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Decentralized Design Considerations and Life-Cycle Costs

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The EPA Supports Decentralized Sewers

- In 1997, the EPA submitted a *Response to Congress on Use of Decentralized Wastewater Treatment Systems*
- Here's an excerpt from the EPA's *Executive Summary*

Adequately managed decentralized wastewater systems are a cost-effective and long-term option for meeting public health and water quality goals ...

Obstacles to Overcome

1. Lack of knowledge and public misperception
2. Legislative and regulatory constraints
3. Lack of management programs
4. Financial barriers
5. Liability and engineering fees

Knowledge Barriers - 18 years later

- Few universities or colleges include decentralized wastewater options in their curriculum
- Many consultants do not evaluate decentralized options in their wastewater evaluations
- Many consultants do not understand the history or cost structures and therefore either dismiss the technology entirely without evaluations or inflate costs in their reports

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Regulatory and Legislative - 18 years later

- Though there is well over 30 years of documented experience many decentralized options are still considered "alternative" or experimental
- Some states only allow consideration of "alternative" options when conventional systems are deemed "unaffordable" (undefined and subjective)
- Many states do not have regulatory language for decentralized systems, discouraging consultants from using these technologies; project timelines and costs are difficult to predict without knowing regulatory approval timelines and requirements
- There is bias in many regulatory agencies toward conventional gravity sewer and activated sludge

Regulatory and Legislative – example language

Example of a regulatory or legislative requirement to use gravity sewer, as pulled from one state's rules:

- *Alternative sewer systems are <u>not</u> to be used in lieu of conventional gravity sewers, but may be acceptable when it can be shown in the engineering report that it is not feasible to provide conventional gravity sewers. Use of alternative sewer systems <u>should only be considered when justified</u> by unusual terrain or geological formations, low population density, difficult construction, or other circumstances where alternative sewer systems would offer a clear advantage over conventional gravity sewers.*

Management Programs - 18 years later

- Area with the most progress since the 1997 EPA Report
- Recognized that centralized management by a responsible management entity (RME) is essential to long-term success of all options
- Only on-lot ownership and responsibilities has not been standardized
- Recommend standardization requiring the RME to own on-lot components for all decentralized technologies

Financial Barriers - 18 years later

- Many funding agencies do not have requirements specifying methods for evaluating cost options (especially life cycle costing)
- The 2% MHI target established by USEPA has not been incorporated into most funding evaluations
- Expensive options (those exceeding $25,000 per residential connection) continue to be funded even though options exist that can bring these costs down significantly; result is additional grant funding is typically used to buy down rates reducing number of connections that can be funded each year
- Lack of training for funding agents with regard to actual and reasonable cost scenarios for use in evaluating consultants options

Liability/Engineering Fees - 18 years later

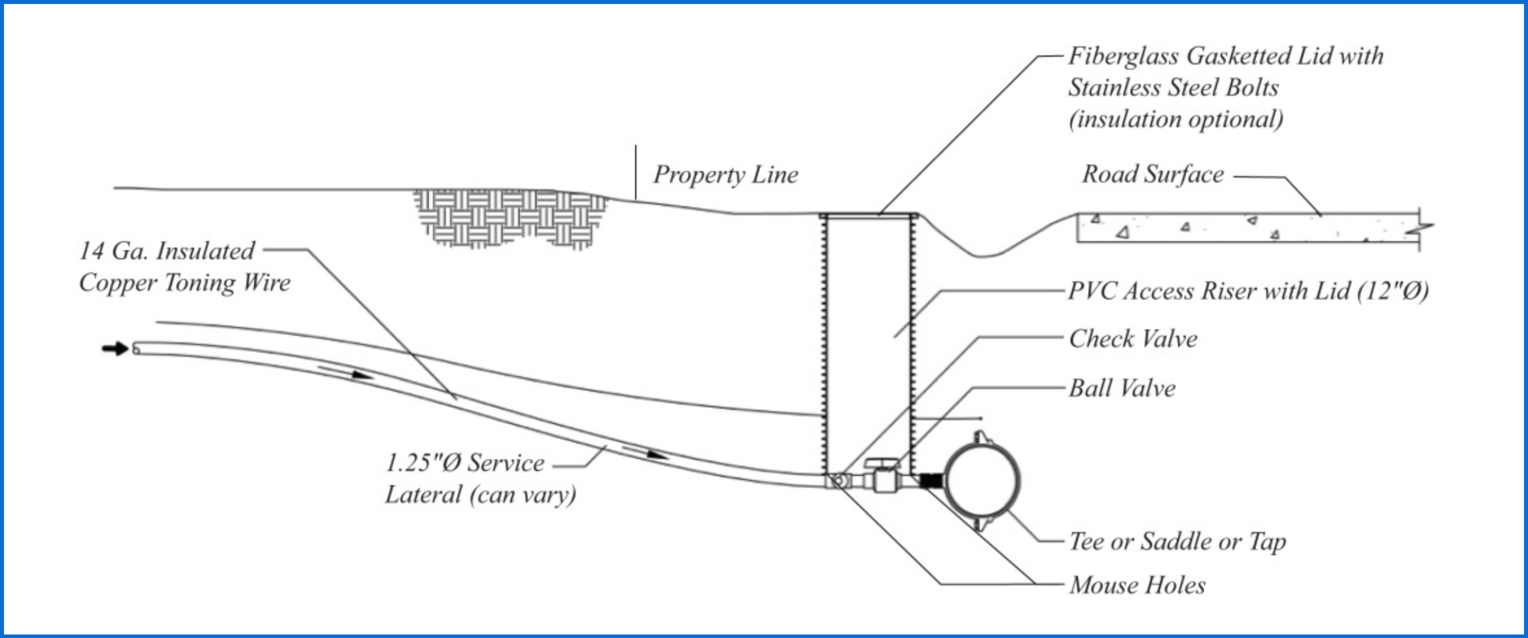
- Lack of training in decentralized design creates liability concerns for consultants, leading many to exclusively use conventional options
- The cost of design for some decentralized options may be comparable or exceed those for centralized, and with lower installed costs and reduced fee there is a direct impact on profitability for consultants, discouraging them from pursuing these options

Evaluating Wastewater Systems
Up-front and life-cycle costs

- Up-front capital costs
  - Includes engineering, construction (including land costs), startup/commissioning
  - Generally *similar* for pressure sewer technologies
- Life-cycle costs
  - Represent the ***total*** cost of owning infrastructure
  - Includes engineering, construction, R&R, and O&M
  - *Varies* significantly for decentralized technologies

Pressure Sewer Service Lateral Components

- 1” to 1.25” diameter service lateral (installed at a constant depth), service connection (ball valve, check valve, and access riser)



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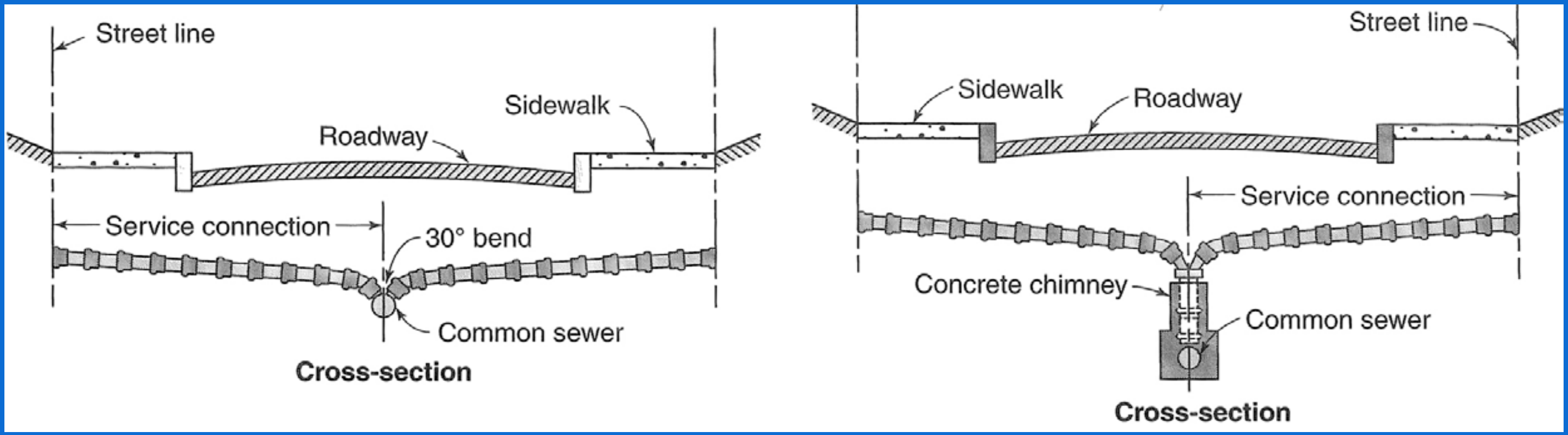
Pressure Sewer Service Lateral Costs

Project Name	Year	Connections	USD/linear Ft	USD/conn.
Carlisle, IA	2008	152	$8.00	$816
Lexington, IN	2010	117	(not Available)	$290
Fulton, AL	2012	130	$2.75	$275
Coffeeville, AL	2014	200	$2.83 to $6.40	$401

On-Lot Component: Gravity Sewers

- 4-6” diameter service lateral installed at a minimum 2% slope



On-Lot Gravity Sewers Capital Costs

Project Name	Year	Connections	USD/Linear Ft	USD/Conn.
Lore City, OH	2013	129	$55 to $115	$2,387
Coolville, OH	2013	196	$27	$700
Harrisville, OH	2013	97	$31	$571
Glenford, OH	2014	64	$40 to $74	$1,686

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Pressure Sewer Phasing Considerations

- For pressure sewers, front end infrastructure (mainlines) represent roughly 20% of overall cost of collection system
- Majority of cost (on-lot) equipment is deferred until home is constructed and generally financed with the home
- Gravity sewers generally require large up-front capital expenditures, often in excess of 80% of the overall cost of the collection and treatment system

Right-of-Way Capital Costs: Pressure Sewers

Item	Cost/Lf (2008 USD)
2” dia. Mainline	$10.70
3” dia. Mainline	$11.40
4” dia. Mainline	$12.90
6” dia. Mainline	$18
8” dia. Mainline	$20

Right-of-Way Components and Capital Costs: Gravity Sewers

- Large diameter mainline laid at a constant slope
- Manholes
- Lift stations (if required)
- Air release valves (if required)

Item	Cost (2008 USD)
6” dia. Mainline (USD/Linear ft)	$27
8” dia. Mainline (USD/Linear ft)	$30
12” dia. Mainline (USD/Linear ft)	$35

Right-of-Way Capital Costs: Gravity Sewer Manhole Capital Costs

Project Name	Year	Conn.	USD/Manhole
Lore City, OH	2013	129	$3,500 to 5,500
Coolville, OH	2013	196	$2,800 to 6,000
Harrisville, OH	2013	97	$2,345 to $4,650
Glenford, OH	2014	64	$2,700 to $4,500

Right-of-Way Capital Costs: Gravity Sewer Lift Station Capital Costs

Project Name	Year	Qty	USD/station
Coolville, OH	2013	1	$50,000
Coolville, OH	2013	1	$45,000
Coolville, OH	2013	1	$45,000
Coolville, OH	2013	1	$50,000
Coolville, OH	2013	1	$90,000
Harrisville, OH	2013	1	$97,250
Harrisville, OH	2013	1	$97,125
Glenford, OH	2014	2	$90,000

NOTE: All lift-stations serve small communities.

Tank Decommissioning and Abandonment Costs

Project Name	Year	Qty	USD/Conn.
Atoka, TN	2009	226	$400
Bayou La Batre, AL	2010	26	$550
Lexington, IL	2010	117	$373
El Dorado, AR	2011	440	$495
Rathbun Lake, IA	2011	27	$475
Fulton, AL	2012	125	$200
Bixby, MN	2012	28	$280

This cost associated with all technologies in a septic tank abatement project

On-Lot Components: Effluent Sewer STEP System

- 1,000 gallon or 1,500 gallon interceptor tank (fiberglass or concrete)
- Tank access equipment
- Pump vault with 1/8” mesh screen
- Control Panel
- ½ HP, 115 VAC high-head effluent pump
- Service connection (ball valve and check valve)
- Short building sewer
- Shallowly buried small diameter service lateral at constant depth (below frost depth)

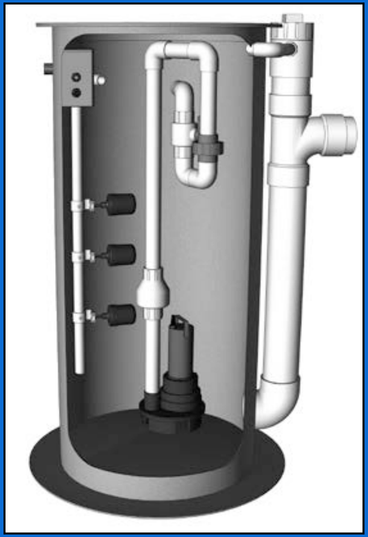
On-Lot STEP Package Capital Costs

Project Name	Year	Volume	Qty	USD/Conn.	Tank Depth
Atoka, TN	2009	1,000 gal	226	$4,700	2-3 ft
Lexington, IN	2010	1,500 gal	117	$4,532	2-3 ft
Bayou La Batre, AL	2010	1,000 gal	26	$4,400	1.5-2 ft
Bayou La Batre, AL	2010	1,500 gal	26	$4,950	1.5-2 ft
Rathbun Lake, IA	2011	1,250 gal	24	$4,289	4-5 ft
Superior, IA	2011	1,000 gal	69	$4,485	4-6 ft
Fulton, AL	2012	1,000 gal	125	$3,400	1.5-2 ft
Fulton, AL	2012	1,500 gal	5	$4,000	1.5-2 ft
Christiansburg, OH	2013	1,000 gal	100	$5,095	< 3 ft
Coffeeville, AL	2014	1,000 gal	190	$3,623	2-3 ft

NOTE: Excludes service connection, building sewer and service lateral.

On-Lot Components: Grinder Systems

- 1 to 2 HP, 230 VAC grinder pump
- 80-100 gallon basin (polyethylene or fiberglass)
- Control panel and level controls
- Service connection (ball valve and check valve)
- Short building sewer
- Shallowly buried small diameter service lateral at constant depth (below frost depth)



On-Lot Grinder Package Capital Costs

Project Name	Year	Qty	USD/Conn.
Carlisle, IA	2008	125	$4035
Leisure Lake, IA	2012	339	$5207

NOTE: Excludes service connection, building sewer and service lateral.

Total Collection System Cost: Effluent Sewers

Project Name	Year	Conn.	Bid	USD/Conn. (2014)
Atoka, TN	2009	226	$1,816,115	$9,113
Ewing, VA	2010	25	$150,884	$6,666
Morefield Bottom, VA	2010	53	$610,979	$12,733
Tishomingo, MO	2010	238	$2,213,656	$10,274
El Dorado, AR	2011	402	$3,085,873	$8,229
Christiansburg, OH	2013	242	$2,042,550	$8,592
Cleveland, MS	2013	36	$401,890	$11,365
Cleveland, MS	2013	43	$453,816	$10,774
McIntosh, AL	2013	409	$3,205,307	$7,978
Coffeeville, AL	2014	200	$1,638,943	$8,195

Note: All costs shown are for Orenco Effluent Sewers

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Total Collection System Cost: Grinder Sewers

Project Name	Year	Connections	Bid	USD/Conn. (2014)
Carlisle, IA	2008	152	$1,409,456	$10,845
Ellston, IA	2010	31	$440,423	$15,693
Fenton, IA	2011	185	$2,014,830	$11,670
Leisure Lake, IA	2012	339	$3,294,798	$10,148
Ringgold, IA	2012	104	$1,390,888	$13,964
Lampton, MS	2013	516	$3,288,329	$6,488

Total Collection System Cost: Gravity Sewers

Project Name	Year	Conn:	Bid	USD/Conn. (2014)
Village of Alma, IL	2005	165	$1,509,737	$11,943
Village Manor, OH	2007	49	$596,995	$14,865
Lawr Chester, OH	2008	170	$2,631,776	$18,106
Marion Township, OH	2009	189	$2,040,240	$12,242
Village of Yorkshire, OH	2010	52	$991,816	$21,068
Promise City, IA	2010	63	$585,982	$10,274
Millwood, OH	2011	48	$1,124,892	$25,112
Town of Morristown, NY	2011	108	$2,497,065	$24,775
Fairview, IA	2011	30	$411,001	$14,680
Los Osos, CA	2012	1757	$29,425,000	$17,487
Coolville, OH	2013	235	$3,634,005	$15,742
Lore City, OH	2013	160	$3,262,767	$20,760

Total Collection System Cost: Summary

- On average, effluent sewers have construction costs that are 41% less than gravity sewers
- Effluent sewer systems integrate primary treatment into collection system which eliminates influent screening, and primary clarification
- Pressure sewers (ES and grinder) are low pressure and watertight, therefore nearly eliminating I&I, and making I&I sources easier to identify

Type	Average	Median	Minimum	Maximum
Effluent Sewer	$9,702	$9,283	$6,666	$15,687
Gravity	$16,394	$15,304	$10,247	$25,112
Grinder	$11,468	$11,258	$6,488	$15,693

Capital Cost Summary

- Small communities face enormous challenges when constructing and maintaining wastewater infrastructure
- Gravity collection systems for small communities typically result in a cost that exceeds affordability thresholds (1.5 to 3% of MHI)
- Pressure sewer systems enable simpler operations, less expensive operational equipment
- Pressure sewers are largely immune to extraneous flow, resulting in major cost savings, both capital and electrical at WWTP
- Effluent sewers ($9,702/connection) have resulted in an average savings of $1,762 (15%) when compared to grinder sewers ($11,468/connection) and $6,692 (41%) when compared to gravity sewers ($16,394/connection)

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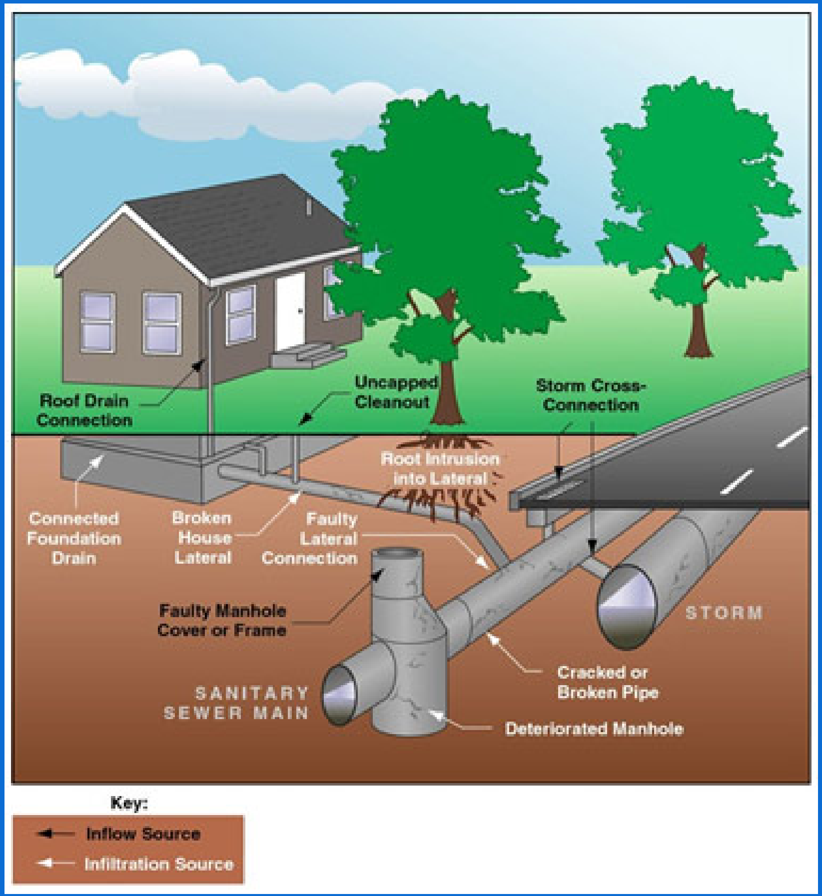
Gravity Sewer I&I Considerations

- Gravity sewer I&I identification and correction programs are typically costly and often times ineffective



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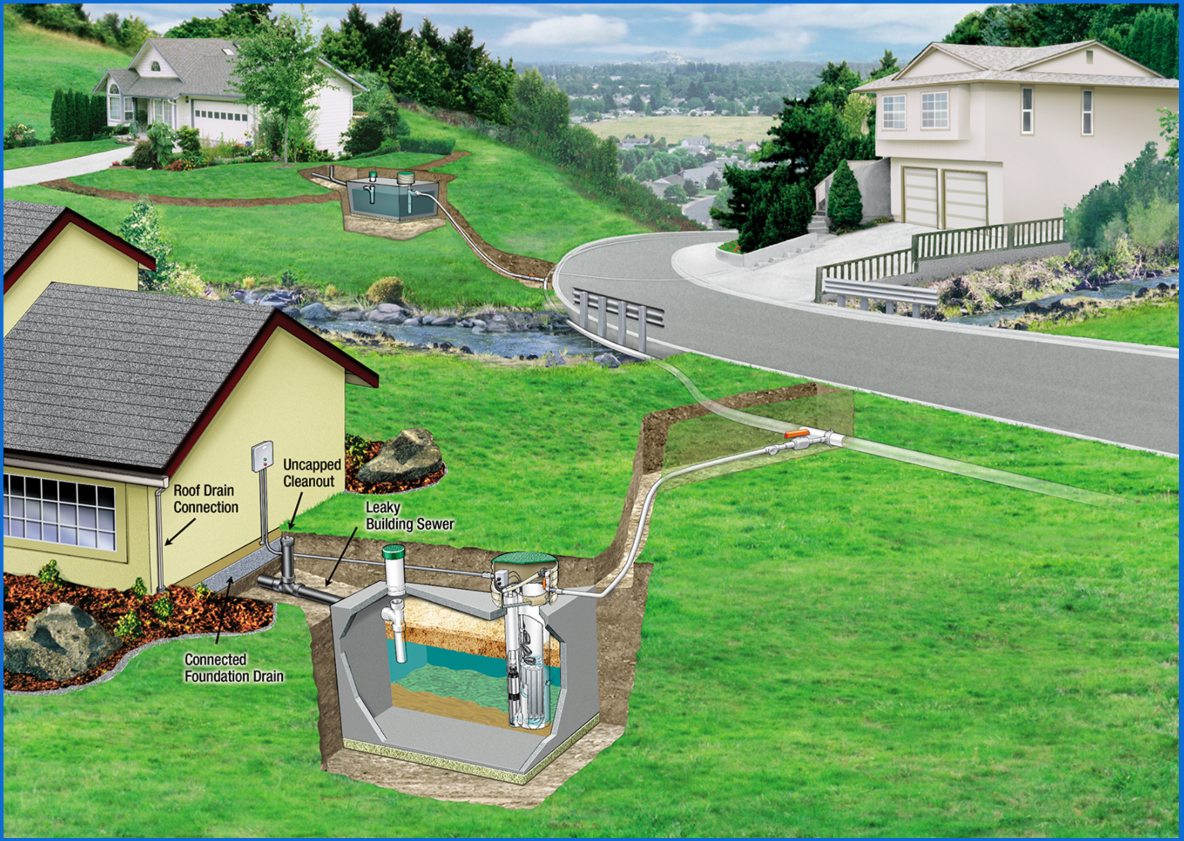
Pressure Sewer I&I Considerations

- Pressure sewer systems provide a relatively easy means of identifying and correcting I&I with all sources coming from the lot



Collection System Waste Stream Comparison

Characteristic	Effluent Sewer	Gravity Sewer	Grinder Sewer
Composition	Liquids only	Liquids and solids	Macerated slurry
Strength of waste	Low strength	Full strength	Full strength
BOD_5	100-150 mg/L	200-450 mg/L	300-450 mg/L
TSS	20-40 mg/L	200-450 mg/L	300-450 mg/L
Fat, Oil, & Grease	10-20 mg/L	50-150 mg/L	60-160 mg/L

Source: Small and Decentralized Wastewater Management Systems, *Crites & Tchobanoglous, 1998.*

Primary Treatment Comparison

Characteristic	Effluent Sewer Interceptor Tanks	Primary Clarification
Settleable Solids	90-95%	90-95%
Suspended Solids	70-90%	40-60%
BOD_5	60-70%	25-50%
Fats, Oil, & Grease	75-90%	60-80%*
Cost	Free ☺ (passive, no energy)	1/3± of total plant cost

* Requires skimming, aeration, and/or chemical addition, otherwise low removal

Collection System Impact on Treatment

- Pressure Sewers provide a significant reduction in plant flow due to the elimination of infiltration (50 gpcd vs. 120+ gpcd)
- Effluent Sewer provides for flow modulation and a reduction of peak flow at the treatment facility
- Effluent Sewer reduces organic treatment needs
- Effluent Sewer greatly reduces solids management at the plant

Treatment System Energy Usage

Energy Intensity Values for Various WWTP Unit Processes (source: EPRI, 2013)

Unit Process	1 MGD Average Flow	5 MGD Average Flow
Attached Growth	630 kWh/MG	580 kWh/MG
Aeration with Nitrification	1080 kWh/MG	1080 kWh/MG
Sequencing Batch Reactors	1090 kWh/MG	1090 kWh/MG
Membrane Bioreactors	2700 kWh/MG	2706 kWh/MG

Life-Cycle Costs

- User charges must include ...
  - ~ Monthly operation and maintenance costs
  - ~ Capital recovery and debt service
  - ~ Reserve fund for equipment replacement and repair
- when this doesn't occur ….
  - ~ USA Today *"…Government Accountability Office estimates that 41% of sewer systems charge customers less than the cost of the service…"*
  - ~ *"…EPA projects that $388 billion will be needed from 2000 to 2019 to address the nation's clean water infrastructure problems…"*

Life-Cycle Costs — Decentralized Technologies

- Effluent vs. Grinder sewers
  - ~ 30 year life-cycle cost analysis
    - Annualized costs at 4% APR
    - Proactive Maintenance (PM)
    - Reactive Maintenance (RM)
    - Equipment repair and replacement (R&R)
    - Tank solids removal (effluent sewer only)
    - Excludes power consumption (paid by homeowner)
    - Excludes upfront capital debt retirement

Proactive Maintenance (PM)

- Effluent sewer system PM
  - Measure sludge/scum, inspect and clean effluent and pump screen, verify panel and float operation.
- Grinder sewer system PM
  - Inspect pump basin, sharpen cutters/blades, verify panel and liquid sensor operation.

Effluent Sewers		Grinder Sewers	
Frequency	3 years	Frequency	3 years
Time	1.5 hours/visit	Time	1.5 hours/visit
Cost	$40.00/hr	Cost	$40.00/hr
UEC PM Cost	**$1.60/month/EDU**	**UEM PM Cost**	**$1.60/month/EDU**

Reactive Maintenance (RM): ES Systems

State	Community	EDUs	Screened	Hrs/mo./100 EDUs
CA	Mt. Lake Estate	8	yes	1.0
CA	Villa Verona	337	yes	2.5
MT	Missoula	350	yes	1.5
OR	Elkton	135	yes	0.7
OR	Glide	1,054	30%	1.5
OR	Lakeside	51	yes	0.3
OR	La Pine	215	yes	1.8
OR	Tangent	180	yes	2.5
WA	Boston Harbor	166	yes	1.6
WA	Conconnully Lake	75	yes	0.5
WA	Diamond Lake	525	yes	1.2

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Reactive Maintenance (RM): STEP and Grinder

Effluent Sewers		**Grinder Sewers**	
Uniform Equivalent Monthly RM	1.5 hours/month/100 EDUs	Uniform Equivalent Monthly RM	1 service call per (8) years – 3 hour service call
Cost	$40.00/hr	Cost	$60.00/hr – (some immediate response)
UEM RM Cost	**$0.60/month/EDU**	**UEM RM Cost**	**$1.90/month/EDU**

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Equipment Repair and Replacement (R&R)

	Effluent Sewers*			Grinder Sewers		
Component	**Freq.**	**Cost/ Event**	**4% Amortized**	**Freq.**	**Cost/E vent**	**4% Amortized**
Pump Replacement	20 yrs	$600	$1.62/mo/EDU	20 yrs	$2,500	$7.00/mo/EDU
Pump Repair	N/A	N/A	N/A	10 yrs	$800	$5.22/mo/EDU
Float Replacement	10 yrs	$100	$0.68/mo/EDU	10 yrs	$100	$0.68/mo/EDU
Misc. Components	10 yrs	$75	$0.51/mo/EDU	10 yrs	$75	$0.51/mo/EDU
		Total:	**$2.81/mo/EDU**		**Total:**	**$13.41/mo/EDU**

* Cost shown associated with STEP systems. Costs for STEG systems are a fraction of this value

Solids Management: ES Systems

ES Systems				
Component	**Freq.**	**Tank Size**	**Cost/Event**	**4% Amortized**
Tank Pump-out	10 yrs	1,000 gal	$300	$2.04/mo/EDU
			Total:	**$2.04/mo/EDU**

- Grinder systems manage solids at the wastewater treatment plant.

O&M Life Cycle Costs: STEP and Grinder

	Proactive Maintenance ($/month/EDU)	Reactive Maintenance ($/month/EDU)	Equipment R&R ($/month/EDU)	Solids Management ($/month/EDU)	Equivalent Monthly Costs ($/month/EDU)
Grinder	$1.60	$1.90	$13.41	Required at WWTP	**$16.91**
STEP	$1.60	$0.60	$2.81	$2.04	**$7.05**

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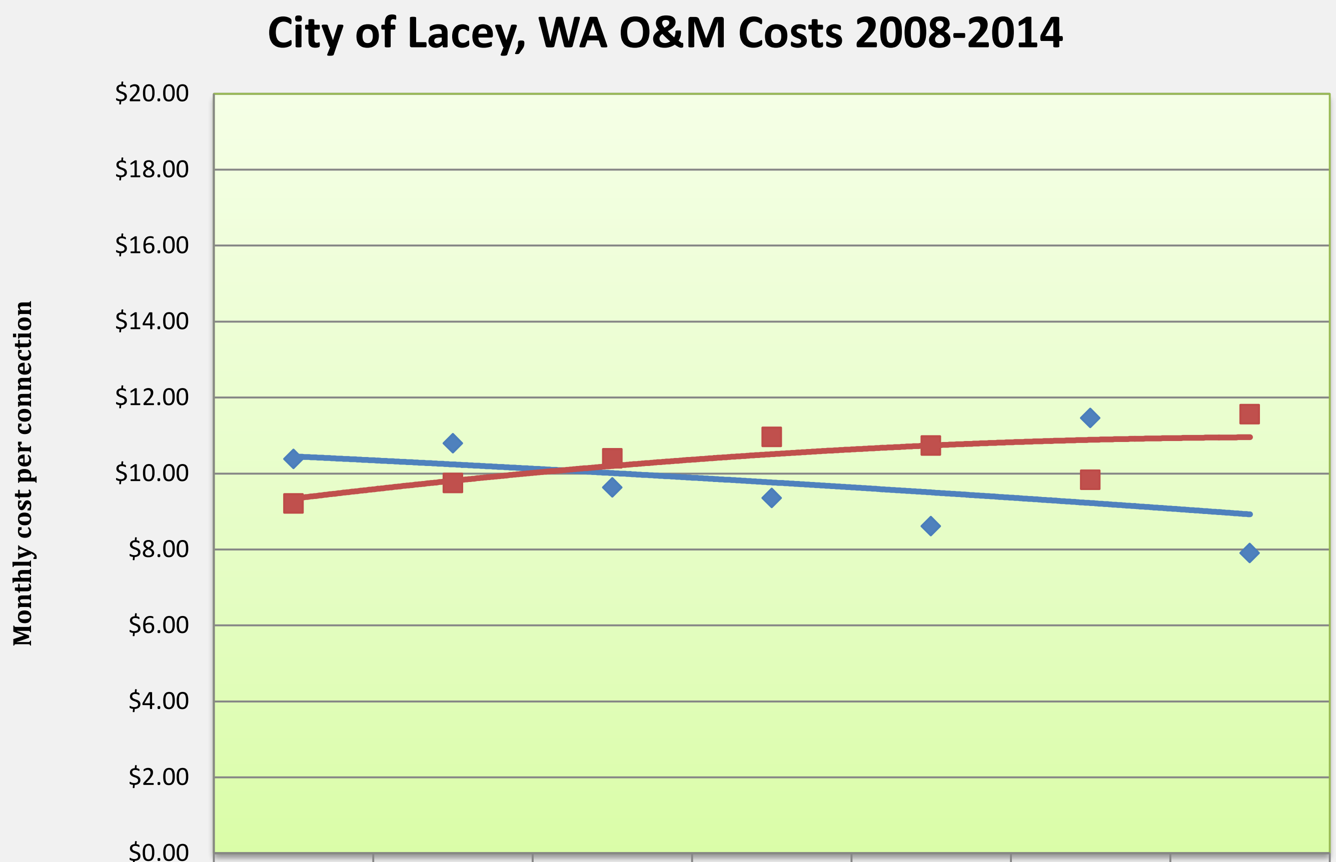
Electrical Usage: STEP and Grinder

- All costs typically funded by homeowner

	Pump	Pump Run Time	Power Cost	Equivalent Monthly Costs ($/month/EDU)
Grinder Sewer	1.5 Hp, 230 VAC, 16 amps	20 mins/day	$0.10/kWh	**$3.70**
Effluent Sewer (STEP)	0.5 Hp, 115 VAC, 12 amps	20 mins/day	$0.10/kWh	**$1.38**

Life-Cycle Costs Lacey, WA



	2008	2009	2010	2011	2012	2013	2014
Effluent Sewer	$10.38	$10.79	$9.63	$9.35	$8.61	$11.46	$7.90
Gravity Sewer	$9.21	$9.75	$10.40	$10.96	$10.73	$9.83	$11.56

******Based on odor control costs allocated by the number of households served.*

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WERF Agrees:

O&M Costs Are Equal for Effluent Sewer & Gravity

	Effluent Sewer	Conventional Gravity Sewer	Grinder Pressure Sewer
Materials/Install	$0.90-1.35 M	$2.43-3.64 M	$1.34-2.01 M
Annual O&M	$60,000-90,000	$65,000-97,000	$106,000-159,000
60 Year Life Cycle Cost – Present Value (2009 Dollars)	$2.45-3.68 M	$4.47-6.71 M	$4.71-6.11 M

Source: WERF Fact Sheets C1, C2, & C3
"Performance & Cost of Decentralized Unit Processes," 2010

Data based on 50,000 gpd or 200 homes

In Summary

- Pressure sewers are cost effective options for communities of all sizes
- Pressure sewer technologies are cost effective when comparing capital costs to those of gravity
- Effluent sewer O&M life-cycle cost comparable to gravity sewer and significantly lower than grinder sewer
- Effluent sewer provides the lowest total life cycle cost
- Pressure sewers provide a reduced hydraulic impact on the treatment plant
- Effluent sewers provide primary treatment, reducing loading at the treatment plant

Issues to Address

- Collection and treatment technology planning should be addressed together, not separately
- Guidelines that are not written for a particular technology should not be relied upon in the evaluation of a system (especially when those guidelines specifically state that they are only to be used for a particular technology!)
- Provide benefit for the primary treatment provided in an effluent sewer when evaluating treatment plant requirements
- Provide greater education of designers
- Provide better distribution of cost data for the use in planning and analysis

Issues to Address - continued

- Use a reasonable period in life-cycle cost analysis
  - ~ Minimum life-cycle cost analysis period should be 30 years
  - ~ A 60 year period is more appropriate for collection technologies
- Require the use of verifiable cost data in evaluation of planning and preliminary costing analyses
- Change funding laws to require that funding be limited to the most cost effective option, based on verifiable estimates and an appropriate life-cycle; any additional cost based on preference should be covered by the system owner

Additional Resources

- Water Environment Research Foundation (WERF) has developed fact sheets for gravity sewers, effluent sewers, grinder sewers, and vacuum sewers
- In addition, WERF has developed an online planning tool that can be used by owners and consultants to prepare rough cost estimates for various collection and treatment technologies

Thank you for your attendance!

Questions?