Part One – A Case Study of Projecting the Costs and Land Requirements for a Sustainable Biosolids Land-Application Program for Columbus, Ohio

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The Master Plan

(City of Columbus, OH solids master plan study, that is)

2 treatment plants

182 MGD, avg combined

Options

- Digestion,
- Incineration,
- Composting,
- Land application, and
- Landfilling

What is required to achieve a sustainable land application program?
Part 1
- Costs and Land Requirements

Part 2
- Energy Use and GHG Emissions
Background

Two treatment & dewatering plants:

- Southerly WWTP (S-WWTP)
  - Cake only
  - Compost, incineration, and landfill

- Jackson Pike WWTP (J P-WWTP)
  - Liquid and cake
  - On-site liquid storage (120d)
  - Land app. & Incineration
Jackson Pike

- Incinerated: 77%
- Composted: 23%
- Land Applied: 0%
- Landfilled: 0%

Southerly

- Incinerated: 45%
- Composted: 5%
- Land Applied: 0%
- Landfilled: 5%
Goals: Cost and Acreage

Scenarios:

- J P-WWTP liquid
  - 100% land app
  - 50% land app
  - 25% land app

- S-WWTP cake
  - 100% land app
  - 50% land app
  - 25% land app

- S-WWTP liquid
  - 100% land app
  - 50% land app
  - 25% land app

And / Or
Peeling the onion...

- Crops
- Biosolids Nutrients
- Ag Rate
- Tonnage
- Acreage
- Ag. Land Availability
- Mileage
- Tonnage
- Cost
Acreage needs: Factors

- Tonnage
- Liquid vs. Cake
- Biosolids-fallow field probability (15%)
- Ag.-rate application efficiency (81.5%)
- Crop PAN-need (165 lbs-PAN/Ac)
- Nutrient analysis
- Nitrogen- or Phosphorus-based applications?
- Carryover-N?
## Tonnage

### Southerly WWTP, annual dry tons

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2030(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incinerated</td>
<td>14,073</td>
<td>15,376</td>
<td>15,771</td>
<td>16,419</td>
<td></td>
</tr>
<tr>
<td>Composted</td>
<td>10,214</td>
<td>9,895</td>
<td>9,407</td>
<td>14,716</td>
<td></td>
</tr>
<tr>
<td>Land Applied</td>
<td>2,070</td>
<td>1,034</td>
<td>321</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Landfilled</td>
<td>2,725</td>
<td>1,491</td>
<td>1,210</td>
<td>1,509</td>
<td></td>
</tr>
<tr>
<td>Plant Total</td>
<td>29,082</td>
<td>27,796</td>
<td>26,709</td>
<td>32,644</td>
<td>22,995</td>
</tr>
</tbody>
</table>

### Jackson Pike WWTP, annual dry tons

<table>
<thead>
<tr>
<th></th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2030(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incinerated</td>
<td>16,161</td>
<td>12,375</td>
<td>10,960</td>
<td>8,455</td>
<td></td>
</tr>
<tr>
<td>Composted</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Land Applied</td>
<td>1,344</td>
<td>1,245</td>
<td>1,311</td>
<td>2,572</td>
<td></td>
</tr>
<tr>
<td>Landfilled</td>
<td>0</td>
<td>5</td>
<td>315</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>Plant Total</td>
<td>17,505</td>
<td>13,625</td>
<td>12,587</td>
<td>11,033</td>
<td>12,410</td>
</tr>
</tbody>
</table>
**Liquid vs. Cake**

**Amm. Volatilization**
- Liquid injection = 1.0
- Cake incorporation = 0.5

56% more PAN/DT via liquid injection, requiring more acreage
Application efficiency

- PAN/ Ac crop limits serve as a ceiling
- How high can you go?
- Some crops are difficult to max out
- 81.5%, on average for a well-managed program
## Crop PAN Need

<table>
<thead>
<tr>
<th>Crop</th>
<th>M-Acres, 2002 Census</th>
<th>lbs PAN/Ac</th>
<th>M-lbs PAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybeans for beans</td>
<td>4.7</td>
<td>75</td>
<td>353.9</td>
</tr>
<tr>
<td>Corn for grain</td>
<td>2.9</td>
<td>220</td>
<td>631.4</td>
</tr>
<tr>
<td>Wheat for grain</td>
<td>.8</td>
<td>130</td>
<td>103.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8.4</strong></td>
<td><strong>129.9</strong></td>
<td><strong>1088.8</strong></td>
</tr>
</tbody>
</table>

- **Summary census data represents state-wide average activity**
- **165 lbs PAN/ Ac utilized in projections**
- **For historic Columbus application data, 165 lbs/ Ac is in the 58th percentile**
## Nutrients; N or P?

<table>
<thead>
<tr>
<th>Yr</th>
<th>SOURCE</th>
<th>TS</th>
<th>AmmN</th>
<th>TKN</th>
<th>OrgN</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>JP-WWTP</td>
<td>9.30%</td>
<td>1.63%</td>
<td>3.52%</td>
<td>1.88%</td>
<td>1.93%</td>
<td>0.41%</td>
</tr>
<tr>
<td>2008</td>
<td>JP-WWTP</td>
<td>9.31%</td>
<td>2.02%</td>
<td>4.45%</td>
<td>2.43%</td>
<td>2.14%</td>
<td>0.24%</td>
</tr>
<tr>
<td>2007</td>
<td>S-WWTP</td>
<td>23.18%</td>
<td>2.07%</td>
<td>4.89%</td>
<td>2.82%</td>
<td>2.40%</td>
<td>0.37%</td>
</tr>
<tr>
<td>2008</td>
<td>S-WWTP</td>
<td>22.88%</td>
<td>2.23%</td>
<td>5.43%</td>
<td>3.20%</td>
<td>1.90%</td>
<td>0.37%</td>
</tr>
</tbody>
</table>

**P/N ag-rate ratio indicates 3-5x more acreage is needed for a P-based program**

**Continuous (annual) application requires 23-30% more acreage due to OrgN mineralization**
Acreage required

- Ag rates known, with efficiency factors
- Tonnage & nutrient content known (2030 annual solids production)
  - JP-WWTP 34 DT/day
  - S-WWTP 63 DT/day

Results

- Annual P-based: 67,000 Acres
- Rotation N-based: 63,000 Acres*

* May elevate soil-P over time
Mileage: Factors

- Required acreage
- Availability of suitable farmland
- Cake vs. Liquid
  - 22 WT/load vs. 6250 gal/load
  - 5.5 DT/load vs. 2.6 DT/load

- Current program is 11,650 acres within an average round-trip of 35 miles
- Additional acreage available within 70-mile round trip
Historic data shows sites have an RMS one-way distance of 14 miles.
Site Selection Criteria

Seasonal Soil Wetness Constrains Land Application

- Regional Soil Drainage Analysis
- Landscape Elevation Analysis
- Topographical Wetness Index (TWI) site selection criteria
Regional Soil Drainage

VP – Very poorly drained
SP – Somewhat poorly drained
MWD – Moderately well drained
WD – Well drained
Topographical Wetness Index

Red lines – roads
Black lines – county boundaries
Blue ovals – regions with better drained soils.
**Site Scale, TWI**

**Madison County, Ohio**
- Poorly defined natural drainage patterns (recently glaciated)
- Poorly drained soils
- High TWI values
- Land application only during dry times

**Fairfield County, Ohio**
- Well defined natural drainage patterns (older landscape)
- Well drained soils
- Low TWI values
- Land application year round
Expanded footprint

- 440,000 acres from Fairfield, Hocking, and Licking counties are in farmland*
- 67,000 acres available w/in average 64 mile round-trip

*2005 USDA National Agricultural Statistical Services (NASS) census data
Available work days

- History of land application
- Lack of site storage
  - Wet-weather days
  - Frozen-soil probability
  - Cropping
- Weekends
- Result: 51% of calendar days are viable for land application

Affects trips per work-day
For this study, storage is not included.

Decreases available working days for hauling:
- Wet-weather conditions
- Frozen-soil conditions
- Cropping
Cost

Contractor
- Loading
- Hauling
- Land application

Historic contract data utilized for projections

Mileage ‘correction’ added as needed
$80/DT (~$20/WT for cake)
Lessons

- Phosphorus limitations → use 3-5 yr farm rotation
- Available acreage is not a problem
- Farm storage (or regional storage) would be helpful
- Data management will be critical
- Land application is the most cost effective option available to Columbus
Stay tuned for Part 2!

Part 2: Energy Use and GHG Emissions for Land Application of Biosolids

Presented by Trudy Johnston, Material Matters, Inc.
Questions?

Thanks…

Special thanks to the Columbus staff who worked with Material Matters toward the exploration of a land application program that is numerically, operationally, and financially feasible.

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Lois B. Wachtman, City of Columbus, Department of Public Utilities