Small Community Wastewater Collection and Treatment Alternatives

A Case Study on a Water & Wastes Digest “2015 Top Projects” Award Winning System at Christiansburg, OH

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Orenco Systems®, Inc.
Introduction

• Christiansburg, Ohio
• Champaign County
• Located in Midwestern Ohio
• 515 people, 250 connections (residential and commercial)
• Town is bounded within a highly urbanized area.
  ~ Densely populated adjacent municipalities; Springfield, Dayton, Troy, Urbana, etc.
• No existing centralized wastewater collection or treatment infrastructure.
  ~ Nearby Creek tested high for bacteria
• Small community, with limited resources
Christiansburg, OH
Existing Wastewater Infrastructure

- Residences had failing septic systems
- Existing parcels were small
  - Many were less than .15 acres
  - Typical Village setting
- Environmental issues
  - Contamination
    - West Fork Honey Creek runs next to town
  - Odors most of the time
    - Especially after rainstorms
  - Health hazards
Christiansburg, OH
Problem and Challenges

• Relatively low density
  ~ Denser village center
  ~ Vacant lots
  ~ Some large lots on outskirts
• Slow growth rate
• Part time operators, limited experience
• No money
• Low median household income
• Strict discharge permits
Christiansburg, OH
Solution
• System needed to have:
  ~ Low up-front capital costs
  ~ Affordable operation & maintenance costs
  ~ Ability to connect more users as needed without expanding WWTP
• Council woman did research and discovered Orenco
  ~ Engineer, Town and Orenco toured existing facilities
• Orenco Effluent Low Pressure Sewer followed by AdvanTex® treatment met all system requirements
• NPDES permit obtained from Ohio EPA
• AdvanTex® treatment layout designed to meet limits
Christiansburg, OH
Project Scope

• 250 Total Connections Installed
• Ohio EPA Permit Limits
  ~ 10 mg/L BOD$_5$
  ~ 12 mg/L TSS
  ~ 1 mg/L NH$_3$-N summer
  ~ 3 mg/L NH$_3$-N Winter
  ~ 161 CFU/100 ml E. coli
• 65,000 gpd average flow
• 85,000 gpd maximum daily flow
Why Was Conventional Sewer not Cost Effective?

• Gravity collection
  ~ Recommended Standards for Wastewater Facilities (2004 Ed.)
    • Minimum 8” dia pipe
    • Minimum slope of 0.4ft/100ft
    • Manholes at 400ft intervals, terminal ends, and changes in grade, size, or alignment
    • Multiple pumps shall be provided
• All of this results in HIGH installation costs
Christiansburg, OH
Collection System Overview

- Septic Tank Effluent Pumping (STEP) Collection
- Components
  ~ Watertight interceptor tank (1000, 1500, or 2000) gallon
  ~ Biotube® pump vault
  ~ Effluent screen
  ~ High head effluent pump, 115VAC, ½ Hp, 10 gpm
  ~ Control panel
  ~ Splice box
  ~ Hose and valve assembly
Christiansburg, Ohio
Low Pressure Effluent Sewer

Collection System Force Mains
~ Small diameter lines, 2 to 4” diameter
~ Follows contour of land
~ No manholes or lift stations
  • Cleanouts at terminal ends of mainlines, etc.
  • Largely immune to I&I and leakage

<table>
<thead>
<tr>
<th>EDUs</th>
<th>Qp</th>
<th>Pipe Size, Inches</th>
<th>Head Loss, ft/1000 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>20</td>
<td>1 1/4</td>
<td>35 ±</td>
</tr>
<tr>
<td>100</td>
<td>65</td>
<td>2</td>
<td>54 ±</td>
</tr>
<tr>
<td>500</td>
<td>265</td>
<td>4</td>
<td>32 ±</td>
</tr>
<tr>
<td>1000</td>
<td>515</td>
<td>6</td>
<td>16 ±</td>
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</table>
Christiansburg, Ohio
WWTP Flow Data

Average:
104 gpd/EDU

Average:
52 gpcd
Christiansburg, OH
On-Lot Description

- 250 STEP Tanks
  - ~1,000 gallon tanks for residential
  - ~1,500 or 2,000 gallon tanks for commercial
- Roth Polyethylene tanks
  - ~2 risers per tank
- One Orenco MVP panel per STEP tank
- Small excavated footprint (~100 sf)
Collection System Comparison

- Effluent Sewer compared to Gravity Sewer
Collection System Cost Comparison

• On average, Orenco Effluent Sewers have construction costs that are 41% less than gravity sewers for communities of similar size.

• STEP systems integrate primary treatment into collection system which eliminates influent screening, and primary clarification at the WWTP.

• Pressure sewers (STEP and grinder) are low pressure and watertight, therefore nearly eliminating I/I which enables smaller secondary and advanced treatment process.

<table>
<thead>
<tr>
<th>Type</th>
<th>Average</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>STEP</td>
<td>$9,702</td>
<td>$9,283</td>
<td>$6,666</td>
<td>$15,687</td>
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<tr>
<td>Gravity</td>
<td>$16,394</td>
<td>$15,304</td>
<td>$10,247</td>
<td>$25,112</td>
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<tr>
<td>Grinder</td>
<td>$11,468</td>
<td>$11,258</td>
<td>$6,488</td>
<td>$15,693</td>
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</table>

NOTE: All costs are USD/connection.
STEP Versus Grinder O&M Costs
($/Month/Connection)

<table>
<thead>
<tr>
<th>System Type</th>
<th>Proactive Maintenance</th>
<th>Reactive Maintenance</th>
<th>Equipment Repair &amp; Replacement</th>
<th>Solids Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grinder Sewer</td>
<td>$1.60</td>
<td>$1.90</td>
<td>$13.41</td>
<td>@ WWTP</td>
</tr>
<tr>
<td>Orenco Effluent Sewer</td>
<td>$1.60</td>
<td>$0.60</td>
<td>$2.81</td>
<td>$2.04</td>
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</table>

<table>
<thead>
<tr>
<th>System Type</th>
<th>Total Equivalent Monthly Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grinder Sewer</td>
<td>$16.91</td>
</tr>
<tr>
<td>Orenco Effluent Sewer</td>
<td>$7.05</td>
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Collection System Cost Comparison
Estimated Gravity O&M

O&M Cost/Connection

- Slip Line Gravity Trunk: $1.00
- Slip Line Lateral Main: $1.67
- Line Manhole: $1.67
- Pumps: $0.42
- Panel: $0.56
- Line Wet Well: $0.28
- Collection System Maintenance: $0.22
- Solids Handling: $6.61
Why Not Conventional Treatment?

• Activated sludge
  ~ Recommended Standards for Wastewater Facilities (2004 Ed.)
    • Process requires close attention and competent operating supervision, including routine laboratory control …Full time oversight/operation.
    • Process requires major energy usage to meet aeration demands …. High power costs.
• Traditional style package plants and variations on activated sludge process do not solve the problem either
AX-MAX Treatment Systems
Packed Bed Filter System

• AX-MAX (7 ft to 42’)
  ~ AX-MAX100-14, AX-MAX150-21, AX-MAX200-28, AX-MAX250-35, AX-MAX300-42

• Integrated recirculation tankage and packed bed media filter
  ~ Lower installation costs, reduced construction oversight
AdvanTex Media

- Textile is specifically engineered for wastewater treatment applications and was designed to maximize surface area
- The more surface area, the more area for bacterial colonization
- High Oxidation
- Treats cBOD and converts Ammonia into Nitrates
AdvanTex® Textile Treatment

• Biological Nutrient Removal
  ~ Attached growth process
  ~ Aerobic microbes attach and grow on media
  ~ Wastewater flows across a zoogloal film created by microbes
  ~ Microbes extract and digest soluble organic matter in wastewater
• Wastewater is applied in small doses and percolates over media in a thin film
  ~ Unsaturated conditions
  ~ Uses low hp, energy efficient pumps
• Low O&M, highly stable, reliable
Christiansburg, OH
AdvanTex® Treatment Facility

- 1st stage
  ~ 9 Orenco AX-MAX units
- 2nd stage
  ~ 3 Orenco AX-MAX units
- Small footprint
  ~ Approximately 10,000 sf
Ancillary Equipment

• Components
  ~ Automatic Alkalinity Feed
    • (Eagle Microsystems)
  ~ UV disinfection
    • (Aquionics)
• Dispersal
  ~ Surface discharge into West Fork Honey Creek
  ~ Strict Ammonia Limits (<1 mg/L)
Christiansburg, OH
AdvanTex® Treatment Results

• Far exceeds NPDES requirements
• Recorded Effluent Quality (summer 2015)
  ∼ 3.6 mg/L cBOD₅
  ∼ 1.7 mg/L TSS
  ∼ < 0.1 mg/L NH₃-N
• Operator Time ~6 hrs/week
• Energy Use ~10kWh/day
• Plant Electricity Bills ~$700/month
# AdvanTex® Treatment Comparison

## Energy Requirement Comparison

<table>
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<tr>
<th>Unit Process</th>
<th>Average Flow (MGD)</th>
<th>kWh per Million Gallons</th>
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<tbody>
<tr>
<td>AdvanTex®</td>
<td>0.25</td>
<td>2170</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>1790</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>0 to 1</td>
<td>5440</td>
</tr>
<tr>
<td></td>
<td>1 to 5</td>
<td>2503</td>
</tr>
<tr>
<td></td>
<td>&gt; 5</td>
<td>2288</td>
</tr>
<tr>
<td>Aerated Lagoon</td>
<td>0 to 1</td>
<td>7288</td>
</tr>
<tr>
<td>Oxidation Ditch</td>
<td>0 to 1.2</td>
<td>6895</td>
</tr>
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</table>

*Energy intensity values for AdvanTex® treatment systems (Jex, 2014)*  
*Energy intensity values for various WWTPs (Science Applications International Corporation, 2006)*
Operation and Maintenance
Collection

• Conveyance System O&M
  ~ Inspection, exercising valves, replacement of odor control filters

• On Lot System O&M
  ~ Proactive (every 3 to 5 years)
    • Tank effluent screen cleaning, pump and controls inspection, sludge and scum measuring
  ~ Reactive (~1.4 hours/EDU/Month/100 EDU’s)
  ~ Equipment repair and replacement (pumps ~20 years)
  ~ Tank pump outs (~10 years)
Properly Sized Tanks Reduce Pumping

The pumping interval for properly sized and managed watertight tanks is about 8 to 12 years.
Operation and Maintenance

Treatment

• Activities
  ~ System operation and pump monitoring
  ~ Annual lateral, nozzle and pump cleaning
  ~ Reactive maintenance
  ~ Media Cleaning (~10 years)
  ~ Electrical panel
    • Remote monitoring and telecommunication with TCOM panel
Christiansburg, Ohio
Total Project Costs (Constructed – From House Plumbing to Discharge)

- Orenco On-Lot STEP (Residential & Commercial) ~ $5,070 per EDU
- Service Laterals ~ $1,038 per EDU
- Tank Abandoning ~ $400 per EDU
- Site Restoration ~ $706 per EDU
- Force Mains ~ $956 per EDU
- AdvanTex® Treatment & WWTP Accessories including Building ~ $6,714 per EDU
- Misc. (i.e. tree removal, storm, etc.) ~ $1,473 per EDU
- Total Constructed Costs ~ $16,358 per EDU
Project Constituents

• Engineering
  ~ Randy VanTilburg, P.E. (Manik Smith Group)
  ~ Brice Schmitmeyer, P.E. (Access Engineering)

• Permitting
  ~ Ohio EPA

• Funding
  ~ Ohio EPA, Ohio Water Development Authority, Ohio Public Works Commission, Community Development Block Grant program.
  ~ Approximately 60% grants and 40% loans
Funding Overview

• Overall Funding
  ~ $2,040,000 Loan (40% Loan)
  ~ $3,060,000 Grant (60% Grant)

• CDBG
  ~ $600,000 Grant

• Ohio Public Works Commission
  ~ $500,000 Grant

• OWDA
  ~ $250,000 Grant

• WPCLF (EPA)
  ~ $1,710,000 Grant
  ~ $2,040,000 Loan
Consumer Rates

• Residential base rate
  ~ $60.00/month/residence

• On-lot packages were installed at no up front cost to the residential or commercial consumers – only paid for package connection
Conclusion

• Won 2015 Top Project Award from Water and Waste Digest
• Small community limitations
• STEP effluent sewer and AdvanTex treatment offers:
  ~ Low O&M requirements
  ~ Low energy usage
  ~ Stable treatment process
  ~ Ease of operation
  ~ Low present worth costs
• Consumer fees are low
• Increased health and safety for the community
• Exceeds NPDES permit limits
Questions?
Presentation Q&A

• What is the mean time between pump outs (pump-out interval) of septic tanks in a STEP system?
  ~ 10 years at 95% confidence level

• T or F: STEP systems are the only collection system that provide primary treatment.
  ~ True

• What are some of the benefits of packed bed filter treatment
  ~ Low O&M, low energy use, reliable, stable, do well with varying and low flows

• T or F: Packed bed filters can meet strict effluent limitations - NH3 less than 1 mg/l, BOD/TSS less than 5 mg/l - when configured properly.
  ~ True
WWTP Flow Path

Equalization Tank

Septic Tank

1st Stage Treatment

Polishing

MBBR Denitrification
Nitrogen Cycle

- Ammonia
  - Nitrification
- Nitrite / Nitrate
  - Denitrification
- Nitrogen Gas
  - Cycle Continues
Questions?
Christiansburg, OH
Wastewater Alternatives Investigated

- Engineering Report Evaluated
  - Conventional gravity collection system to traditional package WWTP
    - Cost prohibitive
    - Concerns about lack of operation experience
  - Conventional gravity collection system pumped to neighboring community
    - No control on what nearby town would charge for treatment