The Sludge Thickens! Gravity Belt Thickening to Increase Efficiency – City of Elyria Wastewater Pollution Control Plant

Terry Korzan – Superintendent – Elyria Wastewater Pollution Control Plant
Tim McCann – Project Manager – AECOM
Agenda

- Elyria WWPCP Background
  - Treatment Process
  - Overall Solids Process
- Thickening Project History
- Plant Performance/Solids Treatment
- Sludge Thickening Alternatives
- Project Details and Description
- Sludge Thickening Considerations
City of Elyria WWPC – Plant Location

– Located on Gulf Road in Elyria, Ohio
– Treats flow from Elyria and surrounding townships
– Mix of residential, commercial and industrial wastewater
– Decrease in industrial flow
– Outfall to Black River
– Tributary to Lake Erie
City of Elyria Wastewater Pollution Control Plant (WWPCP)

- 1929 – Original Construction – 3.6 MGD
  • Primary settling > activated sludge aeration > final settling
- 1961-63 – Upgraded to 8.5 MGD
- 1986-89 – Last Major Expansion – 13 MGD design
  • Additional primary, aeration, and final tanks
  • Intermediate settling tanks
  • Trickling filters
  • Flocculation channel
  • Chlorine contact tank
  • Wet weather storage tank
  • Screen and grit building
City of Elyria WWPC – Plant Overview

Designed as a two-stage biological activated sludge plant. The trickling filters taken out of service in 2007.

− Design dry weather flow: 13 MGD
− Design wet weather flow: 30 MGD
− Design preliminary flow: 60 MGD
− Plans for expansion from 30 to 40 MGD wet weather
− East side influent: 27” and 48” interceptors
− West side influent: 72” interceptor
− East and West head works:
  • Bar screens
  • Detritus (grit) tanks
City of Elyria WWPC – Plant Overview cont.

- Primary clarifiers:
  - 4 east side
  - 2 west side
- Grease skimmers and sludge removal
- Activated sludge process
  - 5 aeration basins
- Phosphorus removal
- Final clarification
- UV disinfection
Elyria WWPCP – Aerial View
City of Elyria WWPC – Solids Handling

- Primary sludge to anaerobic digesters
- WAS to gravity belt thickener
- GBT thickened sludge to anaerobic digesters (filtrate to head works)
- Digested sludge to belt filter presses
- Sludge cake to Lorain County Landfill (filtrate to head works)
Elyria WWPC – Influent Processing

– Average dry weather flow: 6 MGD
– If all six PSTs online, long DT (5.7 hours) → Septicity
– West PSTs designed for 25 MGD flow
– 3 control gates: A, B, and C
– All dry weather flows → West PSTs

– Wet weather:
  • 23 MGD through West PSTs
  • 7 MGD through East PSTs
Sludge Thickening – Project Background

– Elyria is a CSO/separate community
– Developed Long Term Control Plan and negotiating with EPA for plan acceptance
– Address bypasses to the plant excess wet weather flows
– Plan is to increase plant capacity to 40 MGD
– Wet weather storage and treatment for excess flows
City of Elyria WWPC – Historical Sludge

- Plant original design: WAS to primary clarifiers (0.5%)
- WAS very light and floccy
- Dry WX and Wet WX: WAS → Aeration
- Very difficult to control MLSS

- 2008 WAS redirected to PST 1 and PST 2 for gravity thickening
- Total tank volume = 277,560 gallons
- Waste rate varied:
  • 80 GPM = 115,200 GPD (MLSS steady state rate)
  • 300 GPM = 432,000 GDP (MLSS catch up rate)
  • 400 GPM = 576,000 GPD (Biomass bloom rate)
- Tank volume exceeded: WAS → Aeration basins
City of Elyria WWPC – Historical Sludge, cont.

- Inefficient pathway to anaerobic digesters
  - FSTs to PSTs to Telescopic Valves to Sludge Well to Digesters
- Total digester volume: 1.56 MG
- Primary sludge to digesters: 45,000 – 134,000 GPD (2-3% solids at best)
- Digester detention time varied: 12 – 34 days
- Lower sludge volatile reduction (42-45%)
- Four belt filter presses in use Mon – Fri, plus OT during Spring biomass blooms in aeration basins
- 2-3 loads of sludge cake (22 wt/load) hauled out daily
- Sludge cake % solids: 17-21% (paying for water hauled)
Solids Flow Schematic – Prior to Dedicated Sludge Thickening

Primary Settling Tanks

Screening & Grit Removal

Aeration Tanks

Final Settling Tanks

Disinfection & Outfall

* WAS Thickening in PST

Primary Digesters

Secondary Digesters

Belt Press

Landfill

* WAS

WAS

RAS
## Sludge Generation with Thickening in Primary Settling Tank

<table>
<thead>
<tr>
<th>Year</th>
<th>Sludge to Digesters</th>
<th>Primary Sludge</th>
<th>Waste Activated Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Day (GPD)</td>
<td>% Total Solids</td>
<td>% Volatile Solids</td>
</tr>
<tr>
<td>2011</td>
<td>37,760</td>
<td>4.1%</td>
<td>64.0%</td>
</tr>
<tr>
<td>2012</td>
<td>42,240</td>
<td>3.6%</td>
<td>65.2%</td>
</tr>
<tr>
<td>2013</td>
<td>44,580</td>
<td>4.3%</td>
<td>65.2%</td>
</tr>
<tr>
<td>2014</td>
<td>41,800</td>
<td>4.8%</td>
<td>66.5%</td>
</tr>
<tr>
<td>Average</td>
<td>41,600</td>
<td>4.2%</td>
<td>65.2%</td>
</tr>
</tbody>
</table>
Solids Flow Schematic – Thickening Improvements

Primary Settling Tanks

Screening & Grit Removal

Primary Digesters

Secondary Digesters

Aeration Tanks

Sludge Thickening

Belt Press

WAS

Final Settling Tanks

Disinfection & Outfall

RAS

Landfill

The Sludge Thickens! Gravity Belt Thickening to Increase Efficiency – City of Elyria Wastewater Pollution Control Plant
Benefits of Elyria WWPC GBT Process

- Dramatic increase in several operational efficiencies
- Primary sludge to digesters averages 19,000 GPD @ 3.8% solids
- WAS sludge to GBT averages 144,000 GPD @ 0.5% solids (Range = 115,000 to 173,000 GPD)
- GBT thickened sludge to digesters averages 23,000 GPD @ 5-7% solids (only 14% of GBT feed volume)
- Consistent feed to digesters
- Consistent digester detention time of 37-42 days
- Increased volatile reduction (62%)
- Two belt filter presses in use; have days with no presses
- Averaging 17 loads of sludge cake to landfill per month
- Sludge cake % solids = 25-29% (savings on disposal)
Sludge Thickening Basics

- Thickening: Volume reduction by increasing the solids concentration of the sludge by removing a portion of the liquid

**WAS**
- 2,000 kg/hr
- 0.5% solids conc
- 111 L/sec

**Thickener**
- **Filtrate**
  - 100 kg/hr
  - 102 L/sec

**Thickened Sludge**
- 95% Capture
- 6% solids conc.
- 1,900 kg/hr
- 9 L/sec

**92% Reduction in Volume**
Liquid Volume Reduction by Thickening

When the sludge thickens, the gravity belt thickening process increases efficiency. The chart above illustrates the liquid volume reduction in gallons of 2000 lb of dry solids at various concentration percentages. For example, a concentration of 0.50% results in a 50% liquid volume reduction, while 2.00% concentration results in a 75% reduction. The reduction percentages continue to increase with higher concentrations, reaching up to 92% for 6.00% concentration.
Sludge Thickening – Preliminary Engineering

- Identified thickening is needed
- Type of thickening?
- Capacity?
- Which sludge?
- Location?
- Automation?
- Filtrate discharge?
- Preliminary engineering report developed to evaluate capacity, equipment, process, etc.
Determine Sludge Quantities and Characteristics

- Historical average sludge generation rates and characteristics
- Biowin modeling to predict future rates
- Identification of peak quantities
## Anticipated Influent Wastewater Characteristics

<table>
<thead>
<tr>
<th>Loading Condition</th>
<th>Flow (MGD)</th>
<th>CBOD$_5$ (lb/d)</th>
<th>TSS (lb/d)</th>
<th>NH$_3$-N (lb/d)</th>
<th>Total P (lb/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>8.17</td>
<td>8,490</td>
<td>10,900</td>
<td>950</td>
<td>260</td>
</tr>
<tr>
<td>Maximum Month</td>
<td>16.5</td>
<td>10,600</td>
<td>16,700</td>
<td>1,070</td>
<td>290</td>
</tr>
<tr>
<td>Maximum Day (2)</td>
<td>40.0(2)</td>
<td>34,400(1)</td>
<td>55,400(1)</td>
<td>3,130(1)</td>
<td>580(1)</td>
</tr>
</tbody>
</table>

**Notes:**

1. Maximum day loading for parameters represents 99.7 percentile (expected maximum yearly value)
2. Influent to the WWPCP during wet weather will be limited to 40 MGD, the proposed future peak secondary capacity.
### Model-Predicted Sludge Quantities and Generation Rates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Sludge Generated at Average Plant Influent Flow Rate</th>
<th>Sludge Generated at Maximum Month Plant Influent Flow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Primary</td>
<td>WAS</td>
</tr>
<tr>
<td>Sludge Waste Rate, gal/day</td>
<td>20,000</td>
<td>250,000</td>
</tr>
<tr>
<td>Percent Solids</td>
<td>4.50</td>
<td>0.42</td>
</tr>
<tr>
<td>TSS ¹, lb/day</td>
<td>7,670</td>
<td>8,720</td>
</tr>
</tbody>
</table>

**Notes:**
1. Assumed specific gravities of 1.02 for primary sludge, 1.005 for WAS, and 1.013 for combined sludge.
### Peak Sludge Quantities for Design – 25% Safety Factor

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Primary</th>
<th>WAS</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sludge Waste Rate, gal/day</td>
<td>37,500</td>
<td>350,000</td>
<td>387,500</td>
</tr>
<tr>
<td>Percent Solids</td>
<td>4.55</td>
<td>0.54</td>
<td>0.93</td>
</tr>
<tr>
<td>TSS (^1), lb/day</td>
<td>14,500</td>
<td>15,800</td>
<td>30,400</td>
</tr>
</tbody>
</table>

**Notes:**
1. Assumed specific gravities of 1.02 for primary sludge, 1.005 for WAS and 1.013 for combined sludge.
Sludge Thickening Technologies

- Evaluation of viable thickening technologies
- Conventional gravity thickening
- Gravity belt thickening
- Rotary drum thickening
- Other options
  - Centrifuge
  - Floatation thickening
  - Screw thickening
  - Disk thickening
Gravity Thickening

- Process similar to settlement tanks in the liquid stream process
- Most effective on primary sludge, can be used for secondary sludge with polymer addition
- May require covers and odor control
- Provides storage
- Supernatant or Overflow Returned to:
  - Headworks
  - Primary Tanks
  - Return Flow Treatment
Gravity Thickening

<table>
<thead>
<tr>
<th>Sludge Type</th>
<th>Feed Solids Concentration</th>
<th>Thickened Sludge Solids Concentration</th>
<th>Solids Loading, kg/m²/day</th>
<th>Hydraulic Loading, m³/m²/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>1-6</td>
<td>3-10</td>
<td>100-150</td>
<td>15.5-31</td>
</tr>
<tr>
<td>WAS</td>
<td>0.5-1.5</td>
<td>2-3</td>
<td>20-40</td>
<td>4-8</td>
</tr>
<tr>
<td>Primary + WAS</td>
<td>0.5-1.5</td>
<td>2-6</td>
<td>25-70</td>
<td>6-12</td>
</tr>
</tbody>
</table>
Gravity Belt Thickening

– Sizes: 0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 meter
– Open or enclosed
– Manufacturers: Andritz, Komline Sanderson, BDP, Charter Machine
– Process Controls
  • Sludge and polymer feed rates
  • Mixing device pressure drop
  • Belt speed
  • Belt washwater supply pressure
Gravity Belt Thickening

<table>
<thead>
<tr>
<th>Sludge Type</th>
<th>Feed Solids Conc, %</th>
<th>Volume Reduction, %</th>
<th>Thickened Sludge Solids Conc, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>3 to 5</td>
<td>60 to 80</td>
<td>8 to 15</td>
</tr>
<tr>
<td>WAS</td>
<td>0.5 to 0.9</td>
<td>85 to 95</td>
<td>5 to 7</td>
</tr>
<tr>
<td>Primary + WAS</td>
<td>0.8 to 2</td>
<td>85 to 90</td>
<td>6 to 11</td>
</tr>
</tbody>
</table>
Rotary Drum Thickening

- Application: Primary, WAS and Primary + WAS mixture
- Enclosed
- BDP, Parkson
- Process Control
  - Sludge and Polymer feed rates
  - Mixing device pressure drop
  - Drum Speed
  - Pond Depth
### Rotary Drum Thickening

<table>
<thead>
<tr>
<th>Sludge Type</th>
<th>Feed Solids Conc, %</th>
<th>Thickened Sludge Solids Conc, %</th>
<th>Solids Recovery, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>3 to 6</td>
<td>7 to 9</td>
<td>93 to 98</td>
</tr>
<tr>
<td>WAS</td>
<td>0.5 to 1.0</td>
<td>4 to 9</td>
<td>93 to 99</td>
</tr>
<tr>
<td>Primary + WAS</td>
<td>2 to 4</td>
<td>5 to 9</td>
<td>93 to 98</td>
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</table>

**Sizing Criteria for Rotary Drum Thickeners**
## Sludge Thickening Alternative Evaluations

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>Combined Primary and WAS to Digester</th>
<th>Pounds per Day (Dry Wt.)</th>
<th>GPD</th>
<th>% Total Solids</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>- No Sludge Thickening</td>
<td></td>
<td>30,400</td>
<td>387,500</td>
<td>0.93%</td>
</tr>
<tr>
<td></td>
<td>- WAS Thickening in PSTs and No Primary Sludge Thickening (Current Operation)</td>
<td></td>
<td>26,400</td>
<td>94,100</td>
<td>3.3%</td>
</tr>
<tr>
<td>1A</td>
<td>GBT of WAS Only</td>
<td></td>
<td>27,300</td>
<td>62,800</td>
<td>5.1%</td>
</tr>
<tr>
<td>1B</td>
<td>GBT of Combined WAS/Primary Sludge with Pre-Thickening</td>
<td></td>
<td>24,500</td>
<td>41,500</td>
<td>7%</td>
</tr>
<tr>
<td>1C</td>
<td>GBT of Combined WAS/Primary Sludge without Pre-Thickening</td>
<td></td>
<td>28,900</td>
<td>48,900</td>
<td>7%</td>
</tr>
<tr>
<td>2A</td>
<td>RDT of WAS Only</td>
<td></td>
<td>27,300</td>
<td>62,800</td>
<td>5.1%</td>
</tr>
<tr>
<td>2B</td>
<td>RDT of Combined WAS/Primary Sludge</td>
<td></td>
<td>24,500</td>
<td>41,500</td>
<td>7%</td>
</tr>
<tr>
<td>3A</td>
<td>Gravity Thickening of WAS Only</td>
<td></td>
<td>27,900</td>
<td>117,400</td>
<td>2.7%</td>
</tr>
<tr>
<td>3B</td>
<td>Gravity Thickening of Combined WAS/Primary Sludge</td>
<td></td>
<td>25,800</td>
<td>61,900</td>
<td>5%</td>
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</table>
# Alternatives Cost Evaluation

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>1A</th>
<th>1B</th>
<th>1C</th>
<th>2A</th>
<th>2B</th>
<th>3A</th>
<th>3B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital Cost</td>
<td>Total Project Cost(^1)</td>
<td>Annual O&amp;M Cost</td>
<td>Life Cycle Cost(^2)</td>
<td>Capital Cost</td>
<td>Total Project Cost(^1)</td>
<td>Annual O&amp;M Cost</td>
</tr>
<tr>
<td>GBT Thickening of WAS (only)-Attended Operation</td>
<td>$3,522,000</td>
<td>$4,015,000</td>
<td>$39,300</td>
<td>$4,695,000</td>
<td>$3,630,000</td>
<td>$4,138,000</td>
<td>$49,100</td>
</tr>
<tr>
<td>GBT Thickening of WAS and Primary Sludge-Attended Operation</td>
<td>$3,630,000</td>
<td>$4,138,000</td>
<td>$49,100</td>
<td>$4,986,000</td>
<td>$2,540,000</td>
<td>$2,896,000</td>
<td>$94,100</td>
</tr>
<tr>
<td>GBT Thickening of WAS and Primary Sludge-Unattended Operation</td>
<td>$2,540,000</td>
<td>$2,896,000</td>
<td>$94,100</td>
<td>$4,524,000</td>
<td>$3,413,000</td>
<td>$3,891,000</td>
<td>$37,600</td>
</tr>
<tr>
<td>RDT Thickening of WAS (only)-Attended Operation</td>
<td>$3,413,000</td>
<td>$3,891,000</td>
<td>$37,600</td>
<td>$4,542,000</td>
<td>$3,471,000</td>
<td>$3,957,000</td>
<td>$47,400</td>
</tr>
<tr>
<td>RDT Thickening of WAS and Primary Sludge-Attended Operation</td>
<td>$3,471,000</td>
<td>$3,957,000</td>
<td>$47,400</td>
<td>$4,777,000</td>
<td>$2,306,000</td>
<td>$2,629,000</td>
<td>$41,200</td>
</tr>
<tr>
<td>Gravity Thickening of WAS (Only)</td>
<td>$2,306,000</td>
<td>$2,629,000</td>
<td>$41,200</td>
<td>$3,342,000</td>
<td>$2,401,000</td>
<td>$2,737,000</td>
<td>$49,000</td>
</tr>
<tr>
<td>Gravity Thickening of WAS and Primary Sludge</td>
<td>$2,401,000</td>
<td>$2,737,000</td>
<td>$49,000</td>
<td>$3,584,000</td>
<td>$2,401,000</td>
<td>$2,737,000</td>
<td>$49,000</td>
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</tbody>
</table>

\(^1\) Total Project Cost includes Capital Cost and O&M Cost.
\(^2\) Life Cycle Cost includes Capital Cost, O&M Cost, and the additional cost for installation of new equipment.
Selected Alternative – Gravity Belt Thickener

- 87% reduction in sludge feed
- Minimize sludge blankets
  - Continuously waste activated sludge from the FSTs
  - Continuously waste primary sludge from the PSTs
- Continually feed sludge to digesters
  - Maintain more stable digester operation and performance
Location of New Thickening Facilities

– Need to work within existing plant structures and utilities
– Evaluated alternatives to reduce costs
Utilize Existing Tank for Sludge Thickening Location

Chemical Storage & Feed Building

Old Final Settling Tank
Basis of Project Design

- Utilize existing empty settling tank as sludge well
- Construct new building above tank
- Connect off existing WAS line
- New primary sludge line
- Blended sludge mixing
- Thickened sludge pumped to digester feed line
- Polymer solution feed system
Elyria Gravity Belt Thickener

- Komline-Sanderson – Gravabelt
- Porous horizontal belt
- Roto-Kone utilized to lift and decelerate incoming sludge
- Continuous belt washing
- One duty and one standby unit
Elyria Gravity Belt Thickener cont.
Elyria Gravity Belt Thickener cont.
Elyria Gravity Belt Thickener cont.

Polymer Injection

Wash Water Pumps
Sludge Mixing System

- Pulsair mixing system
- Utilizes large air bubbles to keep sludge mixed in the well
- Eliminates mechanical equipment in the sludge
- Air compressor sends pulses of air into the tank
- Flat, round disks push air out on the tank floor
- Air bubbles accumulate into large air bubble
Built on top of existing tank
Cast-in-place concrete floor slab
Sealed from tank below to prevent tank atmosphere into building
Insulated concrete block walls
- Knock-out panel – equipment removal
Match existing chemical building
Precast concrete panel roof
Skylights for natural lighting
Doors for equipment access
Control panel room for controls and electrical equipment
- Independent HVAC system
Sludge Piping

Primary Sludge

Thickened Sludge

The Sludge Thickens! Gravity Belt Thickening to Increase Efficiency – City of Elyria Wastewater Pollution Control Plant
Gravity Thickening Process Pumps
Gravity Thickening Process Pumps, Cont.

Waste Activated Sludge Pumps
- Gorman Rupp Self Priming

GBT Feed Pumps
- Boerger Rotary Lobe
Gravity Thickening Process Pumps, Cont.

Filtrate Pumps
KSB Dry Pit Centrifugal

Thickened Sludge Pumps
Seepex Progressive Cavity
Sludge Thickening – Bid Tabulations

Engineer’s Estimate: $2,700,000

<table>
<thead>
<tr>
<th>Contractor</th>
<th>Bid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractor 1</td>
<td>$3,121,000</td>
</tr>
<tr>
<td>Contractor 2</td>
<td>$2,189,998</td>
</tr>
<tr>
<td>Contractor 3</td>
<td>$2,583,500</td>
</tr>
<tr>
<td>Contractor 4</td>
<td>$2,430,000</td>
</tr>
<tr>
<td>Contractor 5</td>
<td>$2,046,000</td>
</tr>
<tr>
<td>Contractor 6</td>
<td>$2,669,000</td>
</tr>
<tr>
<td>Contractor 7</td>
<td>$2,800,050</td>
</tr>
</tbody>
</table>

The Sludge Thickens! Gravity Belt Thickening to Increase Efficiency – City of Elyria Wastewater Pollution Control Plant
Considerations and Lessons Learned

- Re-piping filtrate from aeration tanks to headworks
  - Polymer caused issues in final settling tanks
  - Better settling in primaries with polymer
- Piping interconnection between GBT units – trip hazard
  - Walkway over the piping
- CCTV Cameras and Alarms
  - Unmanned operation
Questions?
Thank You

Terry Korzan: tkorzan@cityofelyria.org
Tim McCann: timothy.mccann@aecom.com
Elyria WWPCP – Plan View
Elyria WWPCP – Overall Flow Schematic