NEORSD Southerly
Screen and Grit Facility Improvements

Ohio Water Environment Association
2015 Technical Conference and Exhibition

June 23, 2015

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Northeast Ohio Regional Sewer District

History of the NEORSD's Southerly WWTP

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Southerly Wastewater Treatment Center

Southerly WWTP - The Early Years

1858 – First sewer constructed to discharge to Cuyahoga River and Lake Erie

1868 – Cuyahoga River pollution catches fire and again in 1883, and 1887

1911 – Studies to clean river and protect purity of water supply divides Cleveland into four (4) Sewer Districts Easterly, Westerly, Southerly, and Low Level

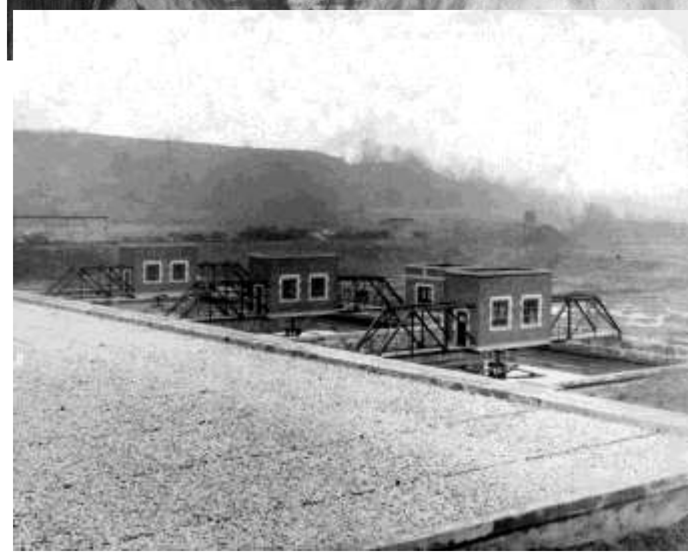
1922 – Cuyahoga River pollution catches fire

1924 – Study recommends full treatment at Southerly site

1927 – Southerly WWTP starts to receive flow

Wet Side Processes

- **1927**
  - Screen and Grit Removal
  - 12 Two-Story Imhoff Tanks
  - Trickling Filters
- **1933**
  - Extended Aeration *(Pilot Study)*
  - 2 Settling Tanks



The Early Years – Dry Side Processes

- 1927
  - Covered Sludge Drying Beds
  - Sludge Lagoons
- 1933
  - Anaerobic Digesters
- 1936
  - Vacuum Filtration
  - Sludge Incineration
- 1938
  - Easterly WWTP Sludge Pumped

Expansion - Wet Side Processes

- 1950

- Anaerobic Digestion Capacity Increase

- 1966

- New Vacuum Filters
- New Multiple Hearth Incinerators (Decommissioned in 2014)

- 1952

- Screen Building / Detritus Tanks
- Primary Settling Tanks 1 – 6
- Aeration Tanks / Clarifiers

- 1955

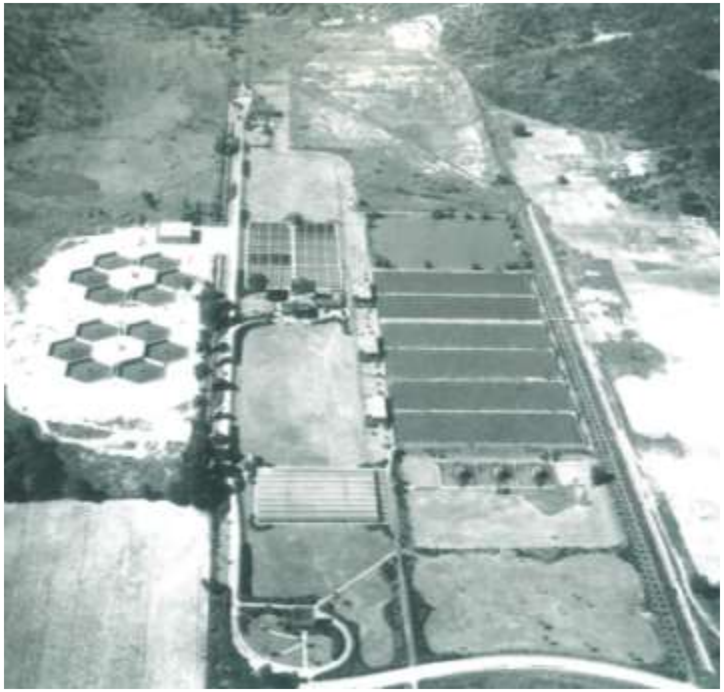
- Blower Building Upgrades

- 1968

- Primary Settling Tanks 7 – 10
- Aeration Tanks: Unit A 1 & 2, Unit B - 3 &4 Aeration Tanks Unit C 6-10

- 1971

- Chlorine Building



Regional Approach

- **Cleveland Regional Sewer District**

  1972 - Judge McMonagle's Court Order

  1974 - Assumed Operation and Maintenance

  - Evaluation and Facility Planning

- **Northeast Ohio Regional Sewer District**

  1979 - Name Changed

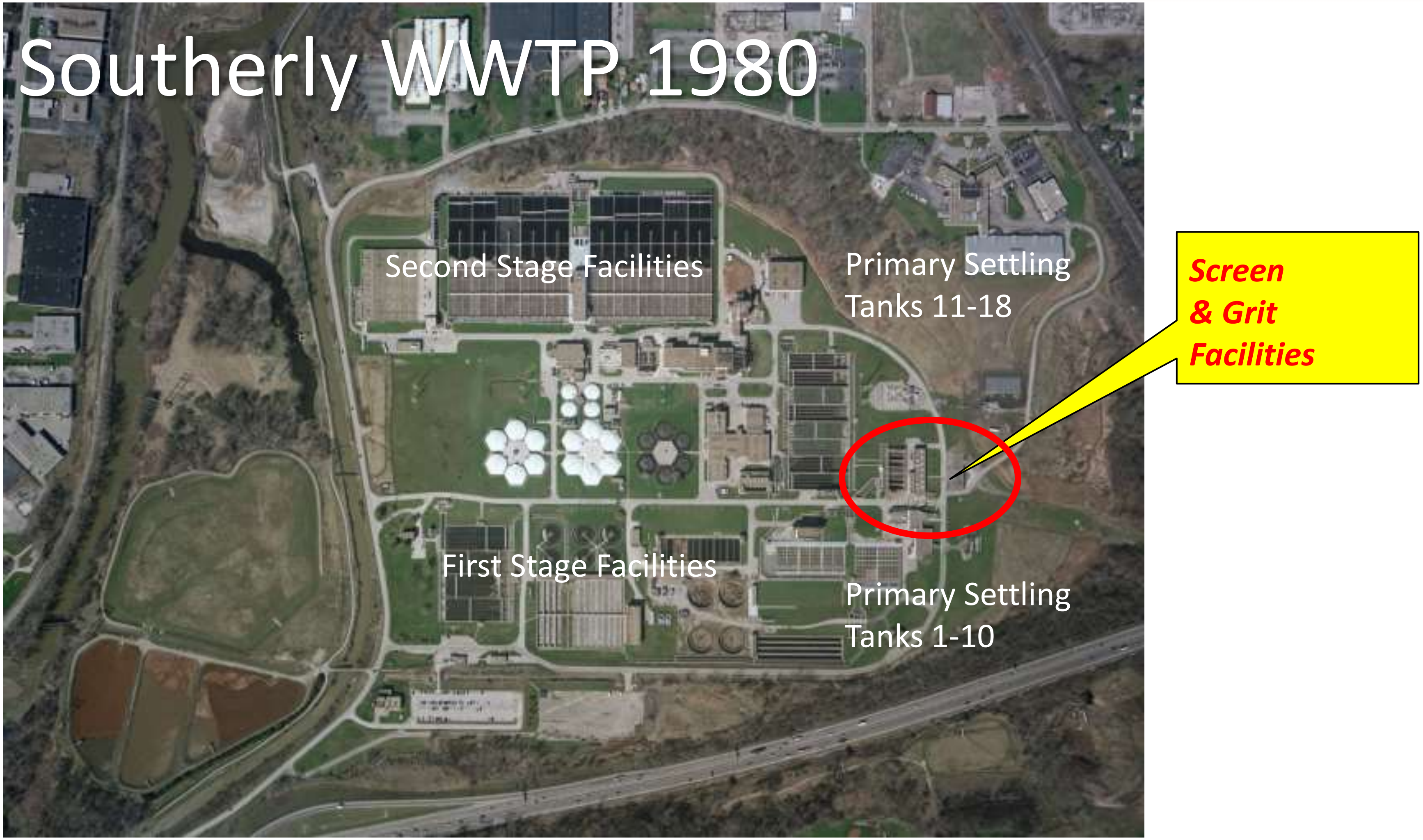
Facility Improvements -Wet Side

- 1980
  - **Screen and Grit Facility**
  - Primary Tanks 11 – 18
  - Second Stage Lift Station
  - Second Stage Aeration
- 1982
  - Cuyahoga Valley Interceptor Lift Station
  - Effluent Filters / Disinfection
- 1987
  - First Stage Aeration Expansion
  - Primary Settling Tanks 1 – 10 Rehabilitation

Facility Improvements – Dry Side

- Dry Side Processes
  - 1979
    - Primary Sludge Cyclone Degritting
    - Gravity Thickeners
    - Sludge Storage Tanks
    - Thermal Conditioning
  - 1993 Gravity Belt Thickening
  - 1997 Centrifuge Dewatering

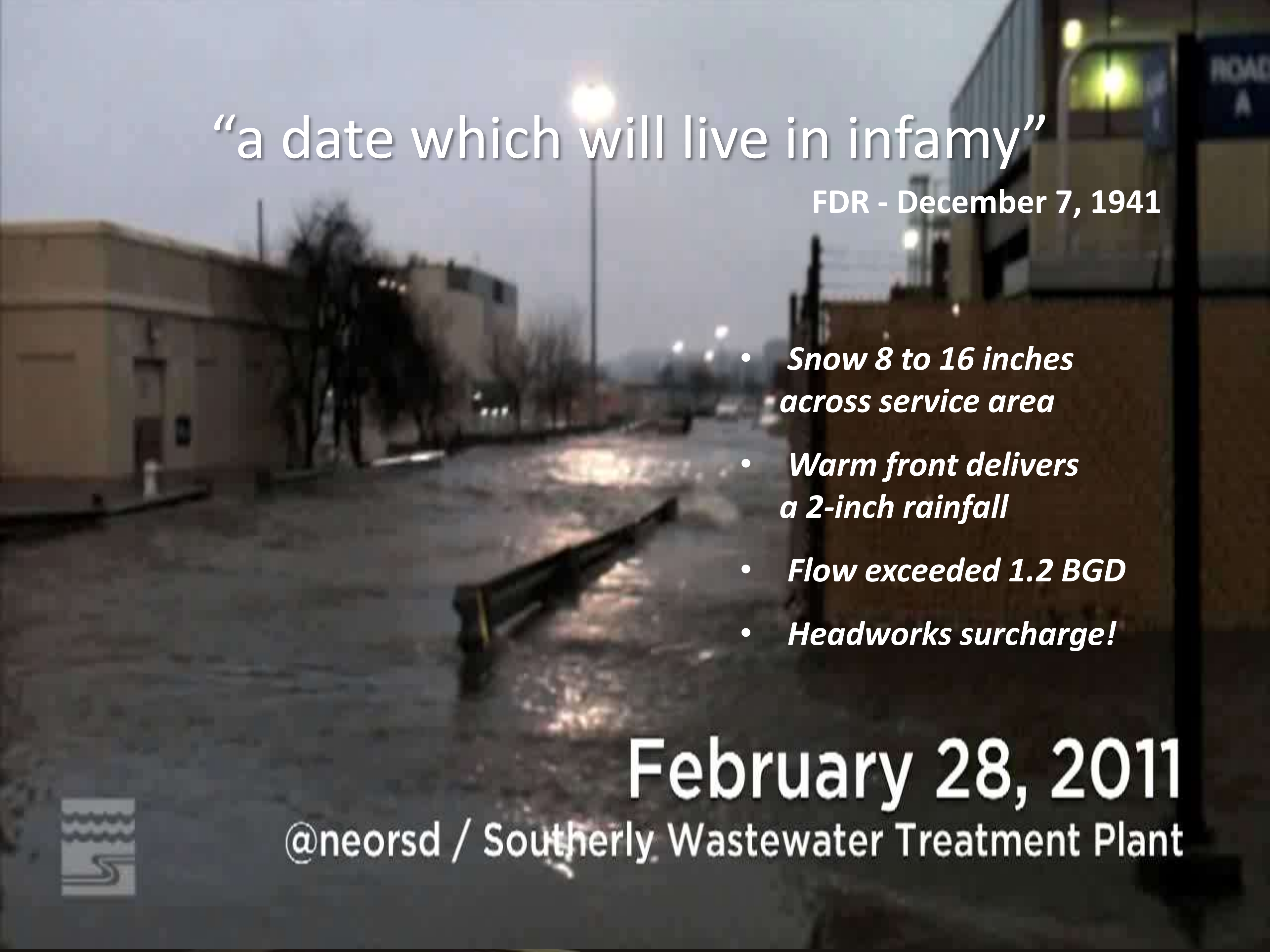
Southerly WWTP 1980



"a date which will live in infamy"

FDR - December 7, 1941

- ***Snow 8 to 16 inches across service area***
- ***Warm front delivers a 2-inch rainfall***
- ***Flow exceeded 1.2 BGD***
- ***Headworks surcharge!***



"the more things change, the more they stay the same"

Jean-Baptiste Alphonse Karr – January 1849

1923 - 1980

1980-2014

2014 -

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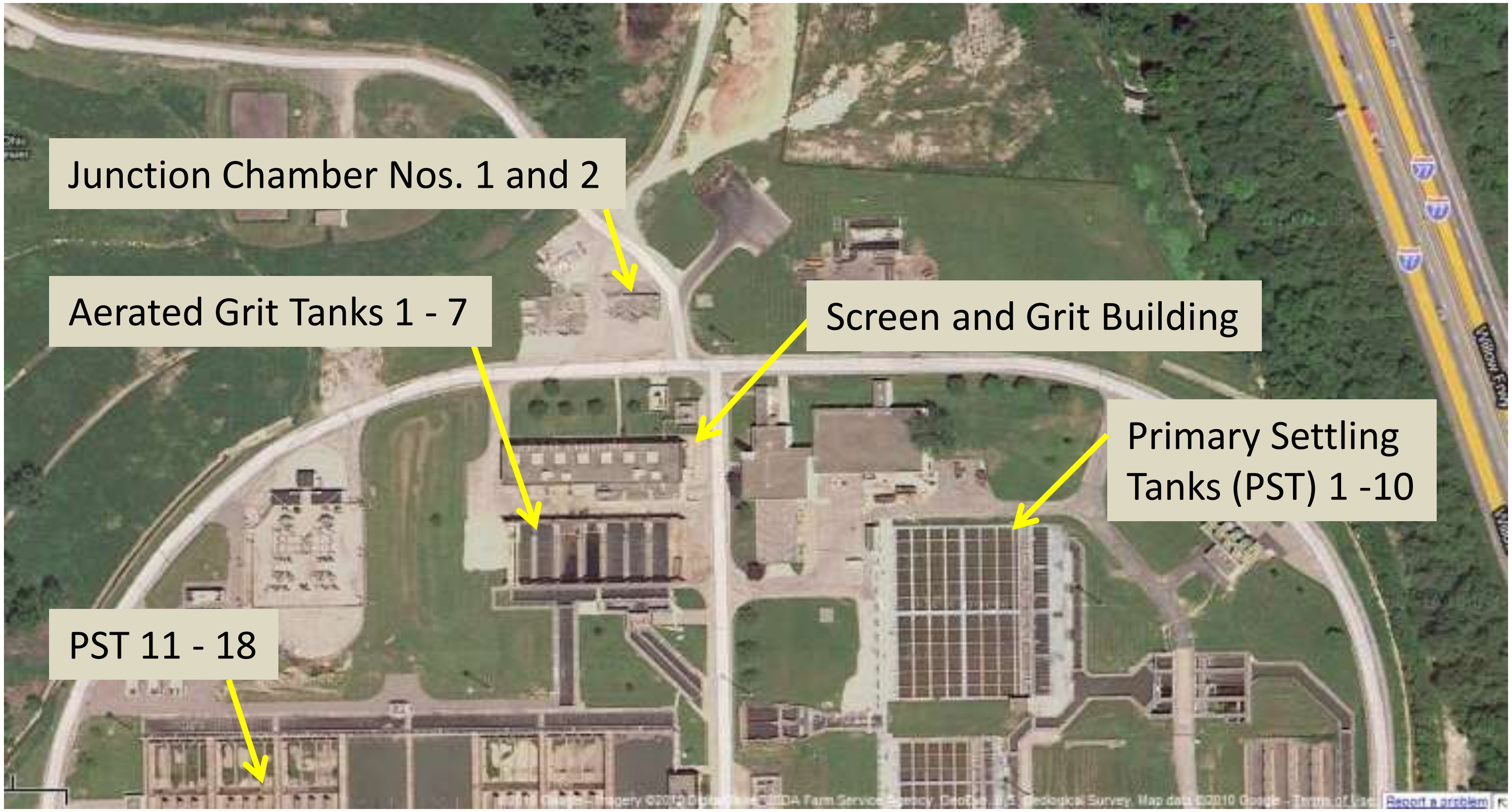
Screen and Grit Facilities



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Scope of Work

- Maximize Hydraulic Capacity
- Replace Sluice Gates
- Architectural Renovation of Screen and Grit Building
- New Bar Screens
- New Screening Conveyors
- New Grit Tank Aeration Systems
- Rehab Channel Aeration Blowers
- Replace Bridge Crane
- Upgrade Electrical Systems
- Install new Emergency Generator to Handle Critical Loads

Summary of Existing Operations Flows and Detention Time

Tanks in Service	1	2	3	4	5	6	6	6
Flow Range, m^3/s	**0 – 3.51**	**3.55 – 7.01**	**7.06 – 10.52**	**10.56 – 14.03**	**14.07 – 17.53**	**17.57 21.04**	**21.08 – 24.54**	**>24.54**
Flow Range, mgd	**0-80**	**81-160**	**161-240**	**241-320**	**321-400**	**401-480**	**481-560**	**>560**
# Occurrences	367	740	109	33	12	7	1	1
% in Range	29%	58%	9%	3%	1%	1%	0%	0%
Cumulative Total (%)	28.90%	87.17%	95.75%	98.35%	99.29%	99.84%	99.92%	100.00%
Detention Time at Average Daily Flow in Minutes								
Low end of range	**NA**	**9.6**	**7.1**	**6.4**	**6.0**	**6.0**	**5.0**	
High end of range	**4.8**	**4.8**	**4.8**	**4.8**	**4.8**	**5.0**	**4.3**	
Detention Time at Max Day Diurnal PF=1.6 in Minutes								
Low end of range	**NA**	**6.0**	**4.5**	**4.0**	**3.7**	**3.7**	**3.1**	
High end of range	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**	**3.1**	**2.8**	

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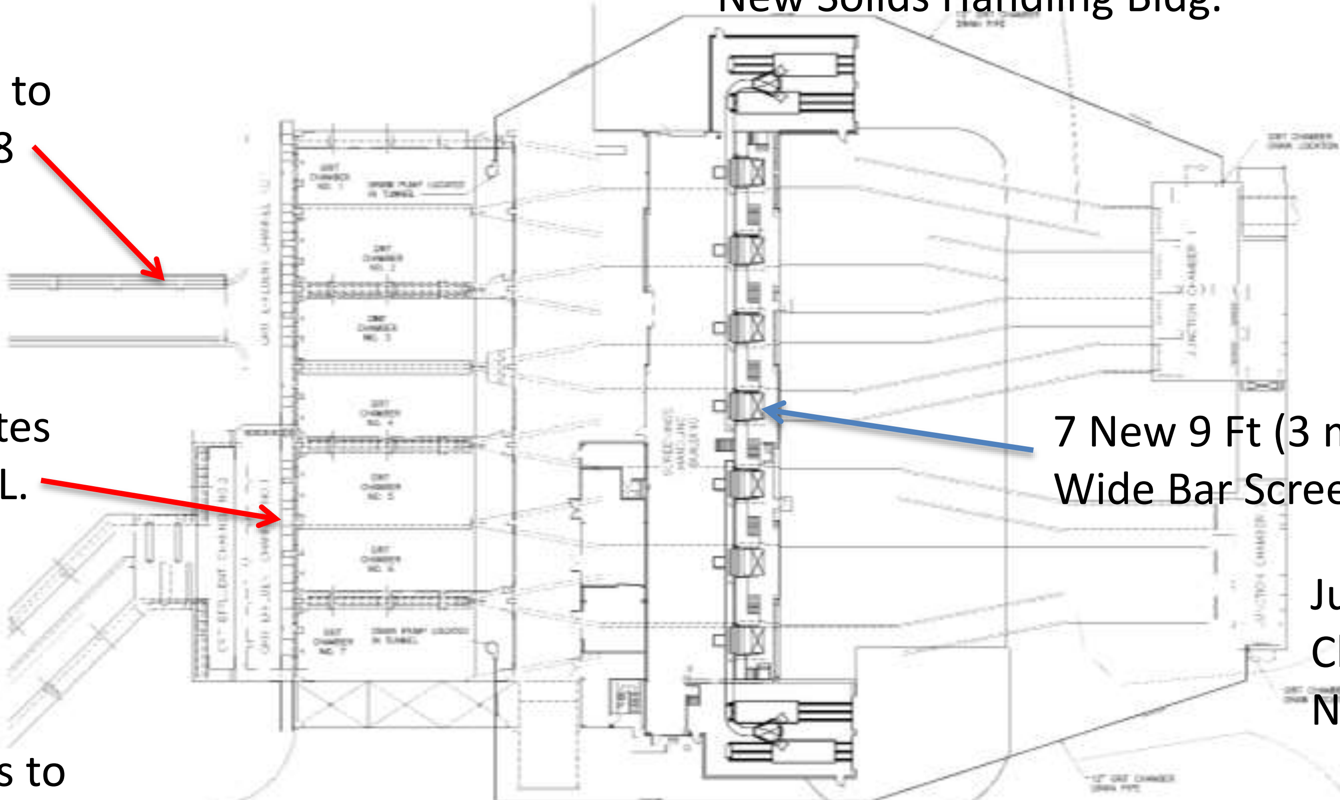
Basis of Design for Improvements

- Seven (7) Parallel Trains: 9' Wide Bar Screen and Aerated Grit Tank
  - New 9 foot wide mechanically cleaned bar screen with 3/4" bar spacing.
  - Upgrade Aerated Grit Tanks: 59 ft. long x 26 ft. wide x 14.5 ft Side Water Depth
  - Replace existing Bridge Crane and Clam Bucket Grit Removal System
- Plant Flow Conditions
  - Average Design Flow: 175 MGD
  - Peak Design Flow: 735 MGD
- Condition I: Reliable Flow @ 735 MGD

  = 112.5 MGD/Tank with 6 tanks in service
- Condition II: Unreliable Flow >1,100 MGD

  = 194 MGD/Tank with 6 tanks in service
- Maximum Water Surface Elev. 32.6 @194 MGD Peak Flow
- 1 Standby Train: Bar Screen and Aerated Grit Tank

Plan View of Headworks Facilities



The Flood - February 28, 2010

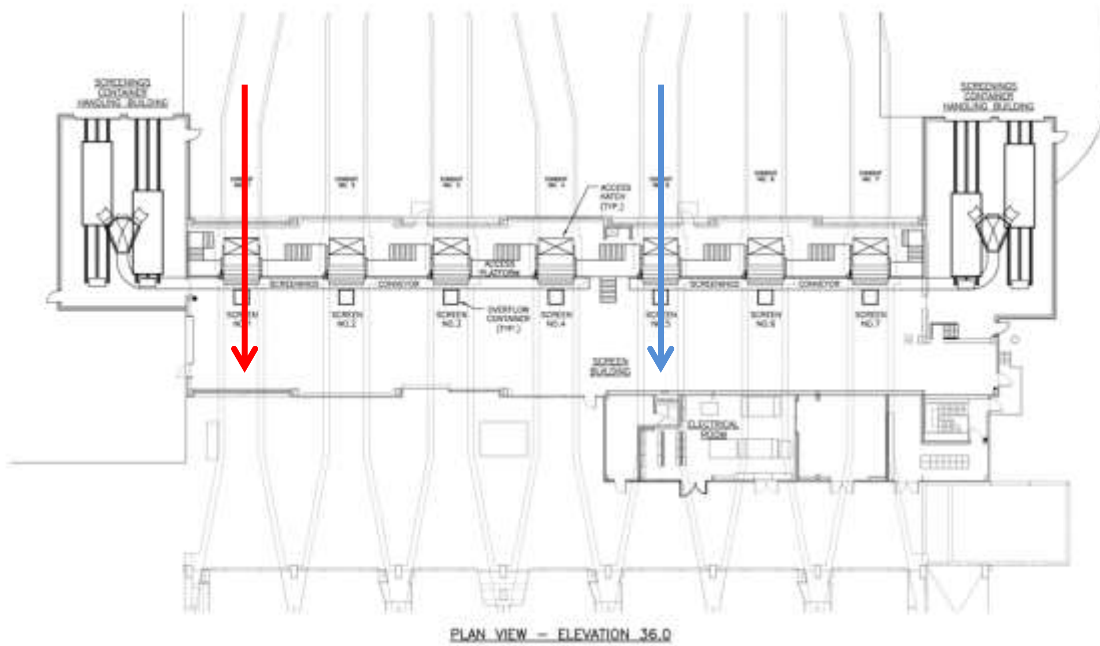
- Flows exceeds 1,000 MGD
- Bar Screens blinded or jam
- Influent conduits surcharge
- PLC communication lost
- Flow reaches 4' deep in Screening Bldg..

Phased Construction of New Bar Screens

1. West conveyor removed – floor hoppers used on Screen 2-4
2. Screen #1 – Remove and use as Bypass Channel during construction of screen 2-4
3. Install West Serpentix Conveyor
4. Remove Screen 5 and East Conveyor
5. Install Screen 1
6. Install Screens 6, then 7
7. Install Screen 5
8. Install East Serpentix Conveyor

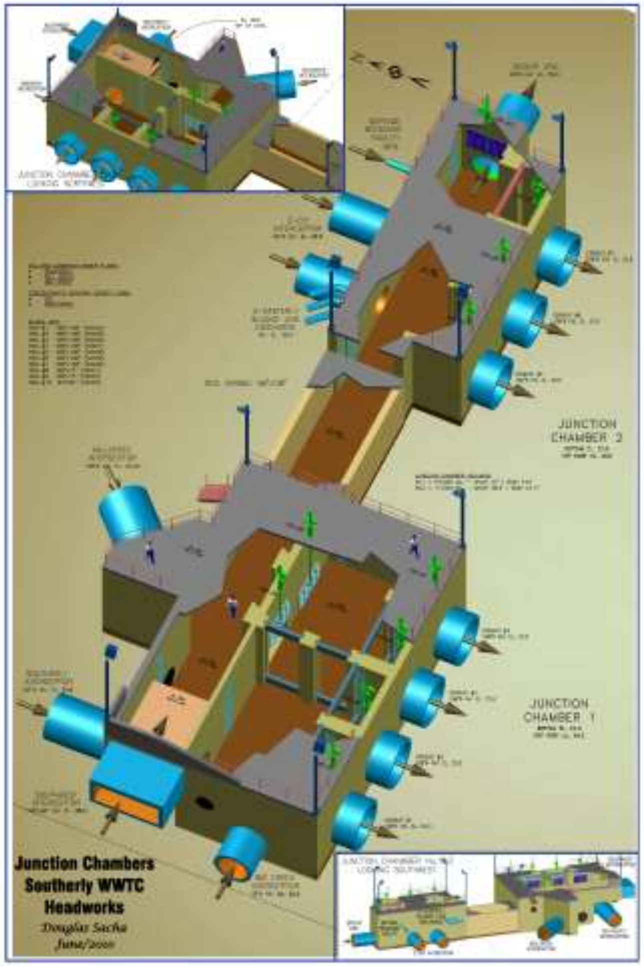
Phase I: Screens 1-4

Phase II: Screens 5-7



Junction Chamber No. 1 and 2

- Replace Sluice Gates and Operators
- New PLC panels for local operation
- Install new250 MW Generator for Critical Loa



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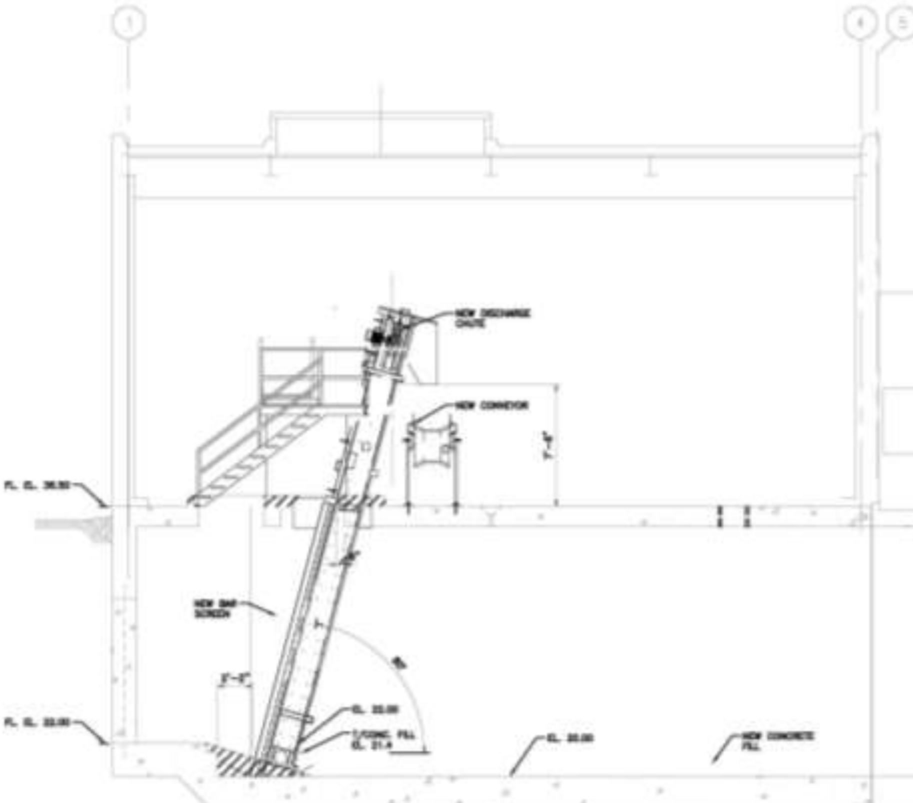
Mechanically Cleaned Bar Screens – Design Criteria

- Specifications:
  - Flow capacity increased to 194 MGD
  - Rake Loading Increased to 45 lbs./lin. Ft. per rake
  - Maximum 5 foot spacing on Rakes
  - Rakes operate on Low/High Speeds
  - Rake Field Cleared every 10/5 seconds
- Conveyor Capacity increased from 20 to 30 Tons per hour
- Install new 9’ x 8’ floor doors in front of each screen
- Maintain manual by-pass for each screen to 2 cy hoppers
- Slope concrete floor to Grit Tanks

Base Design Improvements – Screen System Improvements



Screening Handling Building

- Foundation uses drilled caissons and grade beams to support load bearing walls
- Cavity wall construction; 4” Face Brick, 12” CMU, 4 inch air space w/ 2” insulation
- Precast concrete deck
- New Insulated Metal Panels

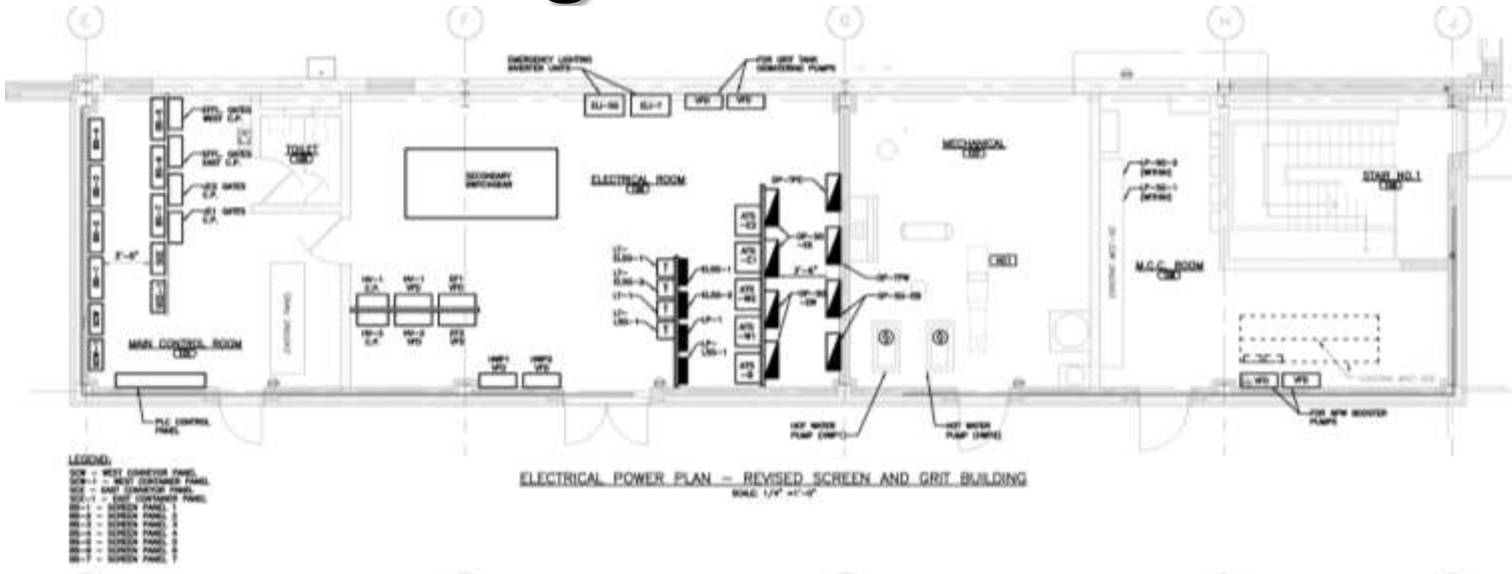
New Screening Handling Bldg. on West Side

Existing vs. New Container Management System for Handling Screenings

Existing Conveyor and 10 CY Screening Dumpster

New Container Management System with 4 - 20 CY Dumpsters

Control Building Renovations



- Main Control Room
- Electrical Room
- Mechanical Room
- MCC Room

Base Design Improvements - Grit Tank

- Demo existing bridge crane
- Construct new bridge crane support columns and beams
- Fillets in tank bottom for improved grit removal at sides
- Install new baffles
- Install new Tideflex air diffusers
- Re-build three existing 100 HP channel aeration blowers

New 4-Ton Capacity Bridge Crane

- New Columns nested inside existing support columns
- Existing crane maintained in service during construction
- New loading station on west side used to assemble crane

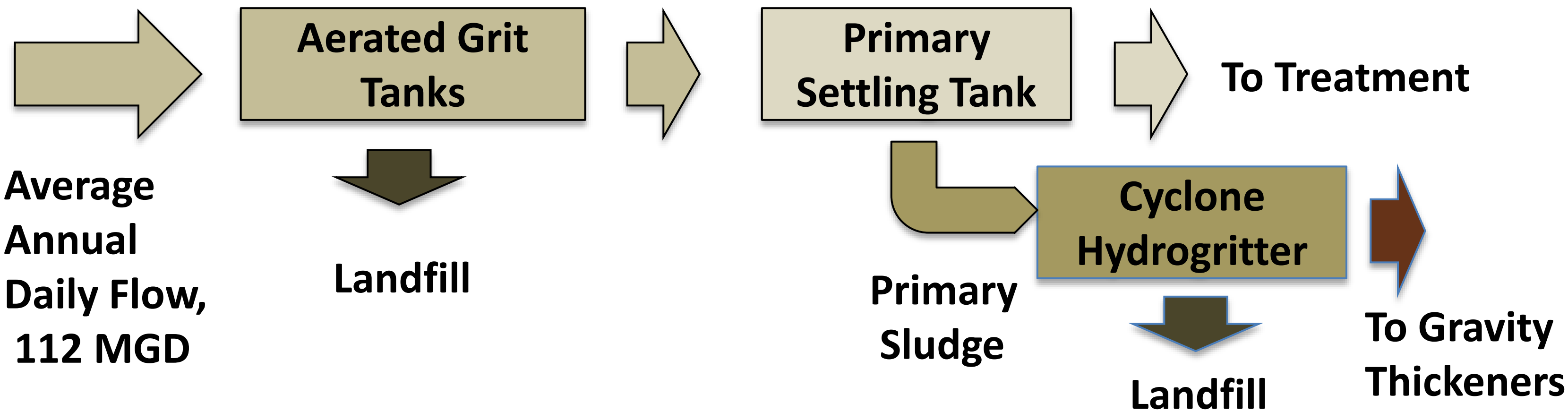
Flow Control Gates (SFCV -1 &2) Effluent Gate to PST 1 -10 Improvements

- Remove 2 existing 29 foot weir gates
- Install 4 - 12 foot wide weir gates to divert up to 300 MGD to PST 1-10
- Install new Roller Gate in Effluent Channel between Grit Tank 4/5
- Modify Primary Fail Safe Controls
  - PLC modulate flow diversion to PST 1-10
  - SFCV and RBV gates close on 2nd Stage Lift Pumps failure
  - All flows diverted to PST 11-18

Design Issues for Existing Grit Tanks

- Poor tank geometry do not conform with MOP-8 minimum standards for Length:Width and Width:Depth
  - 59 feet long x 26 feet wide x 14.5 feet average depth
  - Detention Times: > 5 minutes with 6 tanks in service @ 480 MGD
- Plug flow through the tanks results in short-circuiting and solids carryover.
- No internal transverse or longitudinal baffles.
- Diffused air systems cannot develop scouring velocities to move grit along sloped tank floor toward the collection trough.
- Influent distribution across full width of tank limits development of spiral flow pattern through tank.
- Inadequate mixing reduces grit particle settling and removal
- Tank cannot be drained for cleaning.

Grit Removal Quantities
Aerated Grit Tanks and Primary Tanks



Month	Aerated Grit Quantities, Wet	Primary Settling Cyclone Degritter, Wet	Total Grit Removed, Wet	Average Plant Flow
Average After April, 2005	3,556 kg/day (7,862 lbs/day)	3,771 kg/day (8,314 lbs/day)	7,337 kg/day (16,176lbs/day)	4.94 m^3/s (112MGD)
Removal rate, %	48.6%	51.4%		

Grit Removal Efficiency Comparison Existing vs. Proposed Tank Configurations

Description	Existing Conditions	PROPOSED DESIGN
	Grit Removal in Existing Aerated Grit Tank Lbs/day	Grit Loading in Influent Flow (% Removal) - Lbs/day
Flow	@ 125 MGD	@ 125 MGD
>= 65 mesh, 230 microns,	(55%) 4600	(81.0%) 5,676
< 65 mesh and >=100 mesh, 150 - 229 microns	(24%) 985	(39.7%) 2,477
< 100 mesh and >150 mesh, 100 - 149 microns	(11%) 240	(22.0%) 1,135
< 150 mesh, < 100 microns	(10%) 0	(0.0%) 1,032
Total Grit TS Removed (Dry Solids, lbs/day)	**5,827**	**10, 320**
Total TS Dry Grit Loading, Tons per Year	1,064	1,883

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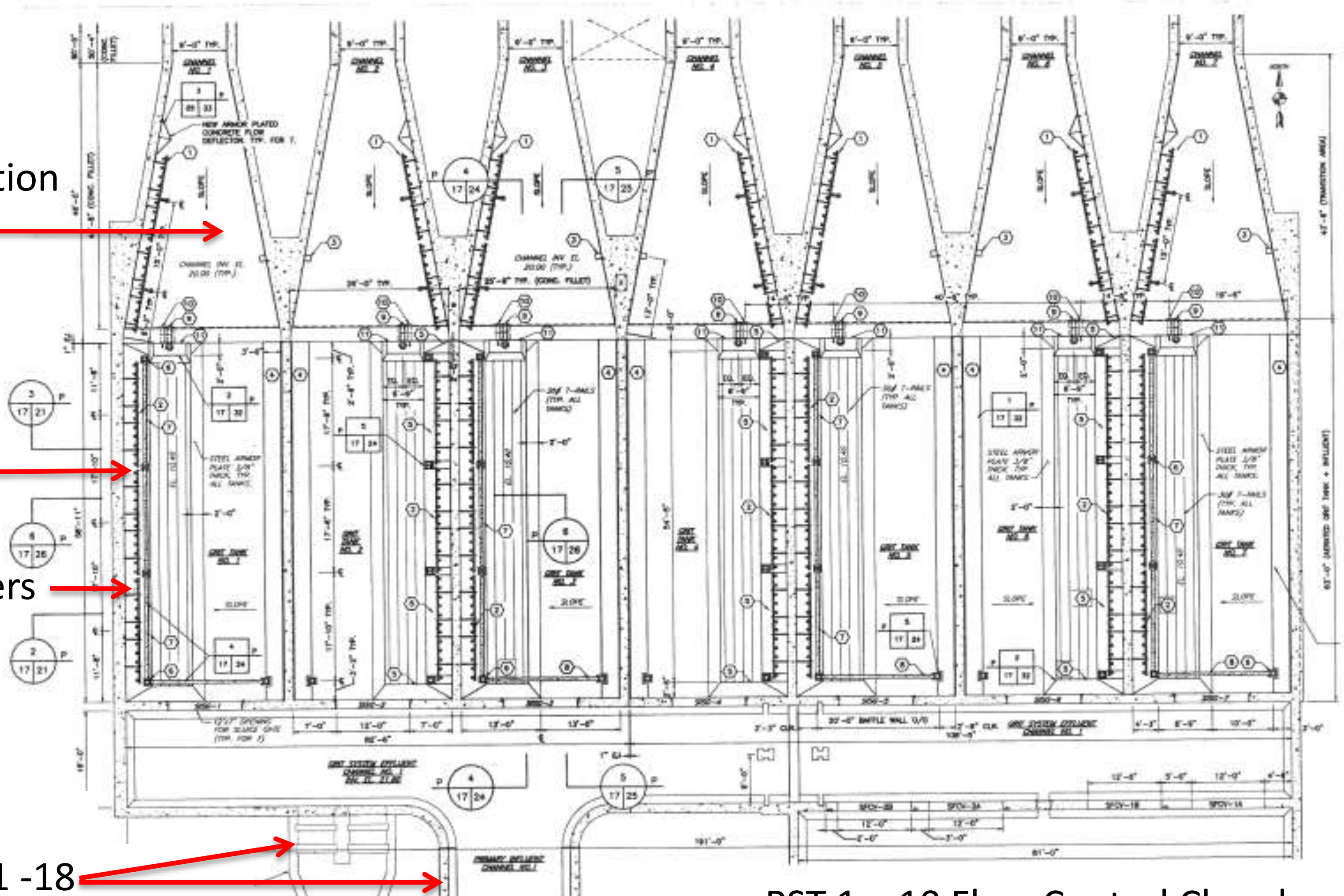
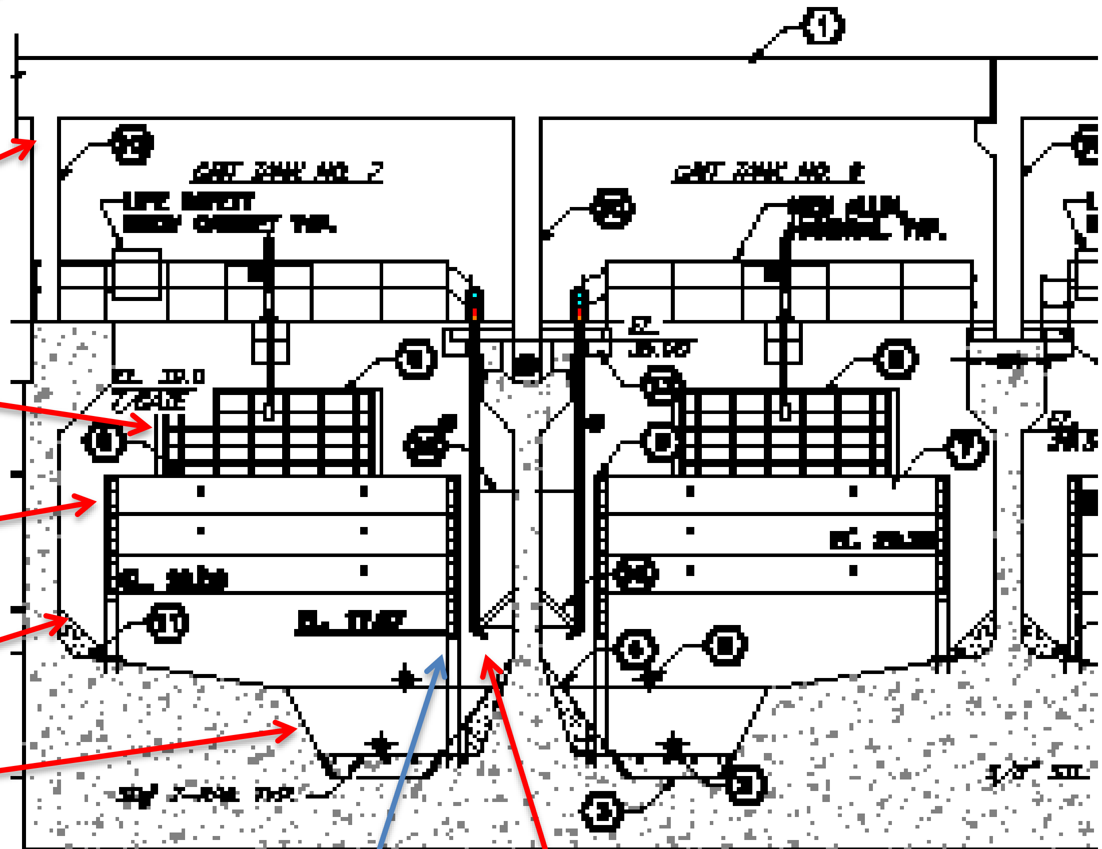
Lower Floor Plan of Grit Tanks



Typical Section thru Grit Tanks 1 & 2 Looking toward Effluent Gate



Overhead Grit Crane Beam

7’ x 14’ Effluent Gate

Effluent End Transverse Baffle

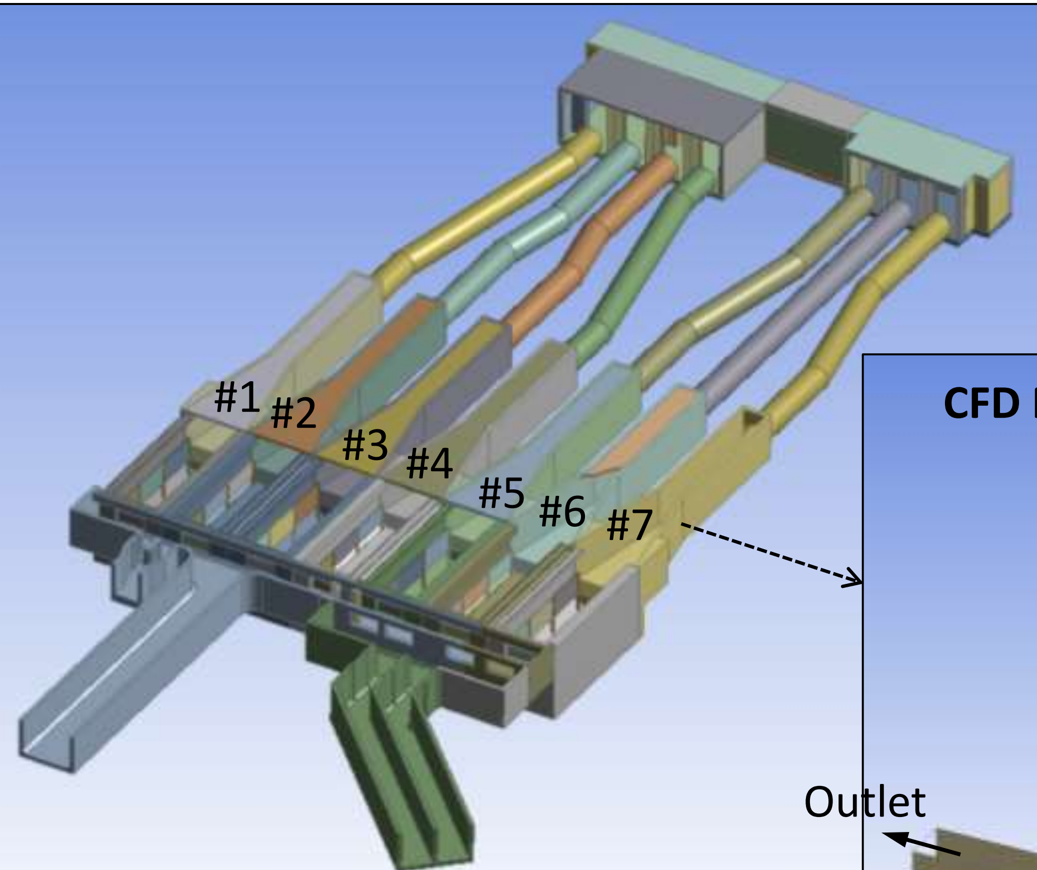
New Concrete Fillets

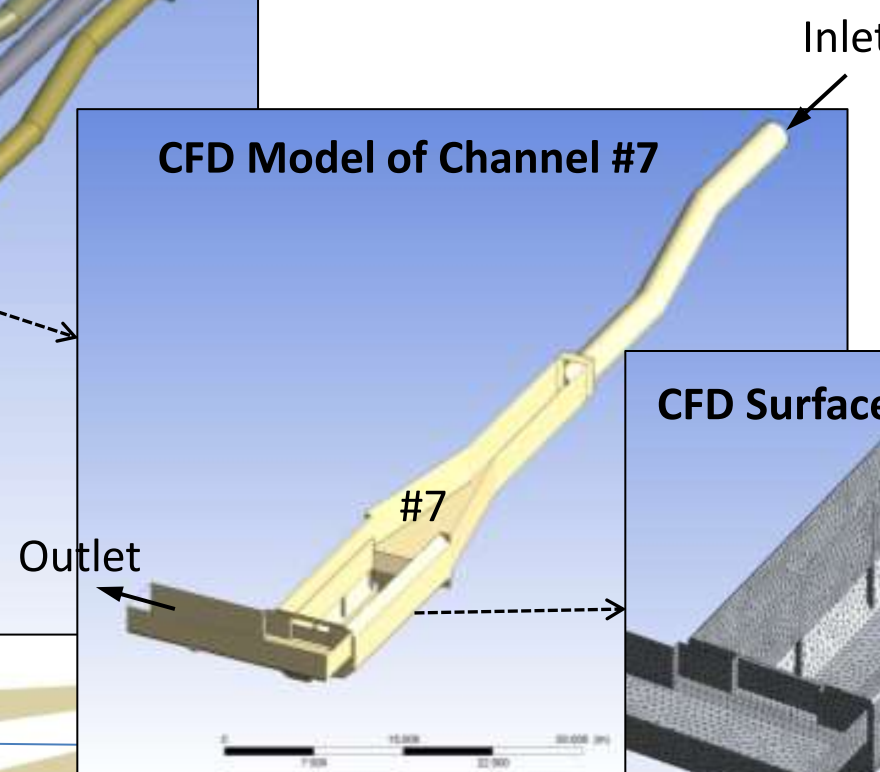
New Grit Sump, Drain Pumps, Fluidizing Header

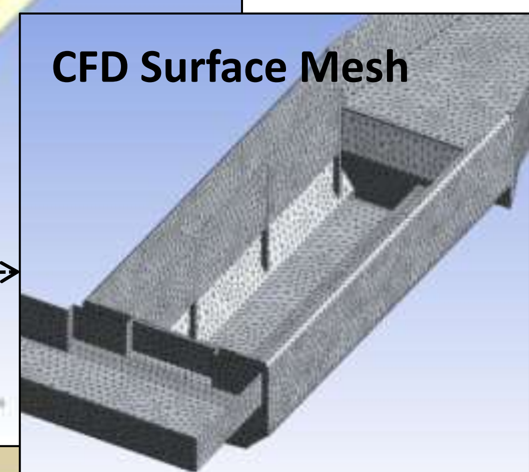
New Longitudinal Baffle Wall

New Air Diffuser Headers

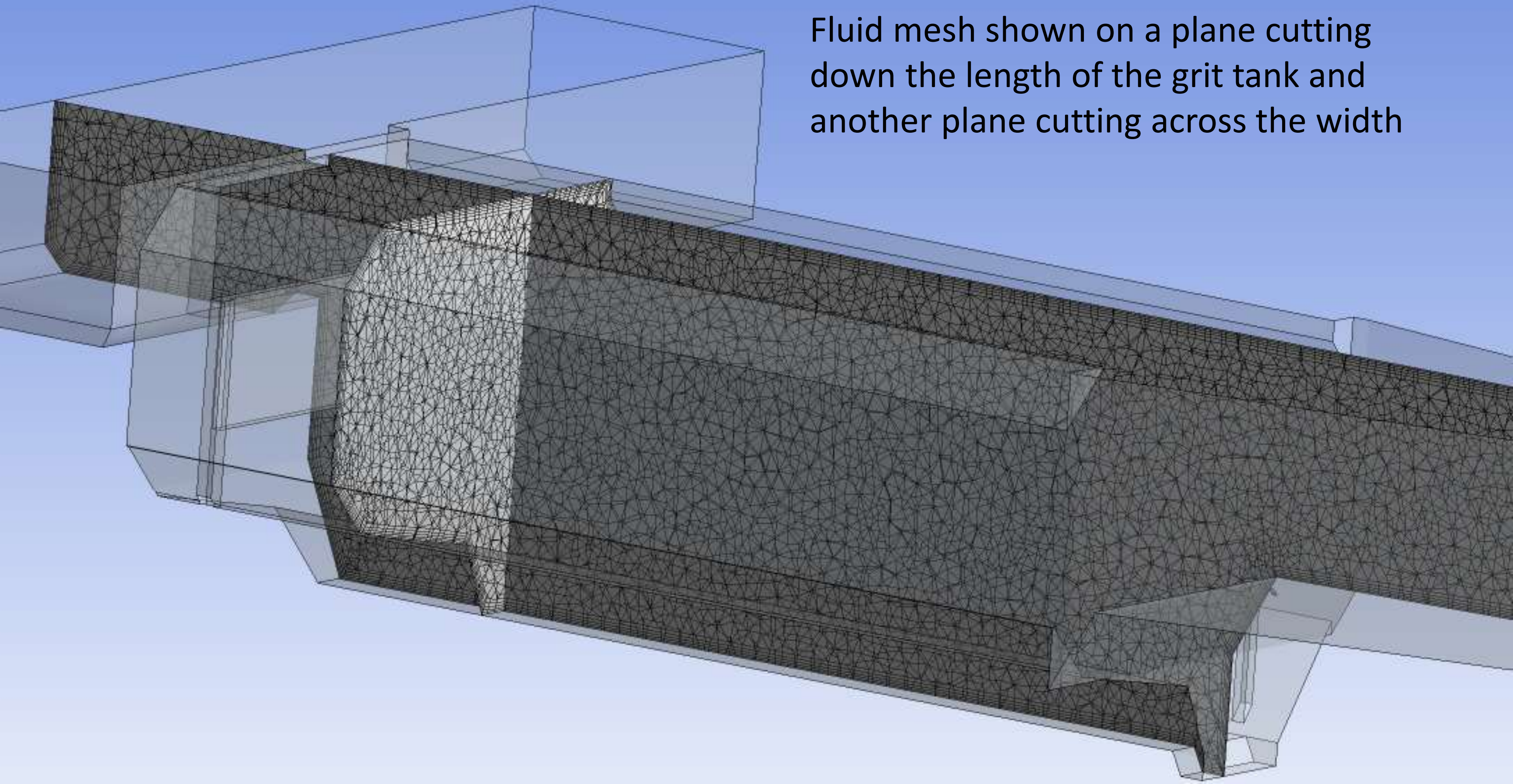
Geometry Description







Geometry Description



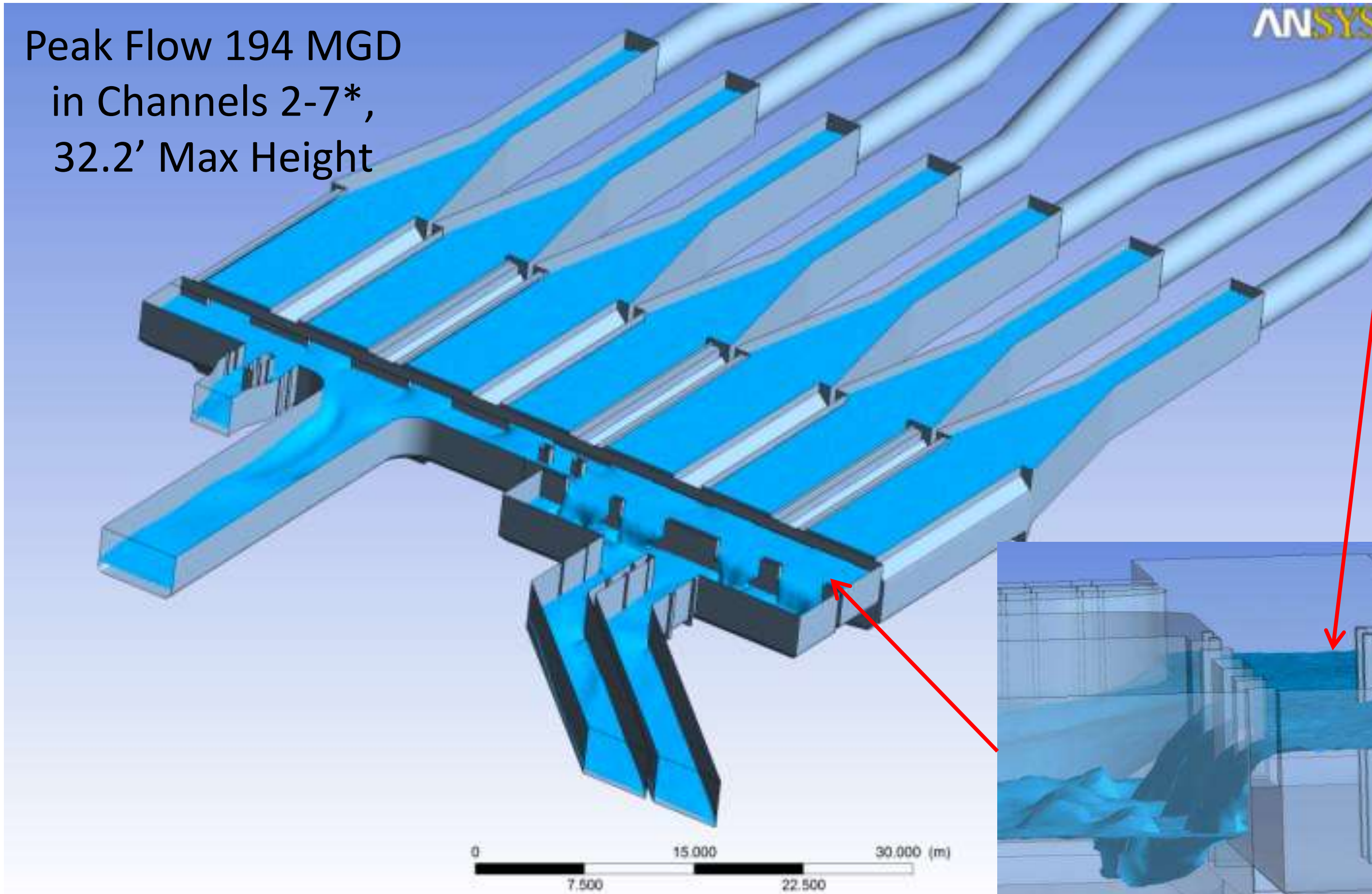
Fluid mesh shown on a plane cutting down the length of the grit tank and another plane cutting across the width

CFD Model Input Parameters

- Steady state flow conditions (i.e. not time varying)
- Turbulent flow
- Multi-phase fluid:
  - Water
  - Air Injection
- Water flow rate per channel:
  - 87 MGD (Nominal - 2 tanks In Service)
  - 194 MGD (Peak – 6 tanks in Service
- Particles Modeled - Grit:
  - 230 microns diameter (>65 mesh grit)
  - 150 to 229 microns diameter 100 to 65 mesh grit)

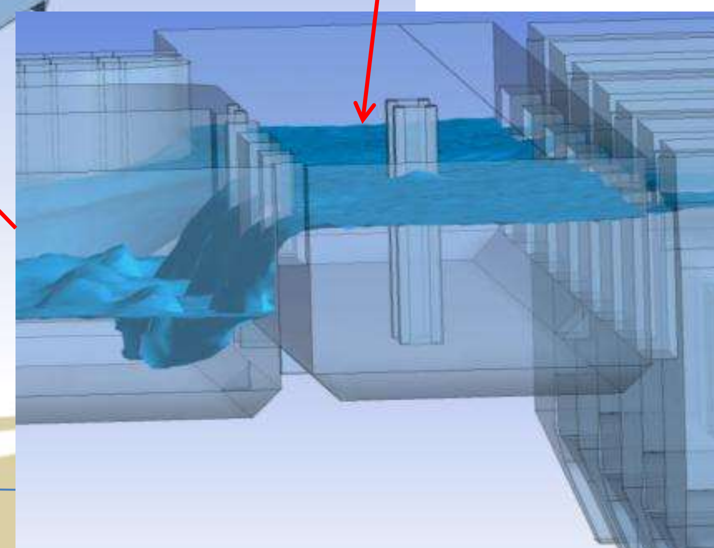
Grit Tank & Channel Filling Simulations

Peak Flow 194 MGD
in Channels 2-7*,
32.2’ Max Height



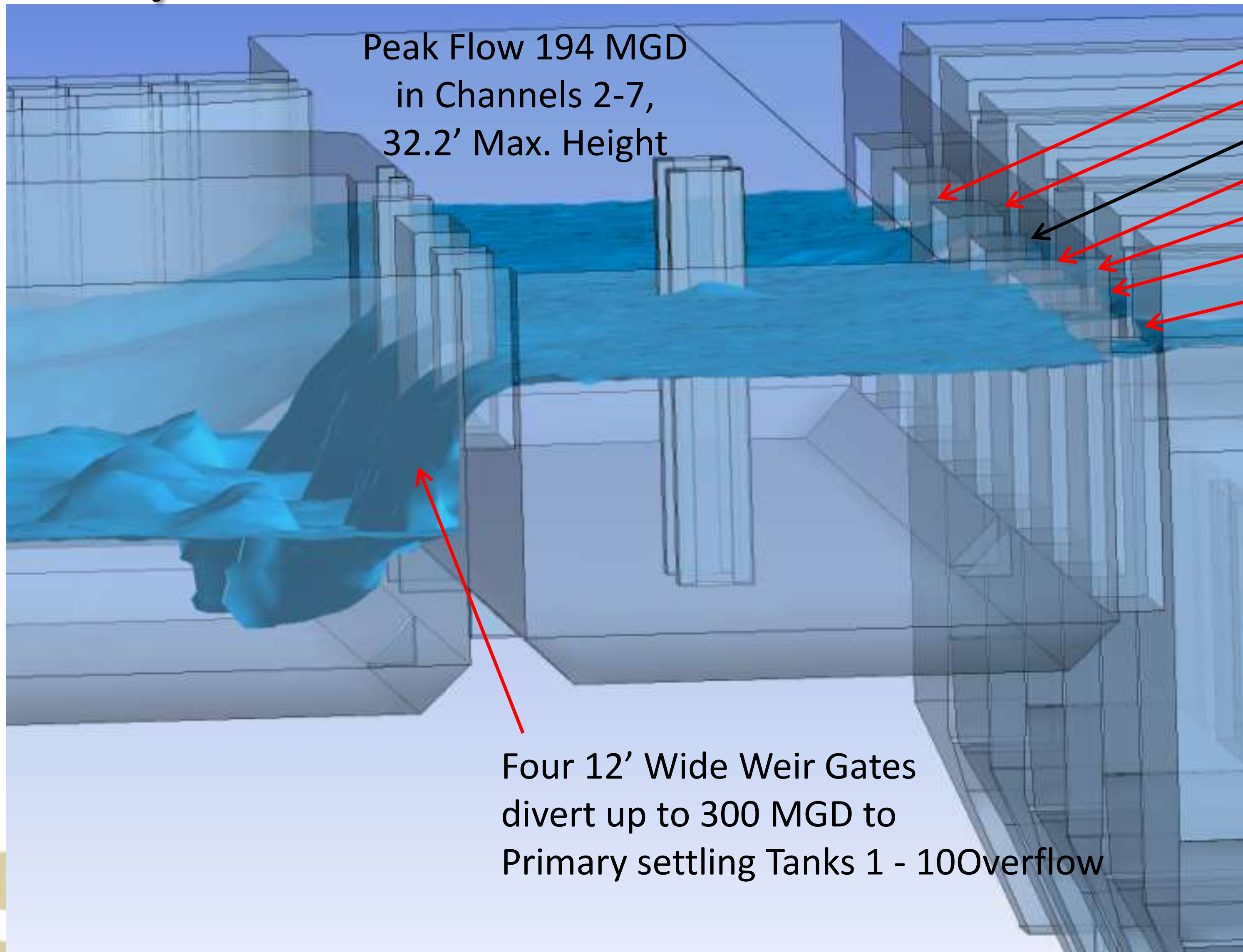
29.6’ in Channel 7

(Grit Tank Water Height Just Upstream of Gate)



*Note: Grit Tank Channel 1 is out of service

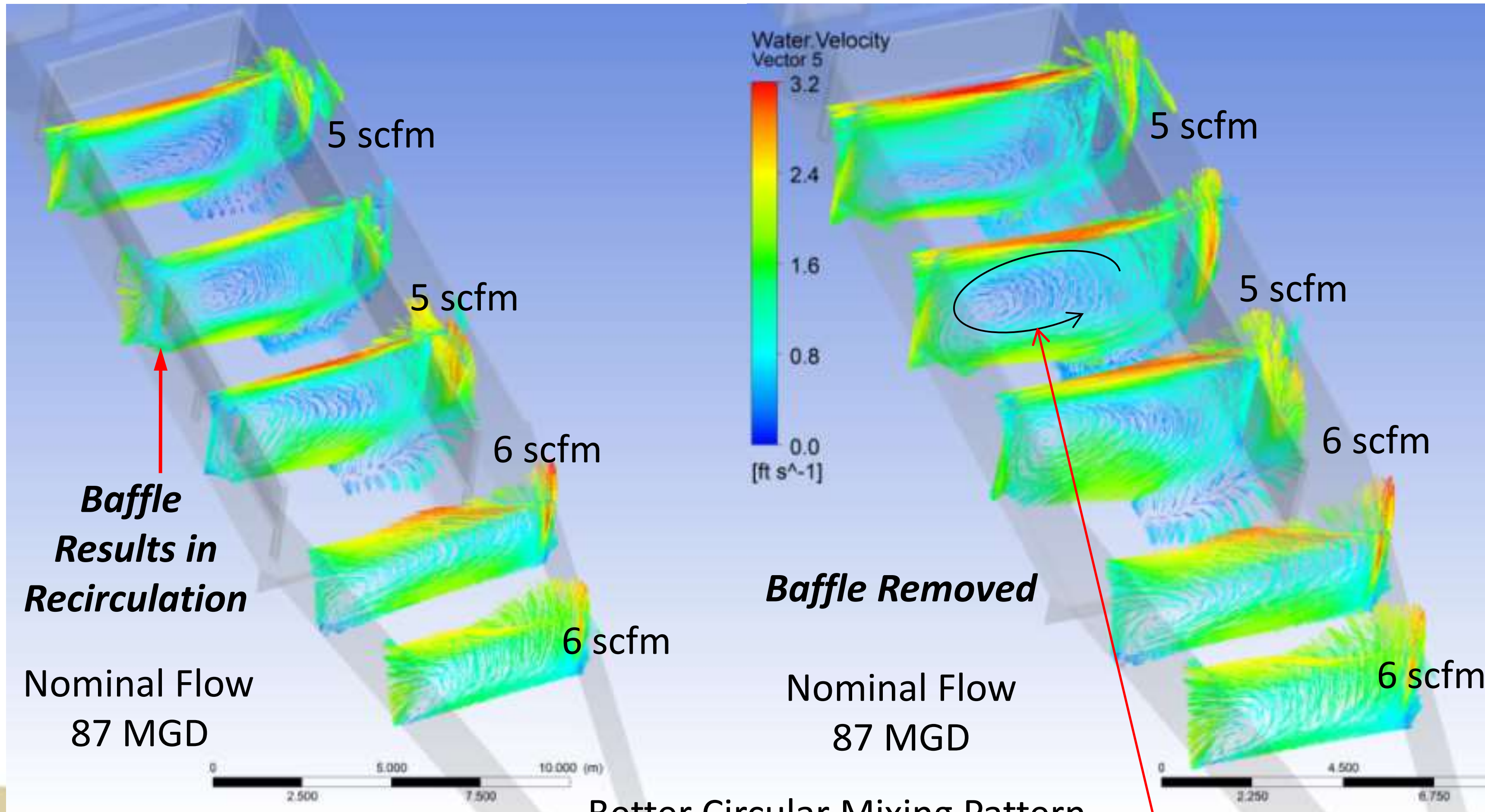
Hydraulic Profile in Grit Tanks



30.0’ in Channel 1
30.8’ in Channel 2
30.9’ in Channel 3
31.5’ in Channel 4
32.0’ in Channel 5
32.1’ in Channel 6
32.2’ in Channel 7

Grit Tank Water Heights Just Upstream of Gate

Velocity Vector Comparison with 1 or 2 Longitudinal Baffle Walls



Better Circular Mixing Pattern with only one longitudinal baffle

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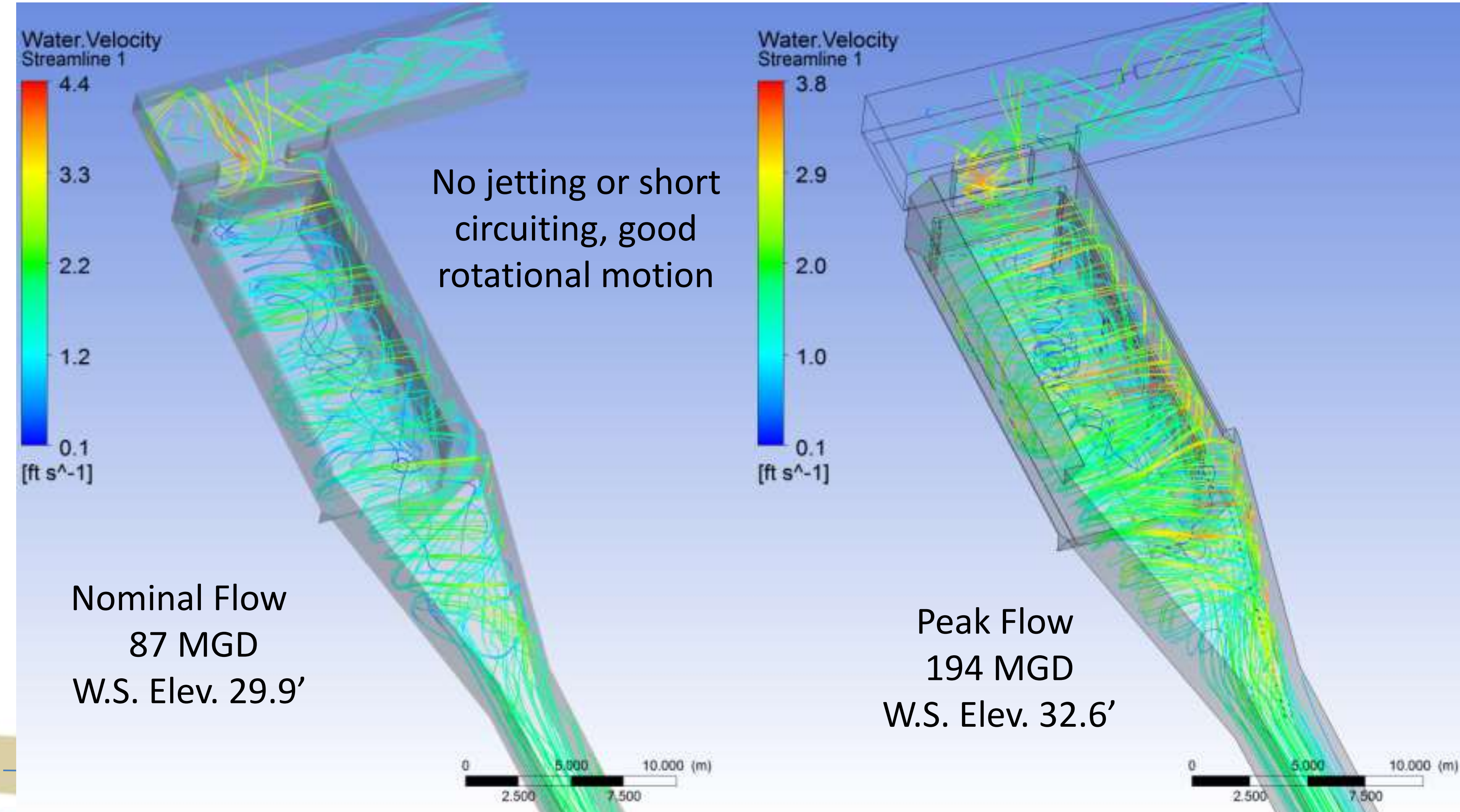
Velocity Patterns with 1 Baffle



No jetting or short circuiting, good rotational motion

Nominal Flow
87 MGD
W.S. Elev. 29.9’

Peak Flow
194 MGD
W.S. Elev. 32.6’

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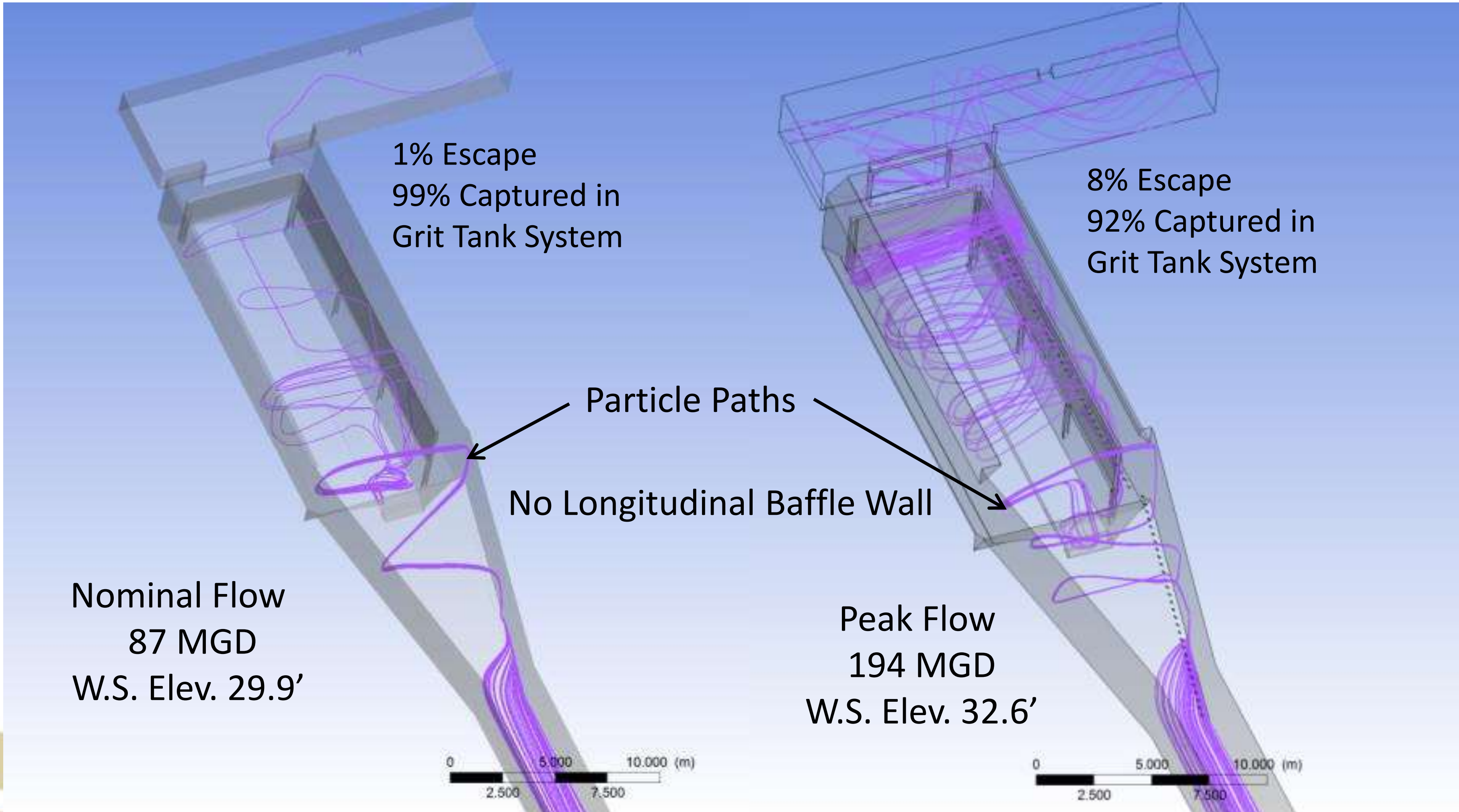
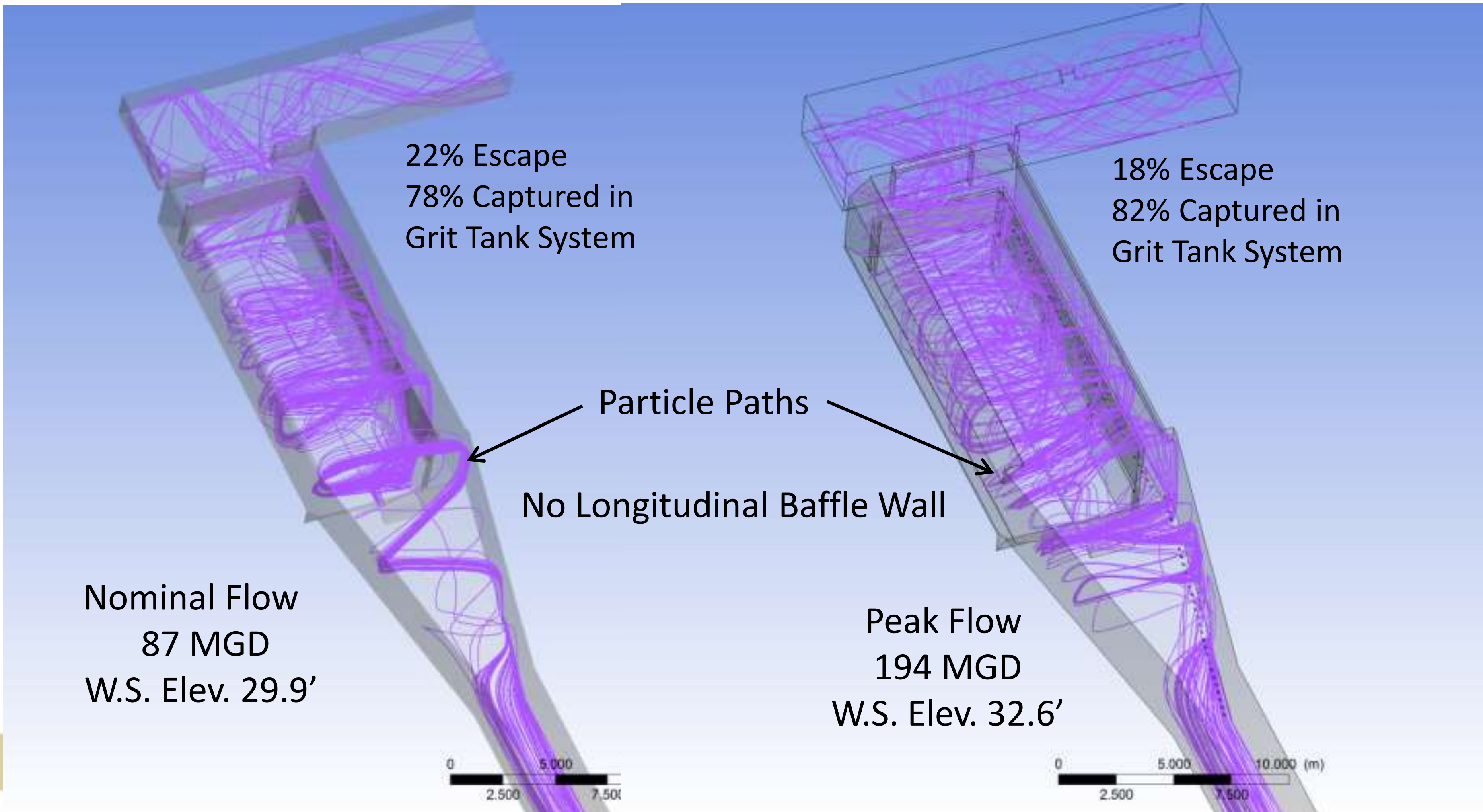
Particulate Removal Modeling Parameters

- Particles Modeled - Grit:
  - 230 microns diameter (>65 mesh)
    grit loading: mass flow = 0.0198 kg/sec
  - 150 to 229 microns diameter (100-65 mesh)
    grit loading: mass flow = 0.0086 kg/sec
- Particles released uniformly across 108” Diameter influent conduit at 240 locations
- Free surface modeled as wall w/ elevation determined from channel filling simulations
  - Bounce coefficient = 1.0 (elastic collision)
- All other physical walls:
  - Bounce coefficient = 0.5 (loses ½ of impending momentum)

Particle Paths – Large Grit
230 microns (>65 mesh), 0.0198 kg/s



Particle Paths - Small Grit
150-229 microns (100-65 mesh), 0.0086 kg/s



Computation Fluid Dynamics (CFD)Results

- Air injection nozzles in transition zone effective in developing spiral flow pattern prior to entry into grit tank.
- The induced circular mixing pattern creates a velocity at the bottom of the grit tank to sweep grit along tank bottom into the grit collection trough.
- Removal of the longitudinal baffle wall along side opposite air diffuser header from the design improves circular mixing in the grit tank.
- Hydraulic profile at 1,160 MGD (194 MGD/tank) is less than maximum allowable water surface of Elevation 32.6 in Grit Tank.
- The grit removal at peak flow of 194 MGD:
  - 92% removal of large grit (>230 microns, >65 mesh)
  - 82% removal of small grit (150 to 230 microns, 100-65 mesh)

Thank You!

We wish to acknowledge the support and assistance provided by NEORSD Management and Engineering; Southerly WWTP Plant Supervisors, O&M Staff, and the Construction Supervisor throughout the design and construction phases of this project.

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