



SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

US Territories Wastewater Operator Training Series

Session 5: Collection Systems Part 1 – Gravity Systems

8/19/25

Collection Systems

Things to know for the Op Cert
test



NEED- CRITERIA

Wastewater
Operator Cla

A Need-to-Know Guide v

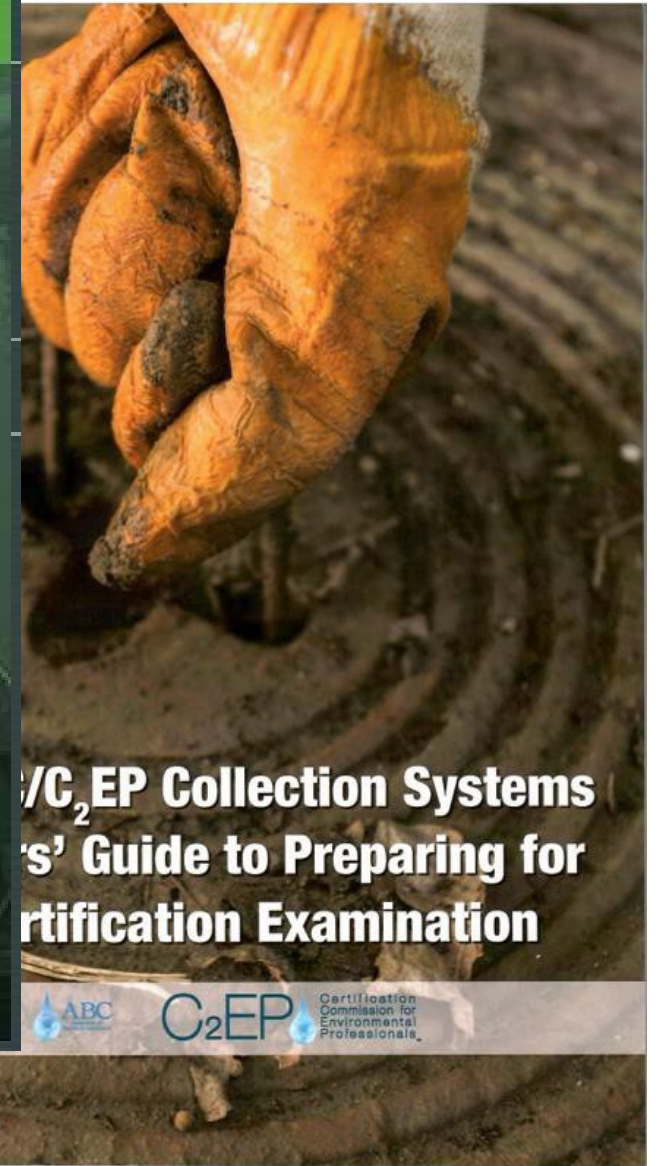
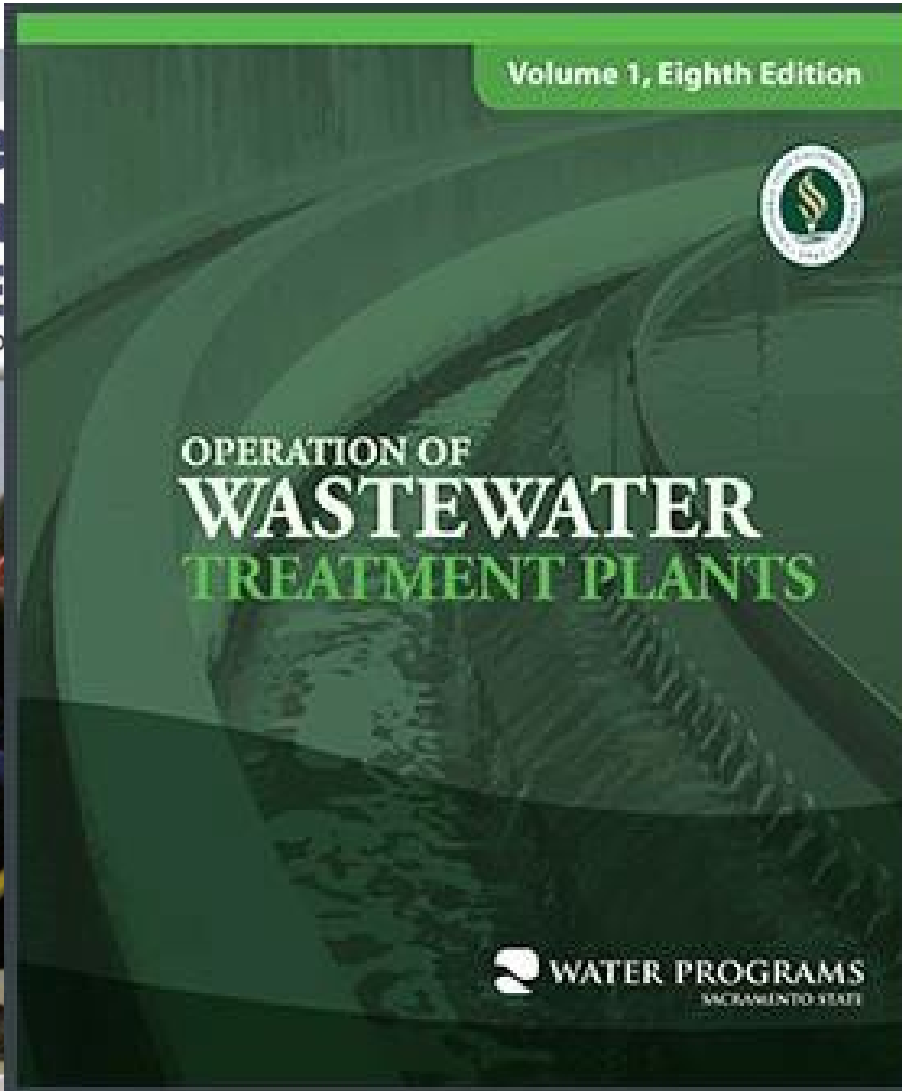
ABC Wastewater Treat



Superior Water Starts h



Certification
Commission for
Environmental
Professionals



C₂EP Collection Systems
's' Guide to Preparing for
Certification Examination



Certification
Commission for
Environmental
Professionals

Collection Operator Exam Content

NUMBER OF QUESTIONS	CONTENT AREA	JOB TASK COMPLEXITY LEVELS
28	Equipment Operation, Evaluation, & Maintenance	 23  5  0
20	Collection System Operation, Maintenance, & Restoration	 18  2  0
18	Lift Station Operation & Maintenance	 16  2  0
18	Collection System Monitoring, Evaluation, & Adjustment	 15  3  0
16	Security, Safety, & Administrative Procedures	 10  6  0
100*	Total	 82  18  0

ABC Wastewater Collection Operator Class I Certification Exam

THIS EXAM INCLUDES

8

calculation questions

NUMBER OF QUESTIONS	CONTENT AREA	JOB TASK COMPLEXITY LEVELS
23	Equipment Operation, Evaluation, & Maintenance	 9  14  0
23	Collection System Operation, Maintenance, & Restoration	 9  14  0
15	Lift Station Operation & Maintenance	 6  9  0
15	Collection System Monitoring, Evaluation, & Adjustment	 6  9  0
24	Security, Safety, & Administrative Procedures	 10  14  0
100*	Total	 40  60  0

ABC Wastewater Collection Operator Class II Certification Exam

THIS EXAM INCLUDES

10

calculation questions

Treatment Operator Exam Content

NUMBER OF QUESTIONS	CONTENT AREA	JOB TASK COMPLEXITY LEVELS
10	Laboratory Analysis	 2  7  1
25	Equipment Evaluation & Maintenance	 12  10  3
25	Equipment Operation	 8  14  3
30	Treatment Process Monitoring, Evaluation, & Adjustment	 5  10  15
10	Security, Safety, & Administrative Procedures	 7  3  0
100*	Total	 34  44  22

ABC Wastewater Treatment Operator Class I Certification Exam

THIS EXAM
INCLUDES

10
calculation
questions

NUMBER OF QUESTIONS	CONTENT AREA	JOB TASK COMPLEXITY LEVELS
15	Laboratory Analysis	 3  9  3
20	Equipment Evaluation & Maintenance	 8  9  3
25	Equipment Operation	 5  15  5
30	Treatment Process Monitoring, Evaluation, & Adjustment	 5  10  15
10	Security, Safety, & Administrative Procedures	 6  4  0
100*	Total	 27  47  26

ABC Wastewater Treatment Operator Class II Certification Exam

THIS EXAM
INCLUDES

12
calculation
questions

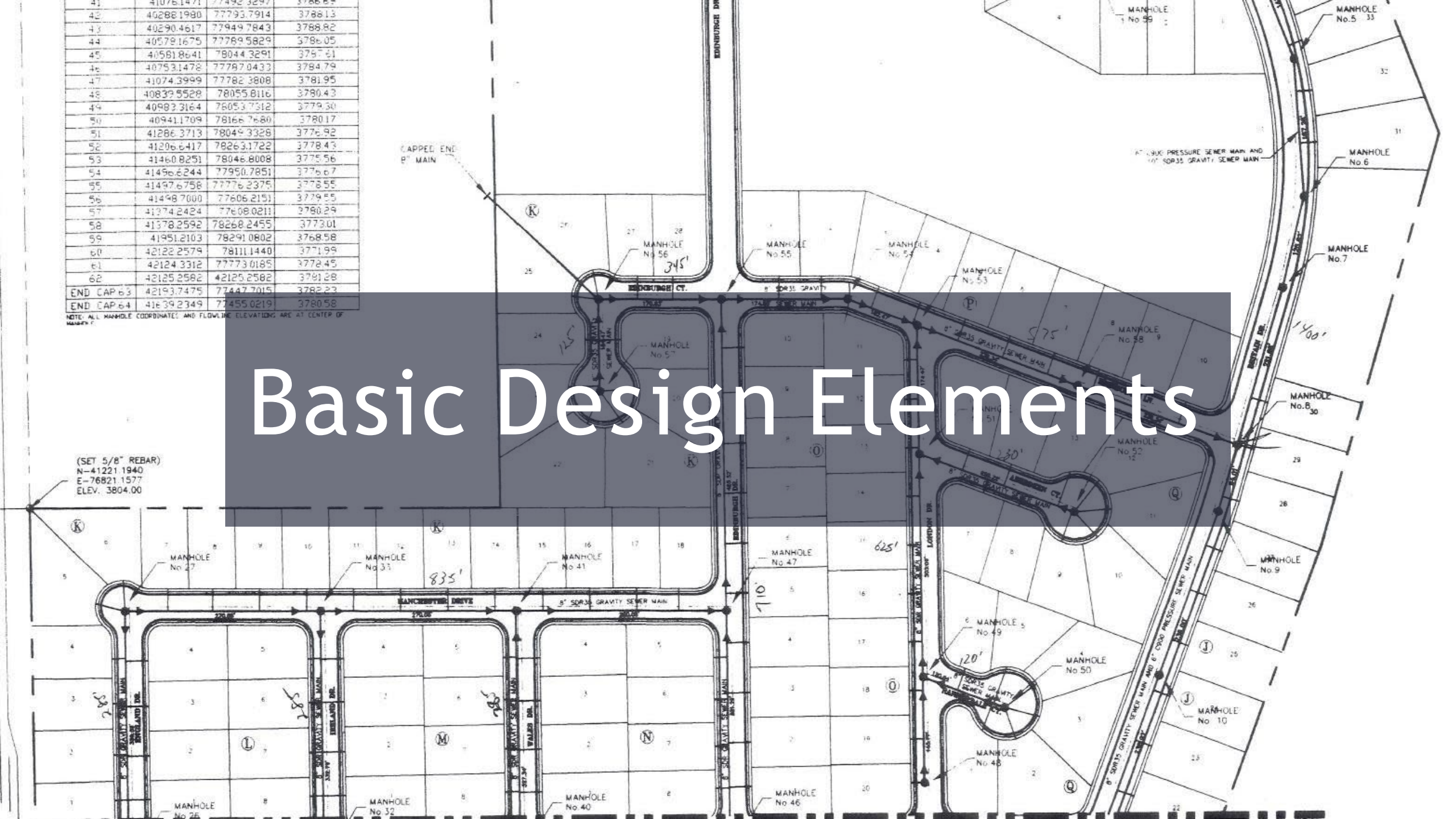
Collection Topics Today

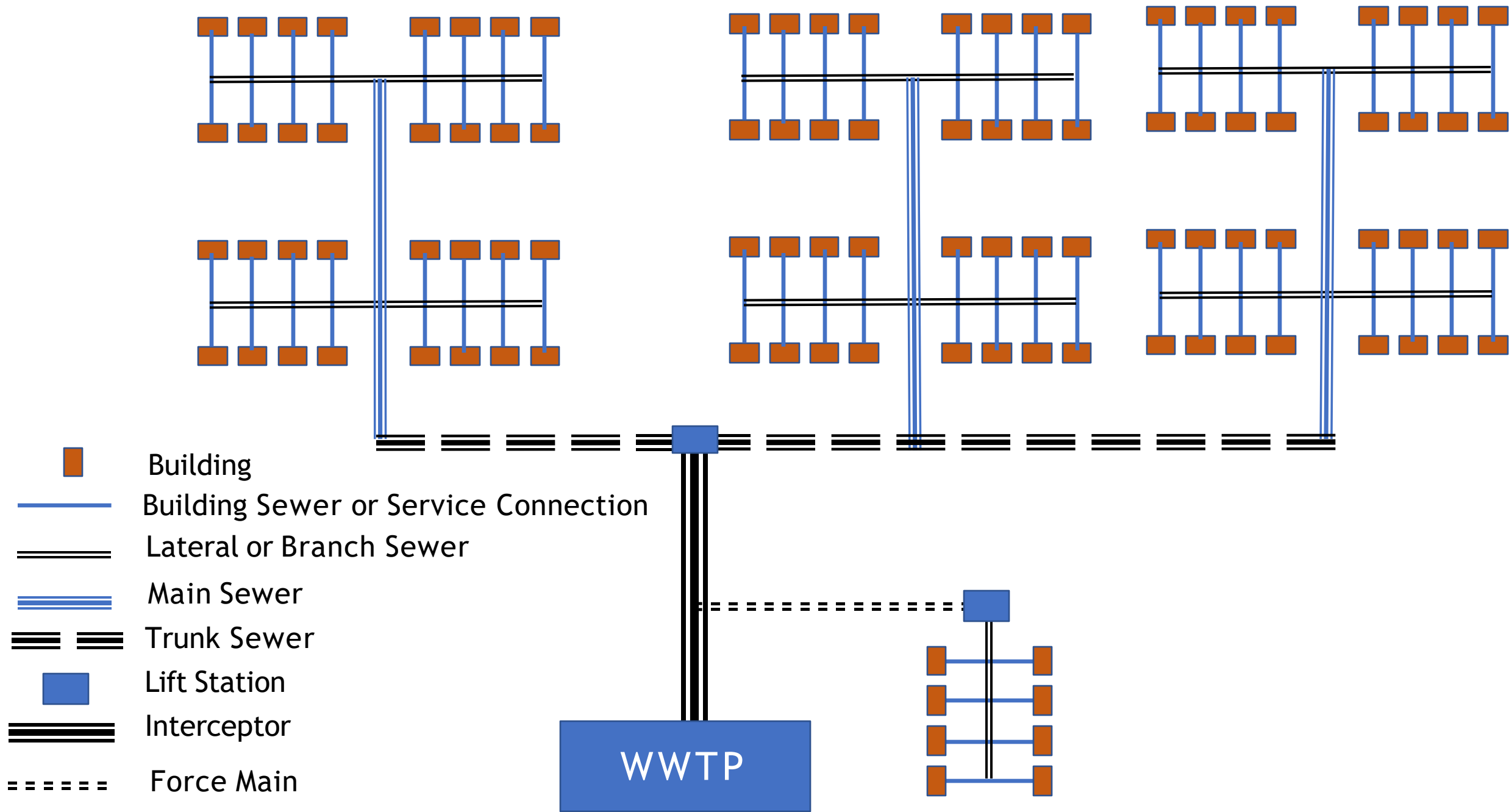
- 1) Design Basics, Terminology, Slope and Velocity
- 2) Pipe Materials and Joint Types
- 3) Installation: Pipe, Bedding, Backfill, Service Connections
- 4) Manholes
- 5) Maps
- 6) Lift Stations (more on 9/2)
- 7) Equipment Cleaning and Maintenance (more on 9/16)

41	41076.1471	77492.3297	3788.65
42	40288.1980	77793.7914	3788.13
43	40290.4617	77949.7843	3788.82
44	40579.1675	77789.5829	3786.05
45	40581.8641	78044.3291	3787.61
46	40753.1478	77787.0433	3784.79
47	41074.3999	77782.3808	3781.95
48	40839.5528	78055.8116	3780.43
49	40983.3164	78053.7312	3779.30
50	40941.1709	78166.7680	3780.17
51	41286.3713	78049.3328	3776.92
52	41206.6417	78263.1722	3778.43
53	41460.8251	78046.8008	3775.56
54	41496.6244	77950.7851	3776.67
55	41497.6758	77776.2375	3778.55
56	41498.7000	77606.2151	3779.55
57	41374.2424	77608.0211	3780.29
58	41378.2592	78268.2455	3773.01
59	41951.2103	78291.0802	3768.58
60	42122.2579	78111.1440	3771.99
61	42124.3312	77773.0185	3772.45
62	42125.2582	42125.2582	3781.28
END CAP 63	42193.7475	77447.7015	3782.23
END CAP 64	41639.2349	77455.0219	3780.58

NOTE: ALL MANHOLE COORDINATES AND FLOWLINE ELEVATIONS ARE AT CENTER OF MANHOLE.

Basic Design Elements

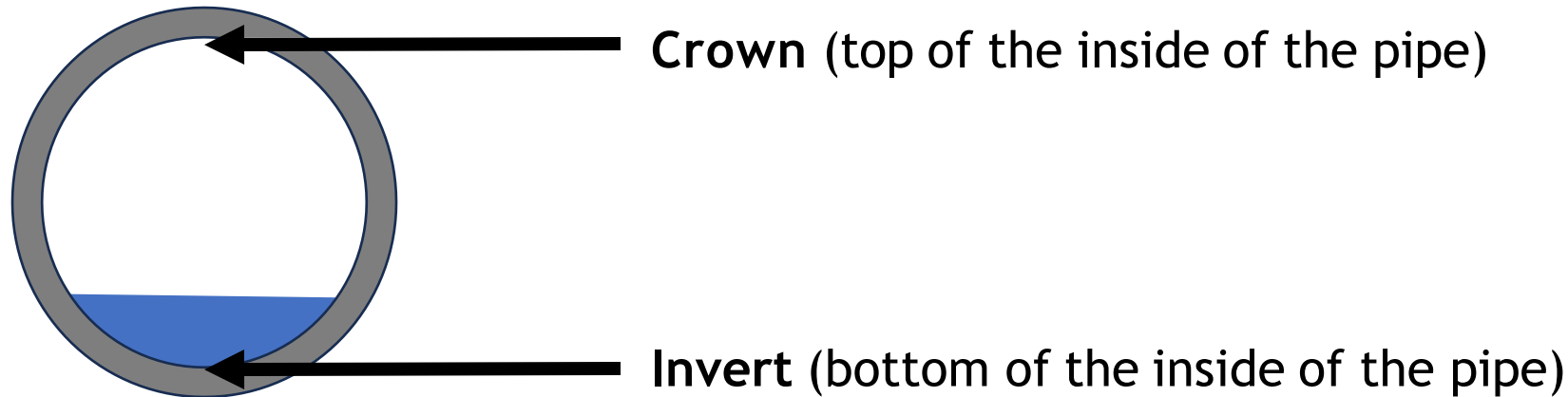




Typical Gravity Wastewater Collection System

Gravity Sewers

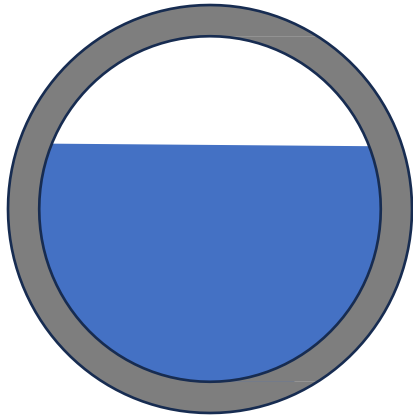
- Pipe diameter increases as you move from sources to treatment facilities
- Gravity sewers are designed to be $\frac{1}{2}$ to $\frac{3}{4}$ full at peak flow. That helps maintain aerobic conditions in the pipe.
- Pipe networks are designed for maximum expected flow (peak flow) when maximum population density has been developed



Gravity Main

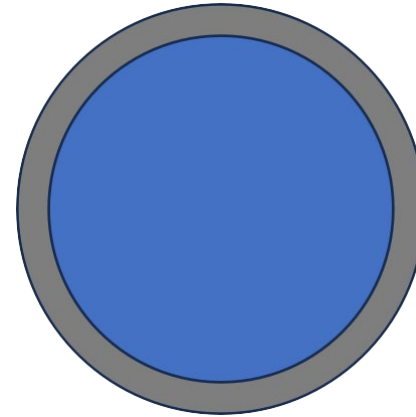
Gravity Sewer Flow

- Gravity sewer flow velocity is determined by slope
- Slope = drop/length (or rise/run) Example a 2' drop over 100' : $2\text{ft}/100\text{ft} = 0.02$ slope
- Force mains are pressurized.



Gravity Main

Gravity Main flow is determined by gravity and slope. They are designed to flow partially full and to maintain air space in the crown.

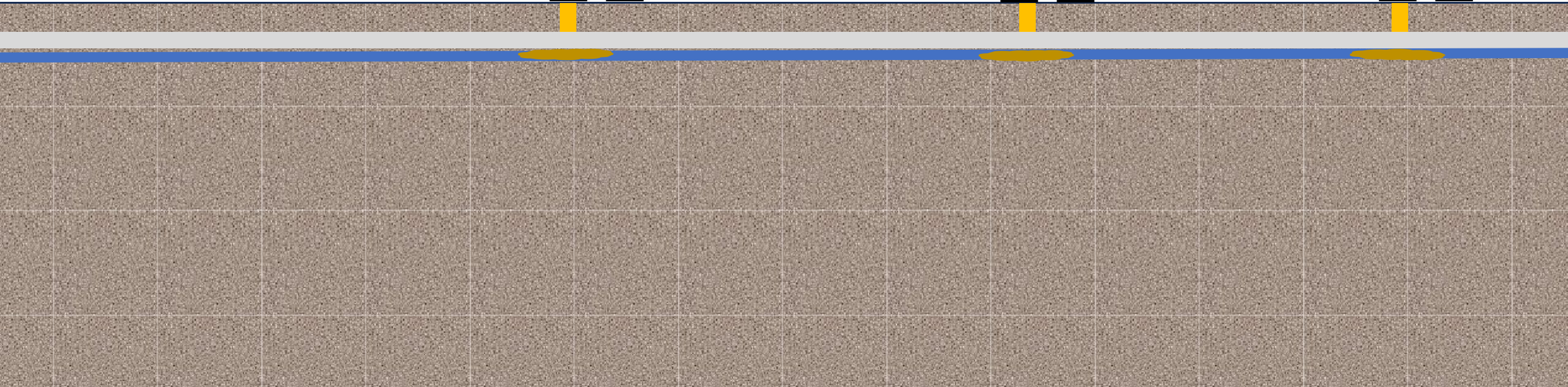


Force Main

Force Main flow is determined by pumps. They are designed to be pressurized and flow full.

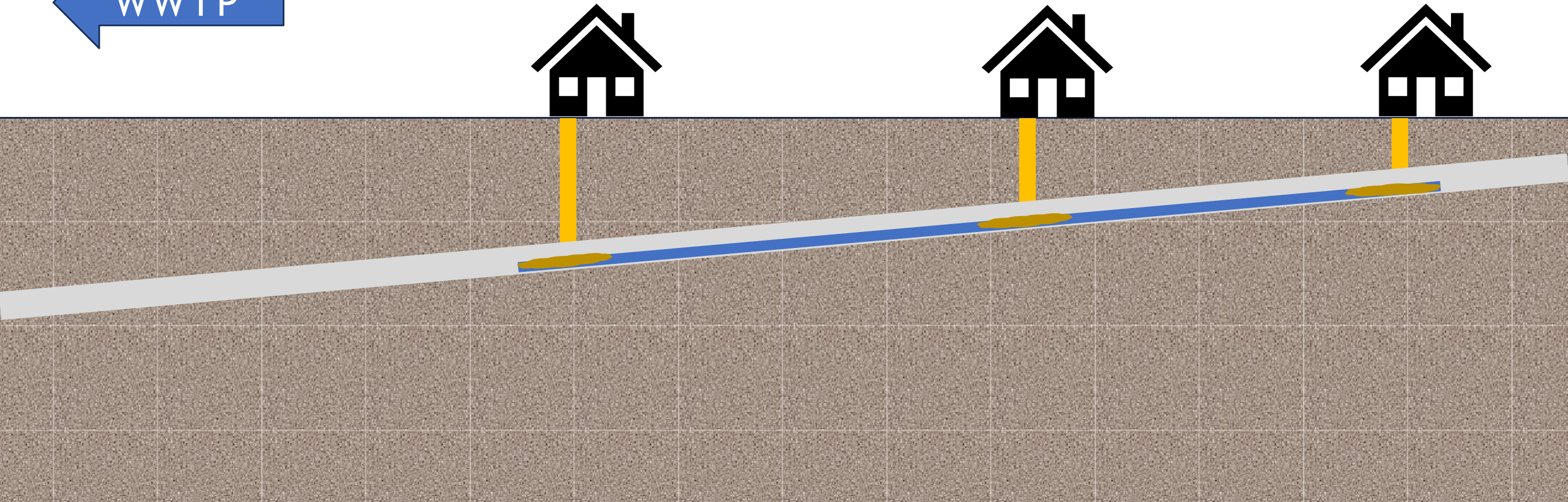
Sewer Slope & Velocity

Slope = drop/length = 0'/100' = 0 slope which means no velocity



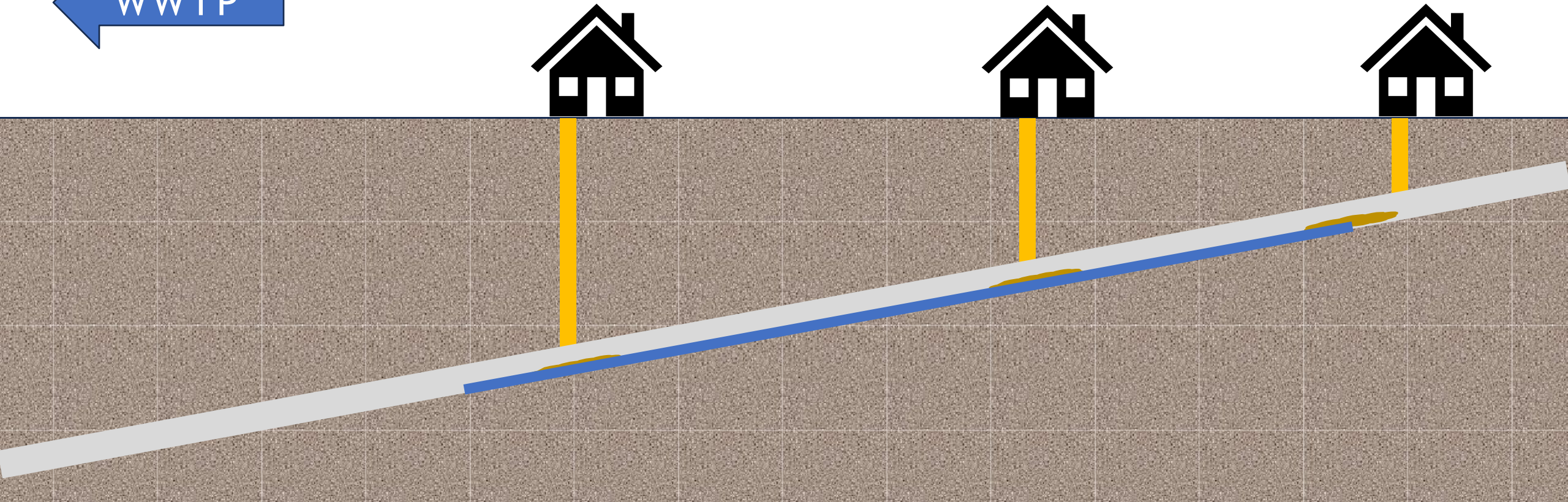
Sewer Slope & Velocity

Minimum Velocity: 2 ft/sec



Sewer Slope & Velocity

High Velocity is bad: $> 8-10 \text{ ft/sec}$



Sewer Slope

- Minimum slope to meet that requirement will vary by pipe diameter:

Sewer Size	Min Slope in feet/100 feet
4"	1.20
6"	0.60
8"	0.40
10"	0.28
12"	0.22
14"	0.17

Slope Differences Visual

4" Pipe: 1.2' / 100'

14" Pipe: 0.17' / 100'

Design Considerations

- Slope follows the lay of the land where possible
- Designed for **2 to 8 ft/sec flow**, 2.5 ft/sec is considered ideal
- Slope should maintain a **minimum velocity of 2 ft/sec** at average or peak flows (flow that prevents buildup in the pipe is called “scouring velocity”)
- **Collection systems are designed for** maximum expected flow (**peak flow**) when maximum population density has been developed
- **Per capita flow** can vary from location to location.
- **Max flow** is typically around **10am to Noon**
- **Peaking factors** are used to size the WWTPs - typically **2.5 to 3.5 times total daily flow**

More Design Considerations

- **Pipes should be sized for available cleaning equipment**
- **Sewer should flow half full during average daily flows (to maintain aerobic conditions and to have room for error)**
- **Sewers are typically 4 to 8 feet deep but may be a LOT deeper.**
- **Laterals, mains and trunks are typically in the center of streets but may not be**
- **Sewers typically must be at least 2 ft vertically below and 4 ft horizontally from water distribution pipes to avoid contamination**

Know the local requirements

- Design requirements can vary by jurisdiction: Know yours
- In **New Mexico**, for example, **per capita flow** is typically **60 to 125 GPD**
- **Michigan mobile home park sewers** require design for **minimum of 200 GPD per home site.**
- **What are the design requirements in your jurisdiction?**



Piping and Joints

Some Pipe Selection Criteria

- Resistance to deterioration
- Ability to withstand surface loads
- Resistance to root intrusion
- Ability to minimize leakage
- Cost
- Service life span



Pipe Materials

Pipe Materials



- AC - Asbestos Cement
- RC & C - Reinforced and Non-reinforced Concrete
- CI & DI - Cast Iron and Ductile Iron
- VC - Vitrified Clay
- FR - Fiberglass Reinforced Pipe
- ABS - Acrylonitrile Butadiene Styrene
- HDPE - High Density Polyethylene
- PVC - Polyvinylchloride

AC - Asbestos Cement

- Rigid and resistant to deterioration by most wastewater
- Subject to crown rot (corrosion by hydrogen sulfide that combines with moisture to form sulfuric acid)
- Use restricted by OSHA because of asbestos content
- Joints are sleeve and rubber gasket couplings

RC & C - Reinforced & Non-Reinforced Concrete

- Very rigid and can withstand high surface loads
- Subject to crown rot (might have coal tar epoxy or plastic lining)
- Joints - Rubber gasketed bell & spigots or mortar or bituminous filled bell and spigots



CI & DI - Cast & Ductile Iron

- Very rigid - resists high surface loads
- Costly
- Should be used for bridge crossings and where lines are shallow
- Joints are typically rubber or caulk gasketed mechanical push on
- Joints might be leaded in old installations



VC - Vitrified Clay

- Rigid & Subject to cracking from root intrusion
- Resistant to acid, caustics, solvents, gasses
- Joints - bells and spigots with factory PVC or PU compression joints or rubber couplings
- Older joints may be bell and spigots with mortar



FR - Fiberglass Reinforced

- Semi-flexible and corrosion resistant
- May be subject to crown rot
- Joints - rubber gasketed bells and spigots
- Subject to failure from unanticipated surface loading



ABS - Acrylonitrile Butadiene Styrene

- Flexible and resistant to most things found in wastewater, BUT
- Petroleum products can soften and erode it
- Joints are solvent weld or gasketed bell and spigot
- Requires careful installation & inspection - can deflect into an oval shape

HDPE - High Density Polyethylene

- Flexible and durable
- Resistant to most things in wastewater
- Joints - Thermally welded butt joints
- Often used in small diameter low pressure sewers and for force mains

PVC - Polyvinylchloride

- Flexible and resistant to most things in wastewater
- Joints are typically rubber gasketed bell and spigot joints
- Solvent cement welding used for pipe up to 8" in diameter
- Subject to damage from heavy loads



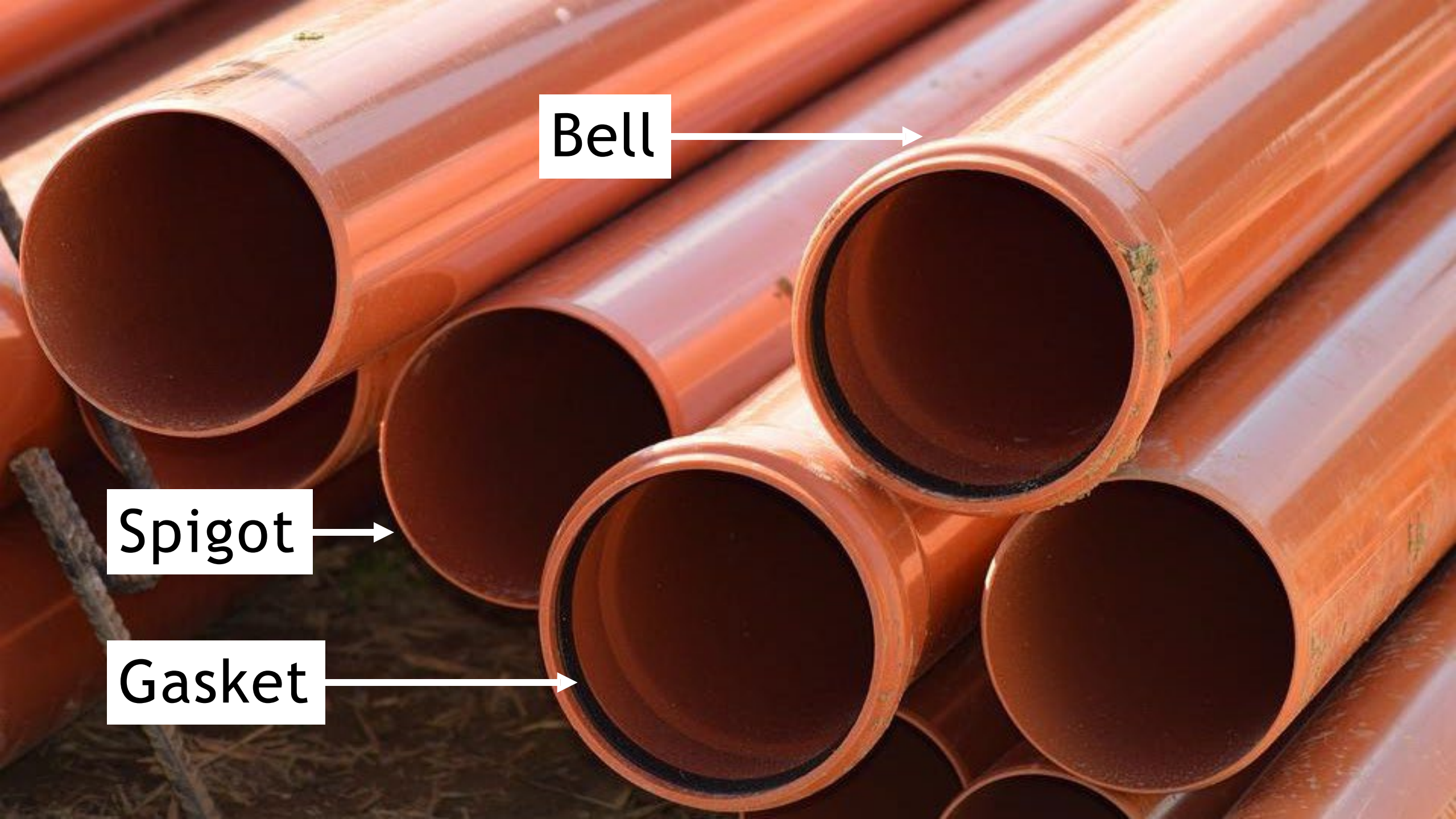
Pipe Joints

Joint #	Joint Description	Joint used with:								
		AC	CI/DI	RC	C	VC	FR	ABS	HDPE	PVC
1	Caulked Bell and Spigot		X							
2	Band Seal Coupling		X			X				X
3	Mortar or Bituminous Filled Bell and Spigot			X	X	X				
4	PVC / PU Preformed Gaskets					X				
5	Rubber Gasket Bell and Spigot		X	X		X	X			X
6	Rubber Gasketed Coupling	X								X
7	Solvent Cemented Coupling or Solvent Bell & Spigot							X		X
8	Butt Welded								X	

Bell

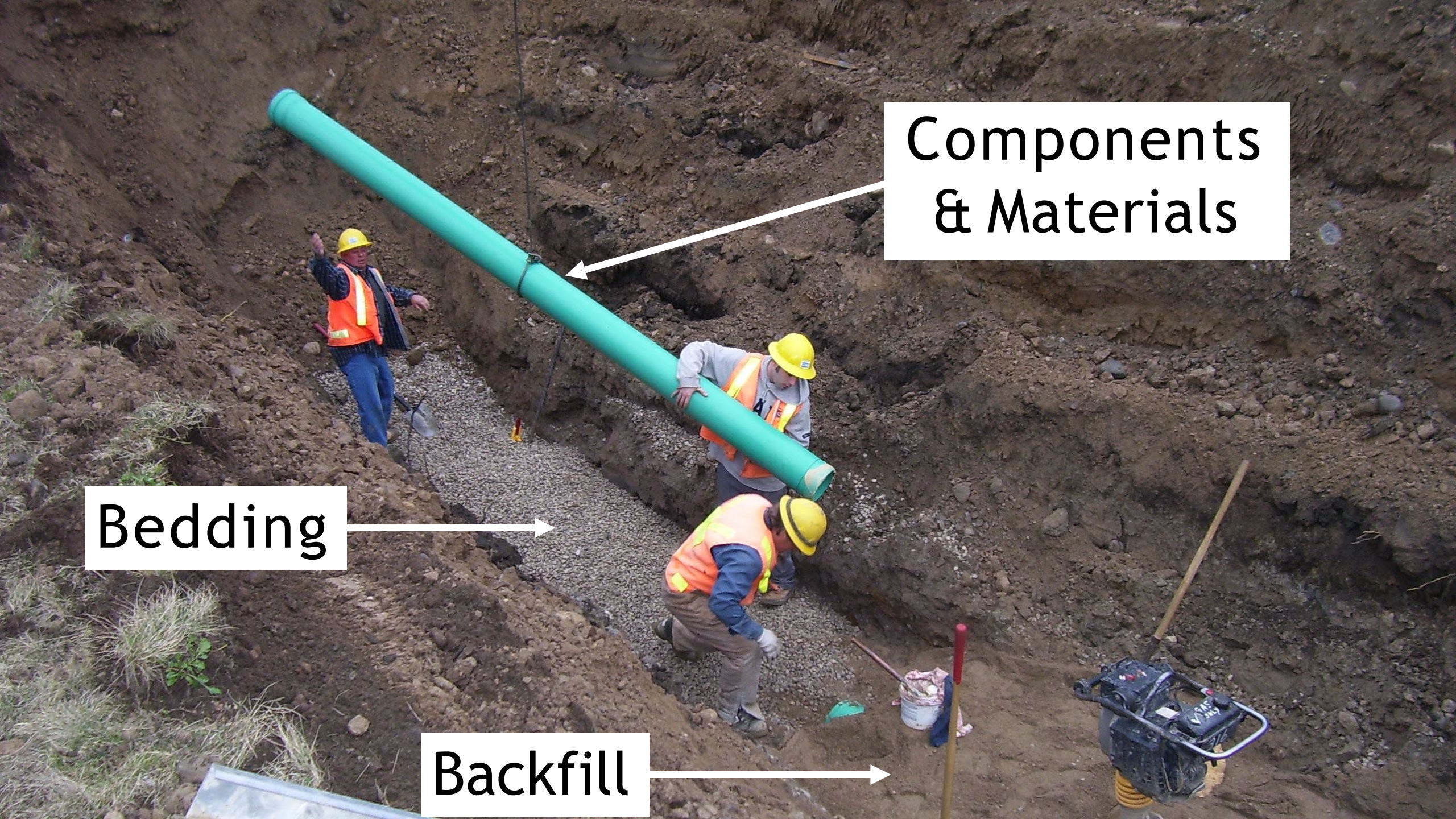
Spigot

Gasket



A photograph showing three construction workers in a deep trench installing a large green pipe. One worker stands on the left, another is positioned behind the pipe, and a third is kneeling in the foreground. A motorized jackhammer is visible on the right side of the trench. The word "Installation" is overlaid in white text on a dark rectangular background.

Installation



Components
& Materials

The image shows a construction site where a large green pipe is being installed in a deep trench. Three workers in orange safety vests and yellow hard hats are visible. One worker is standing on the left, another is leaning against the pipe in the center, and a third is kneeling on the right, working on the bedding. A white arrow points from the 'Components & Materials' label to the green pipe. The trench walls are dark brown soil. At the bottom of the trench, there is a layer of grey gravel bedding. To the right of the pipe, there is a layer of brown soil backfill. A white arrow points from the 'Bedding' label to the gravel layer. Another white arrow points from the 'Backfill' label to the soil layer. A small blue and yellow portable engine or pump is visible on the right side of the trench.

Bedding

Backfill

Installation

- Typically, in excavated trenches
- Lots of safety rules around excavation - read up on safety regs
- Nearby utilities have to be located before excavation (One Call)
- 48-hour notice is typically required (check your state)
- You break it, you buy it. Digger and/or employer are liable for damages

Installation

- Most excavation done with backhoes
- Trench-less technologies becoming more common
 - Pipe Liners
 - Pipe bursting
 - Boring
 - Micro-tunneling

Installing Pipe

- Read the manufacturer's instructions
- Small diameter pipe (<10") can be moved by hand
- Larger pipe should be moved with machinery



Bells face UPSTREAM

A high-angle photograph of a construction site. Two workers in orange safety vests and yellow hard hats are working in a deep trench. One worker is holding a large green pipe, while the other is crouched nearby. The trench walls are made of dark, moist soil. In the foreground, there is a white bucket with a red handle, a blue cloth, and a small green shovel. A black portable engine or generator is visible in the bottom right corner. A semi-transparent dark blue box with white text is overlaid in the center of the image.

Bedding and Backfill

Bedding

- Pipe has to be bedded
- Compacted crushed rock aggregate is ideal
- Sand and pea gravel can be used if compacted
- If native material is used it has to be excavated to true grade with extra care

Bedding

- Must be compacted on trench bottom and pipe sides
- Compacting directly affects load pipe can carry
- Small amounts of bedding must be removed to accommodate bells if bell and spigot joints are used.

Backfill

- Three Elements:
 - Pipe has to be protected from movement, breakage and crushing
 - Backfill should be compacted in layers until the trench is full
 - Then the ground surface gets restored.



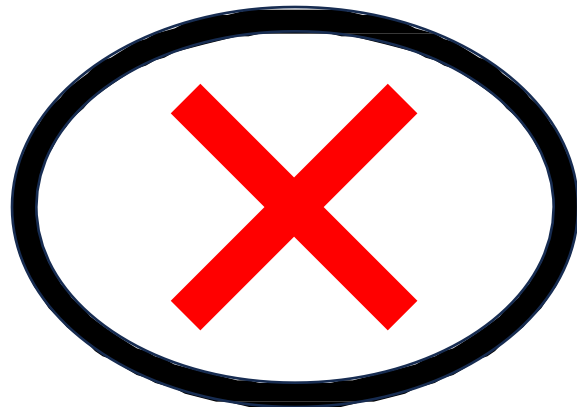
Correctly bedded
pipe is supported
and retains its
circular cross section
under load



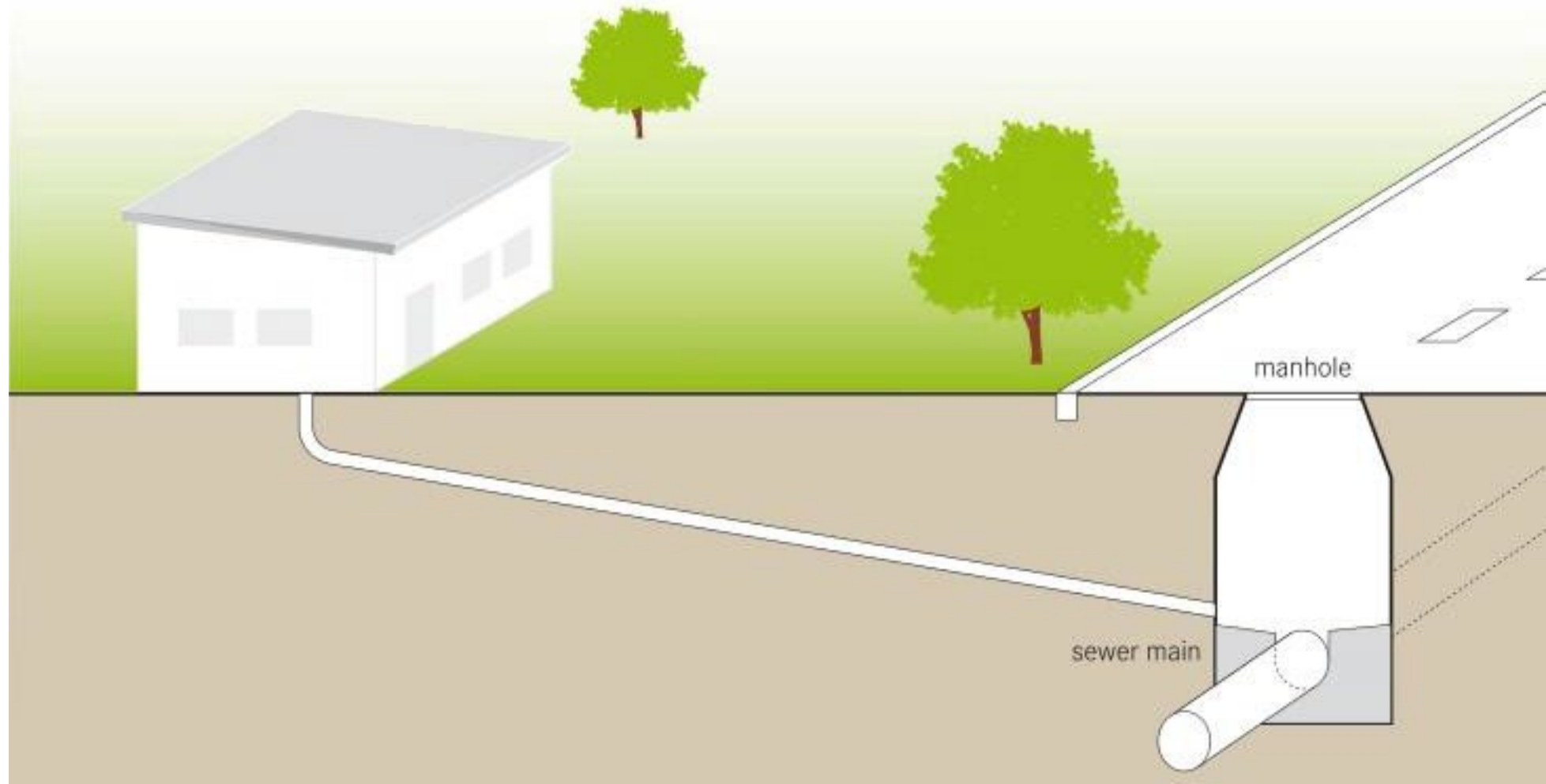
Incorrectly
bedded pipe is not
supported and
may deform under
load

Deflection Testing

- Mandrel tests or CCTV inspections are used to determine whether the newly installed pipe has deflected more than the acceptable design limit



Service Connections



Service Connections



Service Connections

- Aka “Taps”
 - Clamp on Saddle Ts
 - Insertion Wyes and Tees
 - Epoxy Bonded Saddle Tees
 - Synthetic Rubber Wedged inserts
- Must have a tight seal to prevent infiltration and root intrusion
- Building sewer **MUST NOT** protrude into main



Manholes

Manholes: What they are

- Installed in lateral, main trunk and interceptor sewers **for maintenance and cleaning access**

Manholes: Where they are

- Can be placed where sewer **changes direction elevation (drops), pipe size and at junctions**
- Straight runs **usually no more than 300-500 feet apart** - limited by length of cleaning equipment

Manhole Construction:

- Can be brick, pre-cast concrete barrels or fiberglass
- **Most common in NM: Precast concrete with poured in place base**
- Might have **steps**, might have a **ladder**

6 Pre-cast Concrete Manhole Parts:

- Concrete poured in place with channels & sloped bench
- Inlet/Outlet piping sealed where it penetrates the barrel
- Precast concrete barrels fit together and sealed with mortar or bituminous material
- A concentric or eccentric cone section
- Level Adjustment Rings
- Standard tight-fitting, cast-iron ring and lid

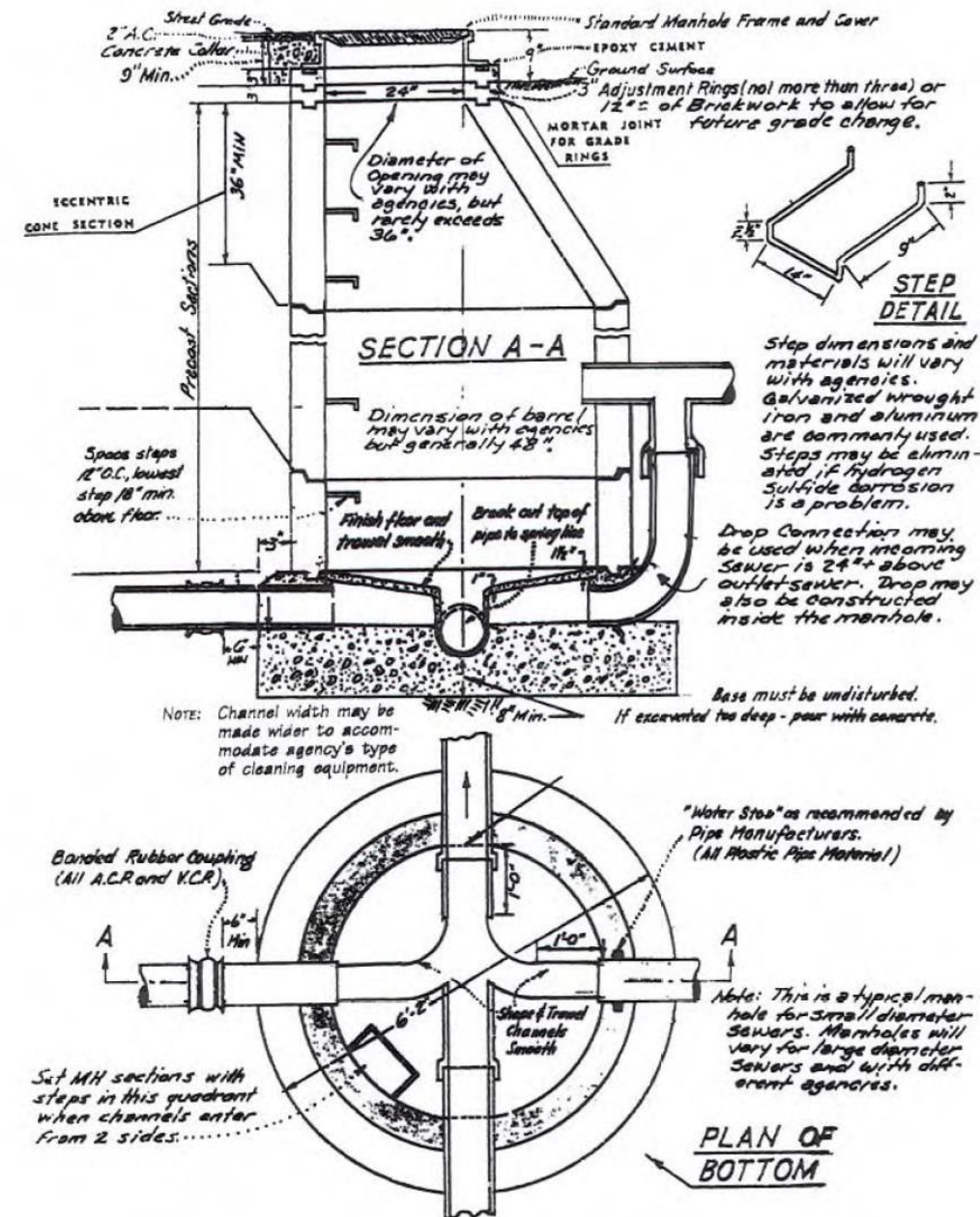


Figure 4.6 - Pre-Cast Concrete Manhole





**Manholes are
Confined Spaces**

Manholes are Confined Spaces

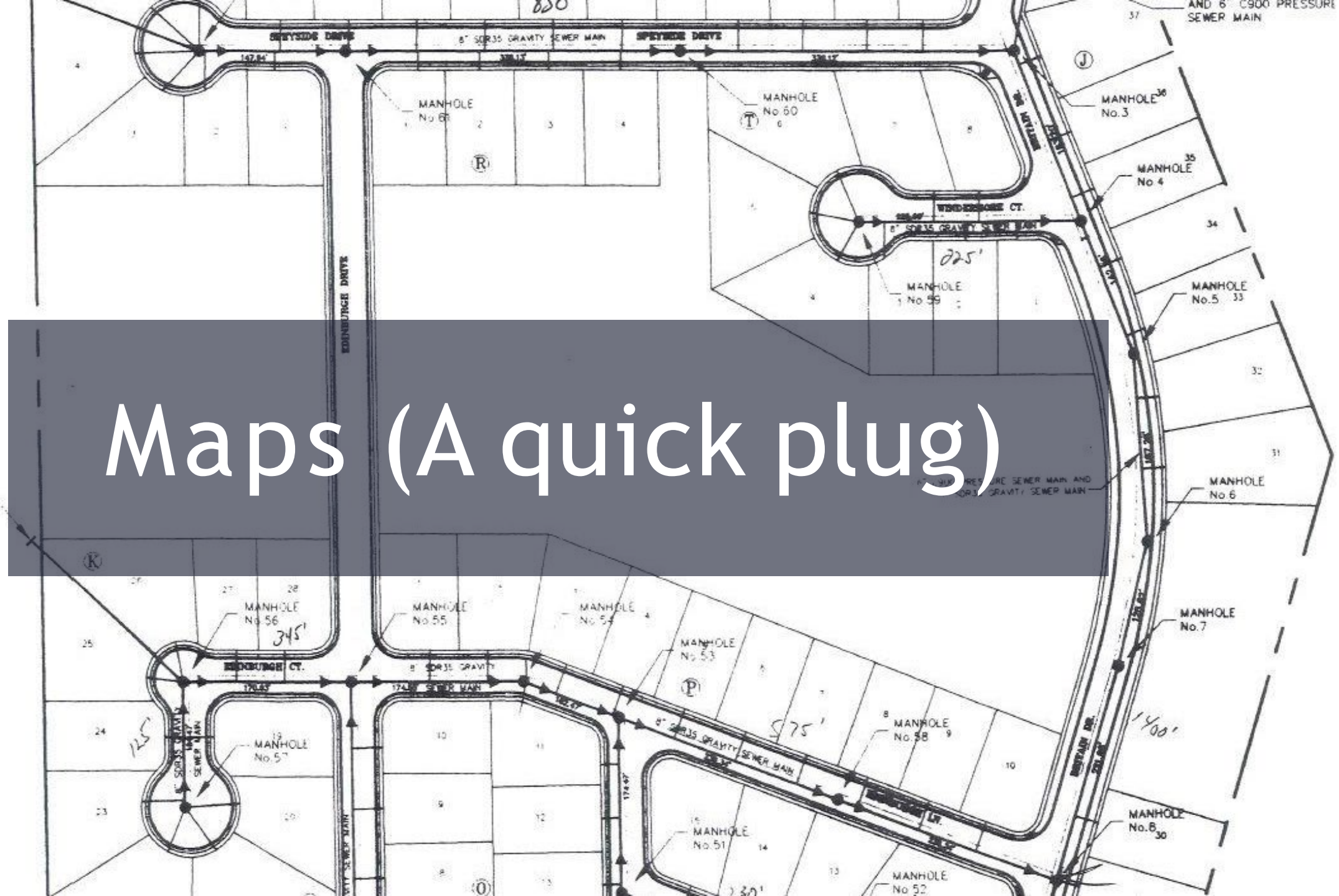
- They have **limited openings** for entry and exit.
- Unfavorable natural ventilation. **Deadly gasses can accumulate** or oxygen can be displaced.
- Not designed for continuous worker occupancy.

Manholes are Confined Spaces

- Entry is covered by OSHA Regulations
- OSHA regulations are covered under operator safety in NM Test guide



3795.78
3797.94
3798.55
3798.45
3799.82
3794.30
3790.08
3792.49
3790.13
3792.83
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3784.79
3781.95
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3776.92
3778.43
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3775.67
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3780.29
3773.01
3768.58
3771.99
3772.45
3781.28
3782.23
3780.58
AT CENTER OF



Maps (A quick plug)

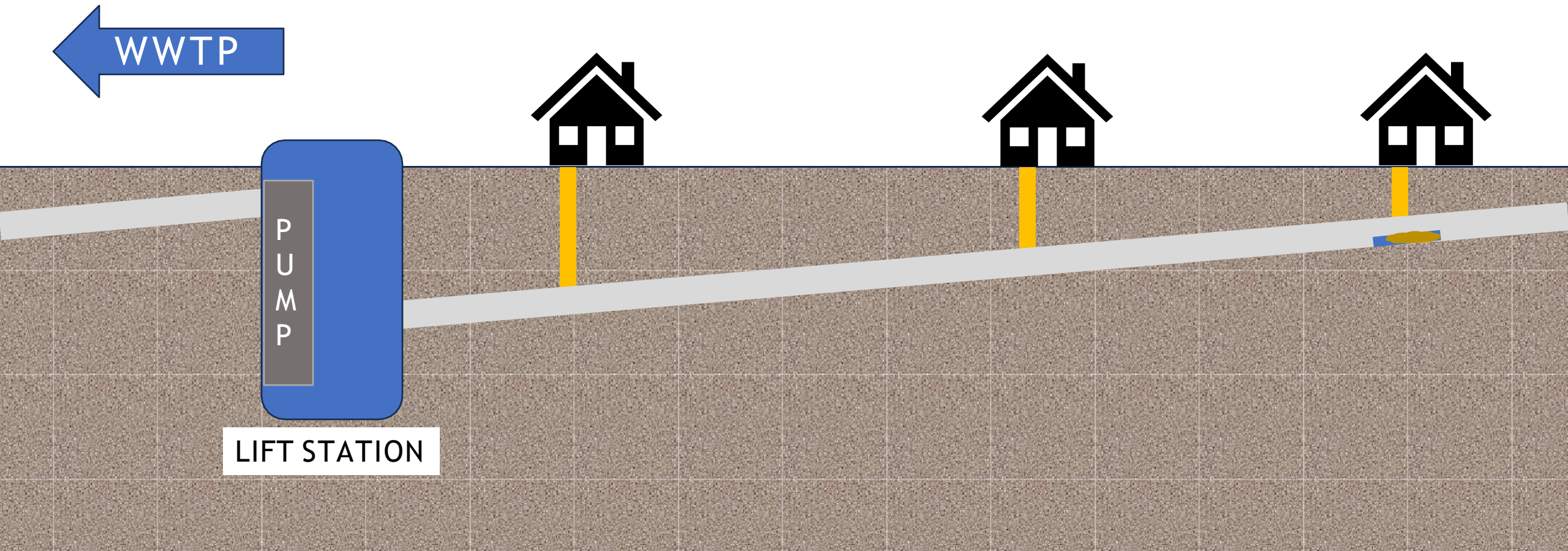
Maps

- 1) Two sets of construction project plans
 - Working plan that guides construction
 - As-built plans that reflect deviations from the working plan
- 2) As-builts become the true record of where everything is actually located and should be made into revised final drawings
- 3) As-builts are your friends. Not having them leads to headaches



Lift Stations

Sewer Slope & Lift Stations



A photograph showing two workers in safety gear (hard hats and high-visibility vests) performing sewer cleaning. They are using a large yellow flexible hose connected to a truck-mounted unit. The scene is set on a street in front of a building with a sign that reads 'MAIN SQUARE BRANCH' and 'ANAPOLIS-MARION COUNTY PUBLIC LIBRARY'. A large metal auger is visible on the truck. Orange traffic cones are placed around the work area.

Sewer Cleaning & Maintenance

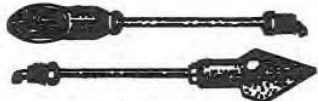
Sales & Rentals
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Equipment



Rodding Tools

SEWER RODDING TOOLS AND USES



SPEARHEAD BLADES

Used in small pipes to remove hard deposits and break up hard obstructions such as glass, bottles, cans, and plaster.



BULLET NOSE

It's designed to be screwed into end of coupler for least resistance when rodding through heavy roots.



PICK-UP TOOL

Used to snare broken sectional sewer rods.



ASSEMBLY WRENCH

Used for holding and turning nuts and couplers in assembly rods and tools.



RATCHET TURNING HANDLE

Used with locking pin through pullout tool and coupler to turn rods.



PULLOUT TOOL

Used to encircle rod coupler to push rods into or pull rods out of line.



ASSEMBLY TURNING HANDLE

Used for assembling nuts and couplers for turning rods; spring loader pin engages hole in coupler.



BAR TURNING HANDLE

Used to secure into hole in coupler for turning, pushing, and pulling rods.



ROD END SWIVEL

Used for pulling cables and wires through a pipe and is designed to be free turning under load at the end coupling.

SEWER RODDING TOOLS AND USES



ROUND STOCK CORKSCREW

For rodding through sewers where conditions are unknown.



SAND LEADER

Used to guide rods across the top of built-up materials in the line by the flipping action of blades.



SQUARE STOCK CORKSCREW

For removing heavy root growth. Sharpened cutting edge will tear loose roots and remove other rigid obstructions when pulled backwards.



ROOT SAW

Used for power sawing of stubborn root masses in the sewer pipe.



DOUBLE CORKSCREW

A double-pronged tool to remove miscellaneous obstructions.



SPRING BLADE ROOT CUTTER CHUCK

This cutter with the proper size blades is used in preventive maintenance work in sewers. Should be rotated at high speed (Power Rodding Machine) and PULLED slowly through the line while rotating to effect a thorough scouring of the pipe. NOTE: This tool is not designed to be pushed into a sewer line.



DOUBLE SAND CORKSCREW

The boring action of the corkscrew helps to pull rod through lines impacted with sand, gravel, and similar buildups. This tool must be kept moving since it may settle into built-up material and become struck.



AUGER

This tool is useful for cutting long strungy roots and for loosening sedimentary deposits in sewer pipe.



PORCUPINES

The turn-type porcupine is used in lines up to 12 inches in diameter. Its function is to scour lines of light buildups in conjunction with water flushing of sewer lines.

Blockage Types

Manual Cleaning

Hydraulic Cleaning

Preventive Maintenance

Emergencies, etc.



Inflow

Infiltration

A person wearing a pink shirt, blue jeans, and a backpack is crouching inside a large, circular, stone-lined well or infiltration pit. The person is looking down at the water level. The well is constructed from rough-hewn stone blocks and has a dark, reflective surface at the bottom. The scene is dimly lit, with the person's reflection visible in the water.

I & I - What they are

- **Inflow** - Water entering through manholes and illegal connections
- **Infiltration** - Groundwater entering sewer through breaks or joints or broken manhole barrels
- Can cause **hydraulic overload** at the WWTTP and **should be limited whenever possible**

Sample Questions

Let's try a few...

A high-contrast, black and white photograph showing a hand from the left, wearing a watch, dropping a ballot into a dark ballot box. The background is bright and overexposed. A semi-transparent dark grey rectangle is overlaid on the center of the image, containing the text 'Sample Questions' in white.

Sample Questions



Attendee Questions?

CONTACT INFORMATION



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