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

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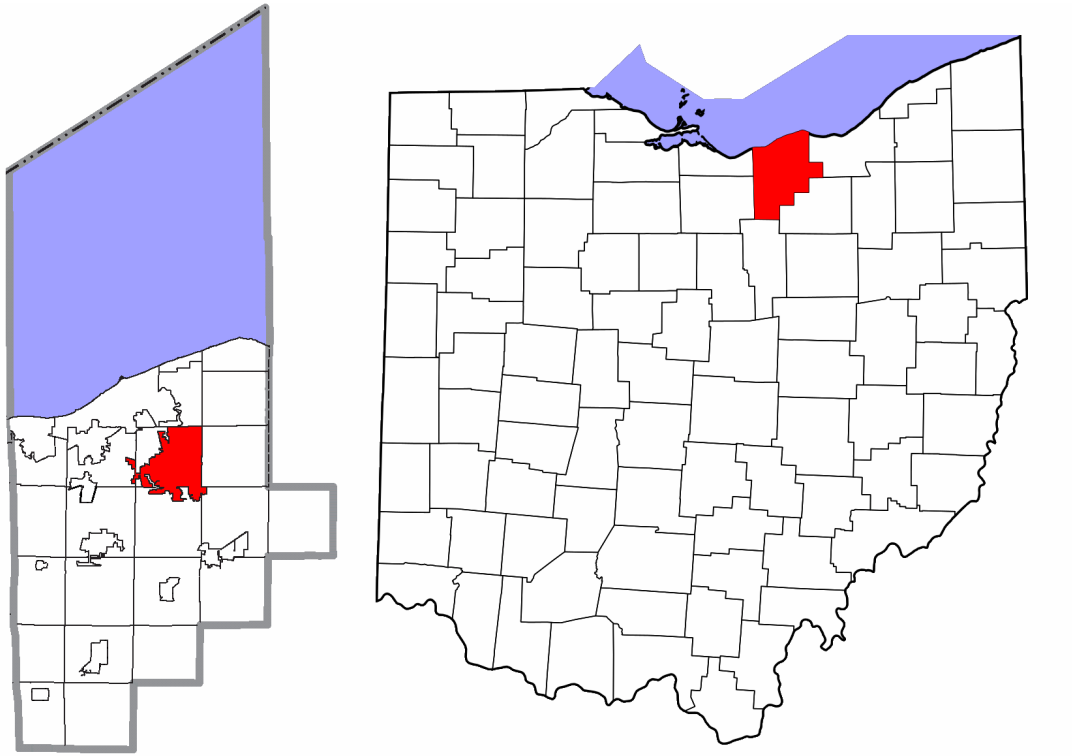
Agenda

- 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



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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

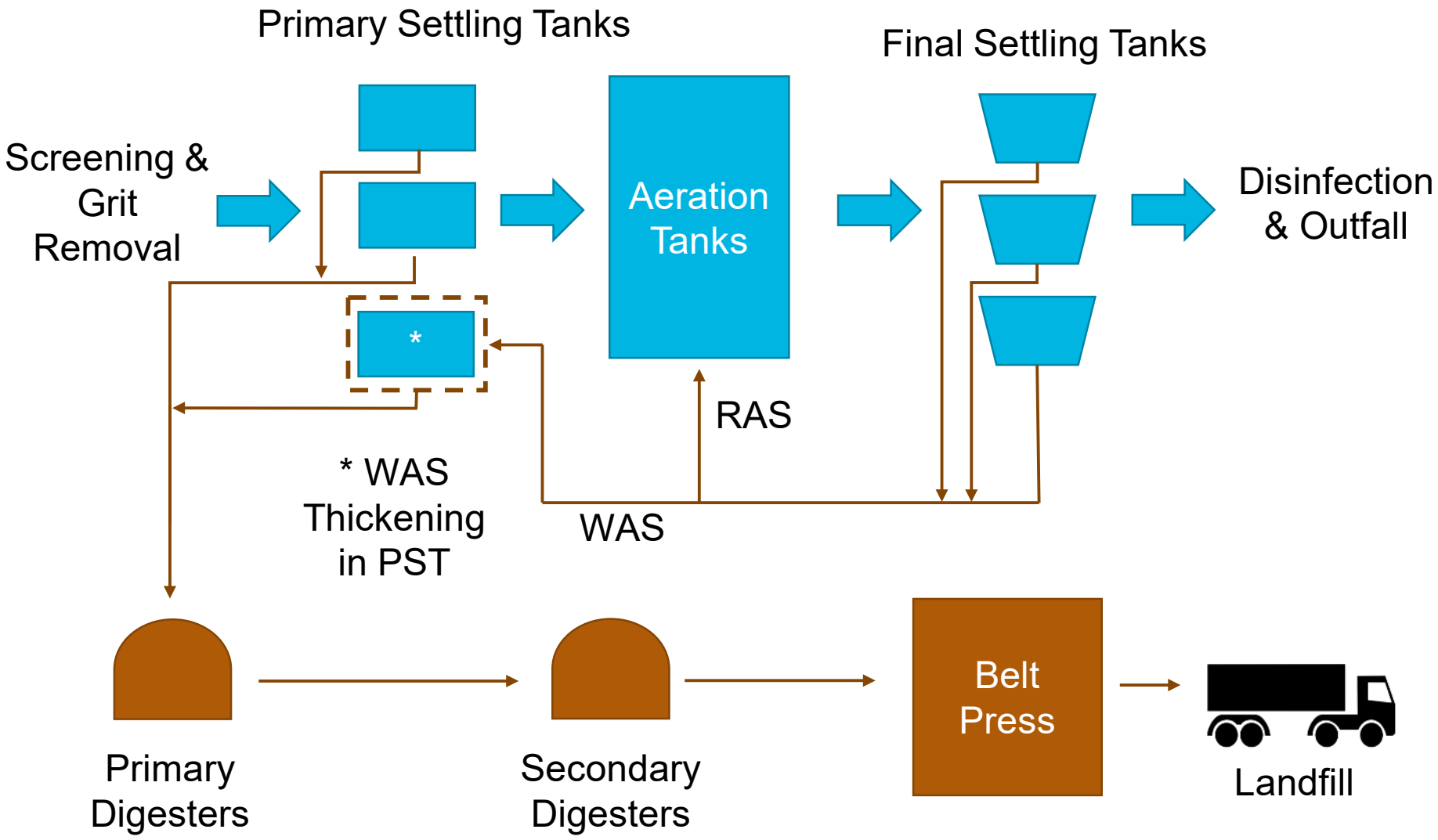
- Plant original design: WAS to primary clarifiers (0.5%)
- WAS very light and floccy
- Dry WX and Wet WX: WAS → Aeration
- Very difficult to control MLSS

- 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



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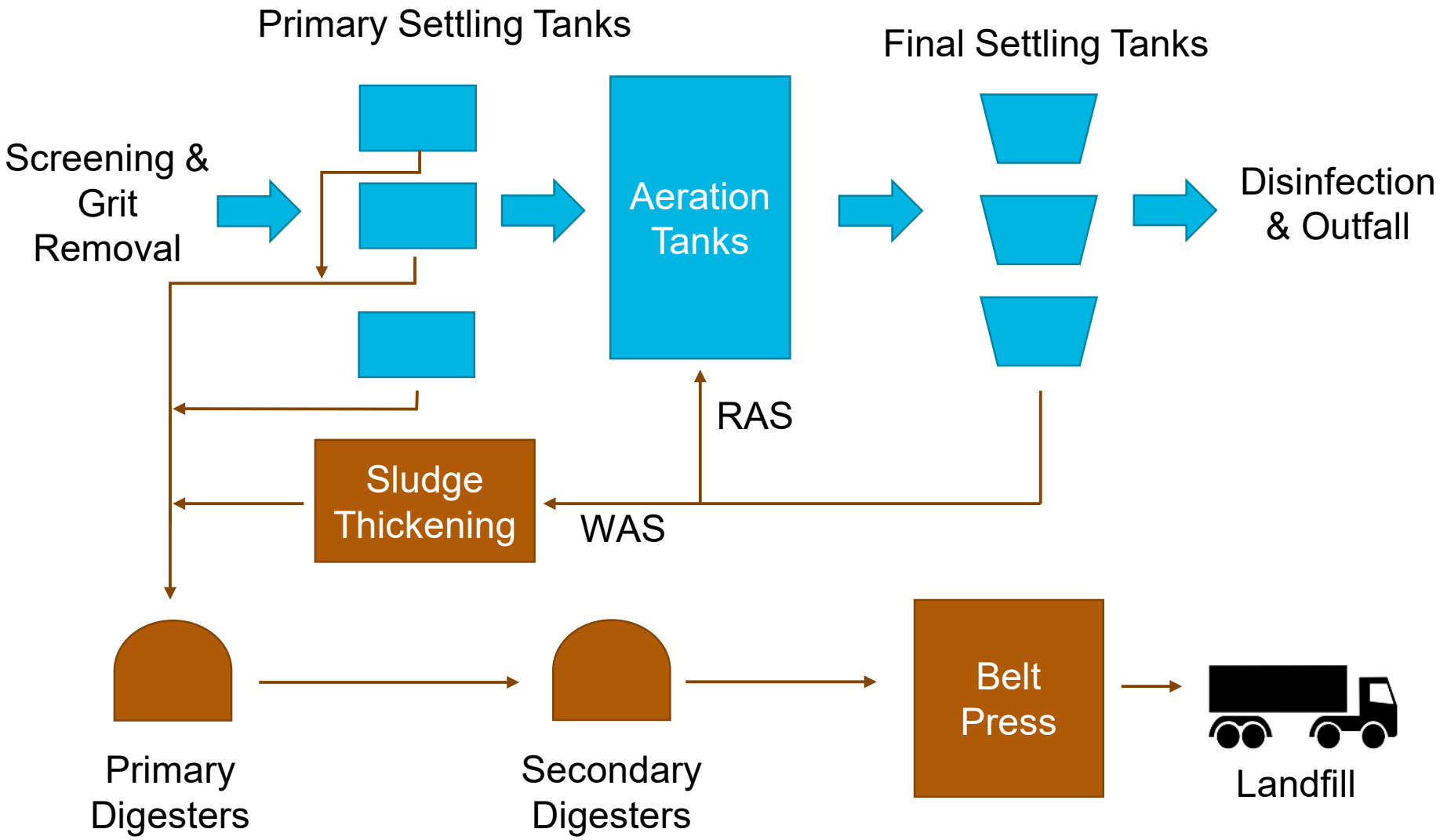
Sludge Generation with Thickening in Primary Settling Tank

Year	Sludge to Digesters	Primary Sludge			Waste Activated Sludge		
	Average Day (GPD)	% Total Solids	% Volatile Solids	% Fixed Solids	% Total Solids	% Volatile Solids	% Fixed Solids
2011	37,760	4.1%	64.0%	34.8%	2.9%	59.4%	40.6%
2012	42,240	3.6%	65.2%	36.1%	2.9%	54.9%	46.2%
2013	44,580	4.3%	65.2%	34.8%	2.7%	58.7%	41.3%
2014	41,800	4.8%	66.5%	33.5%	2.9%	60.0%	40.0%
Average	41,600	4.2%	65.2%	34.8%	2.8%	58.3%	47.5%

Solids Flow Schematic – Thickening Improvements



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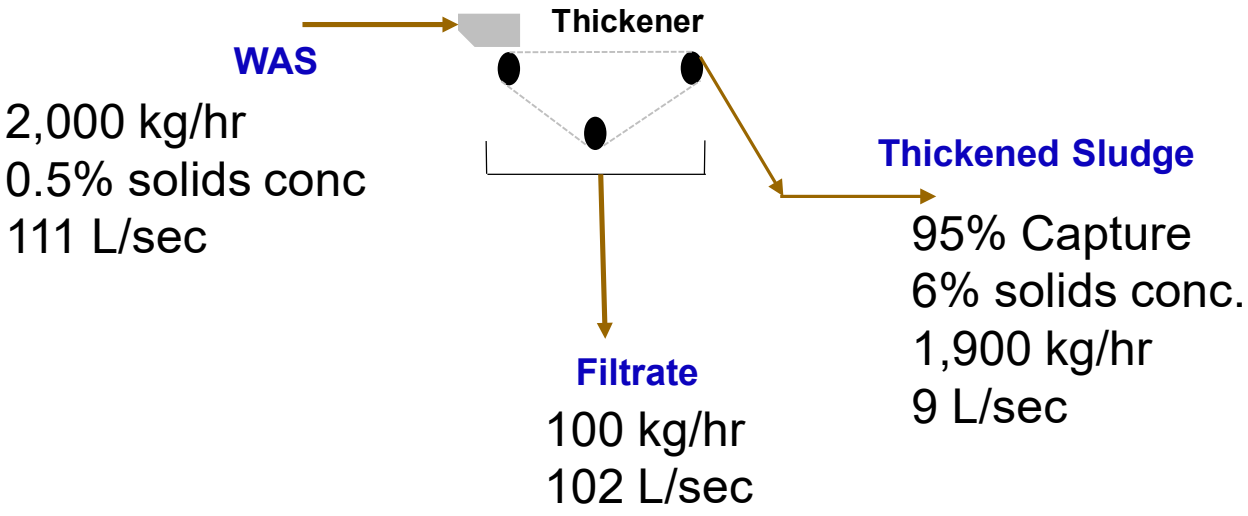
Benefits of Elyria WWPC GBT Process

- 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)

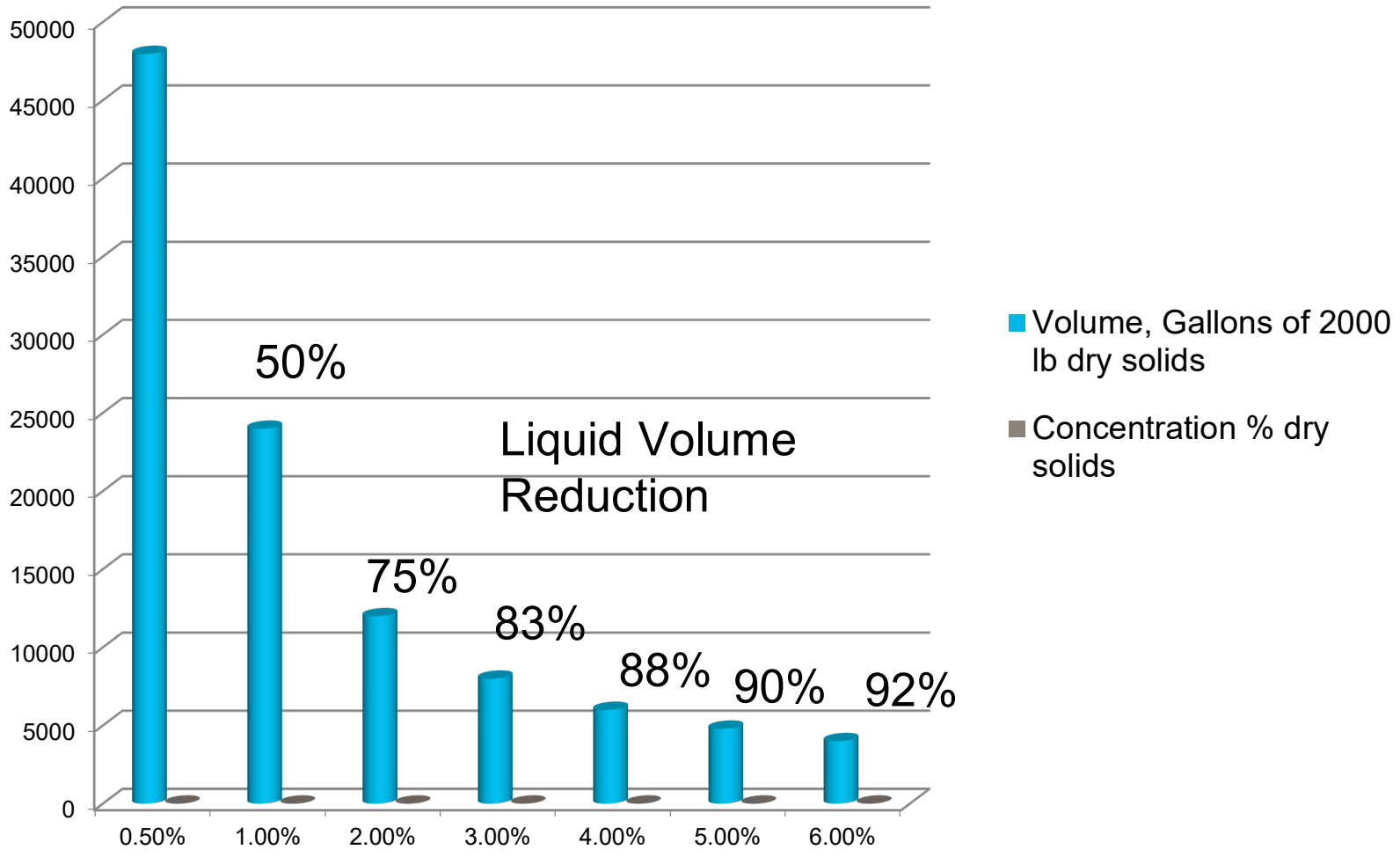
Sludge Thickening Basics

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



92% Reduction in Volume

Liquid Volume Reduction by Thickening



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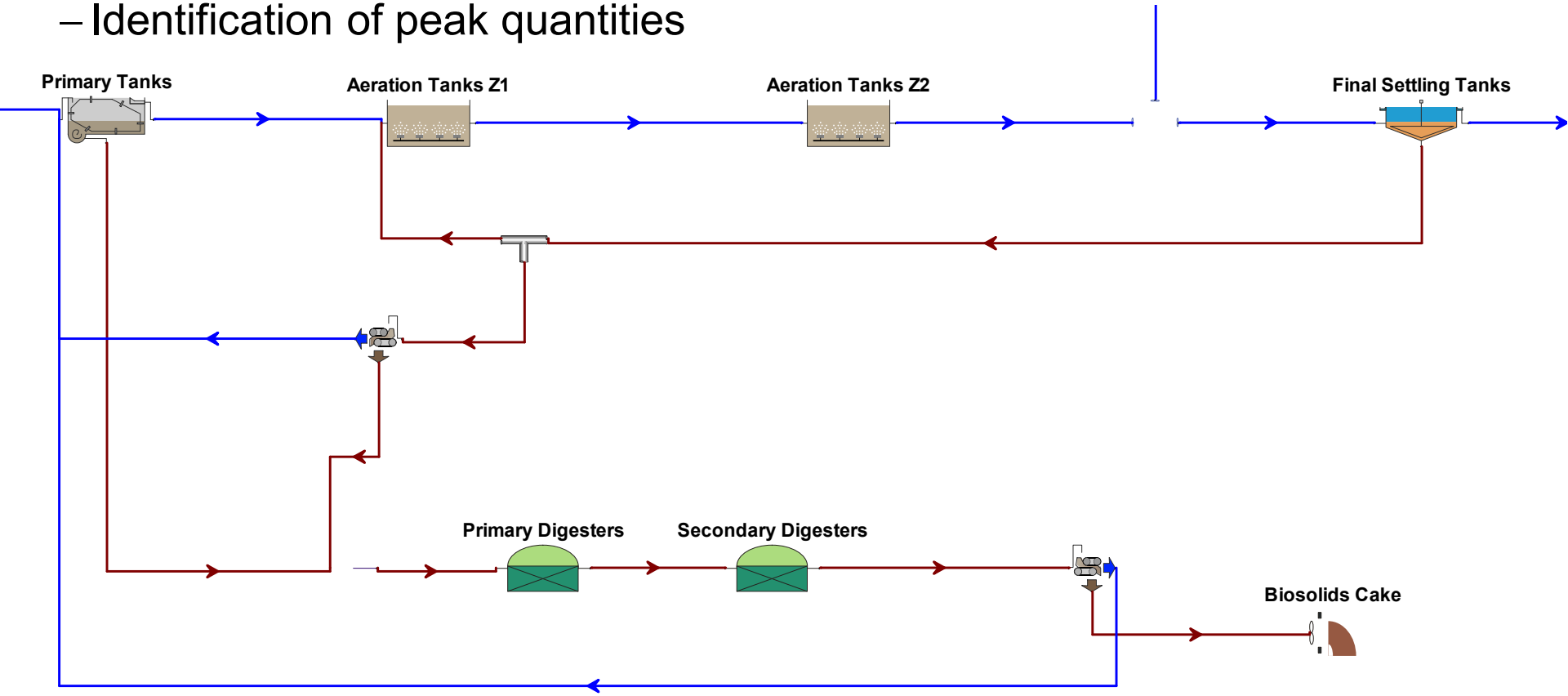
Sludge Thickening – Preliminary Engineering

- 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

Loading Condition	Flow (MGD)	$CBOD_5$ (lb/d)	TSS (lb/d)	NH_3-N (lb/d)	Total P (lb/d)
Average	8.17	8,490	10,900	950	260
Maximum Month	16.5	10,600	16,700	1,070	290
Maximum Day (2)	40.0(2)	34,400(1)	55,400(1)	3,130(1)	580(1)

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

Parameter	Sludge Generated at Average Plant Influent Flow Rate			Sludge Generated at Maximum Month Plant Influent Flow Rate		
	Primary	WAS	Combined	Primary	WAS	Combined
Sludge Waste Rate, gal/day	20,000	250,000	270,000	30,000	280,000	310,000
Percent Solids	4.50	0.42	0.72	4.55	0.54	0.93
TSS [1], lb/day	7,670	8,720	16,390	11,600	12,670	24,460

Notes:

1. **Assumed specific gravities of 1.02 for primary sludge, 1.005 for WAS, and 1.013 for combined sludge.**

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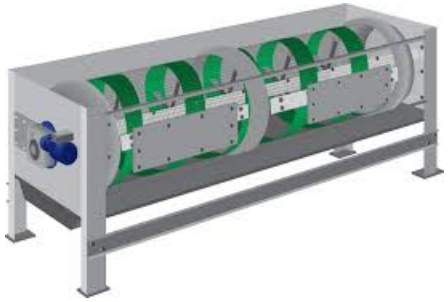
Peak Sludge Quantities for Design – 25% Safety Factor

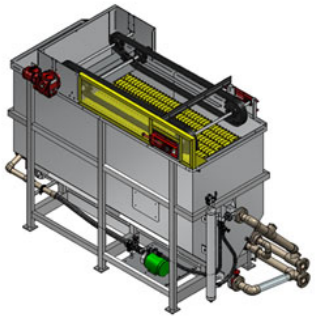
Parameter	Primary	WAS	Combined
Sludge Waste Rate, gal/day	37,500	350,000	387,500
Percent Solids	4.55	0.54	0.93
TSS [1], lb/day	14,500	15,800	30,400

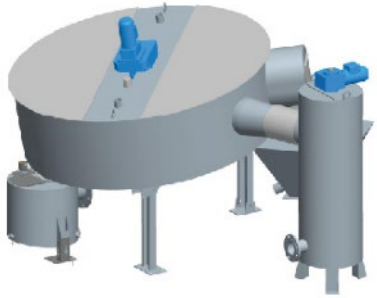
Notes:
1. Assumed specific gravities of 1.02 for primary sludge, 1.005 for WAS and 1.013 for combined sludge.

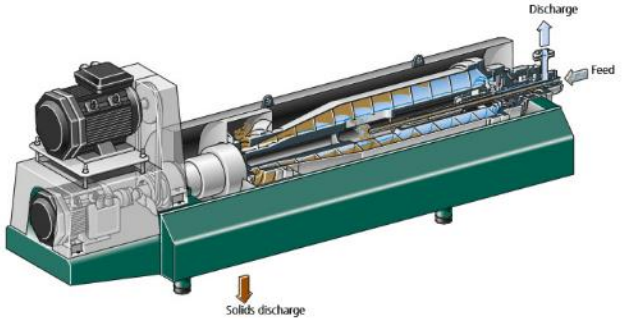
Sludge Thickening Technologies

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



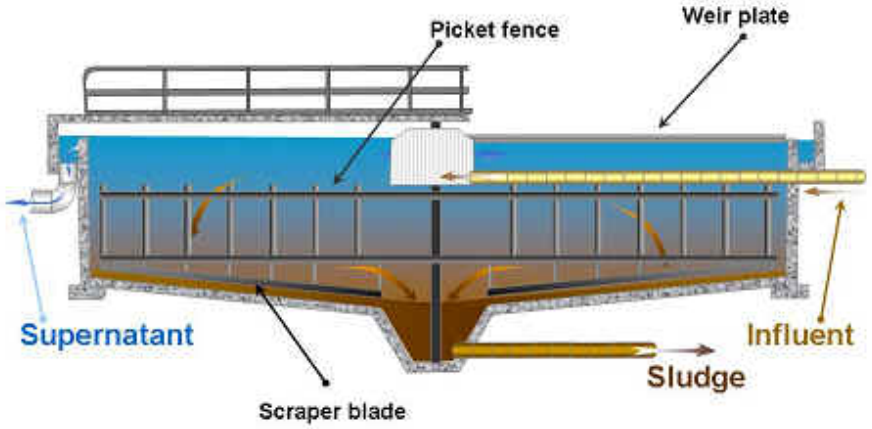






Gravity Thickening

- 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

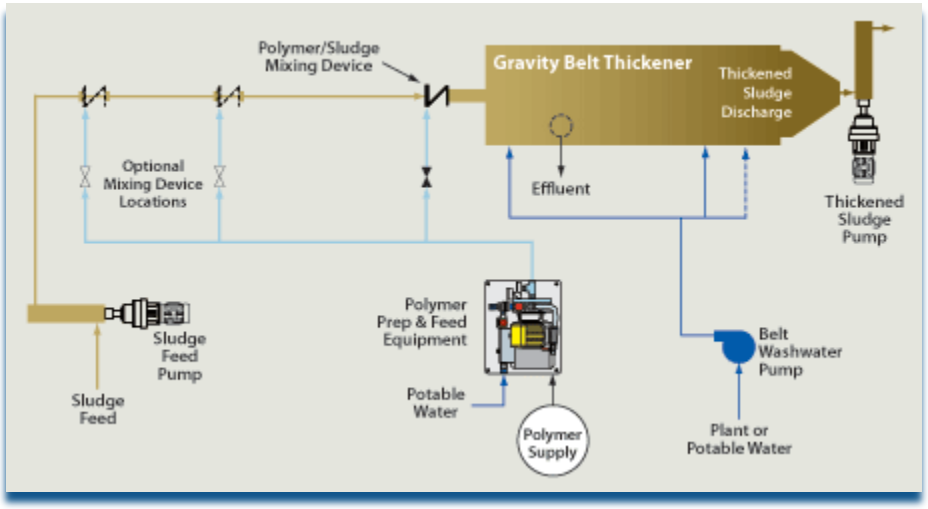


Gravity Thickening

Sludge Type	Feed Solids Concentration	Thickened Sludge Solids Concentration	Solids Loading, $kg/m^2/day$	Hydraulic Loading, $m^3/m^2/day$
Primary	1-6	3-10	100-150	15.5-31
WAS	0.5-1.5	2-3	20-40	4-8
Primary + WAS	0.5-1.5	2-6	25-70	6-12

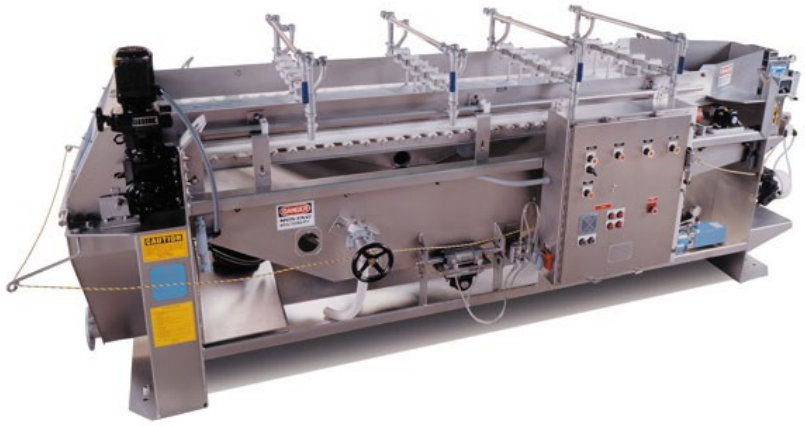
Gravity Belt Thickening

- 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

Sludge Type	Feed Solids Conc, %	Volume Reduction, %	Thickened Sludge Solids Conc, %
Primary	3 to 5	60 to 80	8 to 15
WAS	0.5 to 0.9	85 to 95	5 to 7
Primary + WAS	0.8 to 2	85 to 90	6 to 11



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

Sludge Type	Feed Solids Conc, %	Thickened Sludge Solids Conc, %	Solids Recovery, %
Primary	3 to 6	7 to 9	93 to 98
WAS	0.5 to 1.0	4 to 9	93 to 99
Primary + WAS	2 to 4	5 to 9	93 to 98

Sizing Criteria for Rotary Drum Thickeners

Sludge Thickening Alternative Evaluations

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

Alternatives Cost Evaluation

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

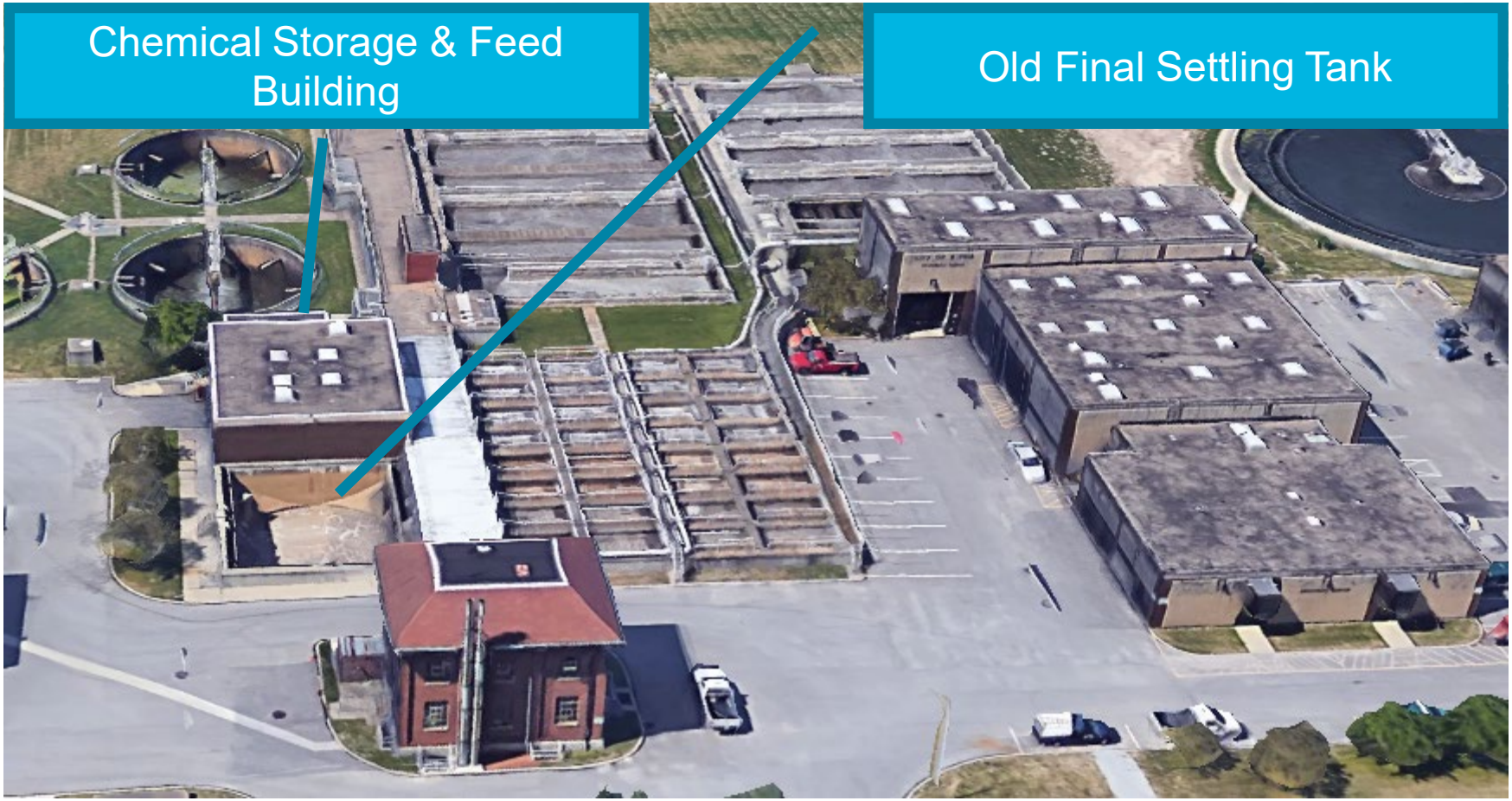
Selected Alternative – Gravity Belt Thickener

- 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



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.

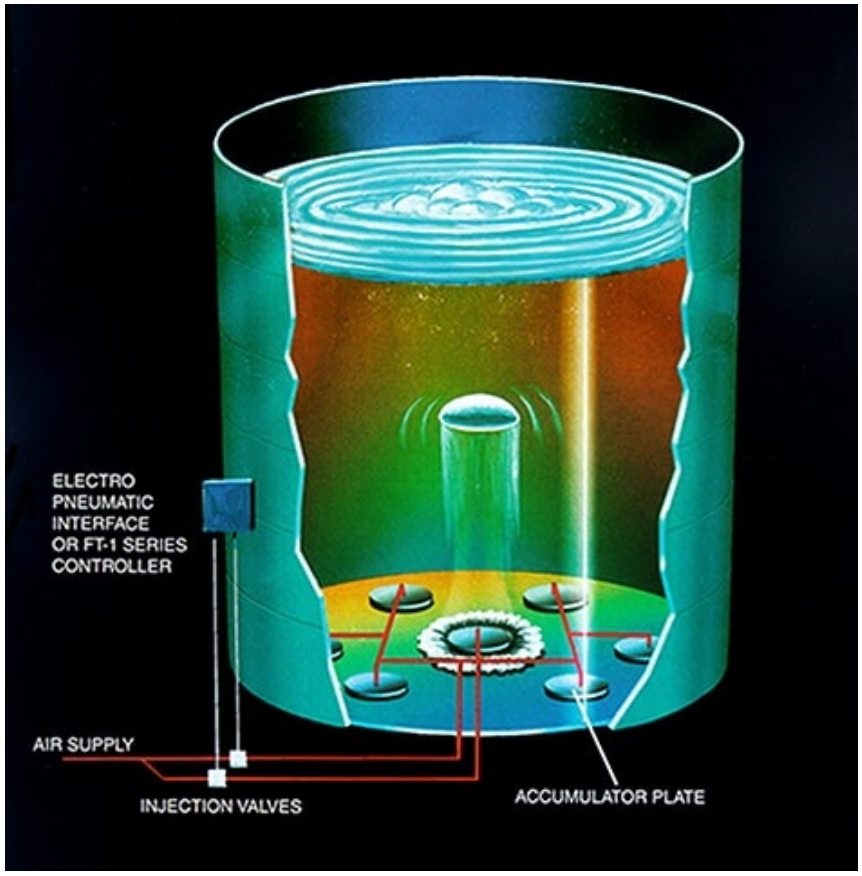
Elyria Gravity Belt Thickener cont.

Polymer Injection

Wash Water Pumps

Sludge Mixing System

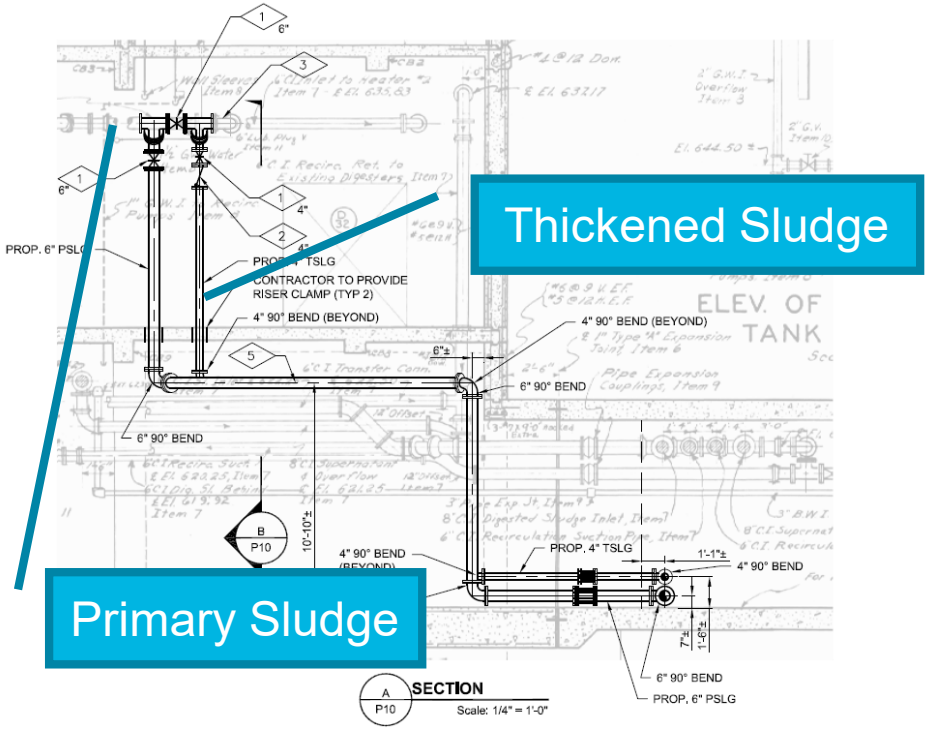
- Pulsair mixing system
- Utilizes large air bubbles to keep sludge mixed in the well
- Eliminates mechanical equipment in the sludge
- Air compressor sends pulses of air into the tank
- Flat, round disks push air out on the tank floor
- Air bubbles accumulate into large air bubble

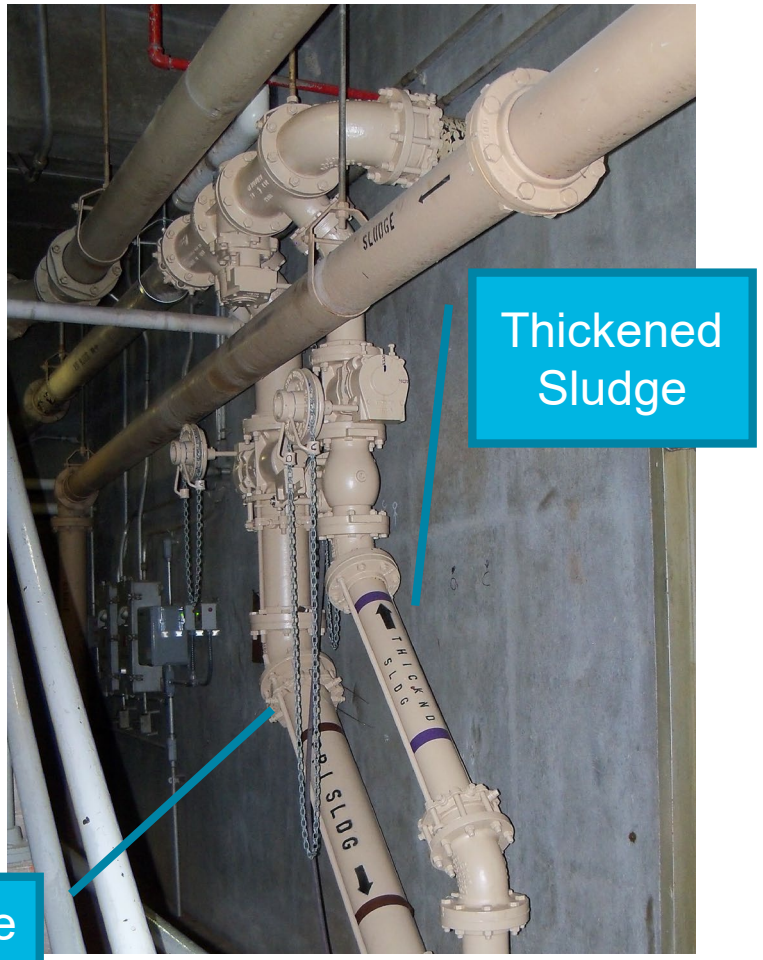


Sludge Thickening Building

- 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





Gravity Thickening Process Pumps

Gravity Thickening Process Pumps, Cont.

Waste Activated Sludge Pumps
Gorman Rupp Self Priming

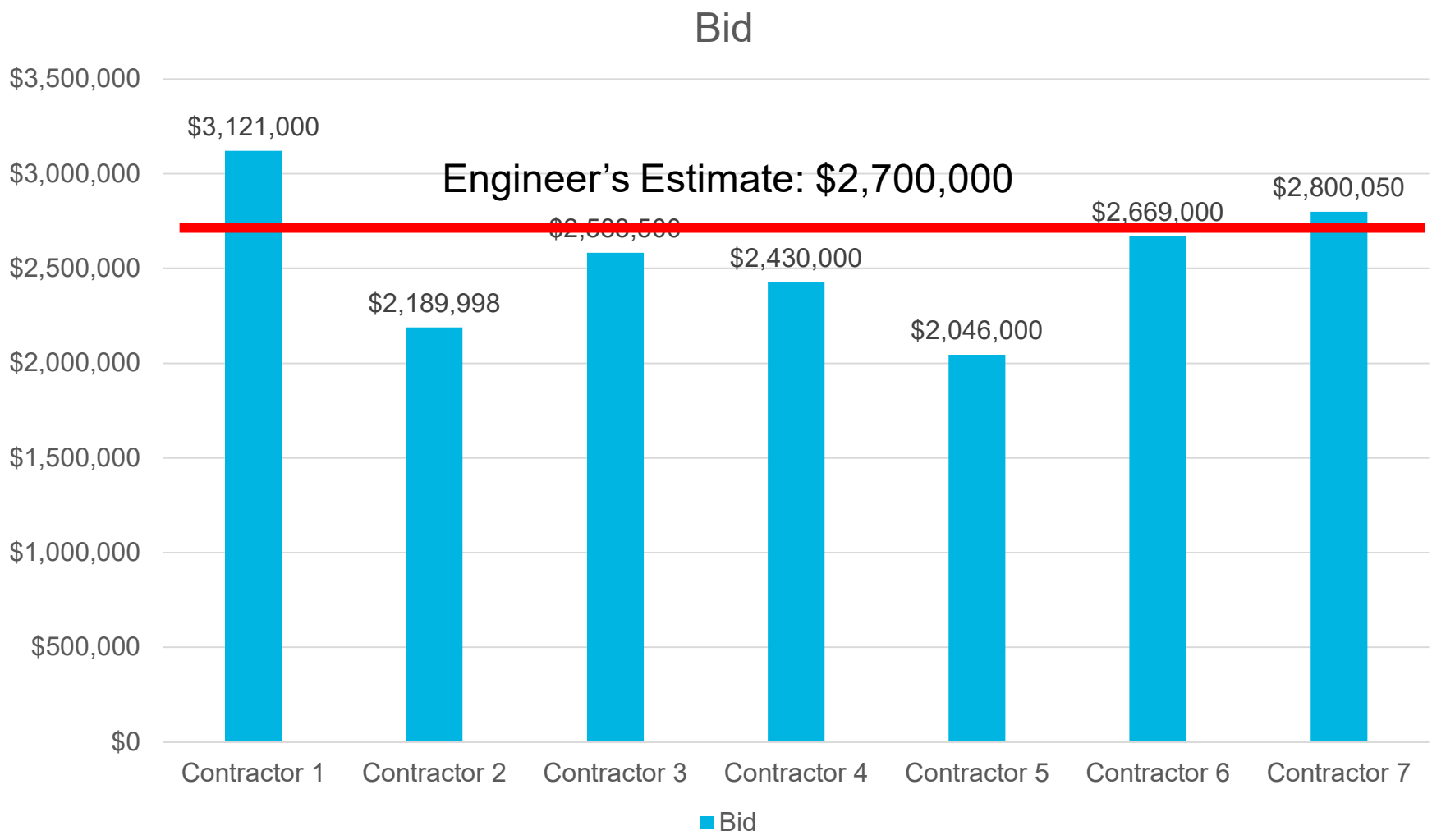
GBT Feed Pumps
Boerger Rotary Lobe

Gravity Thickening Process Pumps, Cont.

Filtrate Pumps
KSB Dry Pit Centrifugal

Thickened Sludge Pumps
Seepex Progressive Cavity

Sludge Thickening – Bid Tabulations



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

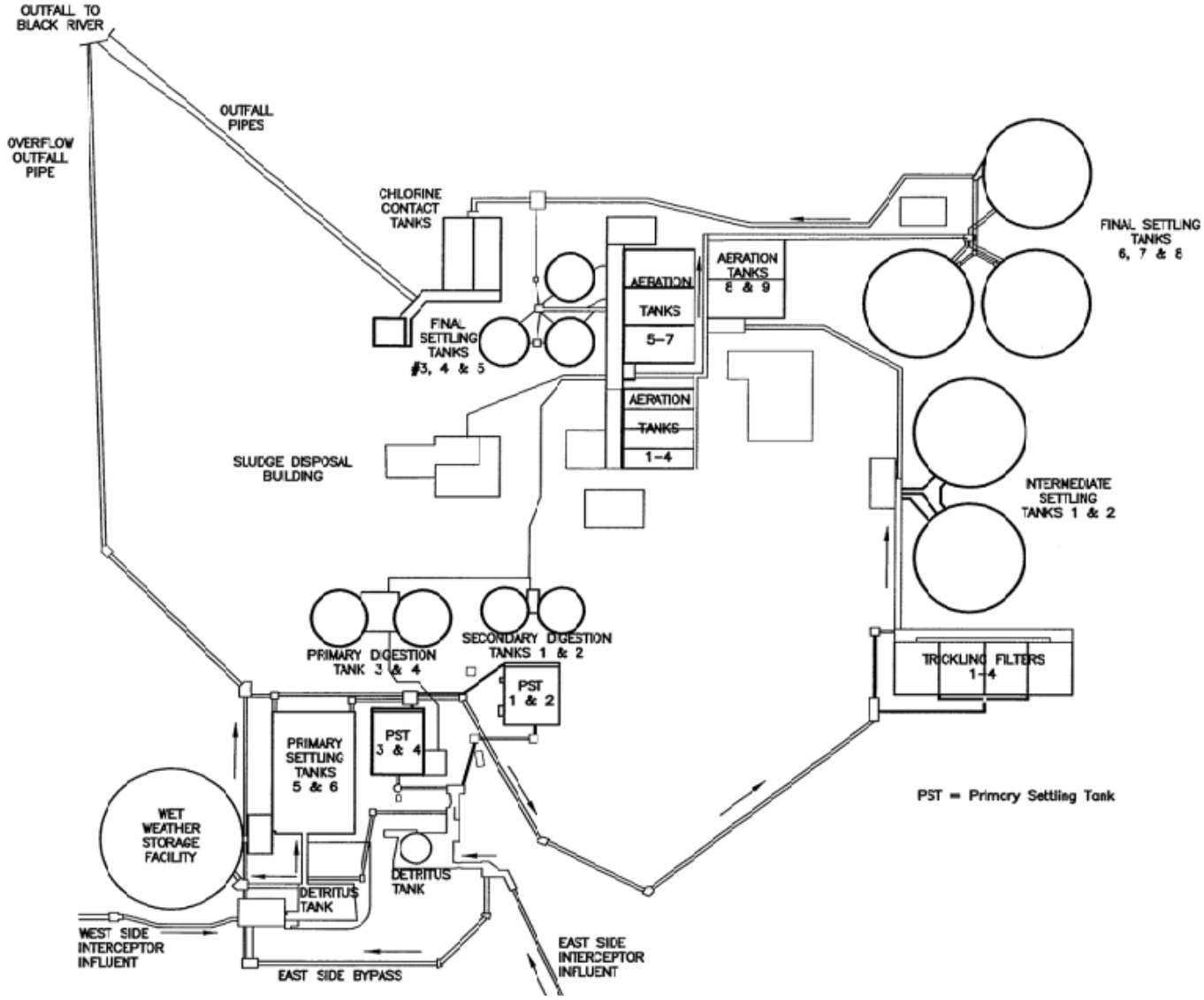

Questions?

Thank You

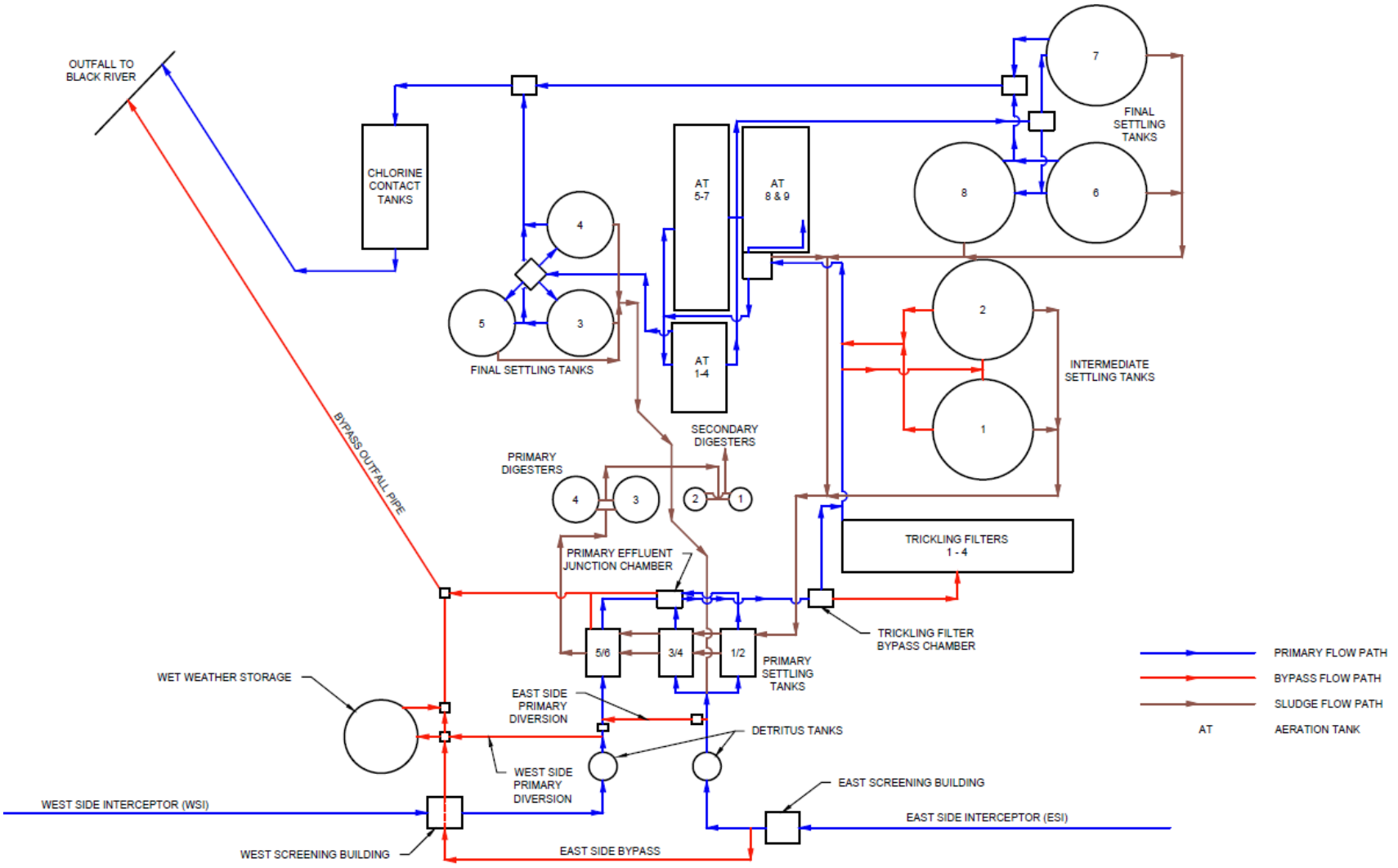
Terry Korzan: tkorzan@cityofelyria.org

Tim McCann: timothy.mccann@aecom.com

Elyria WWPCP – Plan View



Elyria WWPCP – Overall Flow Schematic



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