

DECENTRALIZED DESIGN CONSIDERATIONS AND LIFE-CYCLE COSTS

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ABSTRACT

Decentralized wastewater collection and treatment systems such as effluent sewers (aka STEP/STEG sewers), pressure sewers, and onsite wastewater treatment systems save small communities *millions* – in some cases, tens of millions – of dollars in capital costs and long-term operation and maintenance (O&M) costs when compared with large-diameter (LD) gravity sewers. Decentralized collection systems can affordably serve small, spread-out communities largely because they use small-diameter, shallowly buried PVC or HDPE mainlines – along variable grades – to convey wastewater to a treatment facility rather than using large-diameter, deeply excavated conveyance mains that are laid at a constant slope most often with expensive, high-maintenance lift stations along the route.

Effluent and pressure sewers are designed to operate without the need for full-time, on-site staffing. With their 24-hour storage capacity above a high-level alarm, this is particularly true for effluent sewers. In fact, a single employee can provide O&M services for upwards of 1,000 residential effluent sewer connections (Cagle et al., 2013). Additionally, decentralized sewer options often produce and discharge a higher-quality effluent than do many large municipal treatment facilities at less expense to users, and they can be installed and operational in a fraction of the time it takes to install LD gravity conveyance and treatment systems.

Because of their affordability, decentralized sewer systems have been installed in thousands of communities over the past several decades. A number of these systems are now more than 35 years old. Two of these technologies, effluent sewers and grinder sewers, are being proposed in an ever-increasing number of small communities.

Despite the fact that decentralized sewers appear to be an ideal solution for these smaller communities, most engineers continue to recommend LD gravity sewers with costly municipal treatment options. One frequently cited reason is a concern with the life-cycle costs of pressure/effluent sewers due to the perception that they are more expensive to operate and maintain than gravity sewers. This misconception lingers because operational data from long-term pressure sewer systems hasn't been readily available, mainly due to a lack of documentation, the variety of data, and the variability in equipment quality and O&M procedures.

Because of these unknowns, consultants have been very conservative in their estimates of O&M costs for pressure sewer systems and, in fact, have significantly overestimated them in many instances. At the same time, consultants have typically underestimated O&M costs when designing and evaluating LD gravity sewer systems, and have given little consideration to the

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actual costs for biosolids management, daily staffing needs, reaction times, and electricity, all of which are much higher for gravity sewers than for effluent sewers.

Today, however, enough data is available to accurately summarize the costs associated with proactive maintenance, reactive maintenance, equipment repair and replacement, solids management, and power consumption. When considering all of the relevant data, it becomes clear that the actual costs for effluent sewers are a fraction of what consultants and utilities have estimated.

WHERE TO START AND WHAT TO CONSIDER

The Electric Power Research Institute (EPRI, 1996) reports that approximately 90% of the nation's environmental regulation violations are associated with small rural community water and wastewater systems. The USEPA, in *Wastewater in Small Communities — Basic Information* states that, "... Small communities tend to be economically disadvantaged, under-served and resource-poor," and as a consequence, "... they face significant barriers to building and maintaining effective wastewater treatment services." The following list includes some of the challenges these small communities face:

- Economic and financial limitations
- Inability to sustain community-wide systems (lack of economies of scale)
- Inability to attract and maintain system operators
- Lack of managerial competency and consistency
- Extremes of topography and climate
- Geographic isolation and remoteness

In the late 1960s, the cost of conventional gravity collection systems in rural communities was found to dwarf the cost of treatment and dispersal (Fair et al., 2011). In the late 1960's and early 1970's, the cost of gravity collection for rural communities like Glide, Oregon, was beyond these communities' affordability thresholds even with maximum grant contributions (Douglas County Department of Public Works, 1975). The estimated gravity sewer collection costs were between 85% and 90% of the total collection and treatment costs, and more than twice what the community could afford.

It's a well-established fact that the costs of LD gravity sewers can and do overtax the small communities they are intended to serve. Essential components of LD gravity sewers such as manholes and lift stations are expensive, especially at the economic scale of small communities in rural areas that lack critical density. Additionally, LD gravity sewers require expensive and sometimes specialized heavy equipment (including flush trucks) for access to and maintenance of collection lines. This equipment must be purchased, rented, or contracted at considerable expense. Specialized tools and training, safety equipment, increased staffing for immediate response, and intensive emergency action plans are also typically required for LD gravity sewer systems. Slope requirements for gravity sewers often result in excessive burial depths in hilly or flat terrain, increasing the cost per foot installed of collection lines and requiring expensive lift stations. These costs are all highly variable and can easily skew an evaluation.

In *Small and Decentralized Wastewater Management Systems*, Crites and Tchobanoglous (1998) write that, “Given the fact that complete sewerage is unlikely for many residents, it is clear that decentralized wastewater management is of great importance to the future of wastewater; therefore, it deserves the kind of attention that has heretofore been reserved for conventional centralized wastewater management systems.” The text cites many significant factors to examine, including those listed above from the USEPA. Some additional considerations include locations where:

- Specific wastewater constituents are treated or altered more appropriately at the point of generation
- Localized water reuse opportunities are available
- Fresh water for domestic use is in short supply
- The quantity of effluent discharged to the environment must be limited due to environmental reasons
- Residential density is low

Time and again, reference after reference describes the struggles that small communities have had in trying to provide wastewater solutions for their residents. From the lack of basic operational knowledge to the inability to adequately fund operational management resources, small communities are rarely able to develop or enforce ordinances aimed at regulating sanitary sewer connections, often leading to excessive infiltration and inflow (I/I) over time. Unabated, extraneous flows from sanitary sewers increase the need for (1) larger sanitary sewer pipe, (2) additional lift station capacity with associated operation and maintenance requirements (emergency response protocol, standby power generation, etc), and (3) additional treatment plant capacity with associated O&M requirements, including energy consumption.

Electrical costs associated with the collection and treatment of I/I flows are expensive and they are on the rise. The Water Environment Federation’s *Manual of Practice #32* (2009) discusses the fact that electrical usage in conventional systems consumes 30% to 40% of the O&M budgets at small wastewater treatment plants (WWTPs). In many sanitary sewers, extraneous flow consisting of I/I is a major cause of hydraulic overloading of both collection systems and treatment plants (Santry, 1964; “Municipal Requirements for Sewer Infiltration,” 1965; Brown and Caldwell, 1957). I/I in a sanitary sewer system of one midwestern suburban community was found to be as high as 0.02 cfs/acre or in excess of 1,300 gpd/capita. Average dry weather flows, on the other hand, were less than 70 gpd/capita, (Bizier, 2007). The reports are clear. There are no questions or doubts that I/I is not a new problem, nor has the situation improved in the past 60 years. The effect of I/I is downplayed considerably by promoters of LD gravity sewer collection solutions who continue to claim that it’s simply the nature of the system.

Alternative wastewater collection systems (including effluent sewers and grinder sewers) were conceived to circumvent the challenges of gravity sewers, especially when they are applied to small communities. Alternative sewers are particularly cost-effective in:

- Sparsely populated or suburban areas with long mainline runs
- Hilly or flat terrain, requiring more frequent lift station placement
- Poor soil conditions; rocky areas

- Locations with high groundwater
- Small communities that would require lift station(s) or include creek or river crossings
- Small communities with minimal O&M capability

The cost savings of alternative sewers can be significant. For example, a 1998 report from the Illinois Community Action Association, titled *Alternative Wastewater Systems in Illinois*, included the results of competitive bidding for both effluent sewers and gravity sewers for the City of New Minden, IL. The cost to install an effluent sewer was \$1,090,000 (1998 US Dollars), while the cost to install a comparable gravity sewer was \$2,090,000, equating to a savings of \$1,000,000 (Illinois Community Action Association, 1998).

A detailed cost estimate to sewer over 1,500 residences in the City of Vero Beach, Florida revealed an approximate cost to install a gravity sewer around \$22.5 million. The estimated cost to install a STEP system, in comparison, was around \$11 million (Bolton, 2014). The cost savings is largely attributed to the use of small-diameter mainlines instead of large-diameter (8-inch +) mainlines laid at a constant slope with manholes and multiple lift stations.

The municipal engineering department at Orenco has collected and analyzed constructed costs from more than forty recent, publicly funded and bid-collection systems serving small communities (see Table 1). On average, effluent sewers cost 41% less than gravity sewers. The bid tabulations from these collection systems showed an average difference in cost between an effluent sewer (\$9,702/connection) and a gravity sewer (\$16,394/connection) of \$6,692. If the average difference in cost (between gravity sewers and effluent sewers) were financed over 30 years at 3% interest, the monthly debt retirement cost per connection would be \$28.44 — an insurmountable deficit to overcome, even with the perceived lower operation and maintenance costs of gravity sewers. With effluent sewers, the monthly debt retirement savings of \$28.44/connection is well above estimated O&M costs for Orenco effluent sewers. Molatore (2014), reported in “*Operational Costs of Two Pressure Sewer Technologies: Effluent (STEP) Sewers and Grinder Sewers*,” that the uniform equivalent monthly (O&M) costs for effluent sewers are \$7.05/month/EDU (includes solids management), and the uniform equivalent monthly (O&M) costs for grinder sewers are \$16.91/month/EDU (excludes solids management).

Table 1. Constructed Collection System Costs in USD 2014 (Molatore, 2014).

Collection 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

This correlates well with the collection system fact sheets developed by the Water Environment Research Foundation (2010). Table 2 summarizes these fact sheets in a single table.

Table 2. Constructed Collection System Costs for 200 Homes in USD 2009 (WERF 2010).

Cost Description	Cost Range	Gravity Sewer	Grinder Sewer	Effluent Sewer
Cost of Collection Network	Low	\$2,182,000	\$344,000	\$340,000
	High	\$3,273,000	\$516,000	\$510,000
Network Annual O&M	Low	\$65,000	\$56,000	\$60,000
	High	\$97,000	\$84,000	\$90,000
Installation Cost of On-lot	Low	\$247,000	\$997,000	\$561,000
	High	\$371,000	\$1,496,000	\$842,000
Total Installation Cost	Low	\$2,429,000	\$1,341,000	\$901,000
	High	\$3,644,000	\$2,012,000	\$1,352,000
Total System Capital Cost/Connection	Low	\$12,000	\$7,000	\$5,000
	High	\$18,000	\$10,000	\$7,000
60 Year Life Cycle Cost - Present Value (2009 \$)	Low	\$4,472,000	\$4,707,000	\$2,452,000
	High	\$6,708,000	\$6,106,000	\$3,678,000

Cagle, Cargil, and Dickinson, (2013) reported that, considering up-front capital and repair/replacement costs as well as O&M costs over the projected life of the collection systems for Lacey, Washington, the life-cycle costs of Lacey’s effluent sewer are lower than those of their typical gravity sewer. The City of Lacey began researching effluent sewers in mid-1989. By 1998 it had more than 1,400 effluent sewer connections and currently has grown to approximately 4000 connections. Lacey’s O&M is one of the most aggressive proactive maintenance programs of effluent sewer operations with a zero tolerance for complaints. Lacey also operates a gravity sewer with almost 12,000 connections with the same type of aggressive O&M program.

Table 3 shows O&M practices and annual costs for a few other similarly sized effluent sewer systems that were investigated by Lacey’s operational personnel.

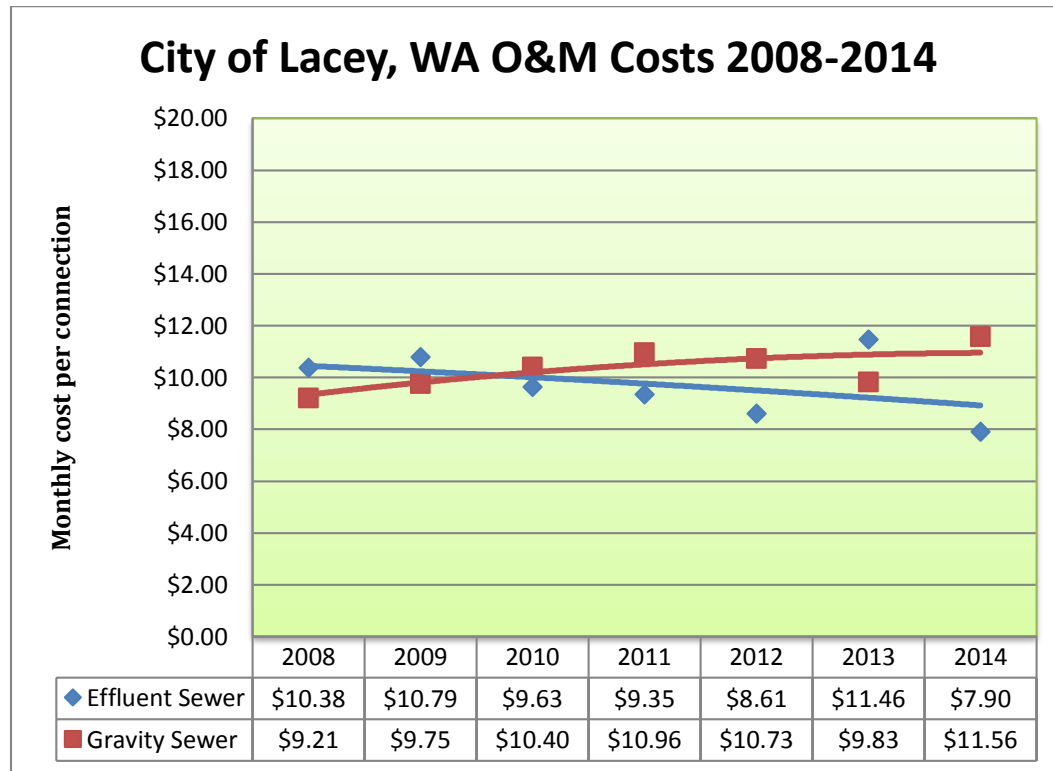
Table 3. Step System Maintenance Protocols and Associated Budgets

City	Connections	Protocol	Annual Call-Out Rate	O&M Budget per Connection
Port Charlotte, FL	7,000	Reactive	>20 percent	\$174 /yr
Missoula, MT	1,300	Pump every 7 years	12.3 percent	\$71 /yr
Camas, WA	3,000	Perform proactive maintenance every 5-6 years	8.5 percent	\$117 /yr
Yelm, WA	1,625	Perform proactive maintenance every 3 years	10.4 percent	\$134/yr

The findings showed that monthly O&M costs for effluent sewers were highly dependent on the maintenance protocols established by the operating entity. Reactive maintenance protocols were not cost-effective long-term, despite their appeal at the start of projects. Lacey’s own experience proved to them that a disciplined proactive maintenance program is the most cost-efficient and effective approach.

In 2008, the City of Lacey restructured its maintenance protocol similar to those systems that maintained a strong and efficient proactive approach. Figure 1, below, represents a comparison of the annualized O&M costs between their LD gravity and effluent collection systems. The annual O&M costs for both systems have been fairly stable over the past seven years. The upward trend of the gravity sewer collection system is reported to be due mainly to water conservation measures (causing solids to accumulate in the lines) and the high cost of lift station operation.

Figure 1. Operational Costs for Effluent Sewer and Gravity 2008-2014 (City of Lacey, WA).



The resulting savings, following the 2008 restructuring, were even better than expected and by 2010, the cost to operate the effluent sewer portion of Lacey’s collection system had dropped below that of their gravity system, despite the difference in scale. Through research and hard work, the city determined that their 4000-connection effluent sewer could be effectively serviced by two full-time employees and that it provided the best overall product to its user base with respect to cost effectiveness and their zero tolerance for user complaints.

TREATMENT SYSTEM IMPACTS

The electrical energy required for wastewater treatment varies widely but is typically between 1000 and 3000 kWh/MG for most treatment facilities (Carlson, 2007). As detailed below, electrical consumption is highly dependent upon the technology of the secondary treatment process, the discharge permit requirements (especially nutrient removal), the overall size of the WWTP, and the actual flows and organic loads versus the design flows and organic loads.

- **Wastewater Treatment Process.** The most common treatment processes being used — suspended growth processes — have high energy requirements associated with delivering oxygen into the wastewater. By comparison, other technologies, such as attached growth processes (common in decentralized applications), have substantially reduced energy requirements (NYSERDA, 2008).
- **Nutrient Removal.** Plants that have biological treatment for nutrient removal and filtration use about 30 to 50% more electricity for aeration, pumping, and solids processing than conventional activated sludge treatment. The electricity requirements for these plants will increase by 20% during the next 15 years, as plants expand treatment capacity to meet population growth and as additional treatment parameters are applied to meet the rigorous mandates of the Safe Drinking Water Act and the Clean Water Act (EPRI, 1996).
- **Size of WWTP Facility.** Energy consumption (kWh/MG) in wastewater treatment plants serving small communities (< 1 MGD) is often two or more times greater than in larger facilities (> 1 MGD). Energy consumption accounts for 15 to 30% of the operation and maintenance (O&M) budgets at large WWTPs and 30 to 40% at small WWTPs (WEF, 2009).
- **Actual Flows vs. Design Flows.** For some wastewater treatment technologies — mainly activated sludge and membrane bioreactors (MBRs) — energy intensity (kWh/MG) decreases as actual flows approach design flows. This is explained in part by the process equipment (blowers, pumps, mixers, etc.) operating at or near peak efficiency. Unfortunately, most plants are oversized based on unrealistic growth projections and do not operate efficiently. These plants are so oversized initially that supplemental food sources are required to maintain a decent level of treatment, which is costly and inefficient. When federal loans are involved, especially grant monies, design engineers seldom win the debate on allowing growth-phasing programs to expand treatment systems as the needs of the community grow. Effluent sewer design flow requirements are considerably lower than LD gravity flow requirements, and up-scaling treatment is less complicated and considerably easier to plan for and implement on periodic schedules when growth approaches 10% of design, making growth-phasing a very economical design approach.

ACTIVATED SLUDGE AND ATTACHED GROWTH TREATMENT PROCESSES

Activated Sludge

Activated sludge treatment systems include a reactor in which the microorganisms responsible for treatment are kept in suspension and aerated. Proper mixing and aeration generally require large amounts of oxygen, typically supplied by high-horsepower (hp) blowers that run continuously. According to *Recommended Standards for Wastewater Facilities* (2004),

“This process [activated sludge] requires close attention and competent operating supervision, including routine laboratory control. These requirements shall be considered when proposing this type of treatment. This process requires major energy usage to meet aeration demands. Energy costs and potential mandatory emergency public power reduction events in relation to critical water quality conditions must be carefully evaluated.”

In the activated sludge process, significant volumes of volatile suspended solids (VSS) are produced during the aeration process. Sludge yield values range from 0.4-0.8 mg VSS/mg BOD₅, with 0.6 mg VSS/mg BOD₅ being a typical value used in plant design (Crites and Tchobanoglous, 1998). Aeration and biosolids processing typically represent around 80% of the overall electrical usage in a standard activated sludge treatment facility (Hazen and Sawyer, 2011).

Attached Growth — Unsaturated

In attached growth systems, wastewater is uniformly distributed onto the media in an unsaturated condition (most commonly used in decentralized applications). Air movement through the void space in the media provides oxygen for aerobic digestion. The energy required for distributing wastewater onto the media and for aeration is considerably less than it is for activated sludge facilities. For example, sand, gravel, and textile treatment systems are types of attached growth treatment processes designed specifically for small communities and small flow applications (typically referred to as “packed bed” or “media” filters). Media filter treatment systems use fractional horsepower fans or passive aeration configurations to draw air through the media to provide sufficient oxygen for aerobic digestion. Low-horsepower, high-head turbine pumps operate intermittently with smart controls that automatically adjust recirculation ratios and pump-run times based on daily flows. On average, recirculating media filter systems reduce electrical usage by up to 50% compared to activated sludge facilities. Packed bed treatment systems are specifically designed to minimize the biosolids production and electrical usage associated with wastewater aeration and, therefore, require much less intensive operational oversight while still producing high-quality effluent.

An effluent sewer’s residential interceptor tanks provide long-term storage and primary treatment, where 80% of the accumulated volatile solids can be effectively digested in a passive manner without consuming electrical power (Metcalf and Eddy, 1972). Philip, et al., concluded that 90% reductions in sludge volume are achievable, and pump-outs frequencies “could be greatly increased (up to 15-20 years in real onsite cases).” Furthermore, the microbial (biomass) population required to perform this digestion ranges between 1/5th and 1/20th of that in an equivalent aerobic suspended growth process (Bitton, 1994). Glide-Idleyld Sanitary District’s effluent sewer serves a community of about 1100 equivalent dwelling units (EDU’s) with a mean annual flow of 161,000 gpd and only produces between 10 and 12 yards of dried solids per year. After drying, the solids are land applied. This value includes the septage solids periodically removed from the interceptor tanks.

The primary clarification in gravity sewer wastewater treatment applications is expected to accomplish about 90%-95% settleable solids, 40%-60% suspended solids, and 25%-50% total BOD₅ reduction, which is not as efficient or effective as the residential interceptor tanks. Primary clarification is not intended to digest organic material and has a short retention time, so solids are continually collected and move to digesters; therefore, overall solids reduction is less efficient. Effluent sewer collection systems afford much greater organic, solids, and grease & oil removal and eliminate the need for comminuters, grit chambers, and primary clarification at the WWT facility, which is upward of one-third of the cost of a gravity collection system’s treatment needs.

BASELINE ELECTRIC ENERGY USE DATA

The following baseline energy intensity values are drawn from: 1) energy audits or surveys conducted at complete wastewater treatment plants, and 2) theoretical or empirically derived values for discrete unit processes (primary clarification, SBR, trickling filter, secondary clarification, etc.).

Water and Wastewater Industry: Energy Best Practices Guidebook (Science Applications International Corporation, 2006)

In 2006, Focus on Energy, a utility-sponsored program to reduce energy in Wisconsin, retained a sub-consultant to conduct on-site surveys of 85 wastewater treatment facilities under typical operating conditions. The following chart shows actual total energy use for three types of wastewater treatment plants, not just for the listed process.

Table 4. Energy Intensity Values for Various WWTPs (Science Applications International Corporation, 2006).

Treatment Type	Flow Range (MGD)	Number of Facilities Surveyed	kWh per Million Gallons
Activated Sludge	0 to 1	26	5440
	1 to 5	24	2503
	> 5	11	2288
Aerated Lagoon	0 to 1	15	7288
Oxidation Ditch	0 to 1.2	19	6895

As illustrated by the data in Table 4, energy consumption for wastewater treatment in small communities (less than 1.2 MGD) occurs at a rate of two to three times that of larger communities. This creates a burden on the utility’s users. Note that attached growth technologies were not surveyed as part of the Wisconsin study.

In 1996, the Electrical Power Research Institute (EPRI, 1996) studied electrical usage in various unit processes across the United States. These values are specific to the processes shown and did not include other processes that may have been used on the project. EPRI updated these values in 2013.

Table 5. Energy Intensity Values (kWh/MG) for Various WWTP Unit Processes (EPRI, 2013).

Unit Process	Average Flow	
	1 MGD	5 MGD
Trickling Filters (Attached Growth)	630 kWh/MG	508 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

The EPRI information clearly demonstrates the ability of attached growth processes to treat wastewater with higher energy efficiency than the other processes evaluated.

SYSTEM COSTS

So how are the final options and their associated costs actually determined, reviewed, and evaluated? Who truly assesses the cost values provided in facility preliminary reports and compares them to actual system costs? The answer in many cases is simple: no one – not the system owner, not the regulating agency, and not the funding agency.

In fact, uninformed owners often dictate technology decisions based on rumors and hearsay, rather than by investigating the actual cost effectiveness of the appropriate options and making a concerted effort to become truly knowledgeable in their decision-making. And, unfortunately, consultants can be put in a position of having to go along with their client's preferences rather than resisting or appearing argumentative and jeopardizing their client/consultant relationship.

Consultants who have not been given specific goals to consider or address (cost, affordability, staffing/management needs, certification levels, O&M limitations, etc.) will often default to a LD gravity sewer as the quickest and easiest system for laying out and acquiring approvals, with little effort focused on evaluating other technologies (collection or treatment) based on the specific project conditions. This is especially true if the consultant has no actual experience with the installation and operation of alternative approaches.

State regulatory agencies typically focus on the “mechanics” of the system relative to its ability to convey the projected flows to the wastewater treatment plant and the plant's capacity for handling average and peak flows while delivering an effluent treated to the required limits. Therefore, system “functionality” is the primary concern and focus of the local jurisdiction. Cost-effectiveness and operability are not part of their evaluation process. Occasionally, regulatory bias also plays a role, with a regulator stating a preference for one technology or another, for example: “I'm familiar with gravity sewer, so the review should go pretty smoothly. I'll have a lot of questions if you plan to go the alternative route.”

Funding agencies are usually technology- and, to a large extent, cost-blind. They seldom evaluate a project to determine whether the proposed solution is the most affordable long-term solution, but rather whether or not the assumed cost of the proposed solution fits within their funding framework. These comparatives are often based upon assumed costs and not actual costs of existing projects. Long-term operational costs are provided in some analyses but not all and, again, are typically estimated based upon the designer's experience (or lack thereof). Those agents who do review the consultant's cost estimates often sign off on whatever the consultant provides in their comparative cost analysis, with little or no effort put into checking reference materials or validating the credibility of local informational sources.

The funding agency generally assumes that if the local regulatory body and system owner are satisfied with the proposed collection and treatment options, they've vetted the mechanics and functionality issues to their satisfaction. Therefore, funding agencies focus primarily on the

“affordability” of the project with respect to the community’s low-to-moderate income levels, as well as the community’s and the owner’s ability to retire the loan debts and handle monthly rates. In doing this, agencies are relying on the assumption that the engineering cost evaluation has been put together with detailed scrutiny and unbiased opinions with respect to the relative options.

Thus, grant monies are needlessly appropriated to projects that install conventional collection and treatment solutions, often because the consulting engineer and funding agency simply lack the knowledge and experience – or confidence – to fairly evaluate life-cycle costs of alternative systems.

What the evidence shows most of us in the onsite and decentralized industry is that even after decades of usage and proof of success, decentralized alternatives are regularly avoided or misrepresented in one fashion or another. Yet here we are in 2015, still roughing together cost estimates to the nearest dollar, and no one seems to question the significance of that. Nor do they consider the fact that cost analyses are not truly vetted by the necessary approving agencies and that actual costs could range as much as 20 to 50% higher or lower, depending on the actual experiences of the group doing the estimating.

As this paper was being written, consultants for the small community of Lime Lake, New York estimated annual O&M for their grinder pumps at \$50/year/EDU, which claims to include preventative and reactive maintenance, as well as equipment repair and replacement expenses. Without assuming interest, the 20-year future worth of an annual annuity valued at \$50/year is \$1,000, which is horribly insufficient considering the industry standard repair cost of \$800 to \$1,000 every 8 to 10 years, and replacement cost of \$2,000 to \$3,000 every 16 to 20 years. Additionally, the preliminary engineering report for the City of Ione, Oregon, provided a broad evaluation for a gravity sewer with multiple treatment system options, yet only evaluated STEP systems with media filters. The report was approved and accepted by the regulatory and funding agencies. If the consultant had paired STEP systems with the same treatment alternatives that were considered with gravity sewers, more than \$1.5M in estimated construction costs could have been saved. Other systems in Oregon have been paired with municipal treatment plant alternatives, so it begs the question about why, in this report, it was overlooked or not considered.

It is time to standardize the methods used to evaluate and analyze costs for sewer system technologies. Funding agencies lack prescriptive guidelines that they could reference when reviewing preliminary engineering reports to determine if the estimated capital and O&M costs of alternative systems are reasonable. Funding agents have stated that their hands are tied with respect to challenging costs and that they are in need of prescriptive guidelines that provide acceptable ranges of reasonable capital and O&M costs for alternative systems. The current limitations allow – and actually enable – inaccurate and highly variable estimates, as well as create an unacceptable opportunity for the misuse of taxpayer and owner funds. It should no longer be up to the discretion of the consultant to use arbitrary values. Instead, they should use values of installed projects with similar attributes. And when those are not locally available, the consultant should use a source that has been peer reviewed and vetted by credible third-party affiliates. For example, in 2010, the Water Environment Research Foundation published research information on the four primary types of wastewater collection technologies being used, and

ultimately developed an online wastewater planning model for evaluating the life-cycle cost impacts of each of these technologies. This model can be found at: http://www.werf.org/i/c/DecentralizedCost/Decentralized_Cost.aspx. Using a model like WERF's as a cost basis is far better than predicting cost based on hypothetical values or conjecture without a documented basis. Sources such as this should also be used as regulatory guidelines to ensure that excessive or inappropriate deviations do not jeopardize a community's financial ability to pay down their loan commitment.

IMPACT ON GROWTH

One of the greatest challenges in designing wastewater systems is designing for future growth. The ability to accurately predict future growth can be more art than science. Using historical growth records of the community, the county in which it exists, or the state alone is not a reliable predictor of future growth. When this is done, systems are frequently overbuilt and the additional cost is borne by the existing users.

The availability cost of a sewer system is the cost required to install the collection mainlines and appurtenances. The availability cost of the City of Vero Beach's STEP system was estimated at less than \$1 million, or less than \$600 per lot (1/10th that of a conventional gravity sewer). A lower availability cost allows local municipalities to make sewer available to residents more quickly and cost effectively. Low availability costs also facilitate non-mandatory connections. Conventional gravity sewers typically require mandatory connections due to the need for cash flow to retire debt associated with the much higher sewer availability cost. Due to the low availability cost of effluent sewers, mandatory connections are not required and the on-lot components of the STEP system can be phased in.

With LD gravity sewer, the cost of overbuilding can be substantial. If growth projections aren't accurate, the existing user base is forced to pay for maintenance and upkeep on infrastructure that is either not in use or under utilized. Lift stations are sized for future growth and typically operated inefficiently until the growth occurs, or they are fitted with small booster pumps for low flows.

And then there is the challenge of operating an overbuilt treatment facility. Using a "Field of Dreams" analogy, it's assumed that, "If we build it, they will come." But real life isn't a movie, and not all systems have happy endings. This strategy has caused many systems to struggle, not only financially, but also to meet performance objectives. One community, Ray City, North Dakota, has gone so far as to give its treatment capacity away, offering to take hauled wastes for free to keep their overbuilt plant operating. Unfortunately, a few private treatment facilities built to provide capacity when the public entities couldn't are being caught in the middle. Now they're being driven out of business (Watchdog, 2015).

With effluent sewer collection systems, approximately 80% of the cost of collection is associated with the on-lot installation of the interceptor tank and pumping equipment. Similarly, decentralized wastewater treatment plants are often built modularly so that only the capacity needed at the time of the build has to be constructed; add-ons to the system's capacity can occur

as additional treatment capacity is needed. The majority of the capacity cost is moved to the future, reducing the net present value of decentralized systems.

Effluent sewers are ideal for slow build-out projections since a significant portion of the system's collection and primary treatment cost is deferred until individual lot construction begins, and then the cost is borne by the developer or property owner. Further, on-lot power costs are also paid by the user. In some slow-to-develop areas, the on-lot systems can be configured to also include the secondary treatment units. Thus, the primary and secondary treatment costs are deferred until the lot is sold and developed.

IN SUMMARY

Small communities face enormous challenges when constructing and maintaining wastewater infrastructure. Affordability (due to the lack of "scale") and maintainability are considered the largest obstacles for these small communities to overcome. Coupled with the fact that these systems can also experience low and highly variable flows, it's important for them to choose wisely when investing in a system for the next 30-60 years.

These communities should select technologies that eliminate inefficiencies related to infrequent operation, use little energy, produce minimal biosolids, and provide the affordability, stability, and compliance required of small wastewater collection and treatment systems. Effluent sewers and packed bed technologies were specifically developed and designed to overcome the shortcomings associated with applying LD gravity sewers to small communities. They provide stable performance with part-time operation, low electrical usage associated with wastewater collection and treatment, and minimal biosolids production.

Despite several decades of beneficial usage of decentralized and onsite options, there are still barriers to ensuring proper and appropriate cost analyses showing the benefits of decentralized options over large-diameter gravity collection system technologies.

As previously mentioned, some forty community bid tabulations showed that effluent sewers provide an average initial cost savings of 41% when compared to gravity sewers, which is comparable to WERF's estimates of a capital savings of over 50% for effluent STEP over gravity. With respect to LD gravity sewers, operational budgets are often underfunded, which ultimately jeopardizes the system's long-term sustainability and threatens the ability of the community to maintain permit compliance requirements. Even when grant subsidies are applied to these large-diameter gravity sewer proposals, the costs still exceed affordability thresholds required to attain reasonable user rates, and which wastes monies that might have best been used to help serve a more needy community.

Feachem et al. (1983), state that,

“Those whose job is to select and design appropriate systems for the collection and treatment of sewage in developing countries must bear in mind that European and North American practices do not represent the zenith of scientific achievement, nor are they the product of a logical and rational design process.

Rather, treatment practices in the developed countries are the product of history, a history that started about 100 years ago when little was known about the fundamental physics and chemistry of the subject and when practically no applicable microbiology had been discovered ... These practices are not especially clever, logical, nor completely effective — and it is not necessarily what would be done today if these same countries had the chance to start again.”

In addition to Feachem’s quote, it’s been brought up time and time again that if it weren’t for grant programs gifting monies to communities and misguided claims that decentralized alternative solutions are second best when compared to large-diameter sewers, rural communities would evaluate all the various possibilities and choose wastewater systems that best address their particular situation.

Therefore, something more than just education is necessary to ensure that these small communities are provided with the most suitable and sustainable wastewater alternative for their needs and means. It’s time to require fair, accurate, unbiased, and verifiable cost evaluations as part of any planning or design document. And it’s time for funding agencies to be provided the tools that will allow them to ensure that they are funding the most cost-effective solution for a community. It’s time to make a bit of new history.

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