WELCOME TO THE JUNE EDITION OF THE 2017 M&R SEMINAR SERIES
BEFORE WE BEGIN

• SAFETY PRECAUTIONS
  • PLEASE FOLLOW EXIT SIGN IN CASE OF EMERGENCY EVALUATION
  • AUTOMATED EXTERNAL DEFIBRILLATOR (AED) LOCATED OUTSIDE

• PLEASE SILENCE CELL PHONES OR SMART PHONES

• QUESTION AND ANSWER SESSION WILL FOLLOW PRESENTATION

• PLEASE FILL EVALUATION FORM

• SEMINAR SLIDES WILL BE POSTED ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ Reports ⇒ M&R Data and Reports ⇒ M&R Seminar Series ⇒ 2017 Seminar Series)

• STREAM VIDEO WILL BE AVAILABLE ON MWRD WEBSITE (www.MWRD.org: Home Page ⇒ MWRDGC RSS Feeds)
CARLA D. DILLON, Ph.D., PE

**Current:** Engineering Supervisor, Orange County Sanitation District (OCSD), Fountain Valley, California

**Experience:** Lead teams responsible for research, interagency coordination, easements/right-of-way, annexations, sewer transfers, etc.; Planning Director of Emergency Operation Center, when active; As Engineer, Senior Engineer with OCSD, responsible for process engineering and optimization of plant odor control systems, optimized treatment processes to minimize odor generation, etc.; Prior to OCSD, as project engineer for Braun Intertec Corporation, 3M Company, CA Regional Water Quality Control Board

**Education:** Ph.D. (Public Administration), University of La Verne, La Verne, CA  
M.S. (Civil Eng w/ minor in Public Health), Univ of Minnesota, Minneapolis, MN  
B.S (Envir Eng), California Polytechnic State University, San Luis Obispo, CA

**Professional:** Licensed Professional Engineer in C;, Certified Water Treatment Operator; Committee Chair of WEF; Committee member of WE&RF

**Award:** 2012 Jennings Randolph International Fellow, AWWA

**Volunteerism:** City of Long Beach, Sustainable City Commission  
U.S. President’s Volunteer Service Program
Odor Control at the Orange County Sanitation District

Dr. Carla D. Dillon, P.E.
Engineering Supervisor
Orange County Sanitation District
Outline

• OCSD Overview
• Collection System Odor Control
• WRRF/Plant Odor Control
• Complaint Process
• Odor Control Master Plan
• Other odor-related Research
OCSD Service Area

- 396 miles of sewers
- 471 square miles
- 185 million gallons per day
- 2.6 million population
- 20 cities, 4 special districts
- 15 pumping stations
- 2 treatment plants
Governance

25 Member Board

- 20 City Council Representatives
- 2 Sanitary District Representatives
- 2 Water District Representative
- 1 Member of the Orange County Board of Supervisors

Committees

- Steering
- Administration
- Operations
- Legislative & Public Affairs
Reclamation Plant No. 1
Fountain Valley

Treatment Plant No. 2
Huntington Beach
Collection System Odor Control
Wastewater Collection System

- Private Lateral
- Manhole
- City Local Sewer
- Manhole
- OCSD Regional Trunkline
- OCSD Treatment Plants
- To OCWD
- Ocean Outfall
- **Ferrous Chloride** – Used in Gravity Trunks
- **Magnesium Hydroxide** – Used in Force Mains
- **Calcium Nitrate** – Used in Force Mains
- **Caustic (Sodium Hydroxide)** – Used for batch dosing
Westside Pump Station (Los Alamitos)

Critical 1-hour response
SARI Facilities in Yorba Linda

- SARI Gate
- Yorba Linda Spur
- Odor Control
- SAVI Ranch
- SARI Metering Station
Collection System Dosing

• Multi-chemical
  • Iron
  • Magnesium Hydroxide
  • Calcium Nitrate
  • Sodium Hydroxide

• Quality assurance of chemicals

• Real time testing

• Dynamic program to allow for quick change

• ≤ 25 ppm H$_2$S headspace

• ≤ 0.5 ppm dissolved sulfides
Water Resource Recovery Facilities
Odor Control
1. METERING AND DIVERSION
Wastewater enters our plant at 3.5 - 5 mph through pipes up to 10 feet in diameter. High tech equipment monitors the temperature, pH, conductivity, and flow of the incoming wastewater.

2. PRELIMINARY TREATMENT
Raw sewage passes through bar screens that trap large items like rags that cannot be recycled. Materials like greaseonalds and coffee grounds are then removed through the grit chamber that uses high pressure air to separate the gritty material.

3. AIR SCRUBBER
Hydrogen Sulfide (sulfur) is captured throughout the process and funneled into large sludge. It passes through a plastic medium and mixes with caustic soda and bleach, causing the odorous compounds to be neutralized.

4. PRIMARY TREATMENT
Primary clarifiers or settling basins, slow the water down to let the solids that are within the water settle out, separate and float to the surface. Scraper arms that move along the top and bottom remove up to 80% of the solids. Solids are then sent to digesters for processing.

5. SECONDARY TREATMENT
Trickling filters and aeration basins are used to further clean the water. In trickling filters, the water is sprayed over a honeycomb type material upon which aerobic bacteria grow. As the water trickles down, the microorganisms consume the solids that were not removed through primary treatment. Aeration tanks use a combination of oxygen and microorganisms, (activated sludge) that consume the remaining organic solids. Treated water is then sent to the Orange County Water District for recycling, or discharged into the ocean.

6. BIOSOLIDS
Solids captured from primary and secondary processes are batch loaded into anaerobic digesters where they are treated to about 96 degrees and treated for 16-21 days. They enter decanting where water is squeezed out using belt presses. The nutrient rich biosolids are trucked off to farms where they are recycled for direct land application, and composting. The digestion process produces methane gas.

7. CENTRAL GENERATION
Methane gas that is captured from digesters is compressed and used to fuel engine-generators that produce electricity, supplying about 30% of our energy needs.
## WRRF Odor Control – Plant No. 1

<table>
<thead>
<tr>
<th>Process Area</th>
<th>Existing Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headworks</td>
<td>Packed bed chemical scrubbers operated in caustic-bleach mode plus trunkline roughing biofilter</td>
</tr>
<tr>
<td>Primaries</td>
<td>Packed bed chemical scrubbers operated in bleach-only mode</td>
</tr>
</tbody>
</table>
**WRRF Odor Control – Plant No. 1**

<table>
<thead>
<tr>
<th>Process Area</th>
<th>Existing Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activated Sludge (AS-1 &amp; AS-2)</td>
<td>None</td>
</tr>
<tr>
<td>Trickling Filters</td>
<td>None</td>
</tr>
<tr>
<td>DAFT</td>
<td>Packed bed chemical scrubbers operated with plant water only</td>
</tr>
</tbody>
</table>
## WRRF Odor Control – Plant No. 1

<table>
<thead>
<tr>
<th>Process Area</th>
<th>Existing Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truckloading/Dewatering</td>
<td>Packed bed chemical scrubbers operated with plant water only</td>
</tr>
<tr>
<td>Wastehauler Station</td>
<td>Biorem Biofilter (demolished)</td>
</tr>
</tbody>
</table>
## WRRF Odor Control – Plant No. 2

<table>
<thead>
<tr>
<th>Plant 2</th>
<th>Existing Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Headworks</strong></td>
<td>2-sec. EBGRT bioscrubber (recirculating) followed by chemical scrubbers operated in caustic-bleach mode plus trunkline roughing bioscrubbers</td>
</tr>
<tr>
<td><strong>Primaries (NSC &amp; SSC)</strong></td>
<td>Packed bed chemical scrubbers operated in bleach-only mode</td>
</tr>
</tbody>
</table>
## WRRF Odor Control – Plant No. 2

<table>
<thead>
<tr>
<th>Plant 2</th>
<th>Existing Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAFTs</td>
<td>Biofilter</td>
</tr>
<tr>
<td>Trickling Filters</td>
<td>Carbon</td>
</tr>
<tr>
<td>Trickling Filters</td>
<td>None</td>
</tr>
<tr>
<td>Contact Basins</td>
<td>None</td>
</tr>
<tr>
<td>Truckloading</td>
<td>None</td>
</tr>
</tbody>
</table>
Odors

• Compliance

• Complaint Process

• Internal Goals
SCAQMD Rule 402 – Nuisance

Prohibits discharge from any source air contaminants which cause nuisance or annoyance or which endanger the comfort, health or safety of any number of persons or the public.
All Complaints Processed Online

• Logged in by anyone receiving complaint into call center
• Everyone shares and tracks information
Prior Goals for Odor Control

- Design all new projects to retain odor within property boundaries (10 D/T)
- No off-site odors from WRRF’s during normal operations
- 12 complaints per year in Collection System
- Respond to WRRF odor complaints within 1 hour
- Respond to Collection System odor complaints within 1 day
- Respond to spills within 1 hour
Odor Complaints
Odor Control Master Plan

• 2003 Master Plan – H2S based
• 2008 Master Plan – D/T based
• 2017 Master Plan –
2017 Odor Control Master Plan

• Why initiate it
• Monitor
  • Chemical
  • OPM
  • D/T
• Pilot
• Model
• Recommended treatment
Previous Goal

Dispersion

D/T = 300

Wind, Weather

D/T = 10

Process Area

Receptor Beyond Fenceline
Master Plan Criteria

- Determine “most detected” odorant removal efficiency by OCSD treatment systems
- Determine which treatment technology is more effective at removing the combination of odorants identified based on three nuisance criteria:
  1. Current system (do nothing)
  2. Best single stage system
  3. Best multiple stage system
- Determine the odor impact at the fence line for each of the above nuisance criteria, which will become the new Level of Service options
- Determine costs associated with each LOS
Limitations of Analytical Methods

Lab Method Reporting Limit (below this, instruments cannot detect it)

Odor Threshold (below this, nose cannot detect it)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Lab Method Reporting Limit</th>
<th>Odor Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butyric Acid</td>
<td>1</td>
<td>0.1</td>
</tr>
<tr>
<td>Trimethyl Amine</td>
<td>5</td>
<td>0.2</td>
</tr>
<tr>
<td>Methyl Mercaptan</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>Dimethyl Trisulfide</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>Dimethyl Disulfide</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Dimethyl Sulfide</td>
<td>0.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>0.1</td>
<td>2.0</td>
</tr>
</tbody>
</table>
### Odorants Detected at OCSD

<table>
<thead>
<tr>
<th>Odorant</th>
<th>Odor Threshold (ppbV)</th>
<th>Odor Description</th>
<th>Method Reporting Limit (ppbV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetic Acid</td>
<td>1,019</td>
<td>Sour, Vinegar</td>
<td>8.0 – 4.0</td>
</tr>
<tr>
<td>Butyric Acid</td>
<td>0.33</td>
<td>Sour, Sweaty</td>
<td>0.68 – 0.34</td>
</tr>
<tr>
<td>Ammonia</td>
<td>38.28</td>
<td>Pungent, Irritating</td>
<td>0.52 – 0.26</td>
</tr>
<tr>
<td>Trimethyl Amine</td>
<td>0.33</td>
<td>Fishy, Pungent</td>
<td>4.2 – 2.1</td>
</tr>
<tr>
<td>Skatole</td>
<td>0.000075</td>
<td>Fecal, Sewery</td>
<td></td>
</tr>
<tr>
<td>2-Methyl Isoborneol</td>
<td>0.013</td>
<td>Earthy/Musty</td>
<td></td>
</tr>
<tr>
<td>Methyl Mercaptan</td>
<td>0.020</td>
<td>Sulfidy, Rotten Vegetables</td>
<td>5.0</td>
</tr>
<tr>
<td>Carbonyl Sulfide</td>
<td>10.32</td>
<td>Sulfidy</td>
<td>5.0</td>
</tr>
<tr>
<td>Dimethyl Trisulfide</td>
<td>1.2</td>
<td>Rotten Garlic</td>
<td>2.5</td>
</tr>
<tr>
<td>Dimethyl Disulfide</td>
<td>0.026</td>
<td>Rotten Garlic</td>
<td>2.5</td>
</tr>
<tr>
<td>Dimethyl Sulfide</td>
<td>0.99</td>
<td>Canned Corn, Cabbage</td>
<td>5.0</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>0.50</td>
<td>Rotten Eggs</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Determining Odors

Methods:
- Analytical
  - Amines
  - Carboxylic Acids
  - Reduced Sulfur
- Sensorial
  - D/T
  - OPM
    - GC/MS
    - GC/MS sniff

Wastewater Odor
• Develop standard analytical protocols for:
  o 2-Methyl Isoborneol (Earthy/Musty odors)
  o Skatole (Fecal odors) to determine its presence at all process areas
• Develop the Weber-Fechner curves for all 7 “most detectable” odorants:
  o Hydrogen Sulfide (H2S) – Rotten Egg
  o Methyl Mercaptan (MM) – Rotten Vegetable
  o Dimethyl Sulfide (DMS) – Canned Corn
  o Dimethyl Disulfide (DMDS) - Rotten Garlic
  o Ammonia - Pungeant
  o 2- Methyl Isoborneal (MIB) - Musty
  o 2-Isopropyl-3-Methoxypyrazine (IPMP) - Musty
  o Indole - Fecal
  o Skatole - Fecal
Relating Odor Intensity with Concentration

- Odor is recognized by everyone
- Odor becomes uncomfortable
- Odor is unbearable

Intensity vs. Concentration

- Action Level
- Recognition threshold

Intensity: 3
Concentration: Odor is recognized by everyone
Weber-Fechner Curves for "Most Detectable" Odorants

- Ammonia
- Hydrogen Sulfide
- Methyl Mercaptan
- Dimethyl Sulfide
- Dimethyl Disulfide
- Dimethyl Isoborneol
- Isopropyl Methylpyrazine
- Skatole
- Indole

Log Concentration (ppbV) vs. Odor Intensity (OPM)
## Existing Average Odorant Removal Rates

<table>
<thead>
<tr>
<th>Treatment System</th>
<th>H₂S (%)</th>
<th>MM (%)</th>
<th>DMS (%)</th>
<th>DMDS (%)</th>
<th>Ammonia (%)</th>
<th>MIB (%)</th>
<th>IPMP (%)</th>
<th>Skatole (%)</th>
<th>Indole (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PLANT 1 Treatment Systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wastehauler Biofilter</td>
<td>99</td>
<td>99</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>-53</td>
<td>-53</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td>Headworks Scrubbers</td>
<td>91</td>
<td>60</td>
<td>40</td>
<td>42</td>
<td>0</td>
<td>-30</td>
<td>-30</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Primary Scrubbers</td>
<td>92</td>
<td>60</td>
<td>60</td>
<td>42</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>DAFT Scrubbers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dewatering/Truckloading Scrubbers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>PLANT 2 Treatment Systems</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headworks Scrubbers</td>
<td>98</td>
<td>97</td>
<td>70</td>
<td>94</td>
<td>0</td>
<td>72</td>
<td>72</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td>Primary Scrubbers North</td>
<td>85</td>
<td>64</td>
<td>27</td>
<td>0</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Primary Scrubbers South</td>
<td>85</td>
<td>64</td>
<td>27</td>
<td>0</td>
<td>20</td>
<td>40</td>
<td>40</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Trickling Filter Scrubbers</td>
<td>95</td>
<td>97</td>
<td>42</td>
<td>-158</td>
<td>0</td>
<td>65</td>
<td>65</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>DAFT Biofilter</td>
<td>90⁺</td>
<td>80⁺</td>
<td>50⁺</td>
<td>0</td>
<td>20⁺</td>
<td>0</td>
<td>0</td>
<td>43.5</td>
<td>43.5</td>
</tr>
<tr>
<td>Dewatering Scrubbers</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Notes:**
- Negative numbers represent odor generation and are likely because of odorant transformation or conversion within treatment beds.
- All removal rates are calculated strictly from treatment units and are not calculated based on receptor concentrations or fenceline concentrations.
-⁺ Representative because no data provided.
- Since nondetectable, used Plant No. 1 primary scrubber removal rate.
Pilot Testing Research

• Test additional treatment systems and/or pilot treatment unit to determine removal efficiency of “most detected”:
  • Chemical Scrubbers (using different chemical reactants)
  • Biofilters (using different natural media and EBRT’s)
  • Biotowers (using different synthetic media and EBRT’s)
  • Adsorbents (using different media)
  • Reaction Chambers (using ionized air, photo catalytic oxidation, ozone generators, etc.)

• Summarize results in a matrix with existing industry knowledge
Pilot Unit

- Foam Cubes
- Matala & Foam
- Coated Pumice
- Seashells
- Lava Rock
- Coal, Coconut, Permanganate, Activated Carbon
Figure ES-1. Odorant Nuisance Impacts, Baseline Existing Condition – Plant No. 1
# Odorants Recommended for Mitigation

## Plant No. 1 Summary of Sources Recommended for Mitigation

<table>
<thead>
<tr>
<th>Source</th>
<th>H$_2$S</th>
<th>MM</th>
<th>Musty</th>
<th>Fecal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headworks Scrubbers</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary Scrubbers</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAFT Scrubbers</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dewatering/Truckloading Scrubbers</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activated Sludge Basin Stacks</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activated Sludge Basins</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Trickling Filter Open Tops</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cake Truck Loading Door</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wastehauler Station</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Odorants Recommended for Mitigation

### Plant No. 2 Summary of Sources Recommended for Mitigation

<table>
<thead>
<tr>
<th>Source</th>
<th>H₂S</th>
<th>MM</th>
<th>Musty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headworks Scrubbers</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Primary Scrubbers North</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Primary Scrubbers South</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Trickling Filter Contact Basins</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>DAFT Biofilter</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Truckloading Silos Fans</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Cake Truck Loading Door</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Process Area</td>
<td>Recommendation</td>
<td></td>
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</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plant 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headworks</td>
<td>45-sec. EBGRT biofilter (lava rock or engineered media)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primaries</td>
<td>45-sec. EBGRT biofilter (lava rock or engineered media)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAFT</td>
<td>Optimize existing chemical scrubbers operated in caustic-bleach mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truckloading/Dewatering</td>
<td>Optimize existing chemical scrubbers operated in caustic-bleach mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activated Sludge (AS-1 &amp; AS-2)</td>
<td>Cover reactor basins and withdraw foul air through new chemical scrubbers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trickling Filters</td>
<td>Cover towers and withdraw foul air through new chemical scrubbers operated in caustic-bleach mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Plant 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Headworks</td>
<td>45-sec. EBGRT biofilter (lava rock or engineered media)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primaries (NSC &amp; SSC)</td>
<td>New chemical scrubbers operated in caustic-bleach mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trickling Filters</td>
<td>Cover reactor basins and withdraw foul air through new chemical scrubbers operated in caustic-bleach mode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truckloading</td>
<td>Withdraw foul air through new chemical scrubbers operated in caustic-bleach mode</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
OCSD Research

Business opportunity • Partnerships
New technology • Lower cost • Environmental stewardship
Current Digester Gas Treatment

Primary Treatment

Iron (FeCl₃)

3000
20 ppm H₂S

Digester Gas

Central Power Generation System Engines

Electricity
Alternative Digester Gas Treatment

Primary Treatment

Digester Gas

3000 ppm
0 ppm

Digester Gas Treatment

Central Power Generation System Engines

Electricity
Primary Treatment → Digester → Central Power Generation System Engines → Electricity

Water → Digester Gas
Why It Works

<table>
<thead>
<tr>
<th>Compound</th>
<th>Solubility (1)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH₄ (methane)</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>H₂S (hydrogen sulfide)</td>
<td>300</td>
<td>73 : 1</td>
</tr>
<tr>
<td>CO₂ (carbon dioxide)</td>
<td>256</td>
<td>64 : 1</td>
</tr>
</tbody>
</table>

(1) ft³ gas per 1000 gal water
Alternative Digester Gas Treatment

Primary Treatment

H₂S 100% removal
Siloxanes 97% removal
Gas volume 25% less

Digester Gas

[ CO₂ out; O₂ & N₂ in ]

Central Power Generation System Engines

Electricity
Next Steps/Recommendation: Large-Scale Pilot Tests

- Construct instrumented test equipment (2” dia. venturi; 500 gal tank)
- Optimize process performance
- Reduce water usage
- Minimize methane loss
- Respond to changes in digester gas flow
Questions

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