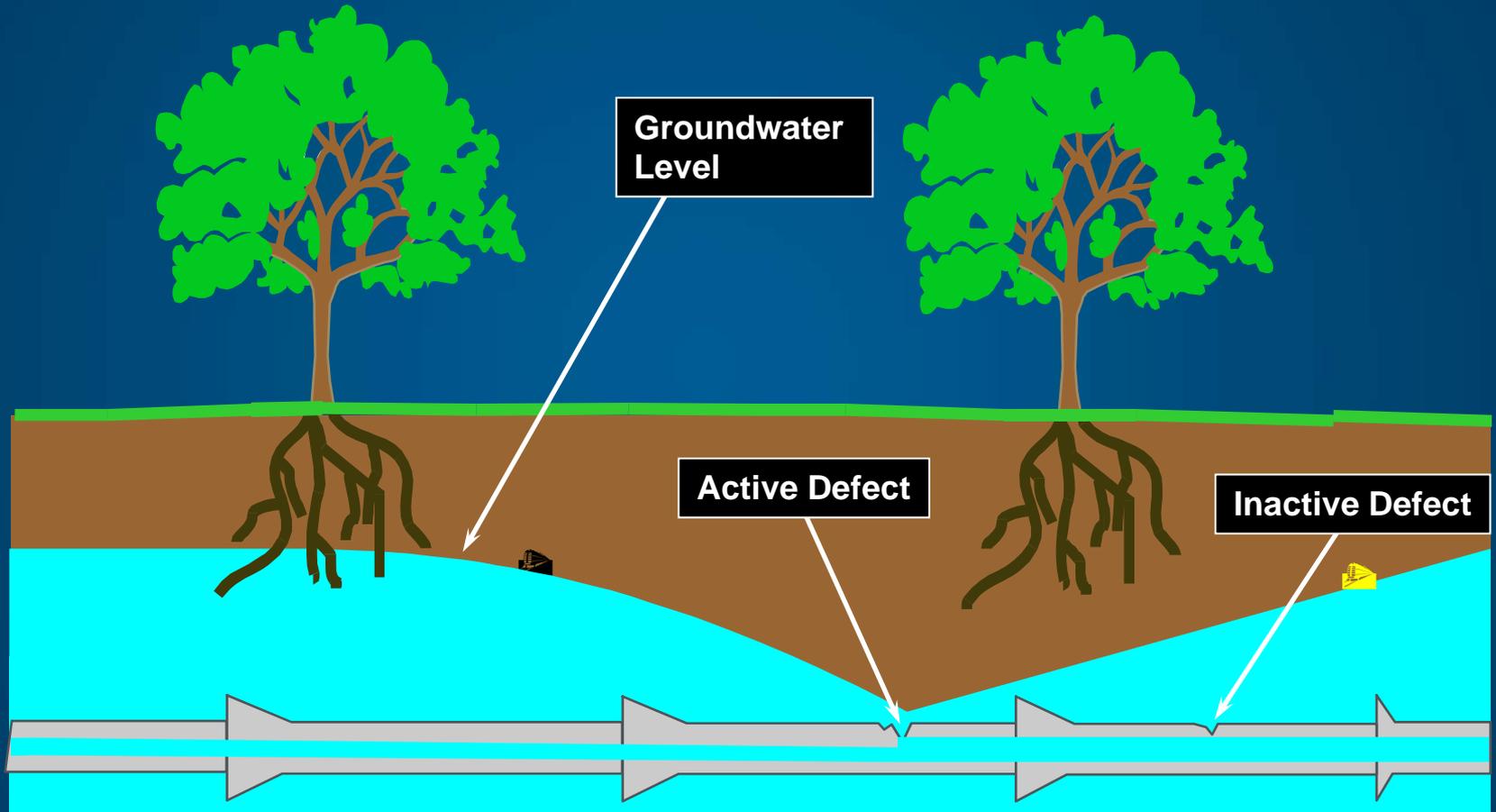


I/I Migration to Service Laterals

- Manhole to Manhole Lining
 - Structural integrity
 - Eliminate I/I within main sewer
- Groundwater Migration “Up” to Service Laterals
 - Water in sewer trench moves “up” to service laterals
 - Net “reduction” in I/I often limited

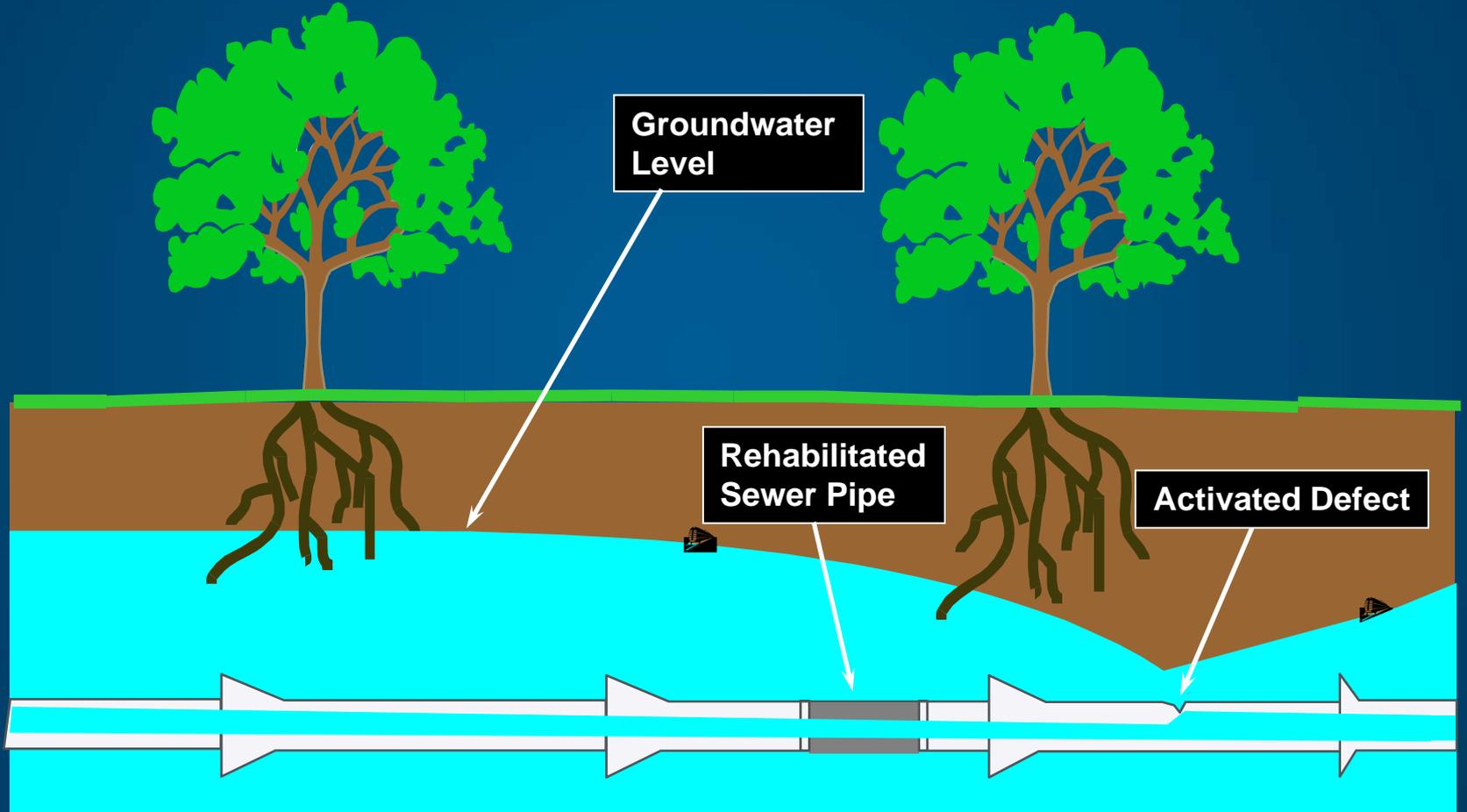
Migration Along Pipe Trench

BEFORE Rehabilitation



Migration Along Pipe Trench

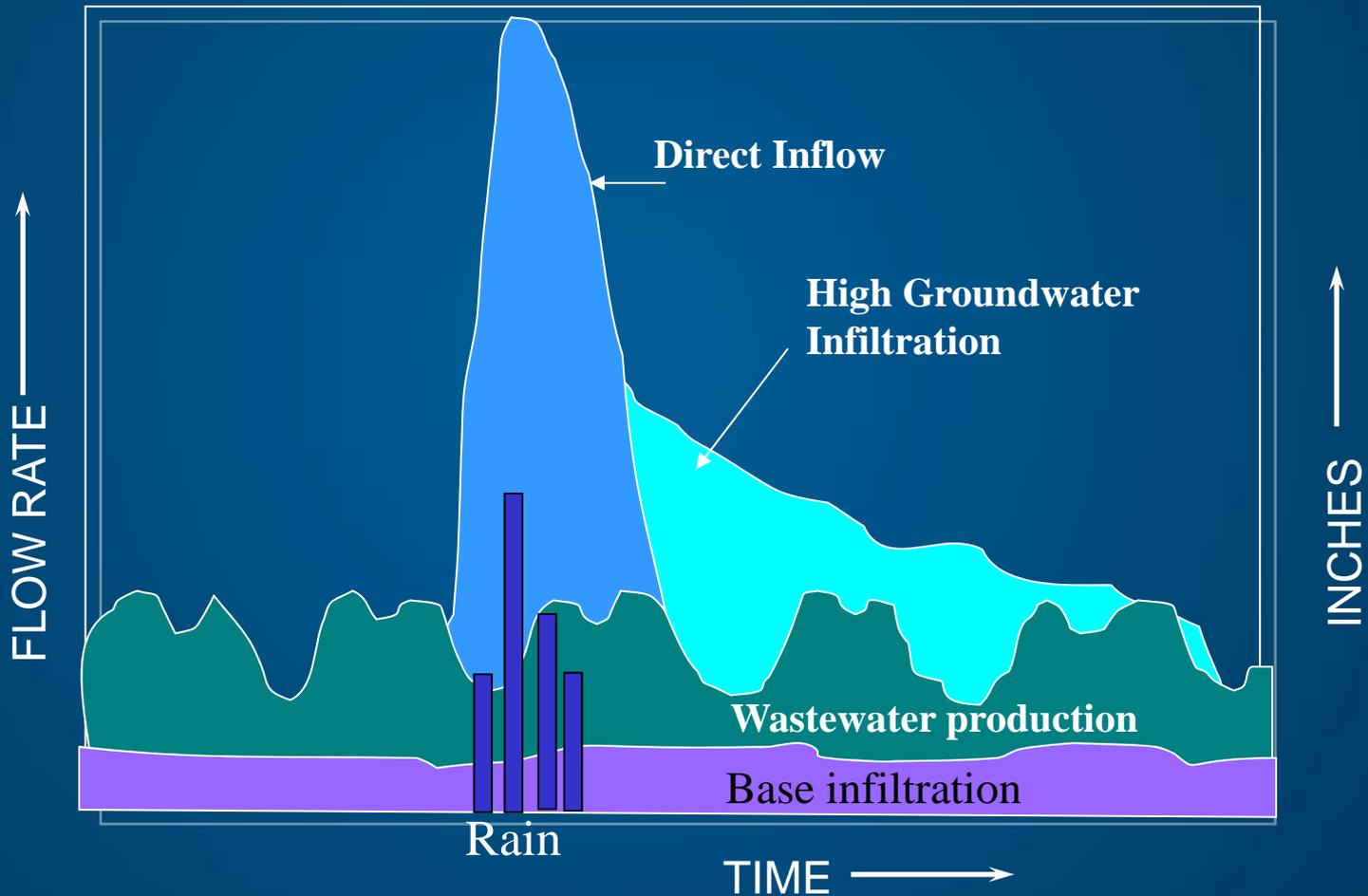
AFTER Rehabilitation



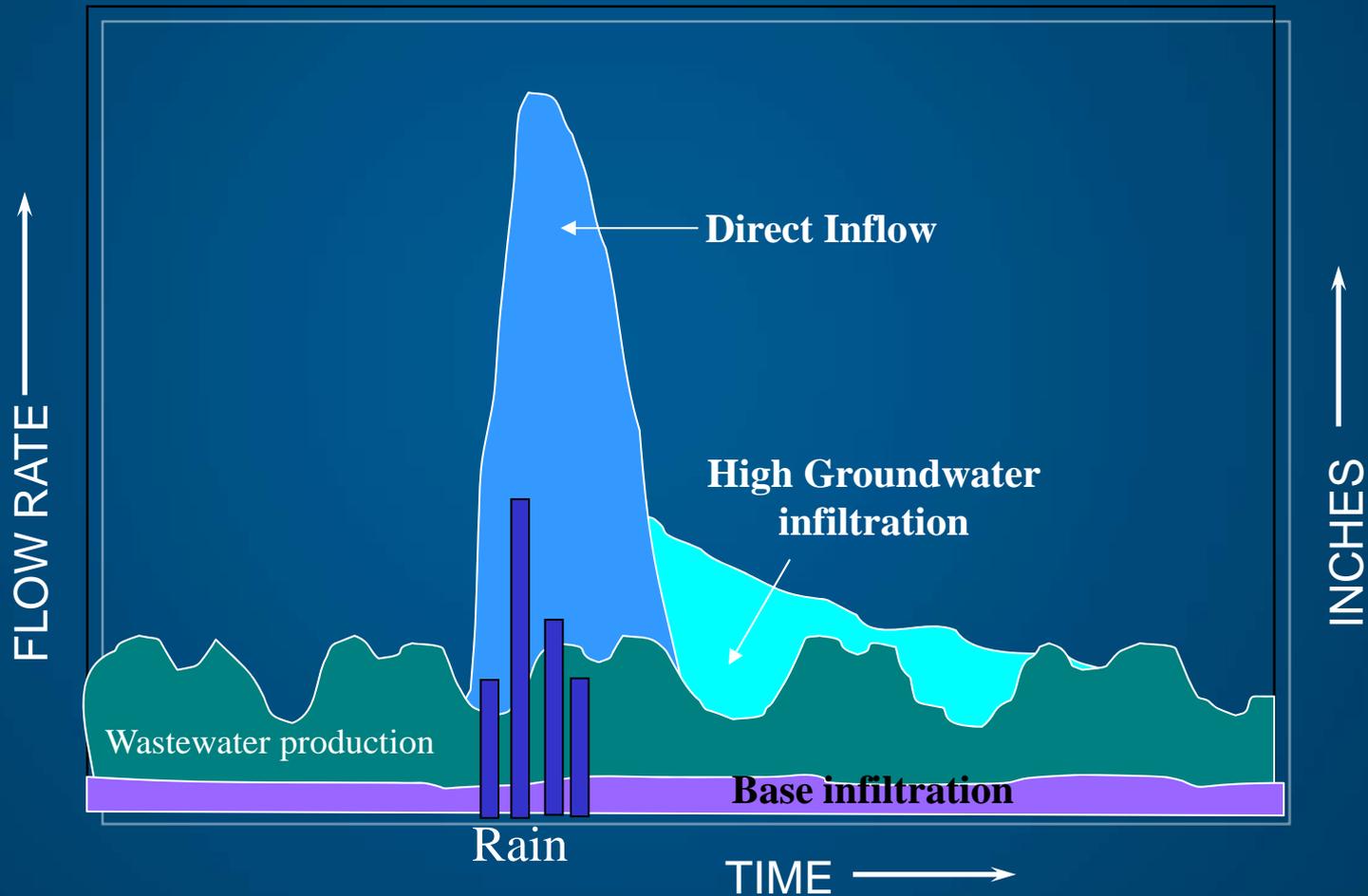
Leaking Service Lateral Video



Sanitary System Before CIPP Lining



Sanitary System After CIPP Lining



Typical Public Sector “Recurring” Sources

- Manholes
 - Frame seals
 - Pipe seals



Typical Public Sector “Recurring” Sources

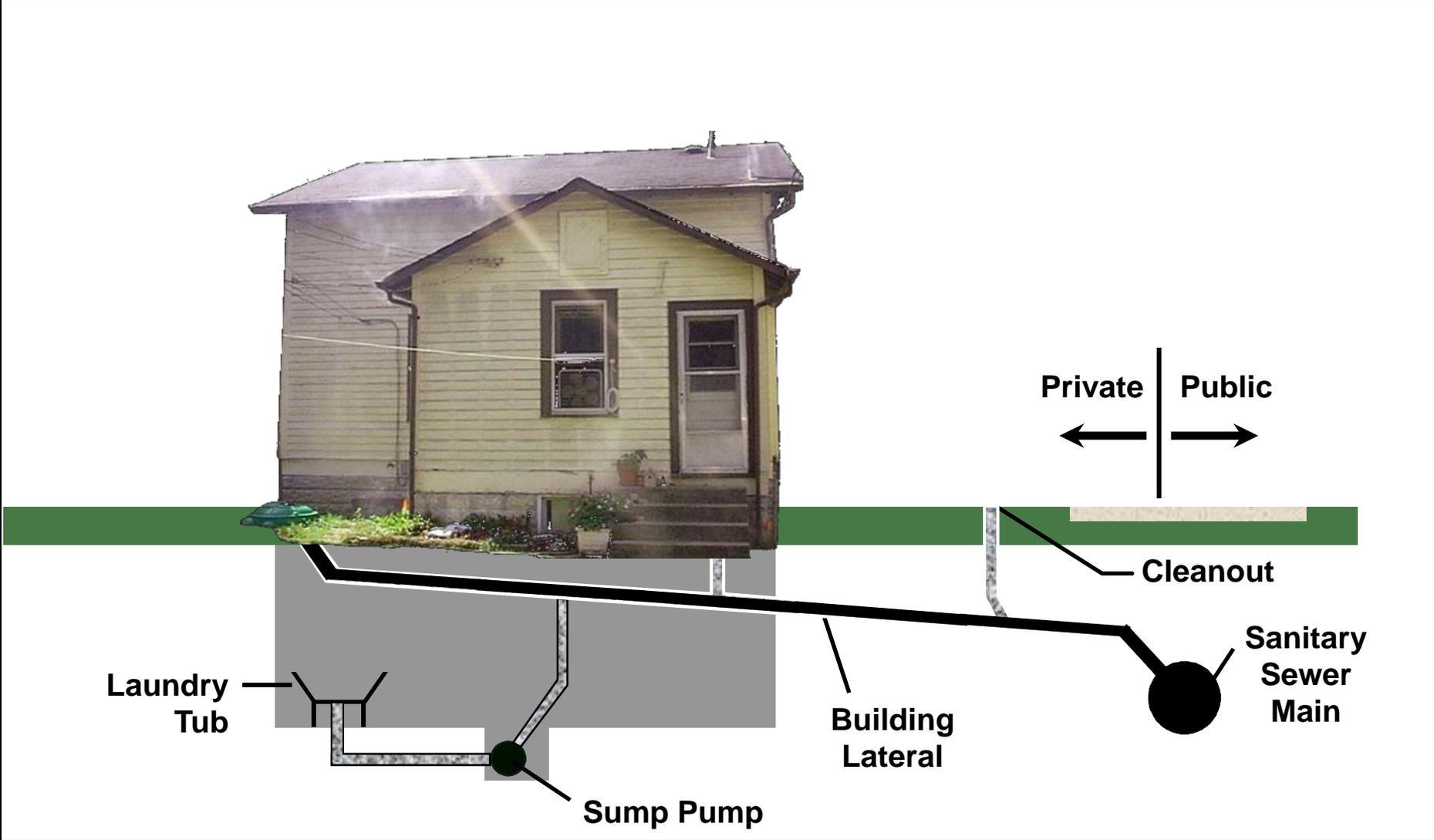
- Main Line Cross Connections
 - Service laterals / storm sewers
 - Service laterals / storm ditches



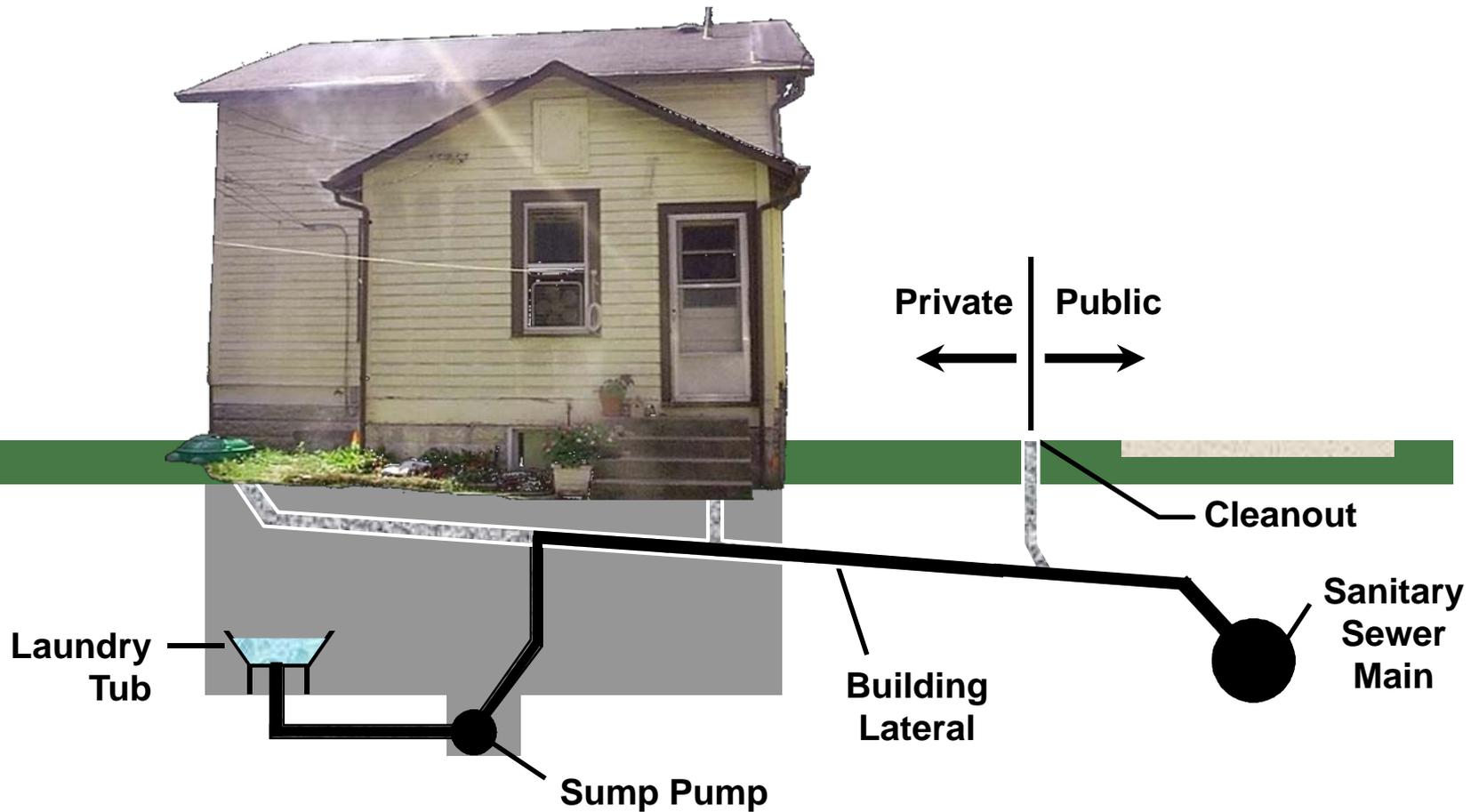
Private Sector Infiltration / Inflow Sources

- **Types of Sources?**
- How Do You Find Them?
- How Do You Eliminate Them?
 - Technical Issues
 - Institutional Issues

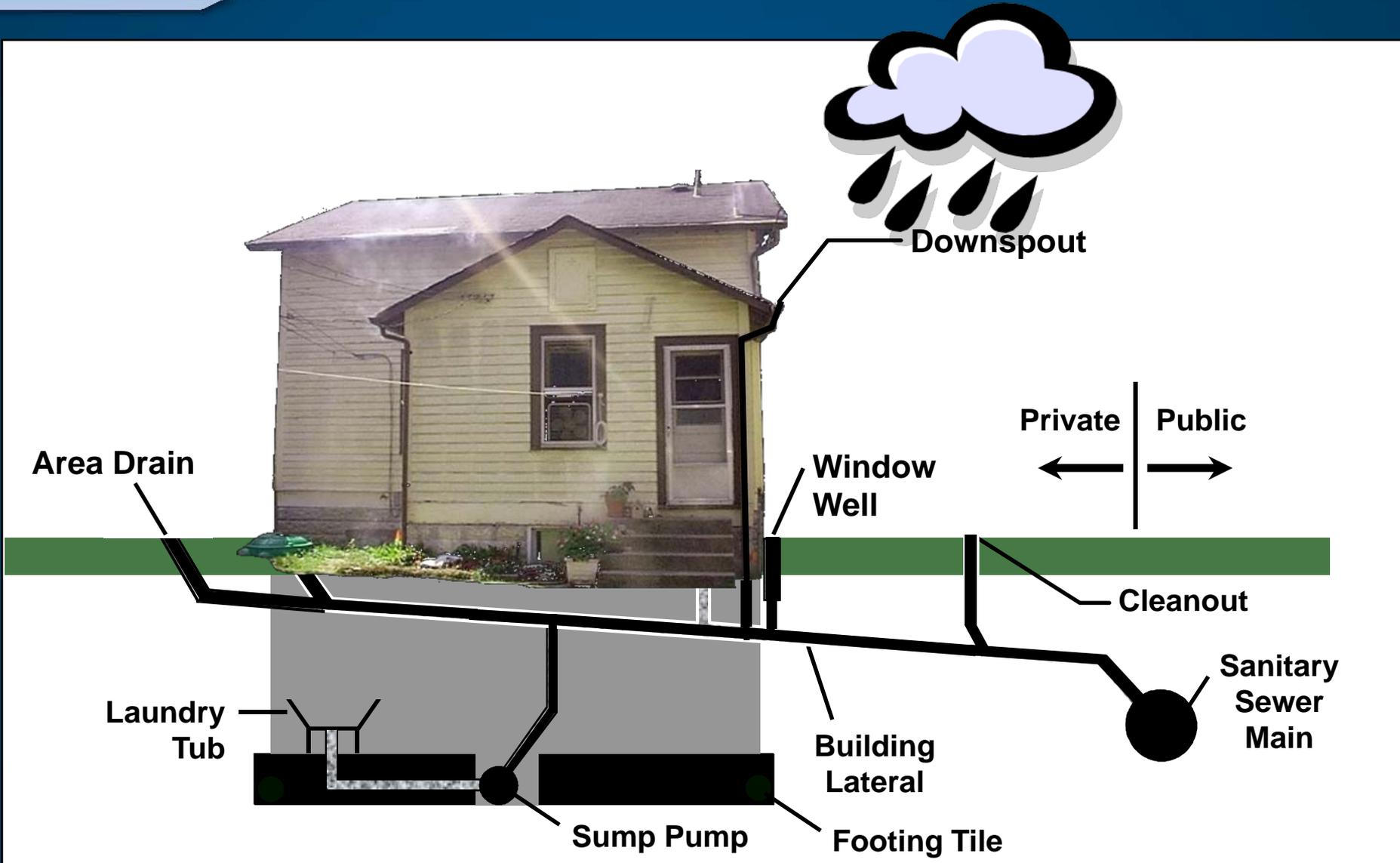
Wastewater Collection - Textbook



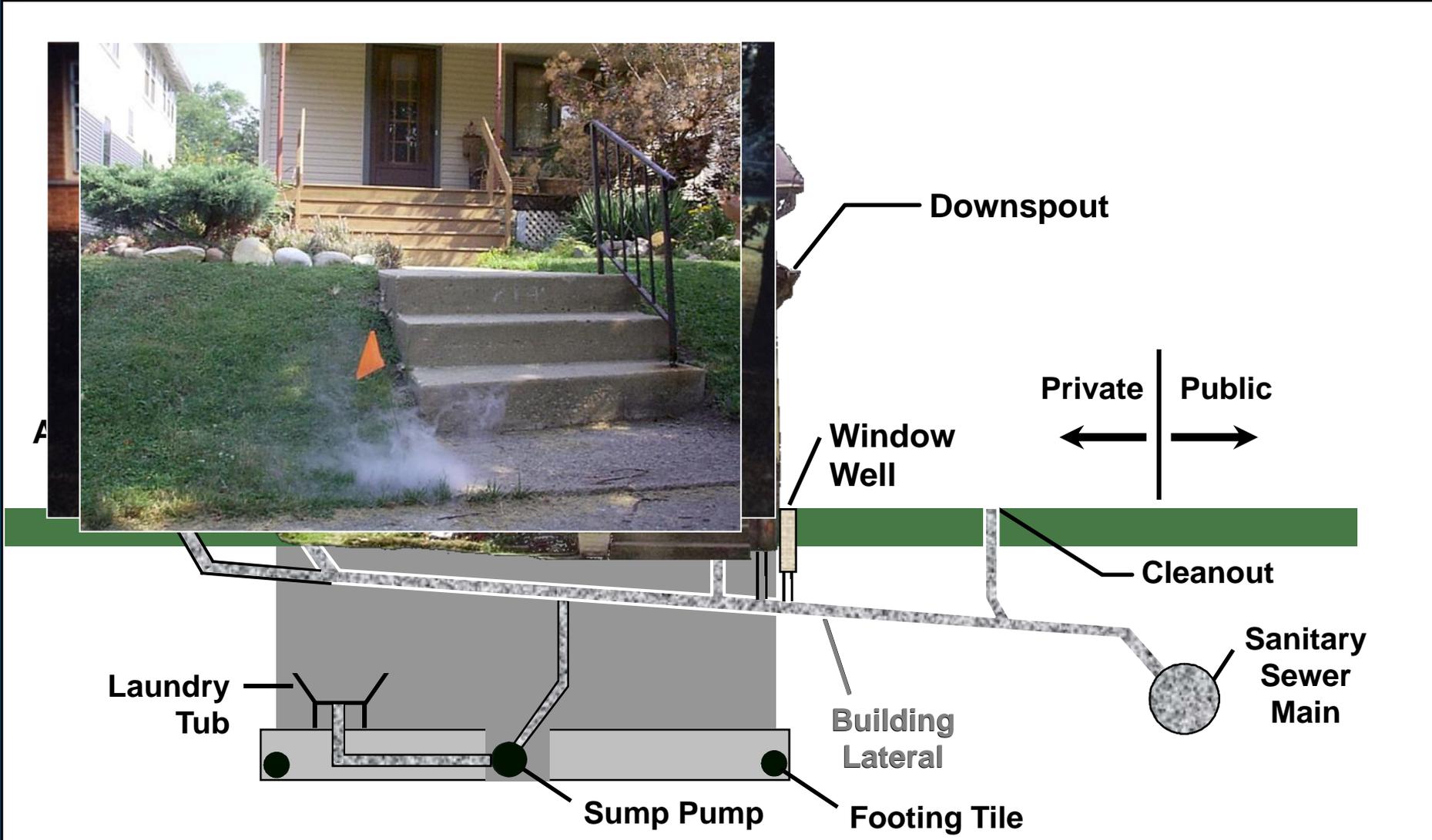
Wastewater Collection - Textbook



Wastewater Collection – Real World



Wastewater Collection – Real World



Wastewater Collection – Real World



Ar

Downspout

Window Well



Cleanout

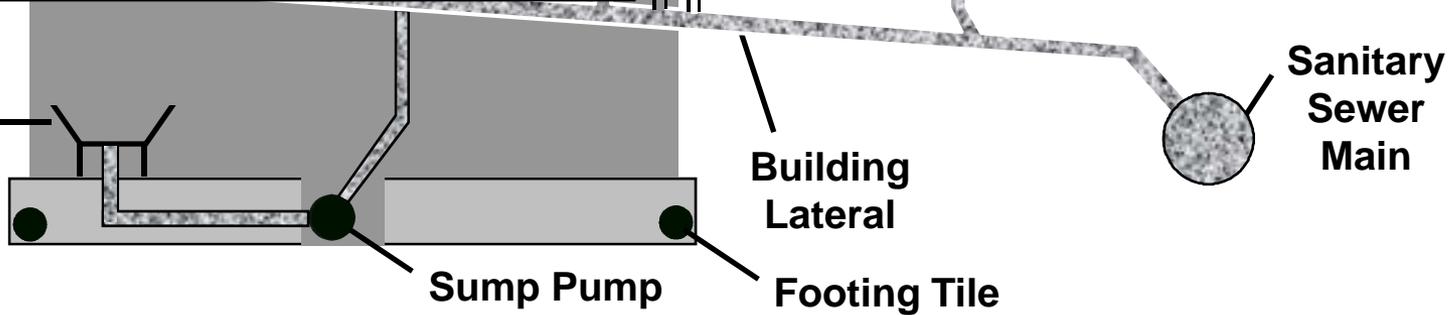
Sanitary Sewer Main

Laundry Tub

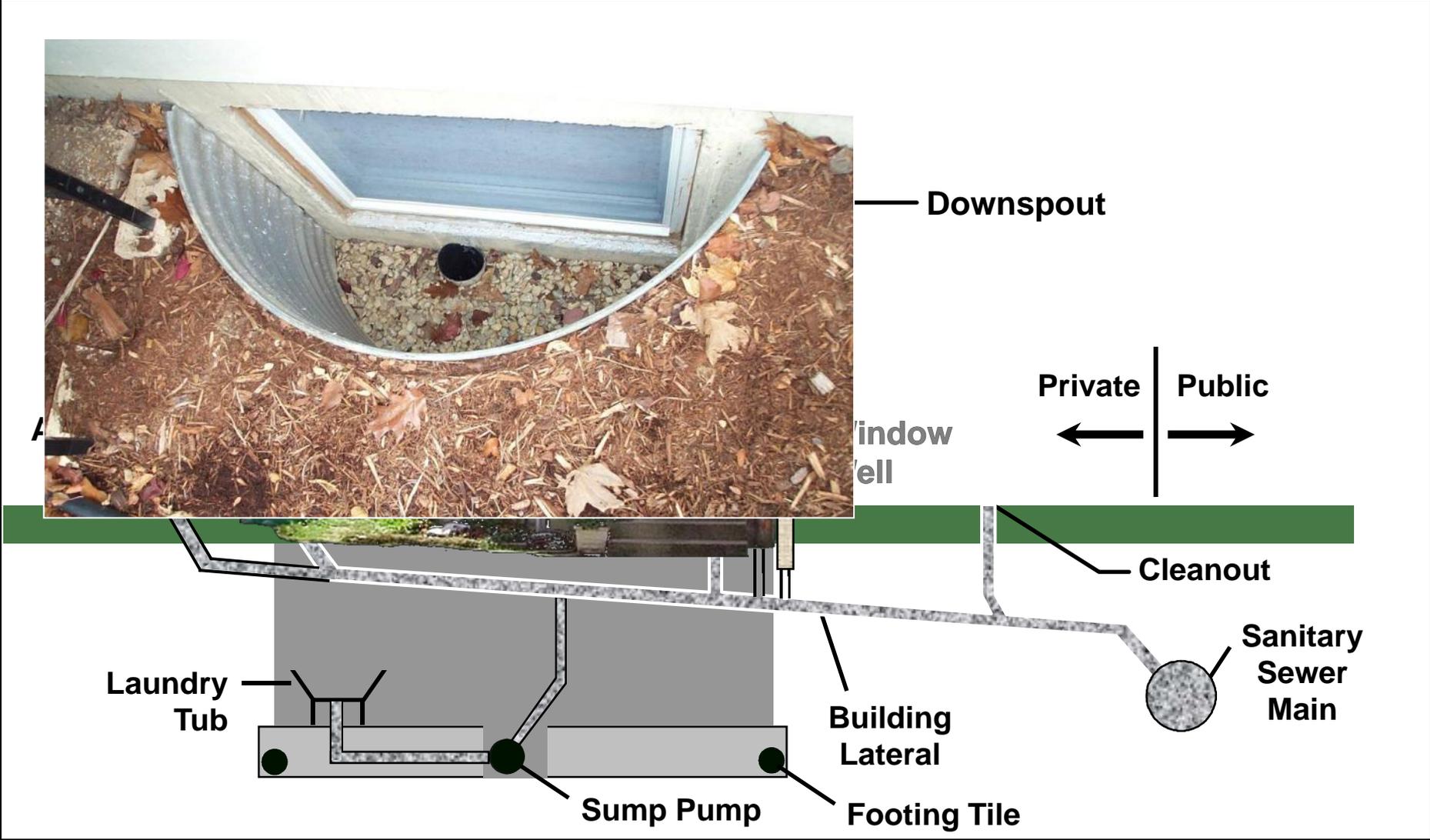
Building Lateral

Sump Pump

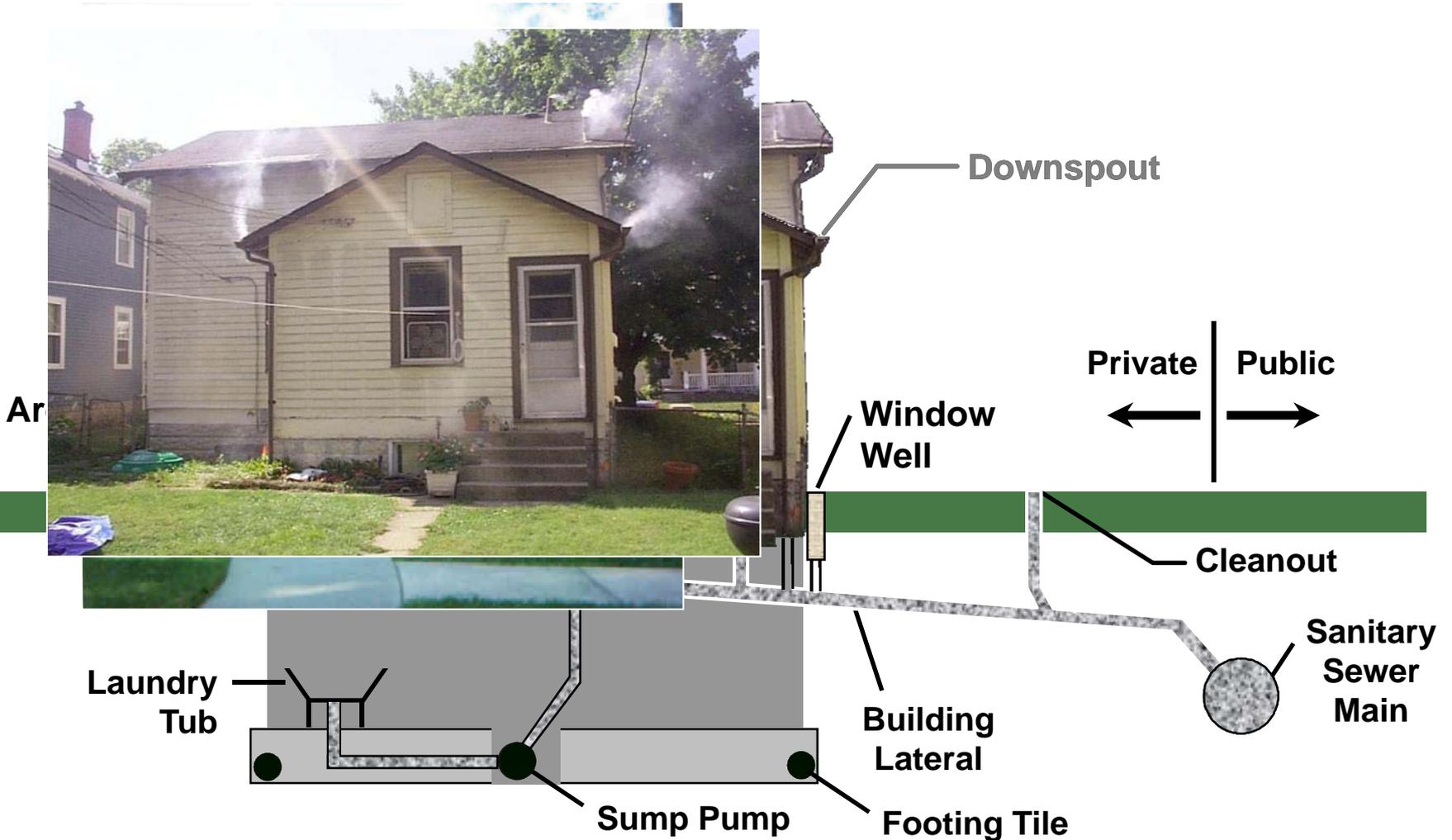
Footing Tile



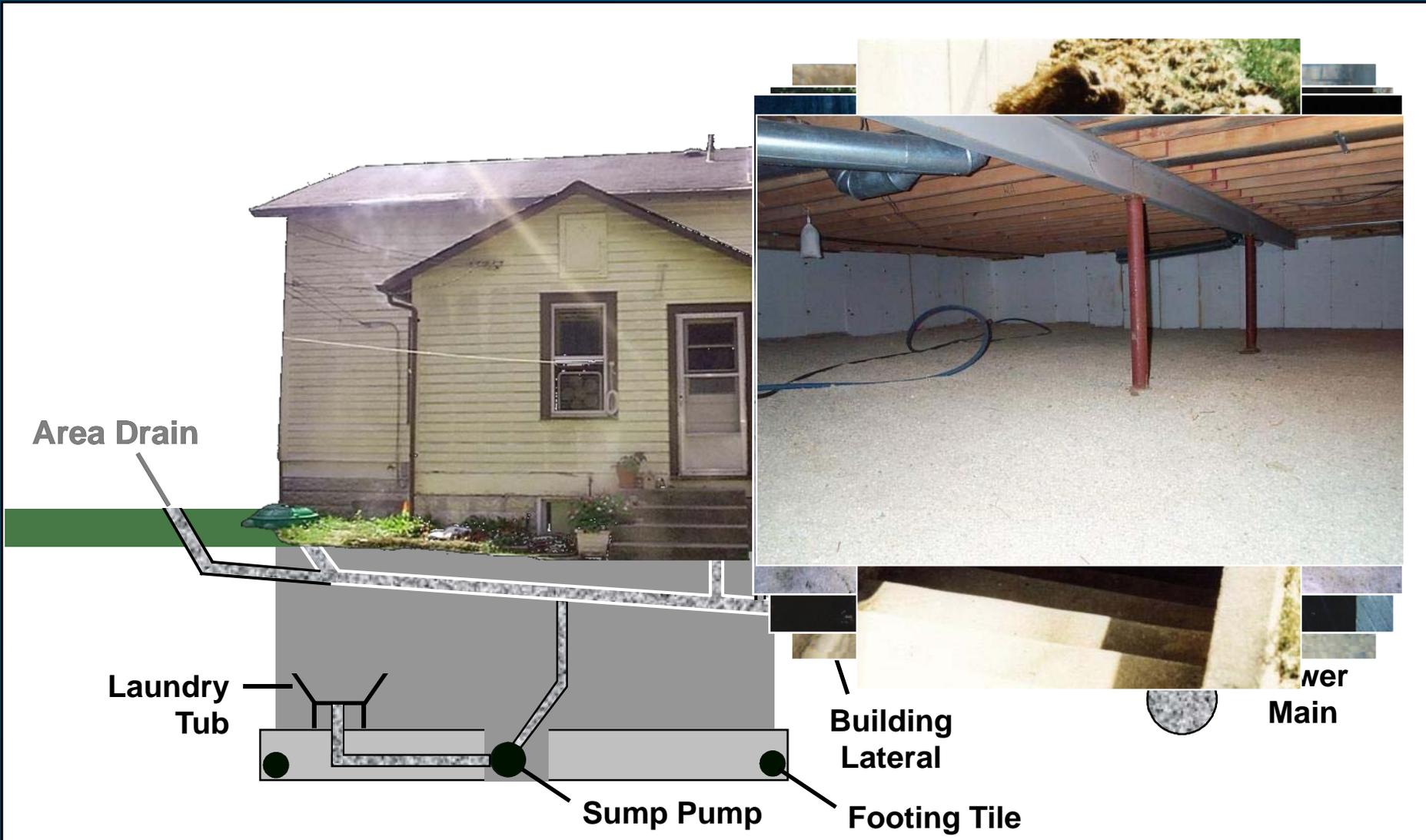
Wastewater Collection – Real World



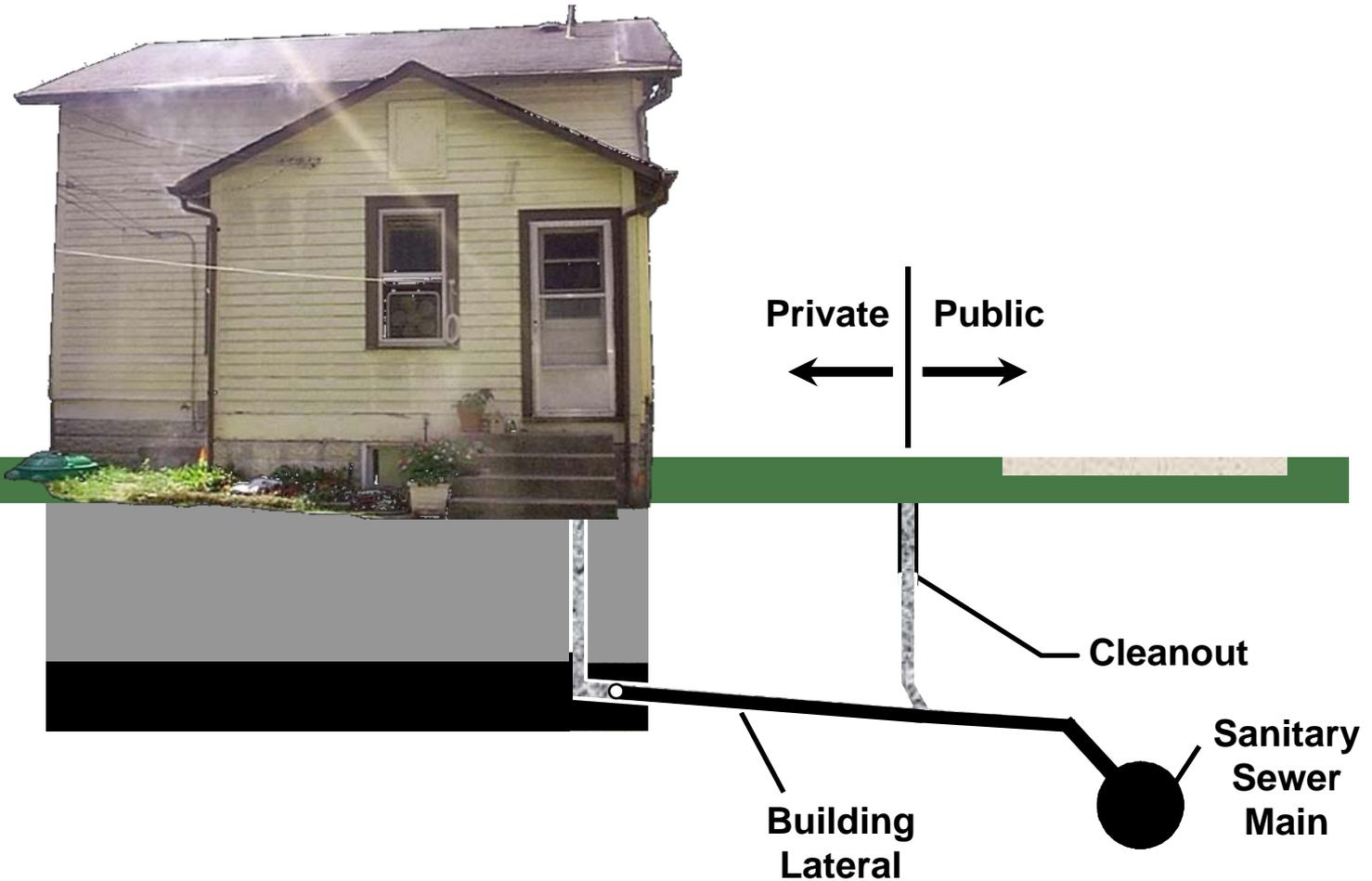
Wastewater Collection – Real World



Wastewater Collection – Real World



Directly Connected Foundation Drain



Foundation Drains



Foundation Drain Video



Private Sector Infiltration/Inflow Sources

- Types of Sources?
- **How Do You Find Them?**
- How Do You Eliminate Them?
 - Technical Issues
 - Institutional Issues

Finding Private Sector Sources

- **Smoke Testing**
 - Watch for "Suspect" Trapped Sources
 - Dual Blower With Plugging Drives Smoke Through Soil Seams



☁ Dye W

- Cor
- Qua

☁ Prope

☁ Intern

Smoke Testing - D		
Source	Defects	
	SINGLE	
Main Sewer Defect		
Indirect Storm Sewer Cross Connection		
Building Lateral Defect	29	100
Area Drains/Downspouts	2	12
Cleanouts	22	80
TOTAL	67	234

Private Sector – Exterior Sources

- Window Well



Private Sector – Exterior Sources

- Window Well
- Stairway



Private Sector – Exterior Sources

- Window Well
- Stairway
- Cleanout



Private Sector – Exterior Sources

- Window Well
- Stairway
- Cleanout
- Downspouts

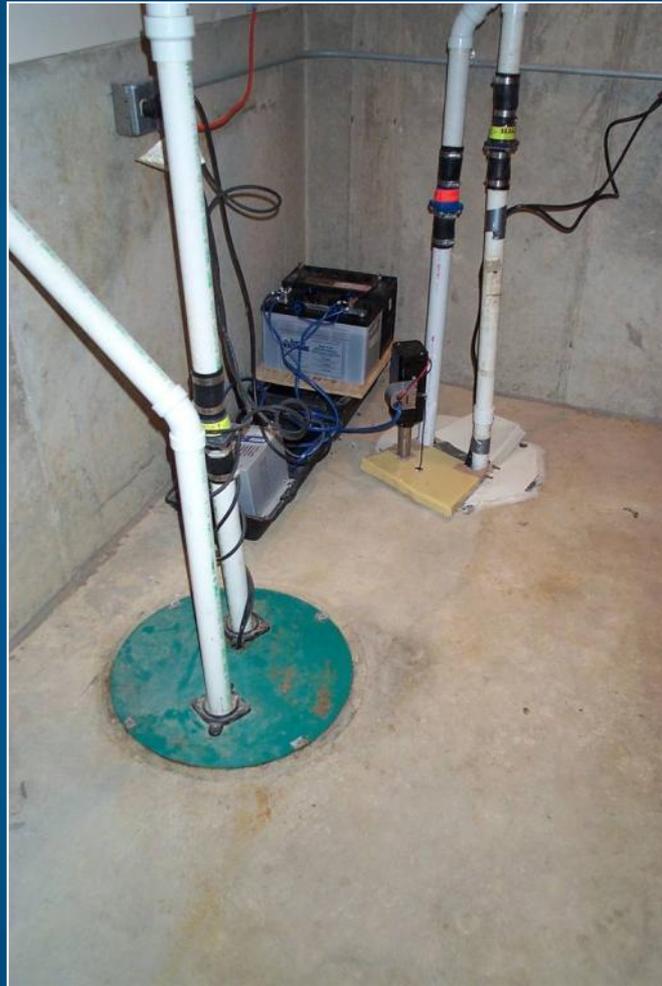


Private Sector – Exterior Sources

- Window Well
- Stairway
- Cleanout
- Downspouts
- Driveway Drains



Private Sector – Interior Sources



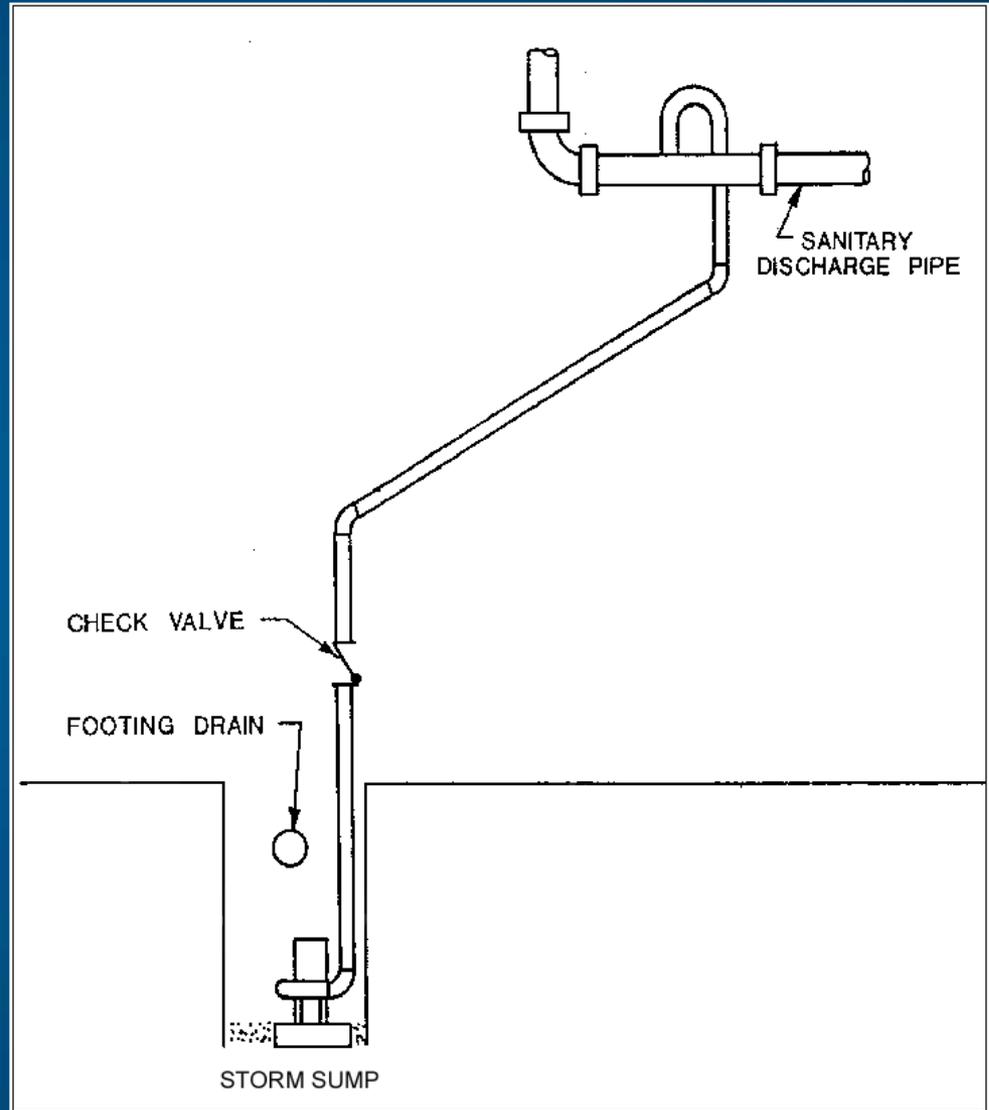
Internal Inspection Public Relations

- ☁️ Press Release
- ☁️ City Newsletter
- ☁️ Door Hangers
- ☁️ Letter to Residents
- ☁️ Photo Identification



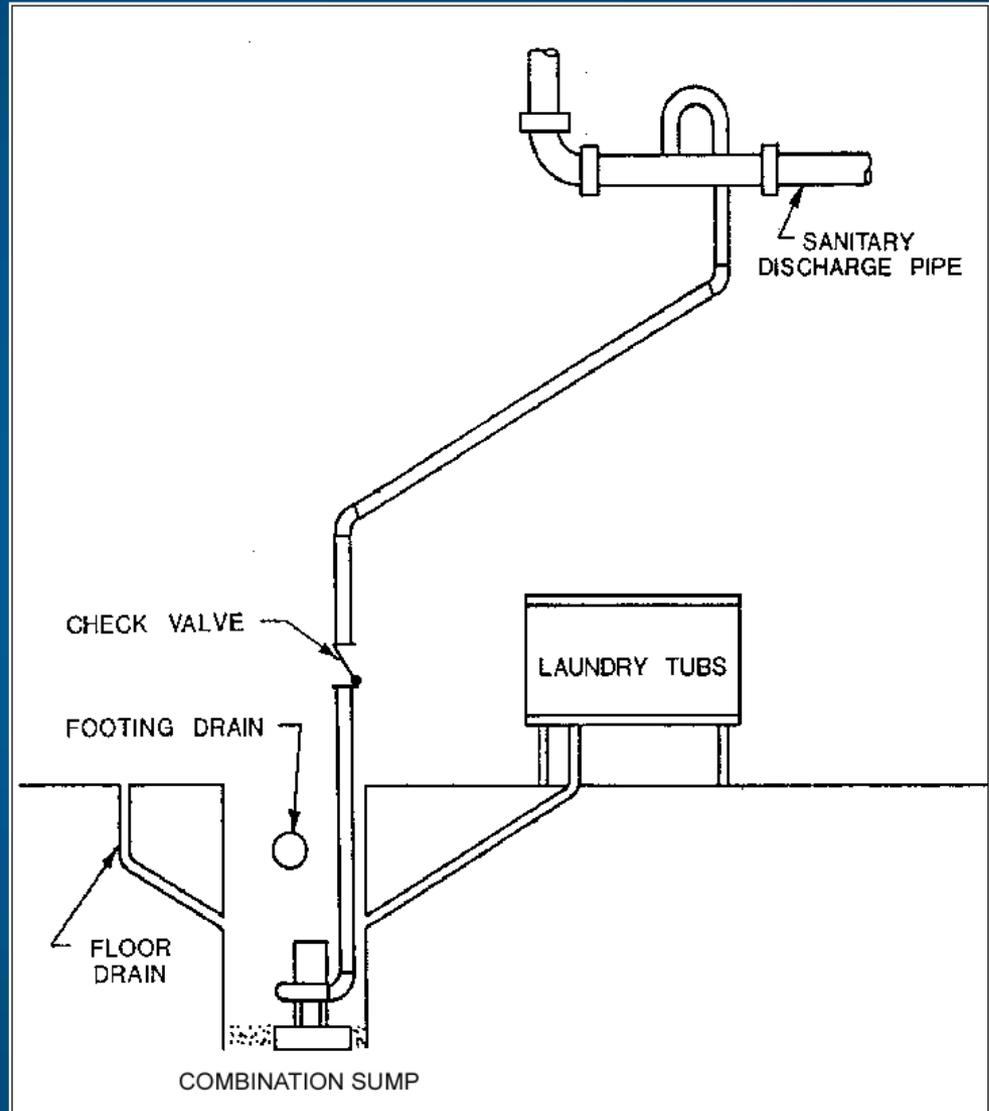
Typical Sump Pump Configuration

Storm Sump to Sanitary Sewer



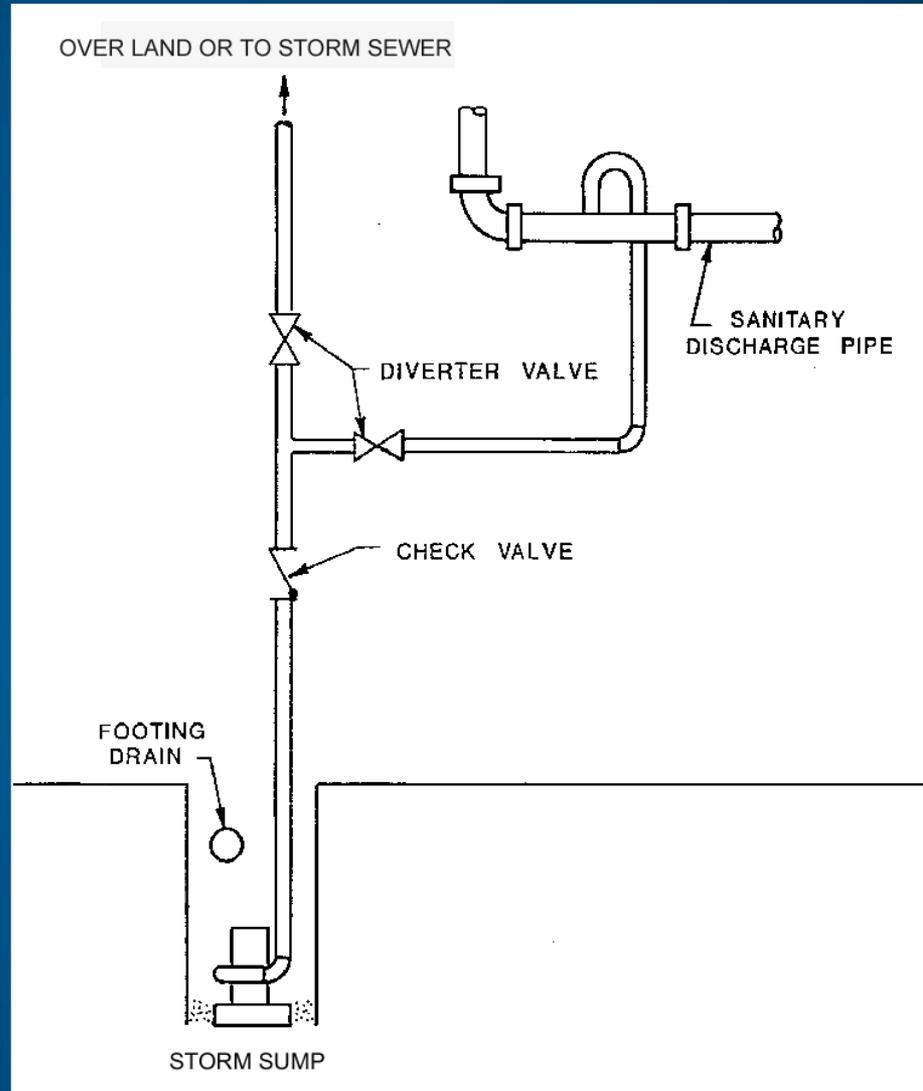
Typical Sump Pump Configuration

Combination Sump to Sanitary Sewer



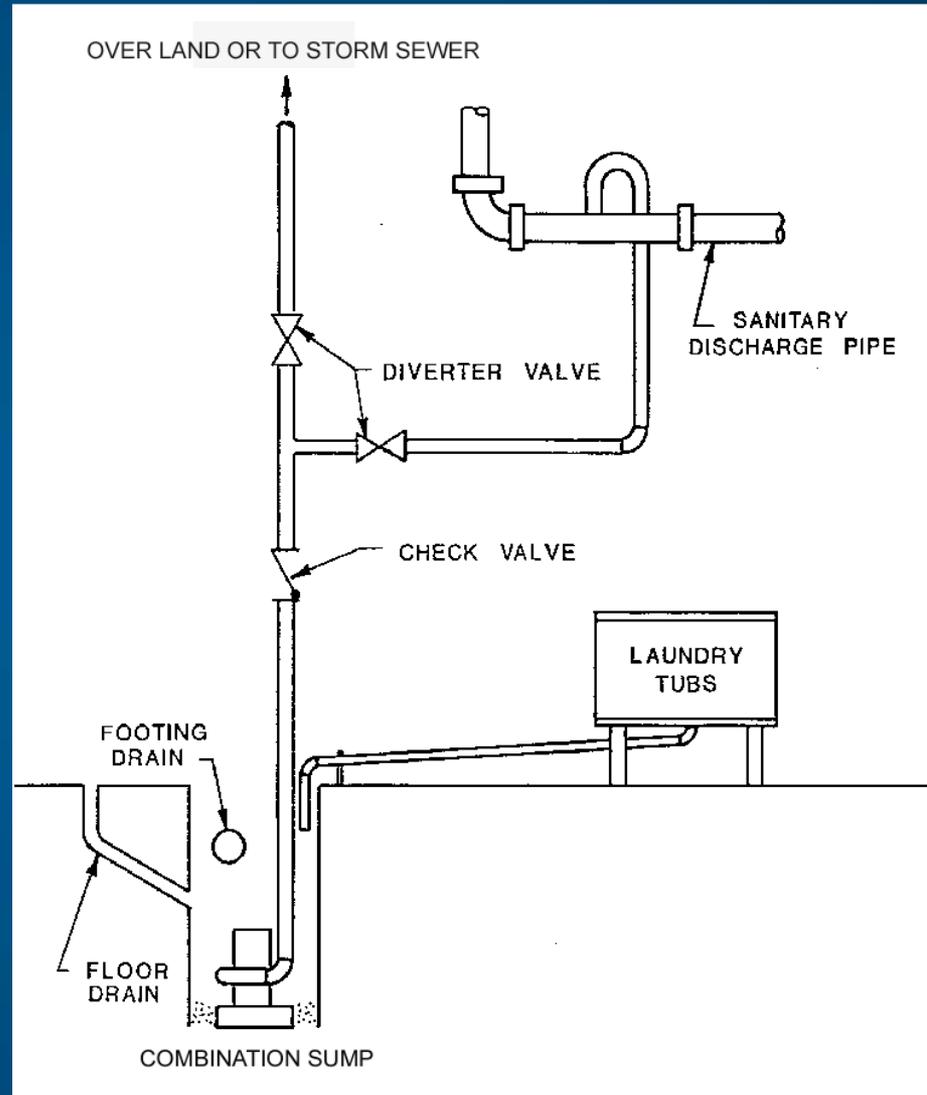
Typical Sump Pump Configuration

Storm Sump With Diverter Valve to Sanitary Sewer



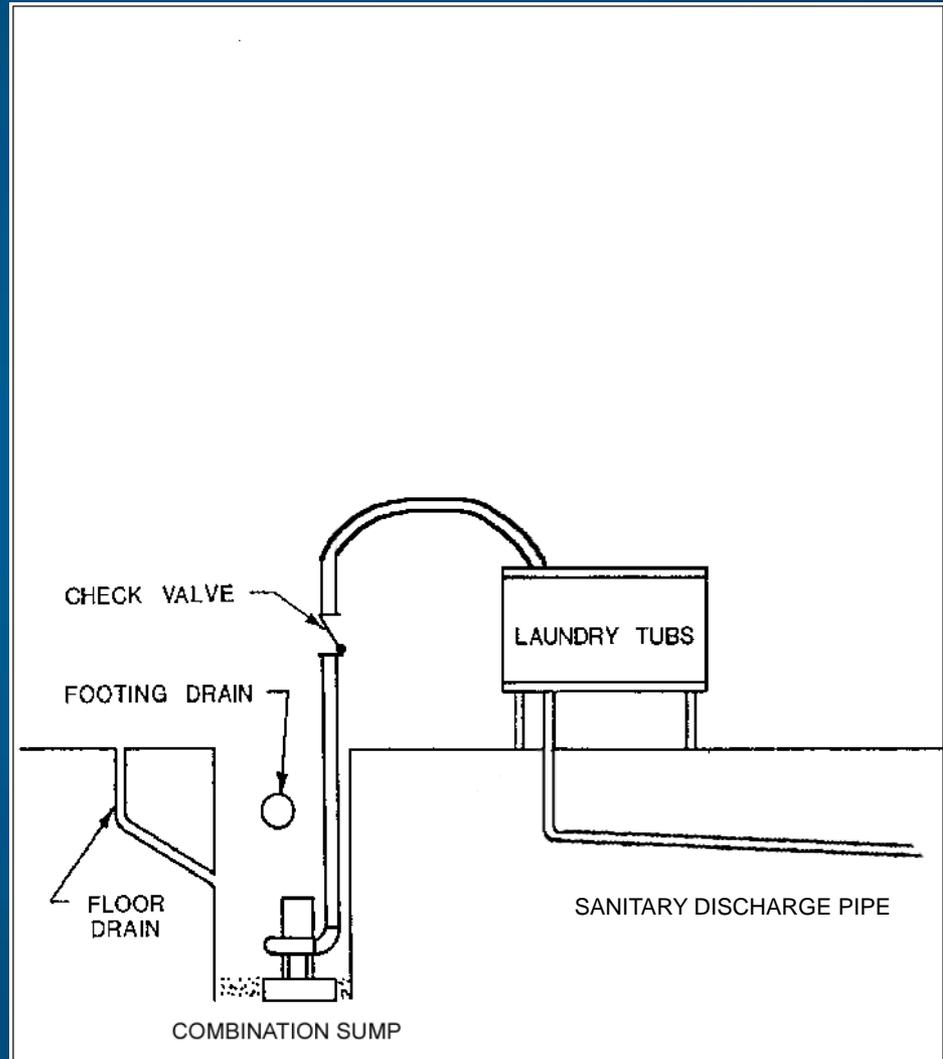
Typical Sump Pump Configuration

Combination Sump With Diverter Valve



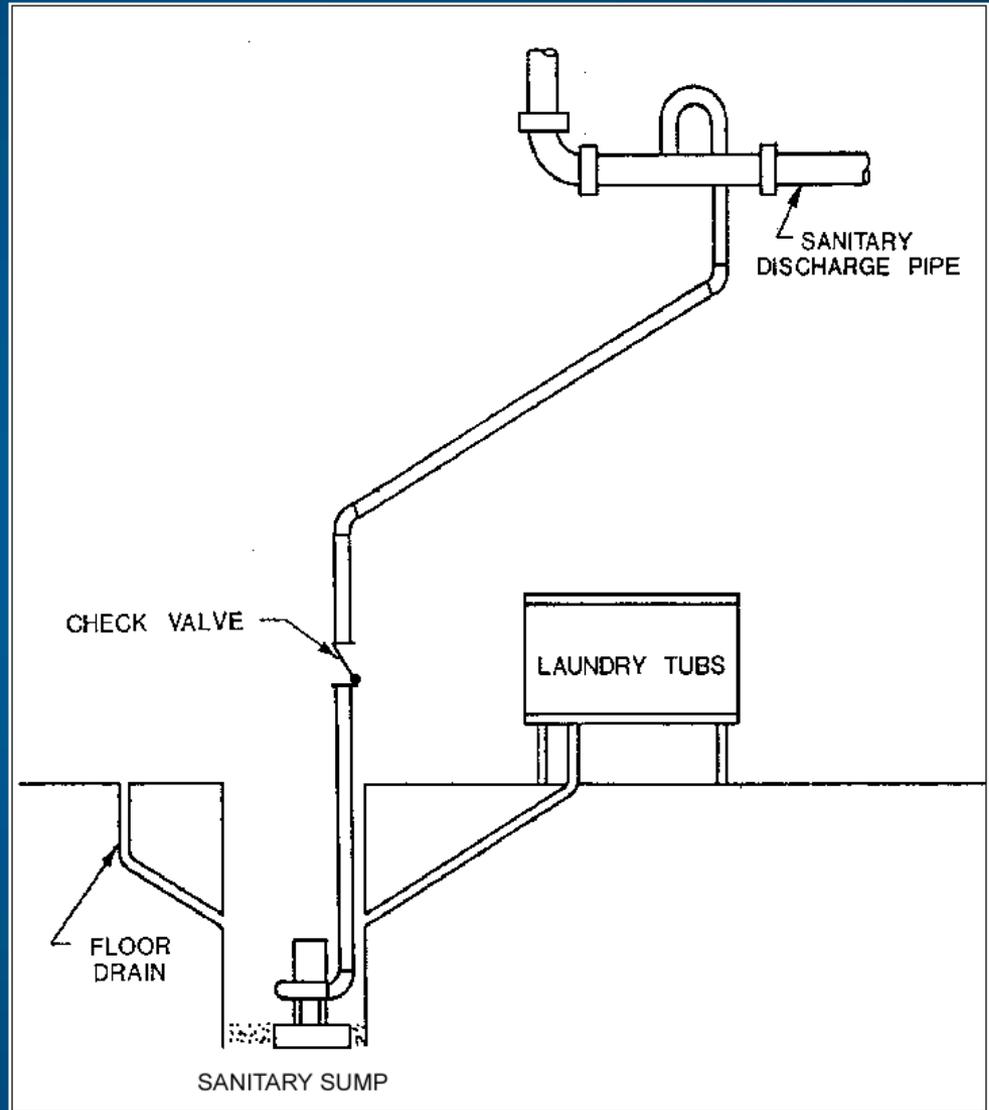
Typical Sump Pump Configuration

Storm Sump to Laundry Tub



Typical Sump Pump Configuration

Unsealed Sanitary Sump



Sump Discharge Pipes



Follow-up Dye Flooding for Confirmation

- Inject Dye in Sump
- Activate Pump
- Check Storm Sewer
- Check Sanitary Sewer
- Check Yard



Residential Sump Pump Peak Discharge Rates

Variables Include:

- Capacity of Sump Pump
- Basement Wall Cracks / Seepage
- Runoff From Roof
- Roof Runoff Over Land or Below Ground
- Drainage Away From Home
- Antecedent Moisture in Ground
- Ground Water Elevation at Time of Storm
- Other Site-Specific Conditions

Typical Residential Sump Pumps

Pentair Pump Group - Hydromatic
e

Back Forward Stop Refresh Home AutoFill Print Mail

Address: http://www.pentairpump.com/fr_hp.html go

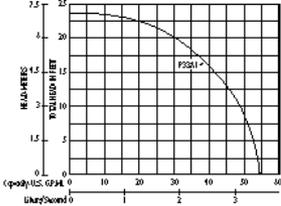
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Distributor-Only
Area
requires user login



Performance Curve

Typical Application	Sump pump
Capacities to	54 GPM (3.4 l/s)
Heads to	23 ft (7.0 m)
Electrical	115V, 1ø, 6.5FLA, 60Hz
Motor	1/3 HP shaded pole 1725 RPM
Minimum Recommended Sump Diameter	12" (304.8mm)
Automatic Operation	Mechanical float with rod
Materials of Construction	Engineered thermoplastic
Impeller	Thermoplastic
Discharge Size	1-1/4" NPT (31.8mm)
Solids handling	1/4" (6.4 mm)
Power cord	8', 16/3, SJT

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Pentair Pump Group

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Typical Submersible Sump Pump

Pentair Pump Group - Hydromatic

Back Forward Stop Refresh Home AutoFill Print Mail

Address: go

Member Services Top Sites Help Chat Live Home Page Apple Computer Apple Support Apple Store Microsoft MacTopia MSN

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HYDRAMATIC Models SW, SD & VS



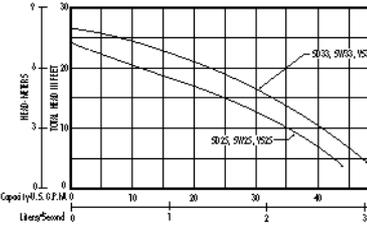
SW25/33



SD25/33



VS25/33



Performance Curve

Typical Application	Sump/Effluent pump
Capacities	SW/SD/VS25 - to 44 GPM (2.8 l/s) SW/SD/VS33 - to 48 GPM (3.0 l/s)
Heads to	SW/SD/VS25 - to 24 ft (7.3 m) SW/SD/VS33 - to 26 ft (7.9 m)
Electrical	SW/SD/VS25 - 115V, 1ø, 8.0FLA, 60Hz SW/SD/VS33 - 115V, 1ø, 10.0FLA, 60Hz
Motor	SW/SD/VS25 - 1/4 HP shaded pole w/thermal overload 1550

Residential Roof Runoff

1 Year Storm Peak Runoff Rate

Roof Area (Square Feet)	30 Minute Duration (1.00 inches in 30 minutes)	5 Minute Duration (0.33 inches in 5 minutes)
1000	21 gpm	41 gpm
1250	26 gpm	51 gpm
1500	31 gpm	62 gpm
2000	42 gpm	82 gpm

Seasonal Impact on Peak Flow / Volume

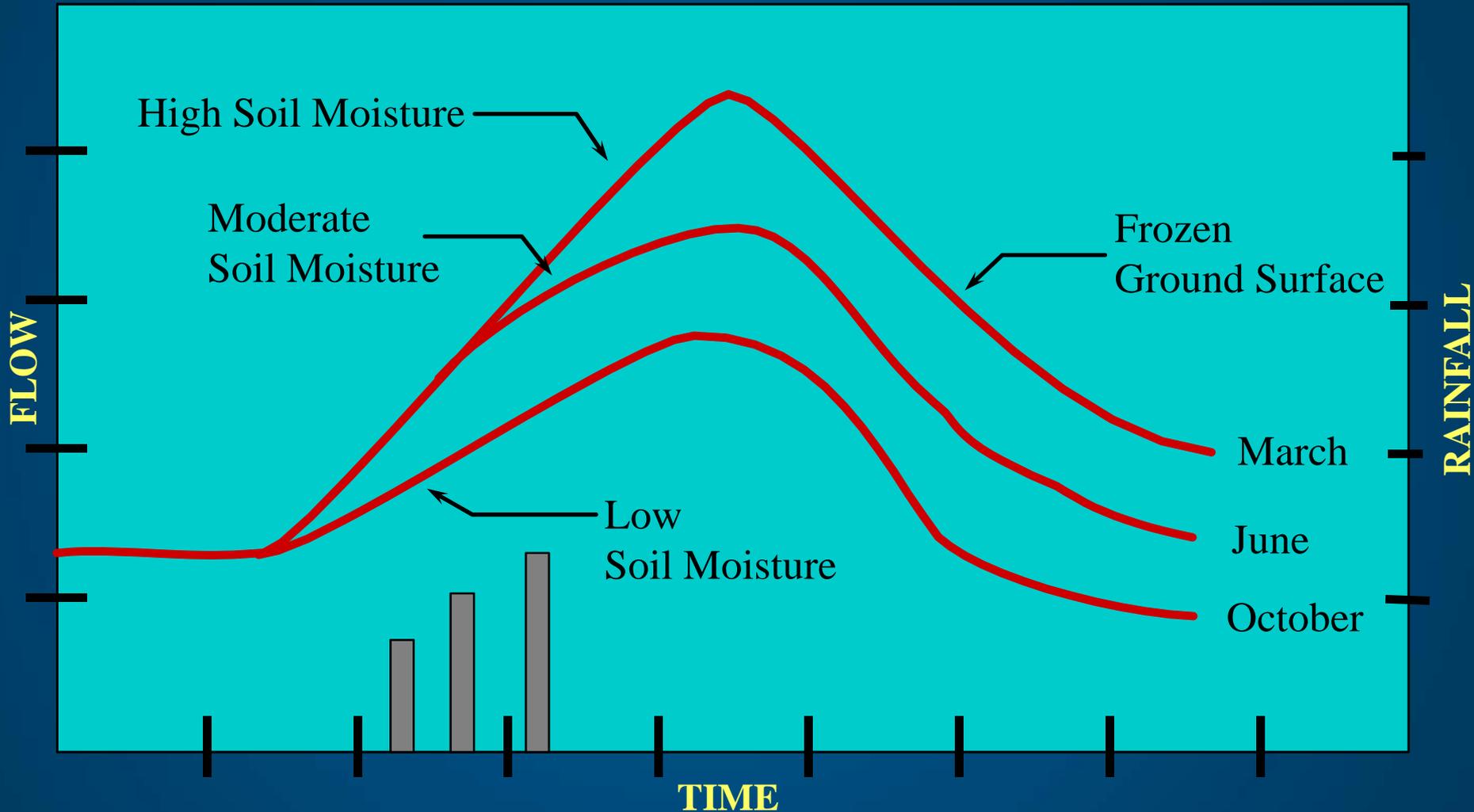
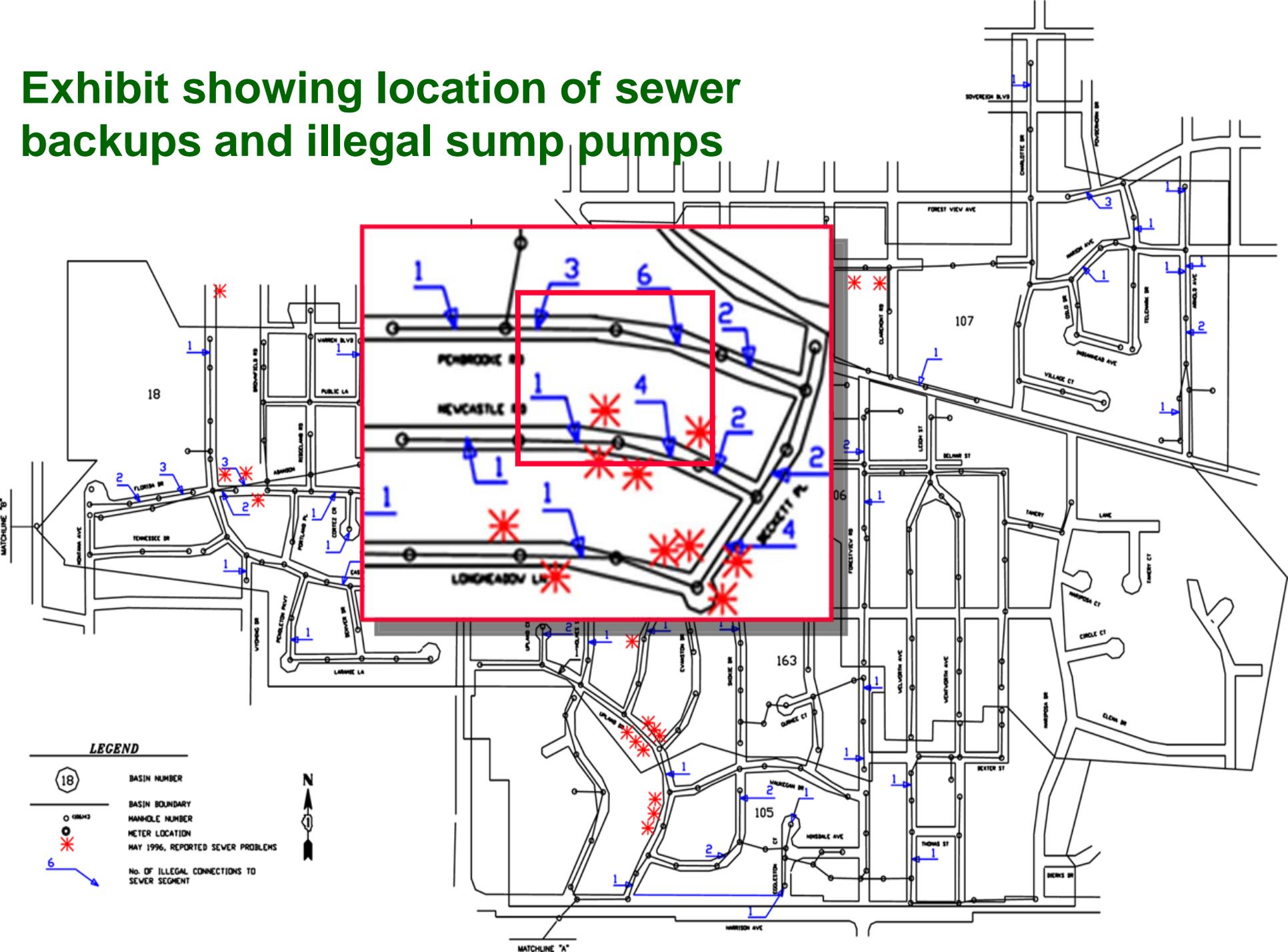


Exhibit showing location of sewer backups and illegal sump pumps



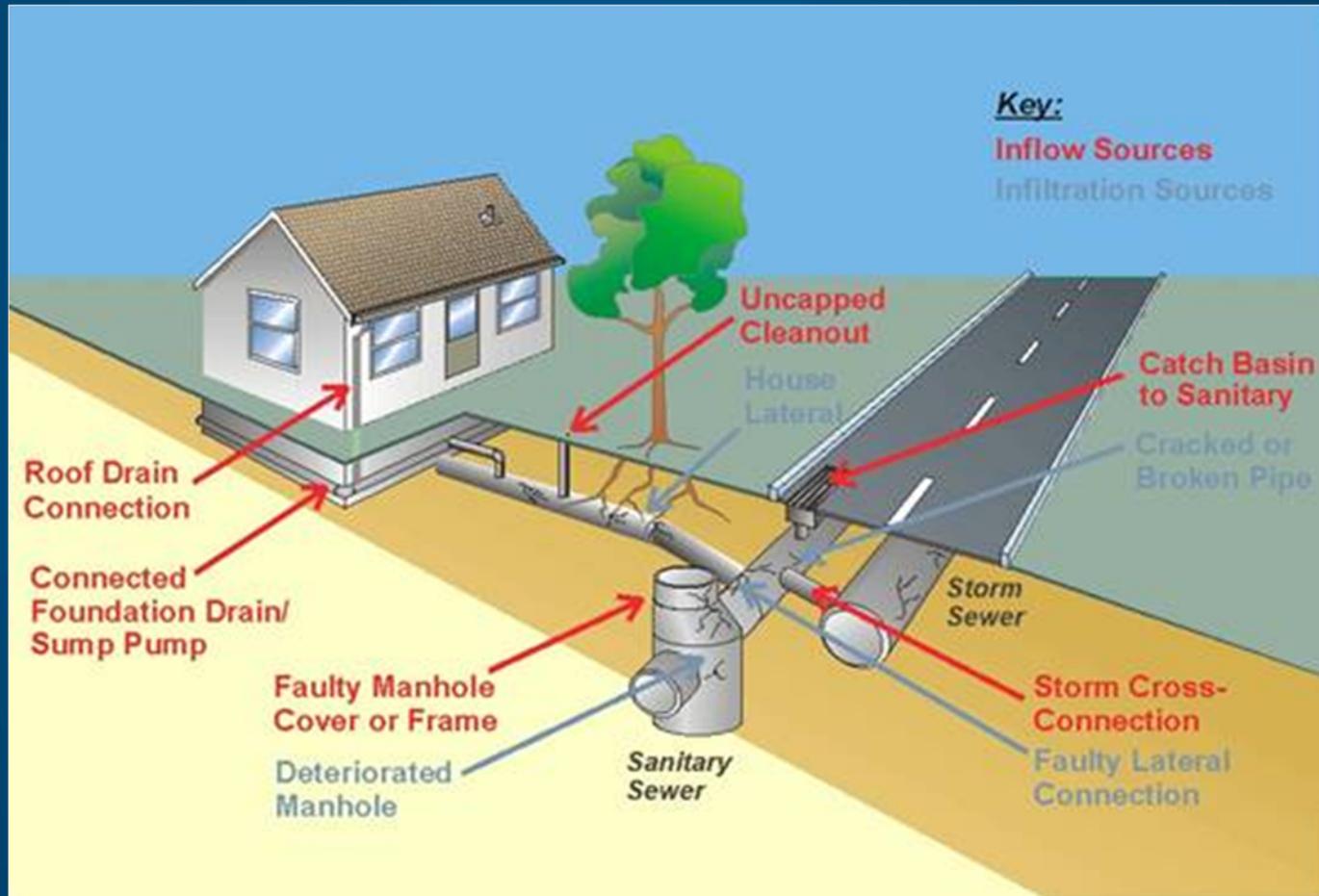
LEGEND

-  BASIN NUMBER
-  BASIN BOUNDARY
-  MANHOLE NUMBER
-  METER LOCATION
-  MAY 1996, REPORTED SEWER PROBLEMS
-  NO. OF ILLEGAL CONNECTIONS TO SEWER SEGMENT

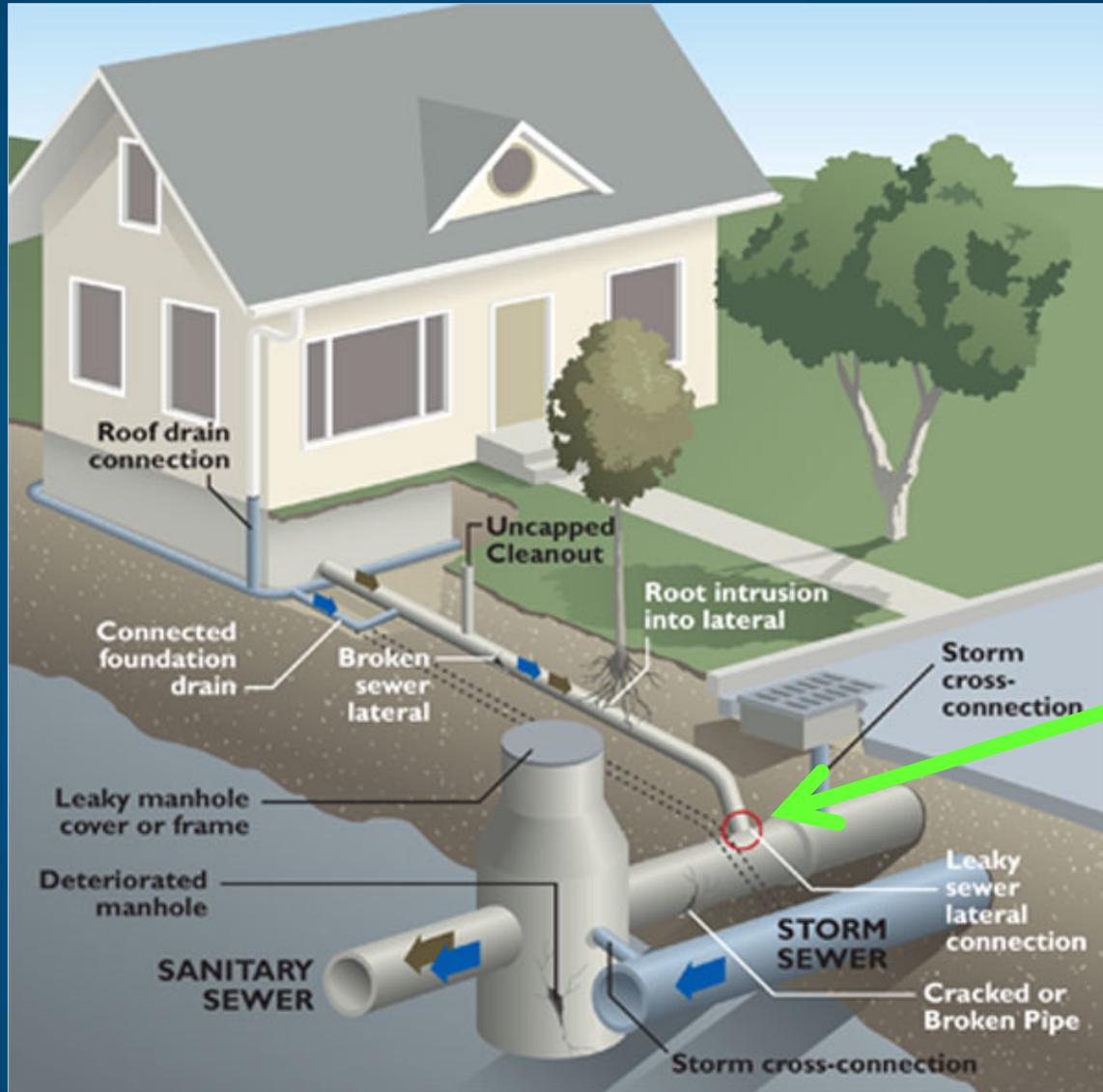


MATCHLINE "A"

- The Last Frontier?



Leaking Service Laterals



Service Lateral Television Inspection

- From the Cleanout
- Inspection Port in the House
- Lateral Launcher



Service Lateral Television Inspection

- Look For:
 - Overall condition
 - Just one defect?
 - Obstructions
 - Narrowing
 - Connection – is it dropped?
 - Illegal I/I connections?
 - Material – PVC you cannot line it
 - Infiltration



Private Defects - Laterals



Typical Flow Rates – Internal

Source	1-Year Storm Flow - GPM
Sumps- Storm, Combined, Diverter, Unsealed	5.0 - 7.0
Foundation Drain	5.0 - 7.0

Typical Flow Rates – External

Source	1-Year Storm Flow - GPM
Patio/Area Drain	1.0 – 10.0
Downspouts	5.0 – 20.0
Stairwell/Window Well Drain	0.5 – 2.0
Driveway Drain	5.0 – 25.0
Cleanout	0.5 – 2.0
Service lateral	0.5 – 3.0

Private Sector Infiltration/Inflow Sources

- Types of Sources?
- How Do You Find Them?
- **How Do You Eliminate Them?**
 - **Technical Issues**
 - Institutional Issues

Sump Pump/Foundation Drain Disconnection

Connection

- ☔ Directly Connected Foundation Drain (Basement with NO Sump Pump)
- ☔ Storm Sump Connected to Sanitary Sewer (Basement with Sump Pump)
- ☔ Combination Sump Connected to Sanitary Sewer (Basement with Laundry Tubs and Single Sump Pump)

Typical Disconnection Procedure

- ☔ Excavate Sump Pit in Basement Floor, Install Sump Basin and Sump Pump, Route Discharge to Rear Yard or Storm Sewer
External excavation to disconnect foundation drain from lateral
- ☔ Reroute Pump Discharge to Rear Yard with Flexible Discharge Pipe Outside or to storm sewer
- ☔ Install Laundry Tub Pump and Reroute Existing Sump Discharge to Rear Yard

Sump Pump / Foundation Drain Disconnection

Connection

- ☔ Unsealed sanitary Sump
- ☔ Diverter Valve

Typical Disconnection Procedure

- ☔ Install new storm sump, route discharge to rear yard / storm sewer
- ☔ Remove valve, disconnect discharge from sanitary sewer

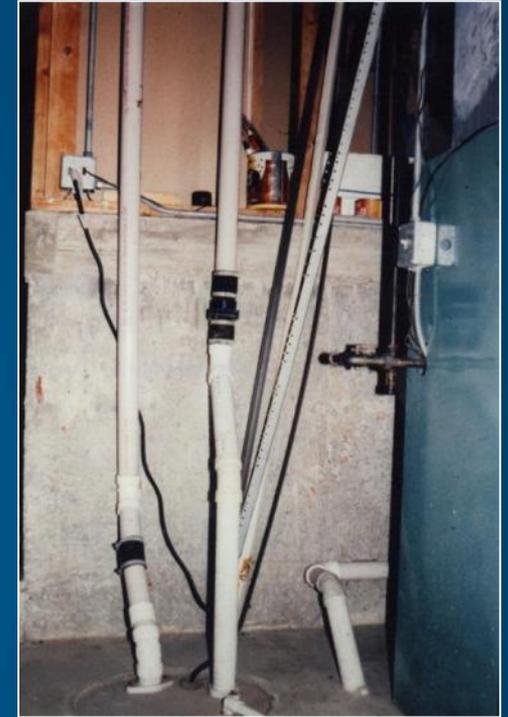
Sump Pump Disconnection Issues

- Localized Yard Ponding / Erosion
- Mosquito Breeding Areas
- Dangerous Ice Patches on Street / Sidewalk if Front Yard / Driveway Discharge
- “Now We Have Stormwater Flooding”
- PVC Easy to Reconnect



Sump Pump Disconnection

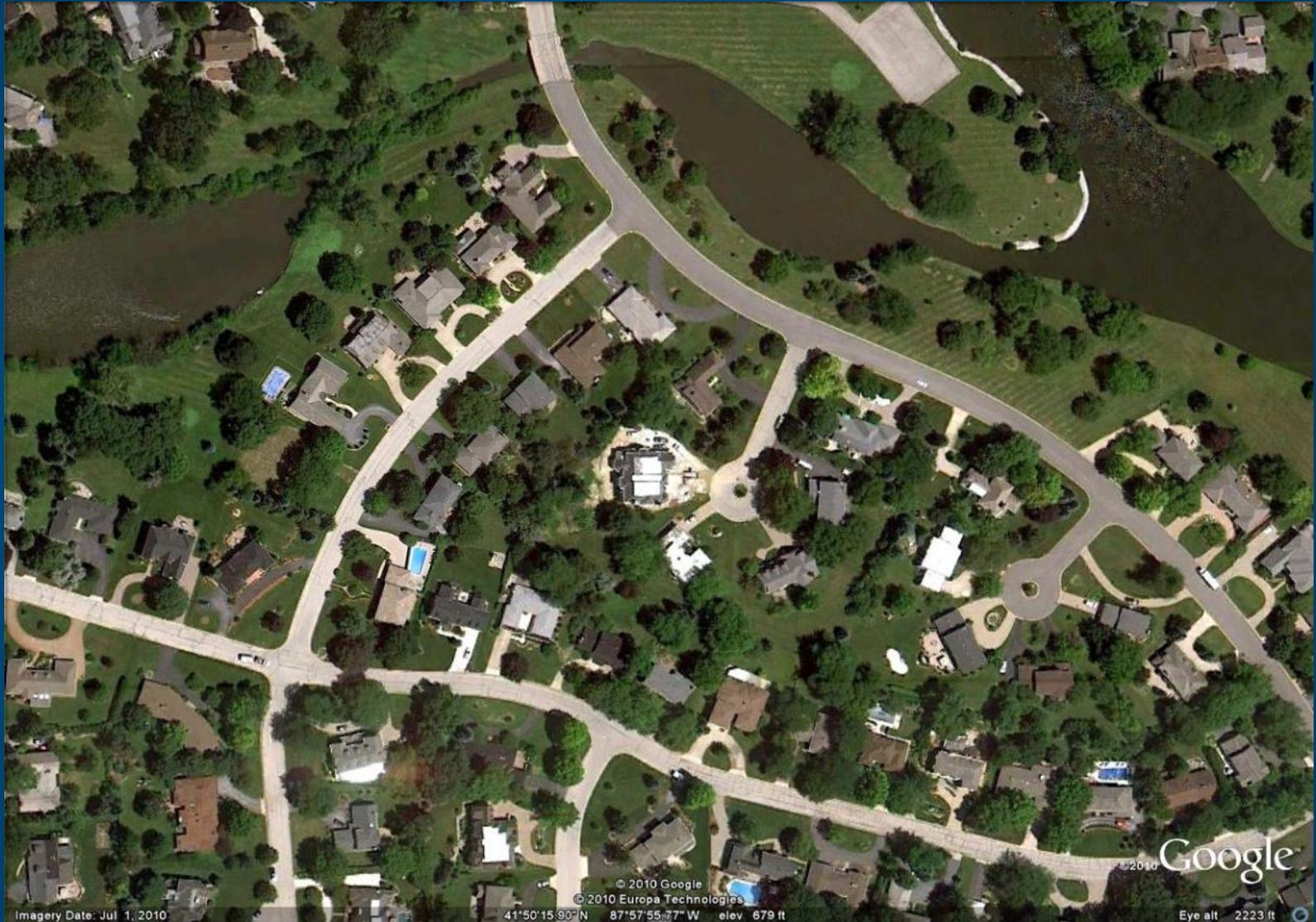
- Air Gap / Storm Sewer



Combination Sump - Laundry Tub Sump Retrofit



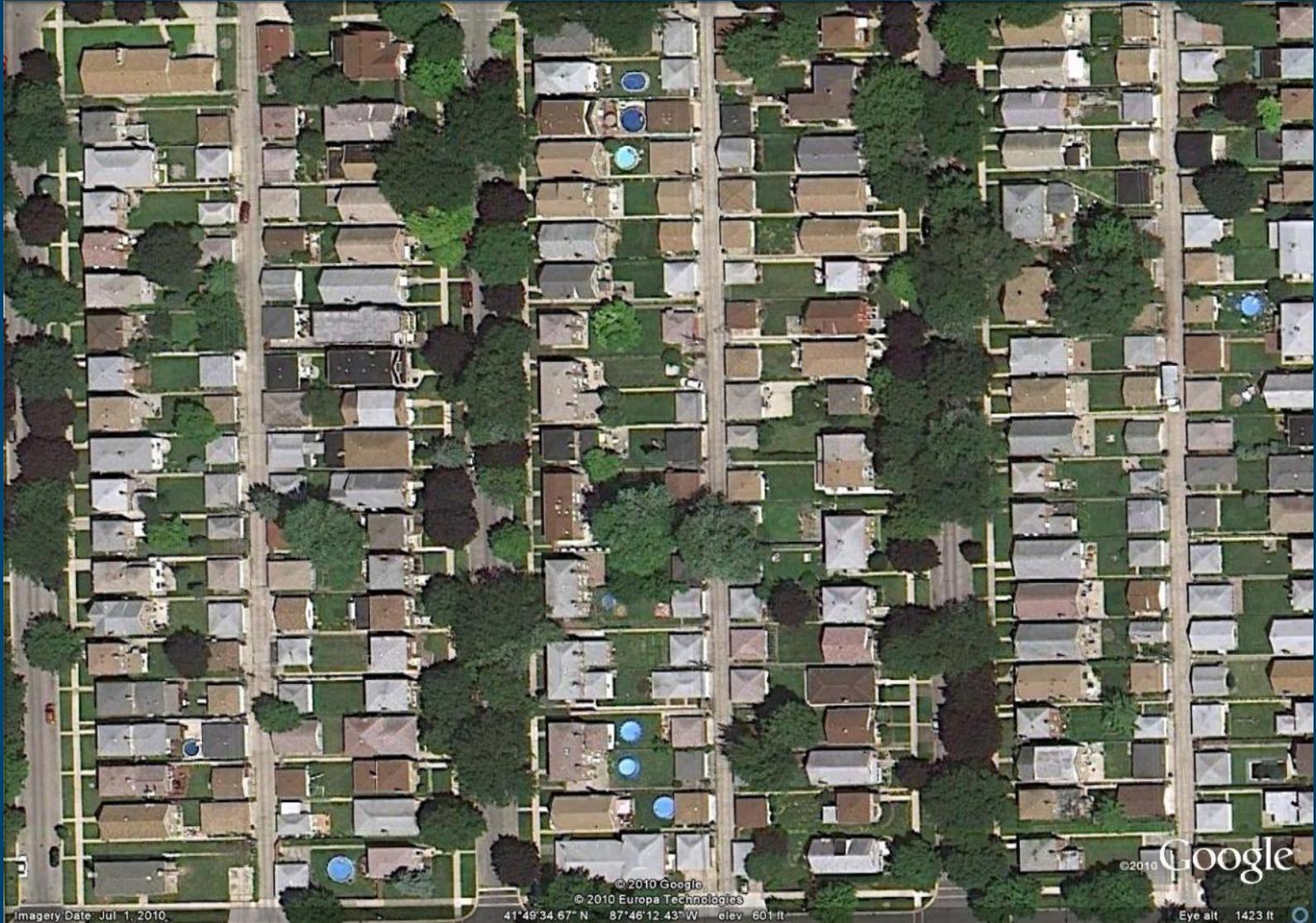
Low Density Residential



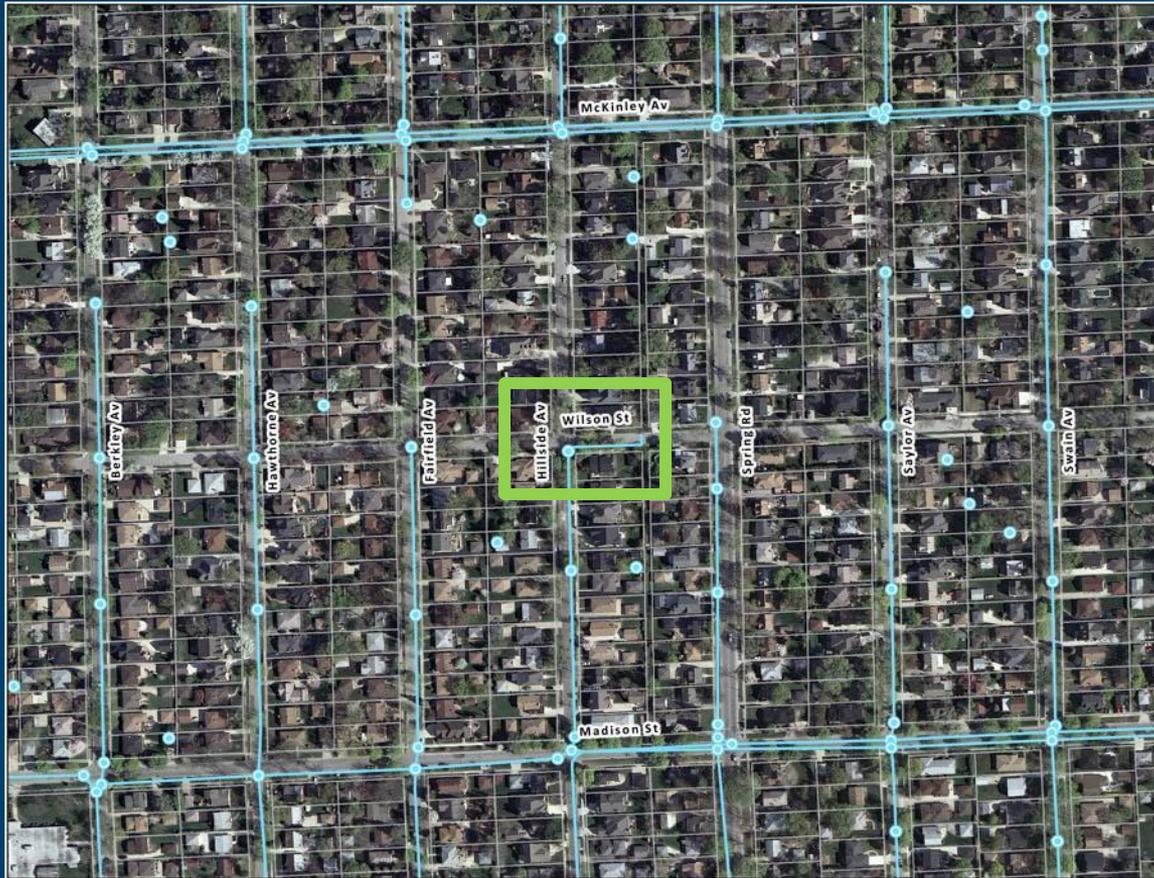
Moderate Density Residential



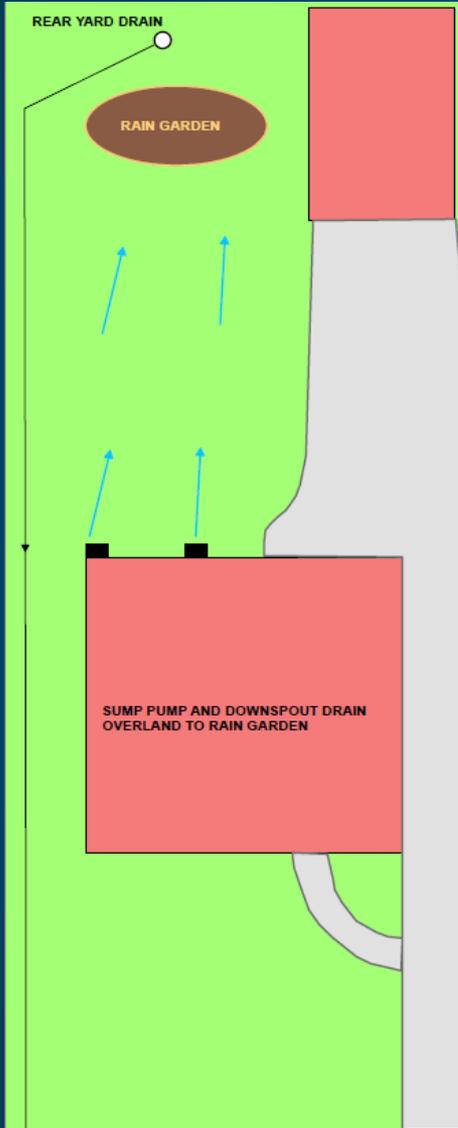
High Density Residential



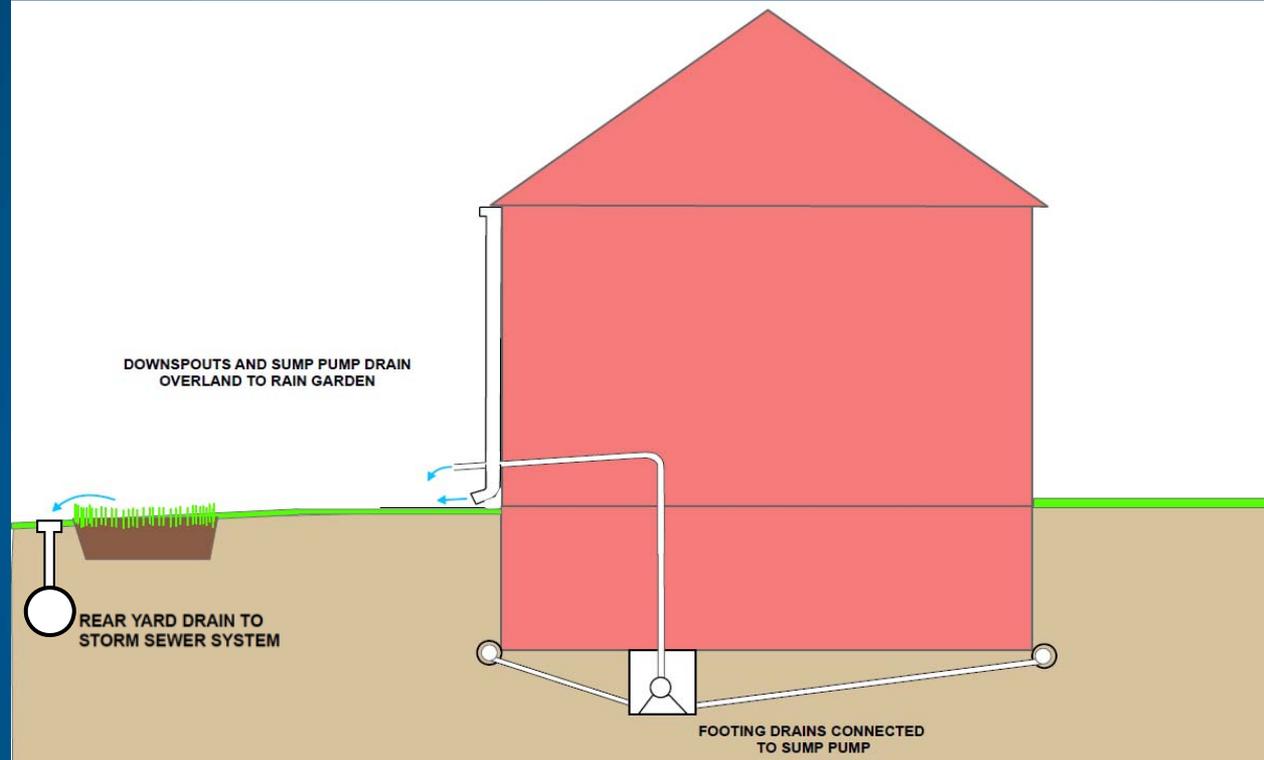
Rear Yard Storm Drains / Swales



Rain Garden Schematic



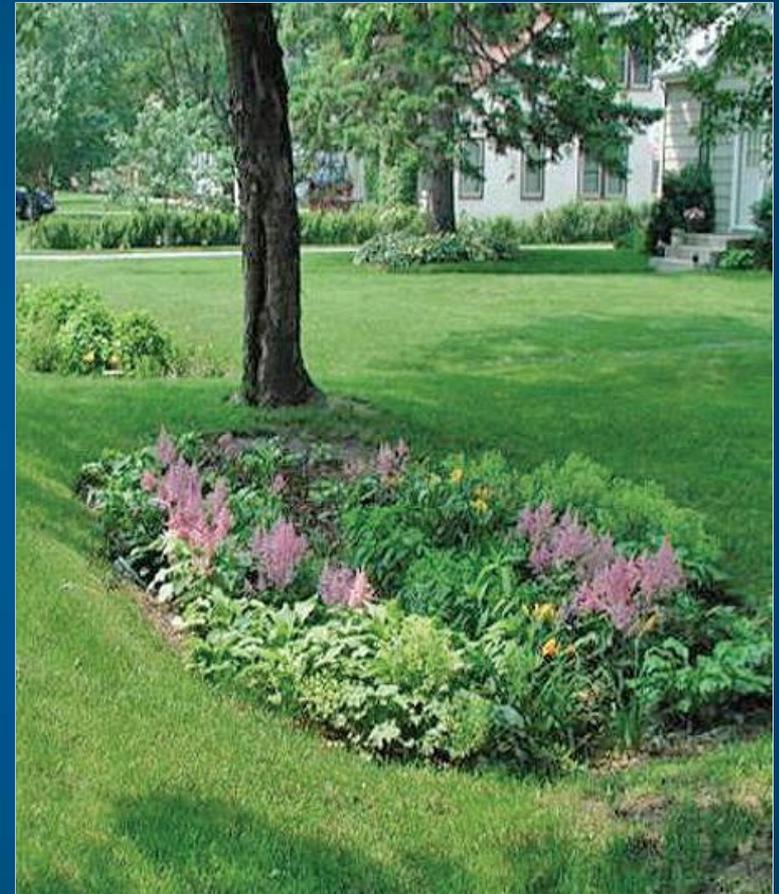
PLAN VIEW



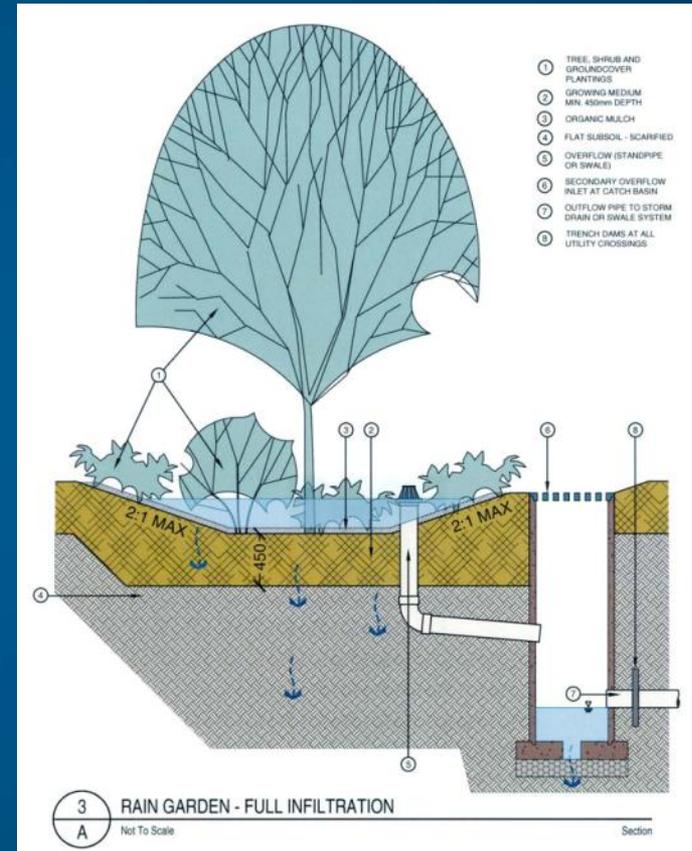
PROFILE VIEW

Rain garden should be located at least 15 feet away from building foundation and outside the zone of influence of the sanitary sewer.

Rain Garden Example

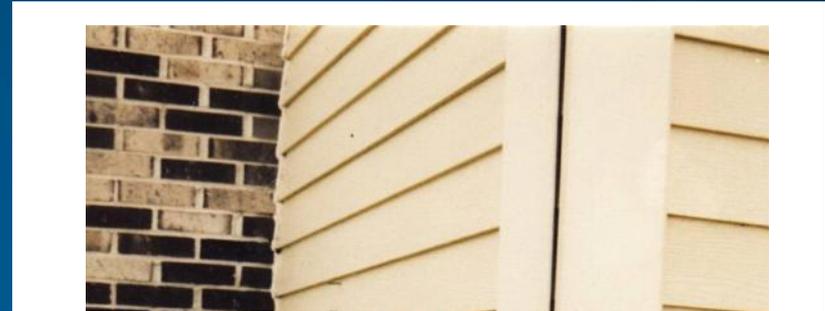


On-Site Detention with Slow Release

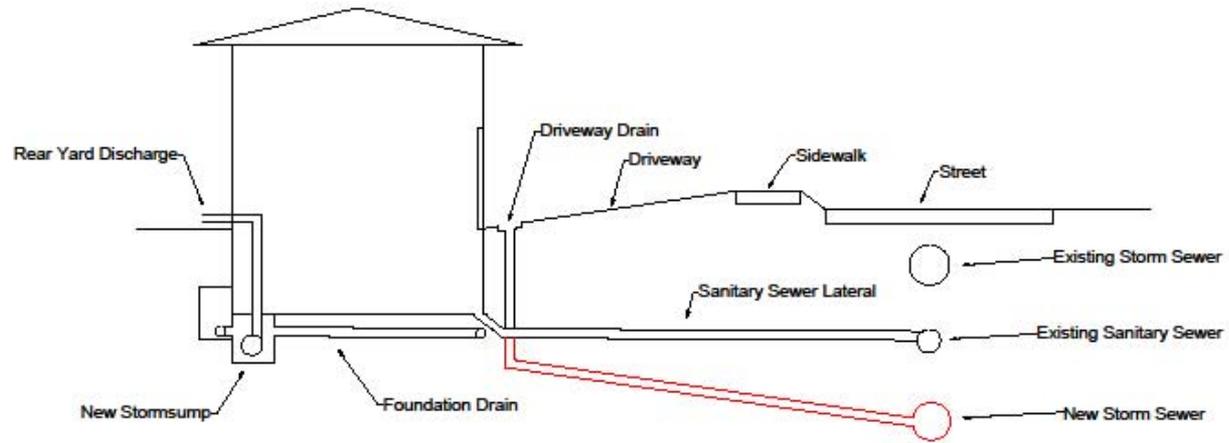


“Exterior” Source Disconnection

- Cleanout
- Downspouts
- Driveway Drains



Potential Reverse Slope Driveway Drain Disconnection



Lateral Rehabilitation Options

- Excavate and Replace
- Full Lining
- Pipe Burst
- Connection to Main
 - Partial Lining - "Top Hat"
 - Excavate and replace
 - Grout
 - Janssen Process

Service Lateral Rehabilitation

- Excavation Not Always Required
- Lots of Unpredictable Service Lateral Alignments, Materials and Blockages



Lateral Excavate and Replace

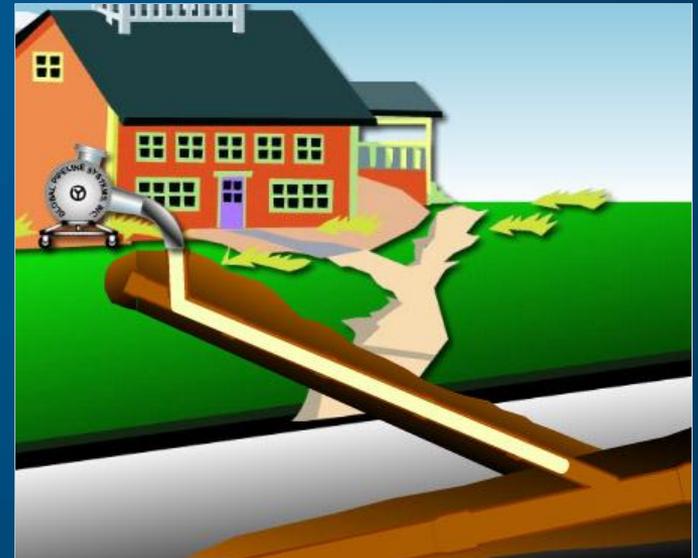
- May Be the Most Cost-Effective for Removing Severe I/I
Condition of Lateral Does Not Permit Lining or Pipe Bursting
- Considerations
 - Depth
 - Length
 - Surface conditions - restoration
 - No cleanouts needed

Lining - Criteria for Lateral Selection

- Active Leaks
- Concentration of Active Leaks in Vicinity
- Lateral Excavation Not Required
- Not PVC
- Relative Location of Storm Sewers or Storm Ditches

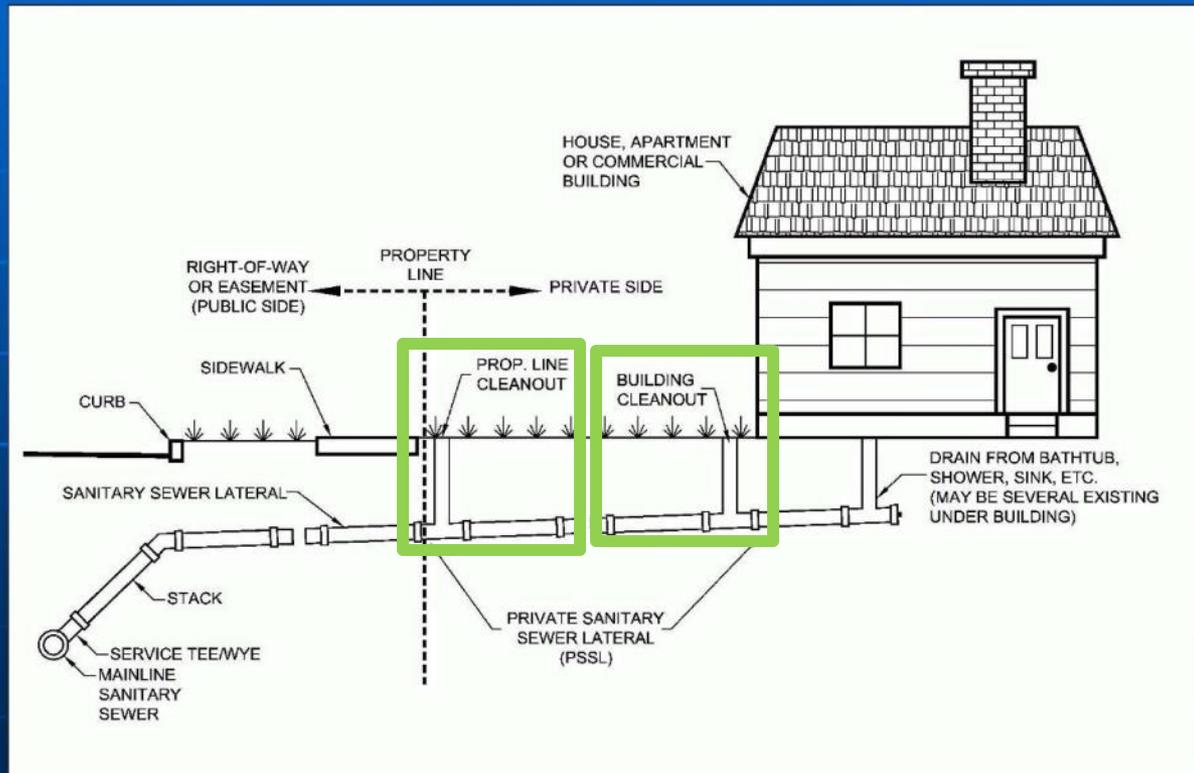
Lateral Lining

- Lateral:
 - Inversion or pull-in (same as main-line)
 - Needs cleanout
 - Needs relatively uniform cross-section
 - Gentle bends – otherwise liner will “pleat” and reduce area
 - Paid for per foot (+ cost of TV+ cost of cleanout)
 - Short-liner (spot repair)



Importance of Cleanout

Typical Sanitary Sewer Lateral



Installation of Cleanout



Installation of Cleanout





VAC EXCAVATING



TEE INSTALLED ON SERVICE LINE



CLEANOUT PRIOR TO RESTORATION



YARD AFTER VAC-A-TEE INSTALLATION

T-Liner Approach to Lateral Lining

**Full-Circle Seal/
a “Stand Alone” Structural Repair**



A top-down view of a circular hole in a brown, textured surface. The hole's interior is lined with a white, fibrous material that has been layered or built up, creating a funnel-like structure. The layers are uneven and show some cracking. The center of the hole is dark and shadowed.

0233.11



T-Liner - Pros

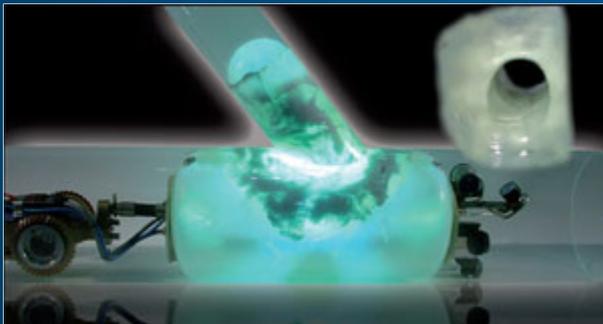
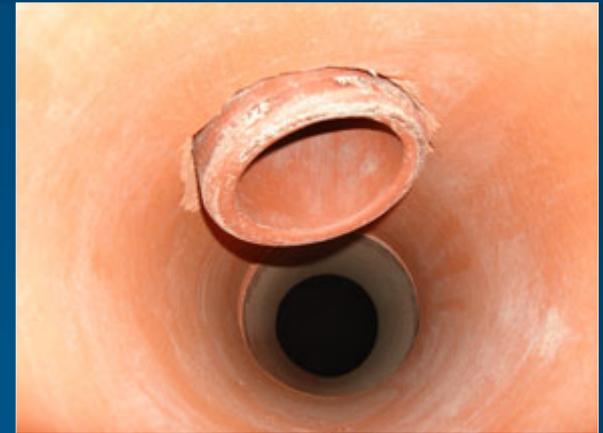
- Very Good Seal Between Lined Pipe and Into Lateral
- Can Vary Length
 - Stubby – 6 inches
 - Shorty – 3 feet
 - Long – 3 to 80+ feet
- Stubby Does Not Need a Cleanout
- If Install Cleanout at Building Connection Can Line Entire Section from Main Line
- Usually Paid Per Segment Set-Up then Per Lateral Per Length (cost is in the connection additional feet are relatively good value \$30-\$40 per foot)

T-Liner - Cons

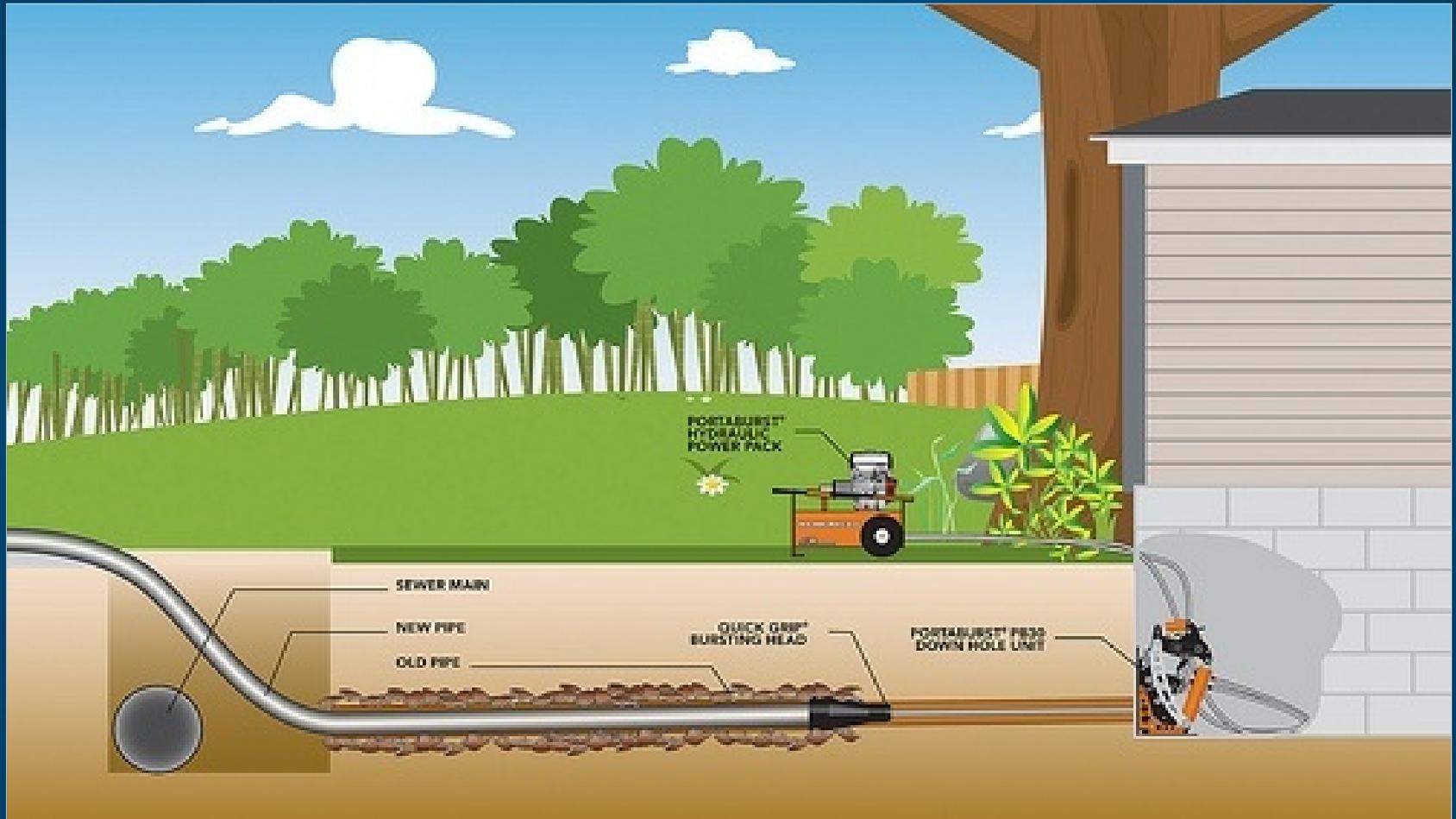
- “Shorty” and Longer Needs a Cleanout
- Cleanouts Can Be Expensive (even Vac-a-Tee) Based on Depth and Ease of Access
- Cannot Do:
 - Connections with severe running infiltration
 - Dropped connections (pipe will not invert)
 - Laterals with severe bends / turns / splits
 - Expensive – excavation can be cheaper

Connection Lining - Top Hat

- Top Hat
 - Does not need cleanout
 - Only seals connection
 - Addresses I/I well (not gushing)
 - Good for break-ins and PVC to VCP connection
 - Some instances of de-lamination
 - Paid for per segment set-up and then per connection
 - Problems if severe dropped connection



Pipe Bursting



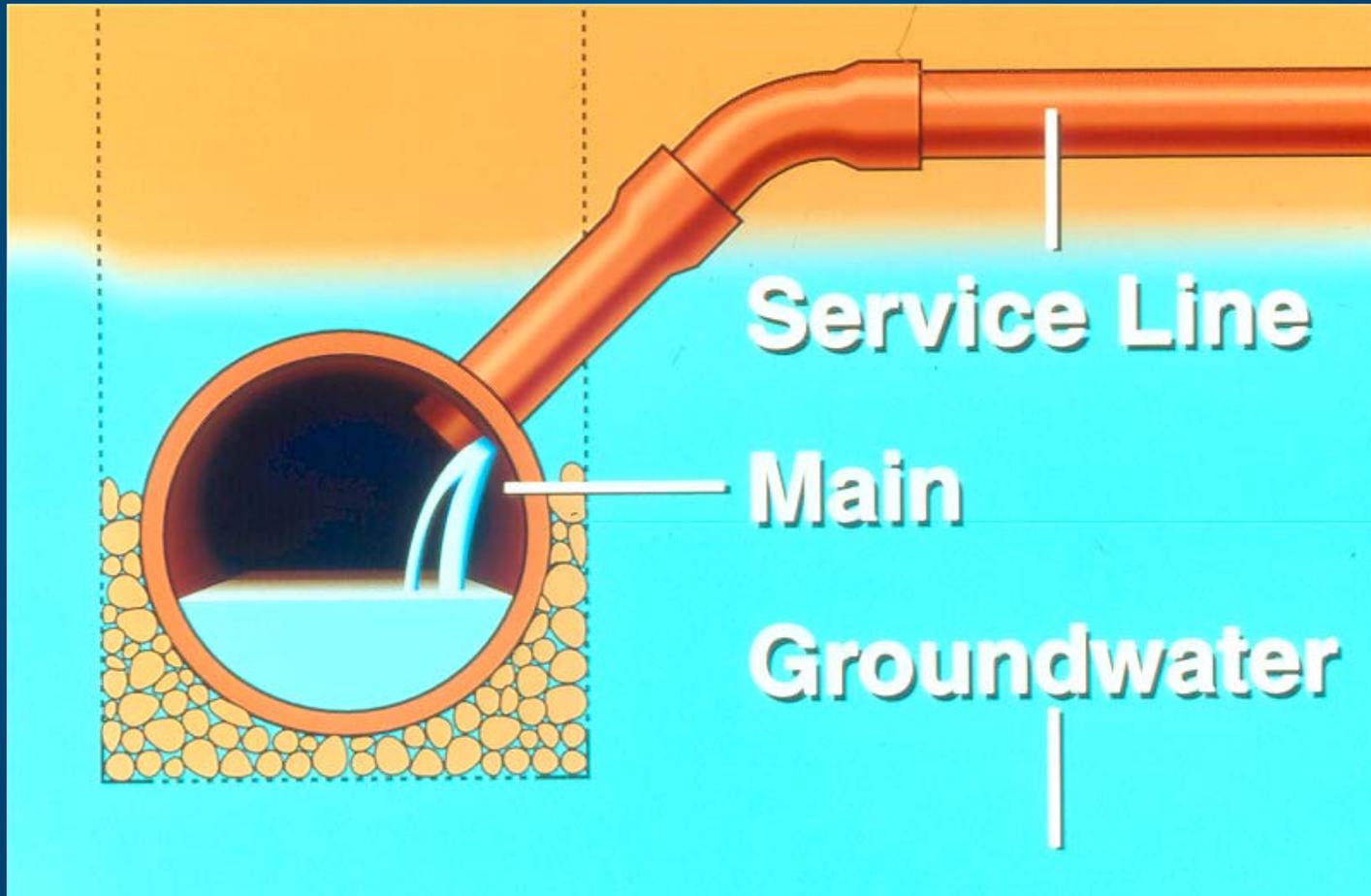
Pipe Bursting

- More Expensive Option
- Excavation – Needs Access Pits
 - Cleanout to main
 - Basement to main
 - Main to basement
- When to Consider?
 - Lateral needs upsizing
 - Very difficult access
 - Very deep lateral
 - Lateral “twists and turns”
 - Lateral is very long

Service Connection Point Repair

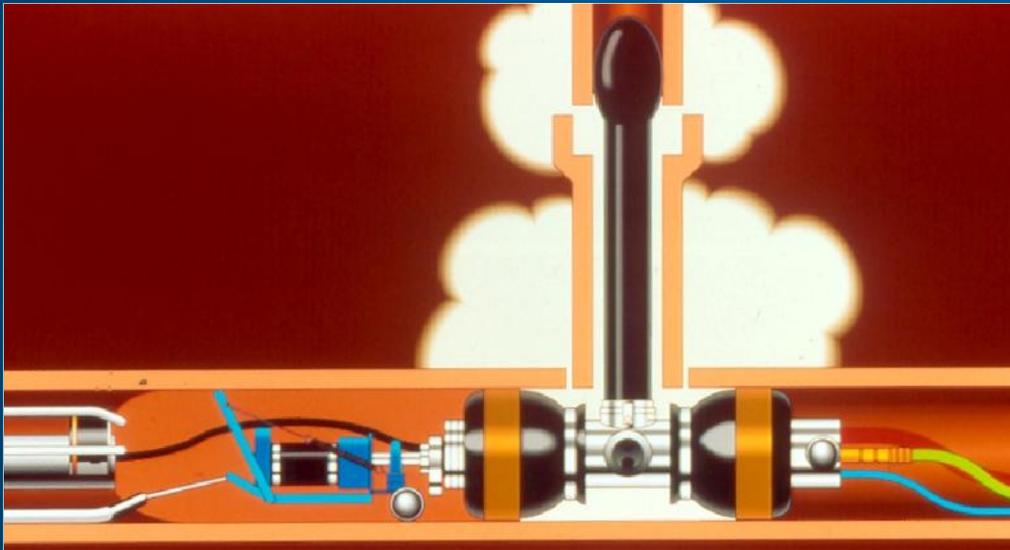
- May Be the Most Cost-Effective for Removing Severe I/I at the Connection if Laterals Facing Each Other and Both Need Rehabilitation
- Considerations
 - Depth
 - Usually will get the riser replaced – main location of I/I
 - Surface conditions - restoration
 - No cleanouts needed

Grouting The Connection



Grouting the Connection

Similar to Mainline Grouting, Special Packer Positioned at Service Connection that Extends Up the Lateral 30 Inches



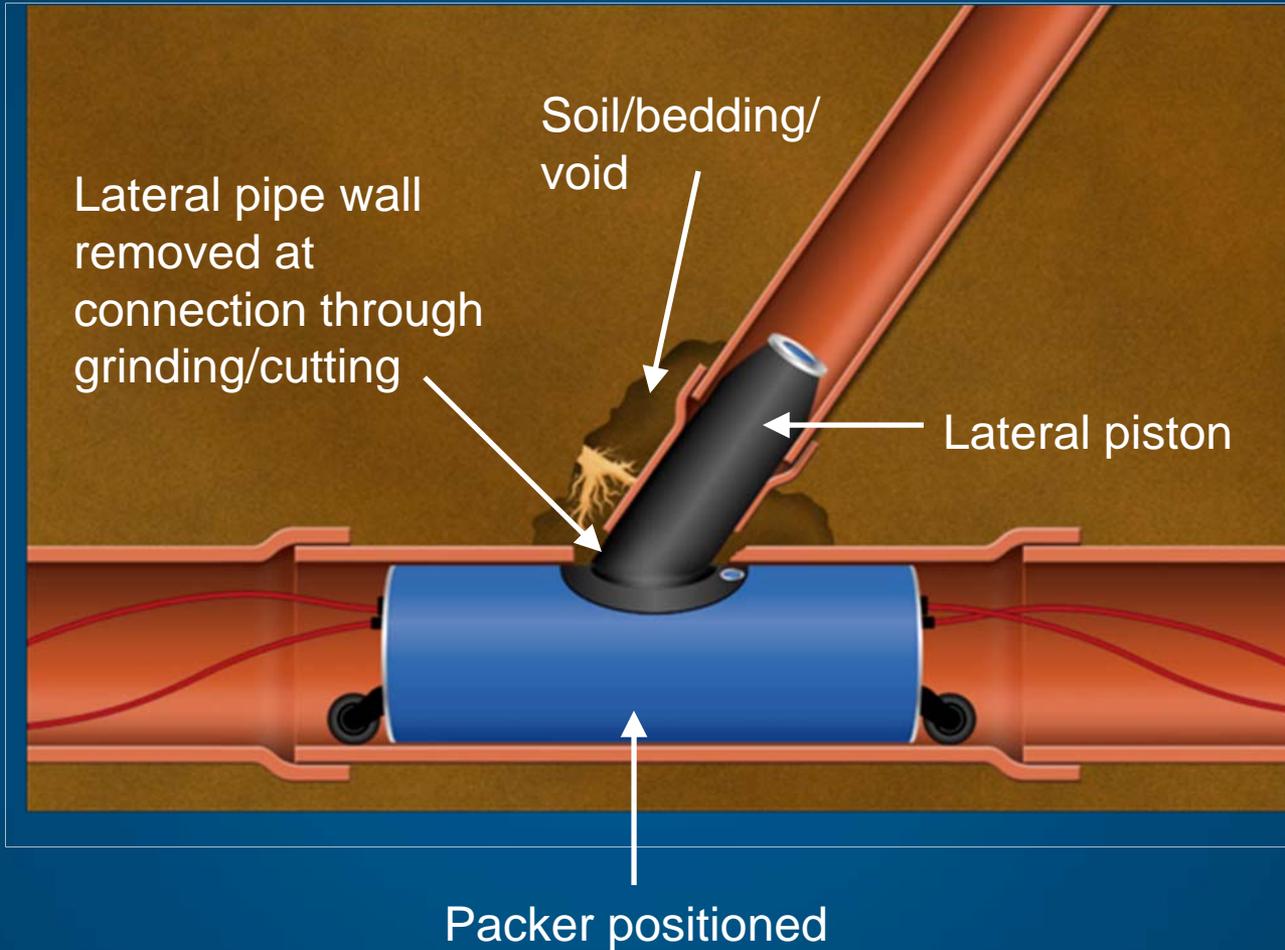
Grouting

- Pros:
 - Can be used very effectively at connection and first joint
 - Historically – long-term improvement (if in wet environment)
 - Cheaper than top-hat or T-liner
- Cons
 - May need more than one application on severe infiltration
 - If lateral is cracked cannot use
 - Needs to stay wet
 - Not as “neat-looking” on protruding taps
 - Not structural repair
- Pay Per Segment Set-Up, Then Per Connection or Per Gallon

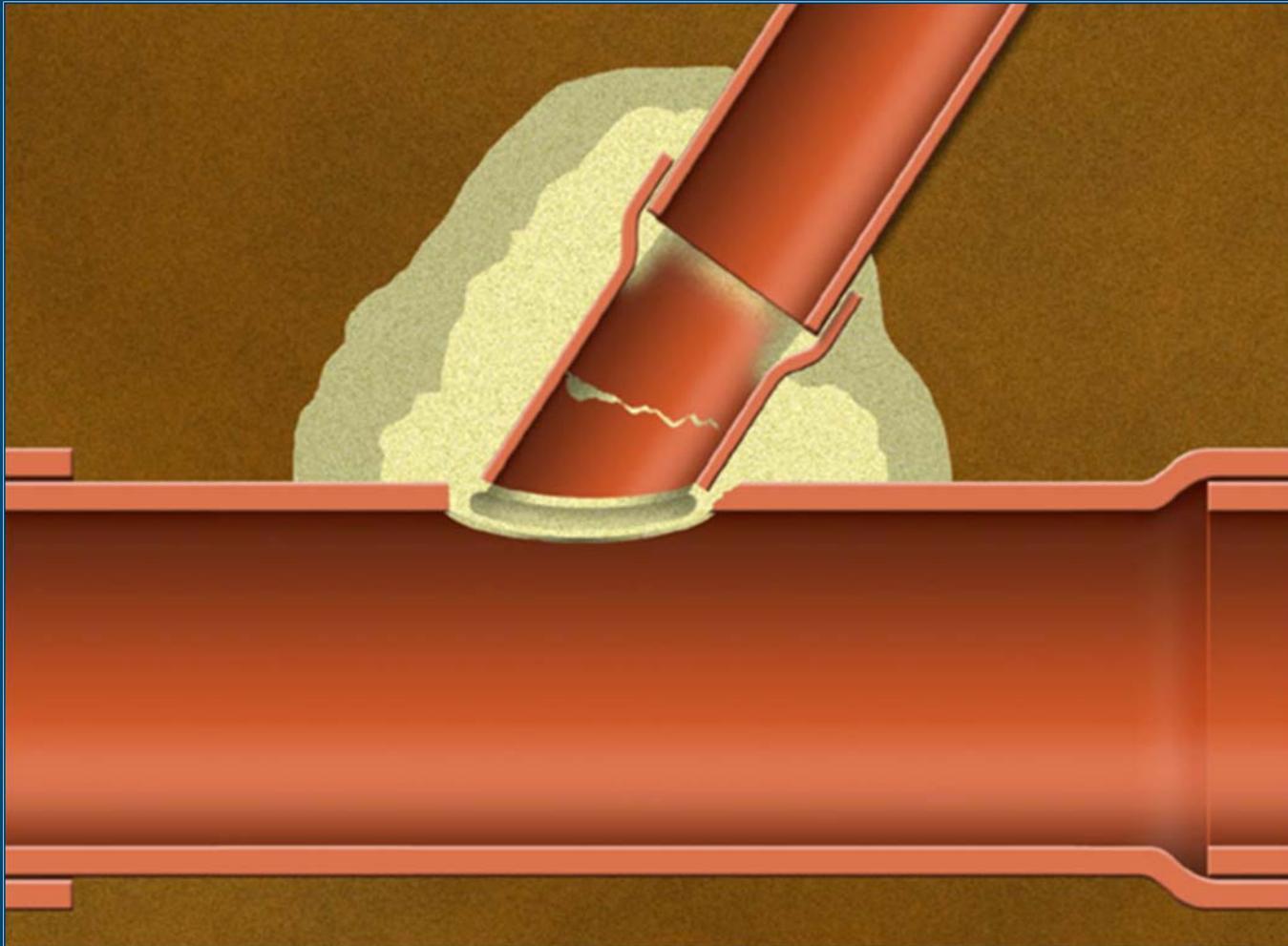
Janssen Process

- Relatively New
- Full Structural Repair of the Connection
- Addresses I/I Gushing at the Connection Excellently
- Injects Epoxy Concrete Mix
- Can Be Installed with Cracked Laterals (Provided Not Longitudinal)

Packer Inserted



Post Injection



Gushing Infiltration Abandoned Lateral



Abandoned Service Sealed



Typical Rehabilitation Costs - Internal

Source	Average Rehabilitation Cost
Storm Sump	\$300 - \$750
Sump with Diverter Valve	\$300 - \$750
Combination Sump	\$2,500 - \$5,000
Unsealed Sanitary Sump	\$1,500 - \$3,000
Foundation Drain	\$5,000 - \$10,000

Typical Rehabilitation Costs - External

Source	Average Rehabilitation Cost
Patio/Area Drain	\$2,500 - \$5,000
Downspouts	\$100 - \$500
Stairwell/Window Well Drain	\$2,500 - \$5,000
Driveway Drain	\$2,500 - \$10,000
Cleanout Cap	\$100 - \$500

Service Lateral Rehabilitation Costs

Source	Average Rehabilitation Cost
Excavate & Replace	\$5,000 - \$15,000
Full Lining from Cleanout (T Liner) <ul style="list-style-type: none"> - With Cleanout - Without Cleanout 	\$5,000 - \$7,000 \$3,500 - \$5,500
Pipe Burst	\$10,000 - \$15,000

Service Lateral Connection Rehabilitation Costs

Source	Average Rehabilitation Cost
Connection Lining - Top Hat	\$1,500 - \$2,000
Excavate & Replace	\$5,000 - \$15,000
Grout (all connections on line segment)	\$500 - \$1,000
Janssen Process	\$2,000 - \$3,000

Private Sector Infiltration/Inflow

- Types of Sources?
- How Do You Find Them?
- How Do You Eliminate Them?
 - Technical Issues
 - **Institutional Issues**
 - **Enforcement Mechanisms**
 - **Funding Options**

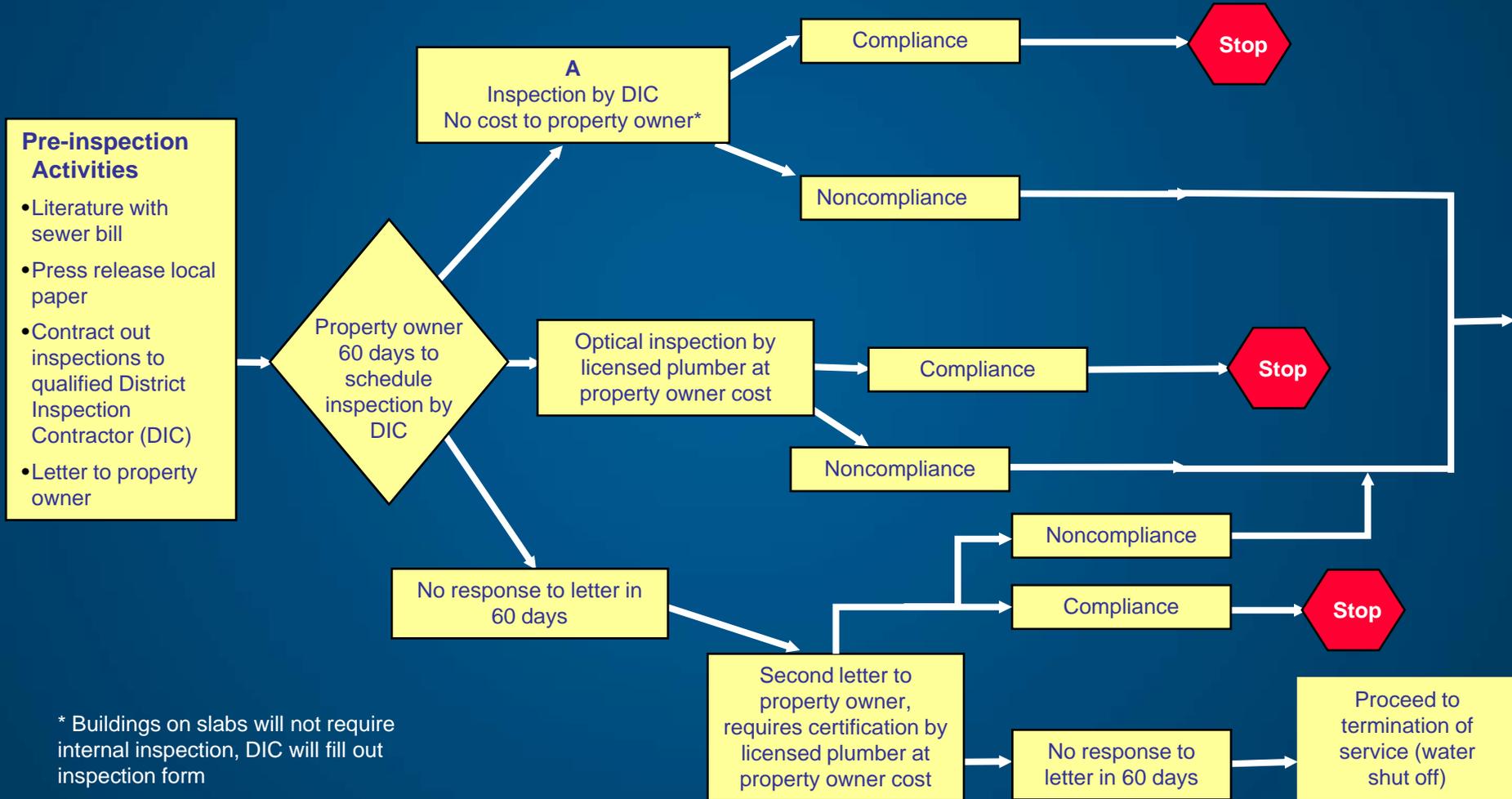
Private Sector Enforcement Mechanisms

- Sewer Use Ordinances
- Property Transfer Inspection
- Periodic Re-inspection
- Search Warrant
- Service Shutoff
- Sewer Use Surcharge
- Fines



RRWRD Updated Private Property Inflow Source Disconnection Program

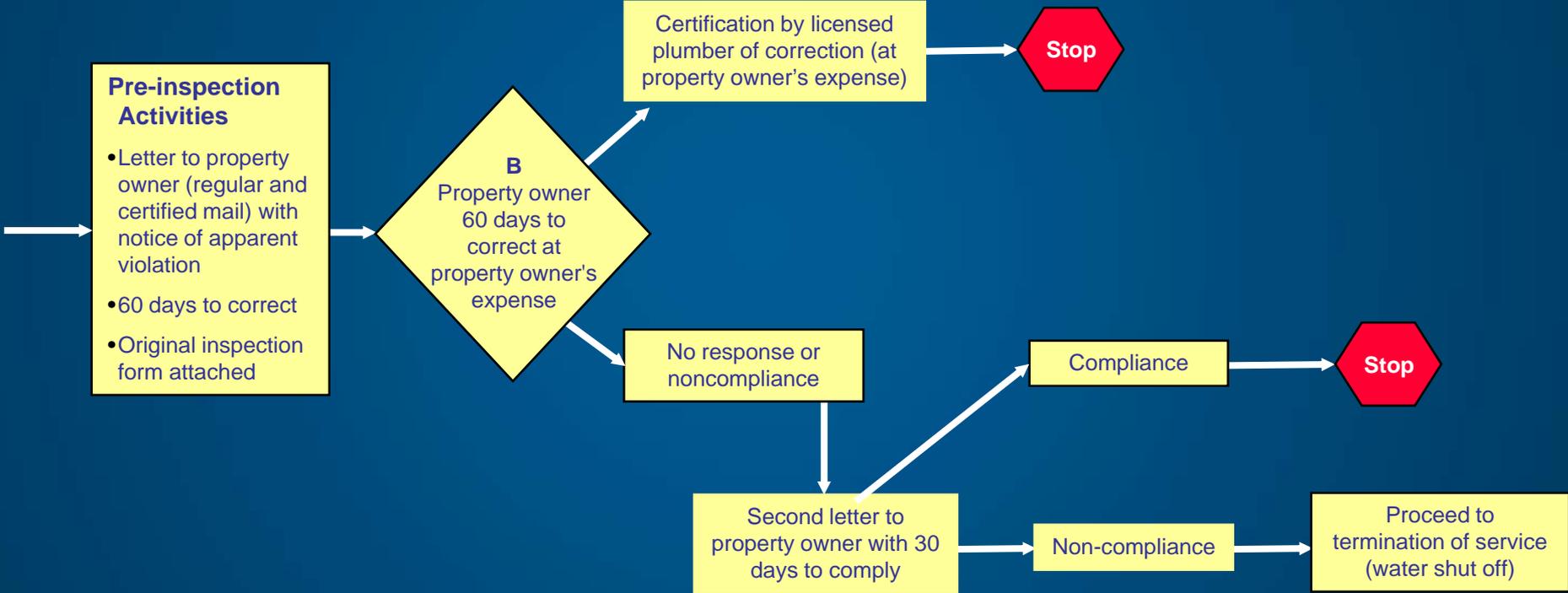
Initial Inspection



* Buildings on slabs will not require internal inspection, DIC will fill out inspection form

RRWRD Updated Private Property Inflow Source Disconnection Program

Follow-up Inspection – Illegal Connection Verified During Initial Inspection



Typical Private Sector Funding Mechanisms

- Property Owner Finance
- Municipal Cost Participation
 - Full funding
 - Funding to maximum reimbursement amount
 - Loan for full cost
 - Loan up to maximum amount

Typical Private Sector Funding Sources

- Property Owner Finance
- Municipal Cost Participation
 - Sewer fund
 - Stormwater user charge fund
 - General fund
- IEPA State Revolving Fund Loans
 - Private Sector Not Currently Eligible

When Is Cost Sharing Typically Used?

- Combination Sumps
- Driveway Drains
- Area Drains
- Foundation Drains
- Lateral Lining

“Cost-Effective” Rehabilitation

- Private Sector
 - Downspouts, storm sumps, diverter valves – **norm**
 - Unsealed and combination sumps, patio, driveway, window well, stairwell drains - **site specific**
 - Service laterals - **emerging** with new technology
 - Direct foundation drains - **rare**

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Private Property Virtual Library

Information For Utilities From Utilities
 The Private Property Virtual Library (PPVL) is a growing library of case studies from private property-related programs at wastewater utilities. It is intended to be a resource for other utilities seeking information or advice about private property programs. To help contribute information to this library, download the [questionnaire](#) and return it to Laurie Chase, PPVL Project Manager, at lchase@blueheronengineering.com.

What Data Does the PPVL Contain?
 The library includes information gathered from successful private property programs targeting:

- Sanitary lateral repair or replacement
- inflow and infiltration (I/I) source detection and elimination
- Lateral condition assessment
- Privately owned pump station operation and maintenance
- Sewer easements

Detailed Information Gathered includes:

- Utility completed questionnaires
- Public education materials
- Outreach letters to residents
- Ordinances and codes
- Operating and maintenance procedures
- Design details and specifications

Disclaimer
 The Private Property Virtual Library (PPVL) provides additional information that may be useful or interesting and is being provided consistent with the intended purpose of the WEF Website. However, WEF cannot attest to the accuracy of information provided by the PPVL. WEF does not endorse the information, products, or views presented in the PPVL or its associated discussion forum.



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