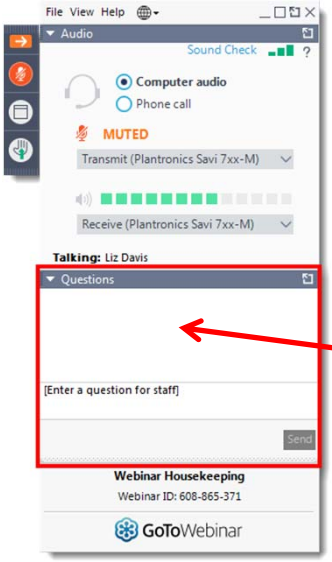
1

How to Participate Today



- **Audio Modes**
  - Listen using Mic & Speakers
  - Or, select "Use Telephone" and dial the conference (please remember long distance phone charges apply).
- **Submit your questions using the Questions pane.**
- **A recording will be available for replay shortly after this webcast.**

2

Discussion Outline

Background
- KUB Introduction

Facility Overview, Drivers, Challenges
- Fourth Creek WWTP
- Kuwahee WWTP

Technology Introduction
- Biologically Enhanced High Rate Clarification
- Pilot Summary
- System Design and Schedule

Full-Scale Operation and Performance

Questions

3

3

Knoxville Utilities Board (KUB)

- KUB provides electric, natural gas, water, and wastewater services to more than 400,000 customers in and around Knoxville, TN.
- KUB owns and operates four wastewater treatment plants (WWTP)
- In February 2005, a Consent Decree with TDEC, USEPA, City of Knoxville, TN Clean Water Network and KUB became effective with the goal of eliminating sanitary sewer overflows (SSOs).
  - *KUB prepared Comprehensive Performance Evaluation (CPE) of our WWTPs and their ability to meet our NPDES permit requirements.*
  - *The results included the initiation of the Composite Correction Plan and Process Controls Plan*

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KUB Evaluation

- Four treatment facilities
  - Kuwahee wet weather treatment capacity for 70 MGD increased to 120 MGD
    - NPDES Violations from 2002-2005
      - 39 NPDES Permit violations
      - 126 Diversions and 16 bypasses
  - Fourth Creek WWTP full treatment capacity from 15 to 34 MGD
    - NPDES Violations from 2002-2005 (all associated with wet-weather conditions)
      - 45 total: 28 TSS, 8 settleable, 1 Fecal, 8 BOD
      - 92 Diversions and 12 bypasses
- ***Three-tiered approach***
  - Fourth Creek and Kuwahee WWTP Improvements
  - Peak Storage/SSO Storage
  - Collection System Improvements – Reduce wet weather induced I/I
    - Average upgrade of 2% of system annually and pump station upgrades
    - Existing System Optimization (CMOM programs, CEPT, Biological treatment)

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KUB Evaluation

Criteria

- Hydraulic and Biological Treatment limitations were found at both facilities
- Confirmation of existing system design capacities
  - Performance Evaluation + Hydraulic Modeling
- Wet Weather Diversions (Current and Future) – Frequency, duration and volume

Options

- Collection system improvements won't mitigate diversions completely and is costly
- Detailed Evaluation Alternatives:

Diversion	Non-Diversion
CEPT	CEPT + BIOACTIFLO™ with Storage
CEPT + ACTIFLO® with Storage	CEPT + BIOACTIFLO™ without Storage
CEPT + ACTIFLO® without Storage	

- Both Deep Bed Filters and Full Biological Treatment ranked low and were determined infeasible (Site Constraints, Operational/Maintenance Challenges, BW disposal)

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KUB Evaluation

- Detailed Evaluation took into consideration:
  - *Performance Evaluation*
  - *Cost and Non-Cost factors*
  - *Diversion frequency*
  - *Implementation impacts*

- CEPT option alone, based on modeling, would not be able to consistently meet NPDES permit

- Recommendation
  - *Phased implementation of BIOACTIFLO™, to provide secondary treatment to peak, wet weather flows in excess of the capacity of the existing WWTP biological processes*
  - *Based on Hydraulic modeling of the 2-year, 24-hour storm event*

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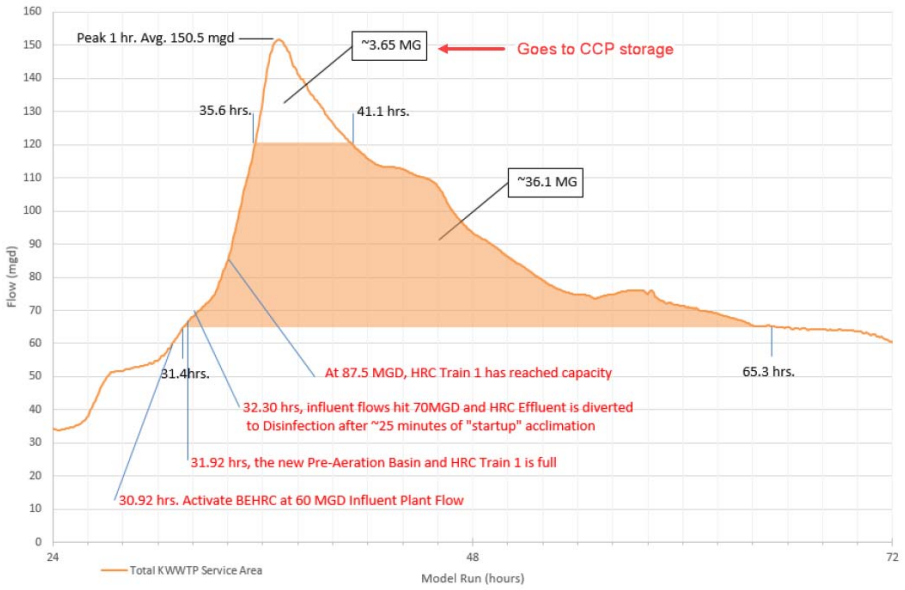
KUB Evaluation



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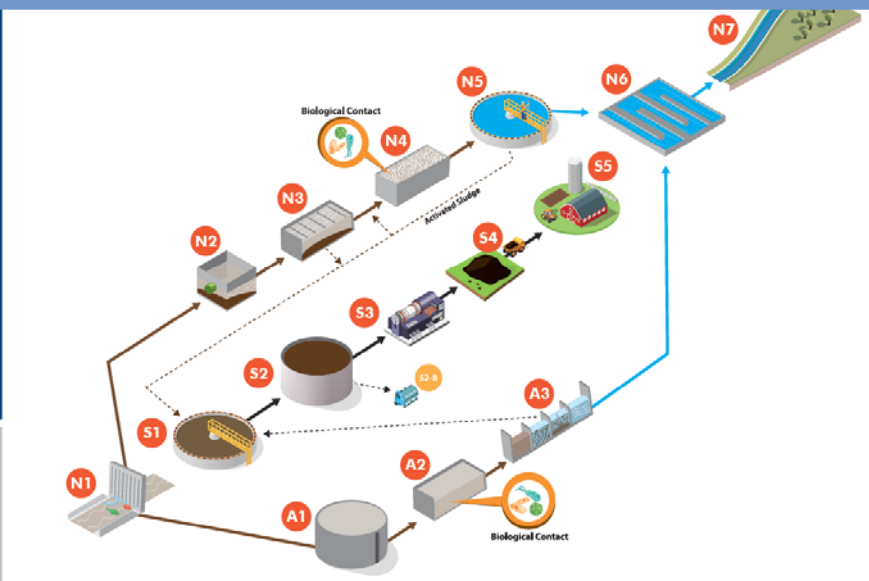
KUB Evaluation

Normal Treatment Train
N1. Influent Screens
N2. Grit Removal
N3. Primary Clarifier
N4. Aeration Tanks
N5. Final Clarifier
N6. Disinfection Contact Tank
N7. Tennessee River

Solids Treatment Train
S1. Solids Thickener
S2. Digester
(S2-B. Biogas Generator)
S3. Centrifuge
S4. Biosolids Cake
S5. Farm

Wet Weather Treatment Train
A1. Wet Weather Storage
A2. Biological Contact Tank
A3. High Rate Clarifier

Knoxville Utilities Board



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Fourth Creek WWTP

- Location: Knoxville, TN
- Originally constructed in 1966
- Outfall into Tennessee River
- Permitted Flow: 10.8 MGD avg, 24 MGD peak
- Effluent TSS: 30 mg/L Daily Avg, 45 mg/L Daily Max
- Effluent BOD_5: 30 mg/L Daily Avg, 45 mg/L Daily Max
- Constraints:
  - *Wet weather flow measurement peaked at 39 MGD*
  - *Hydraulic and Biological capacity limitations*
  - *Prior at 10.8 MGD*
    - Primary Clarifier 1.7 hours,
    - Secondary Clarifiers 2.5 hours

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Fourth Creek WWTP

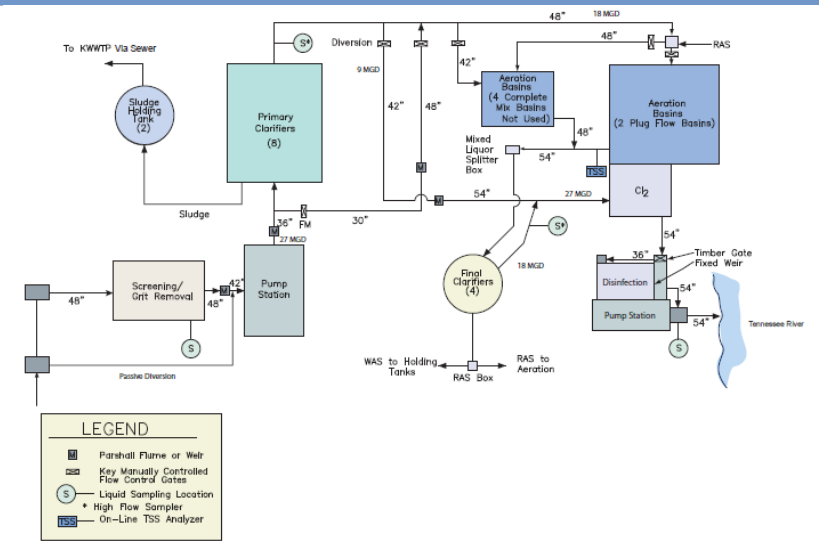

Figure 4-2
Existing Fourth Creek WWTP Process Schematic

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Kuwahee WWTP

- Location: Knoxville, TN, Near Downtown/Univ. of Tennessee
- Originally constructed in the 1950's
- Outfall into Tennessee River
- Permitted Flow: 44 MGD avg, 70 MGD peak
- Effluent TSS: 30 mg/L Daily Avg, 45 mg/L Daily Max
- Effluent $CBOD_5$: 25 mg/L Daily Avg, 40 mg/L Daily Max
- Constraints
  - *Available footprint*
  - *Industrial Discharges*
  - *Hydraulic and Biological capacity limitations*

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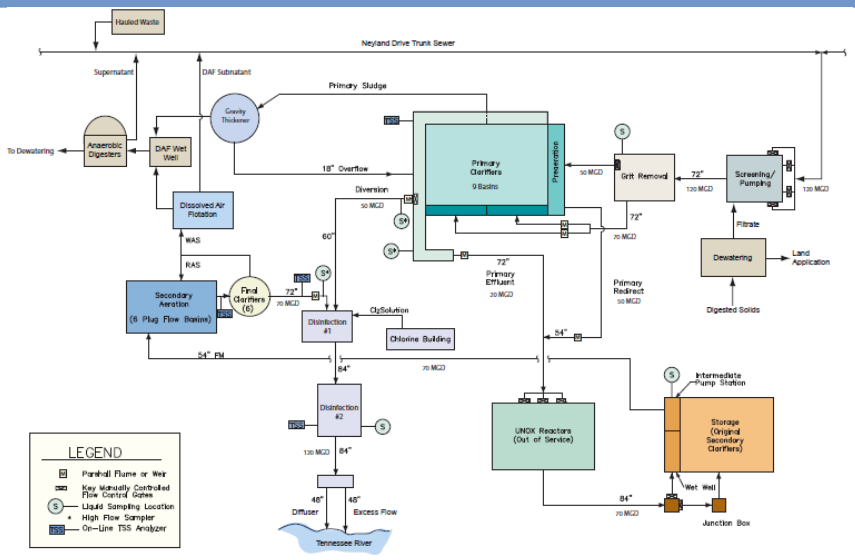
Kuwahee WWTP



CDM

Figure 4-1
Existing Kuwahee WWTP Process Schematic

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Technology Introduction

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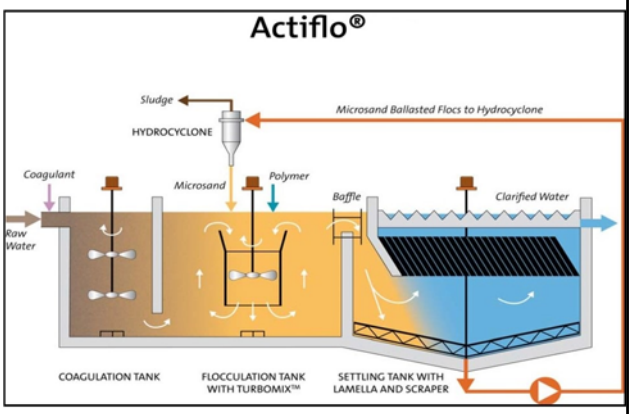
ACTIFLO® for High Rate Clarification (HRC)

- ACTIFLO® for SSO/CSO Treatment
  - *Physical / Chemical process using standard coagulation and flocculation practices*
  - *Uses sand as a ballast to increase the settling rate of the flocculated material*
  - *Rapid Start-up (15 min's) and high surface loading rates (50-70 gpm/sf)*
  - *Small Footprint with Minimal Equipment*
  - *Exceptional TSS and particulate BOD Removals*
  - *CON's – Limited soluble BOD reduction – Doesn't provide biological treatment of wet weather flows (if required)*



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Biologically Enhanced High Rate Clarification (BEHRC)

- BIOACTIFLO™ for SSO/CSO Treatment
  - *Pairs Contact Stabilization with ACTIFLO®*
  - *Contact Tank Facilitates sBOD uptake*
  - *Exceptional TSS and Total BOD Removals*
  - *Provides 100% biological treatment of all wet weather flows = MEETS SECONDARY STANDARDS*

BIOACTIFLO™

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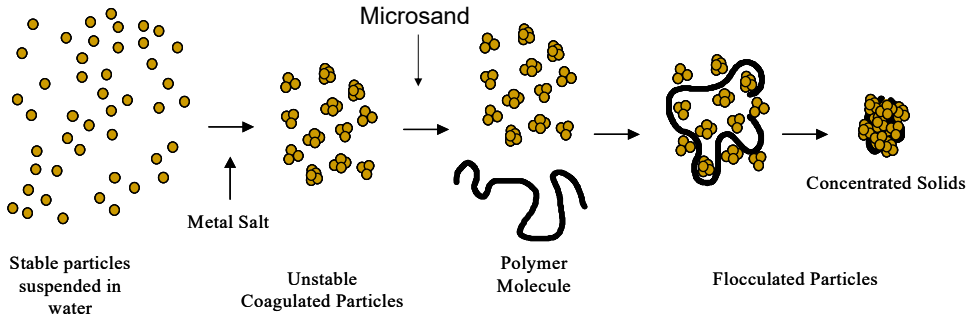
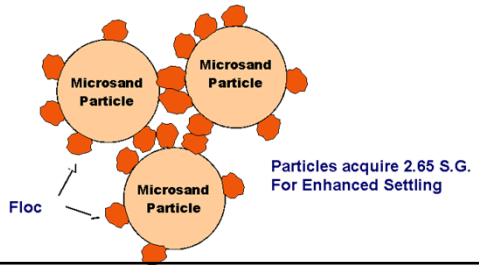
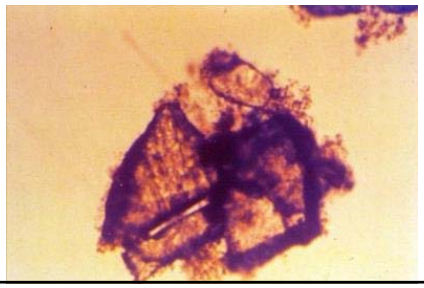
Ballasted Coagulation and Flocculation







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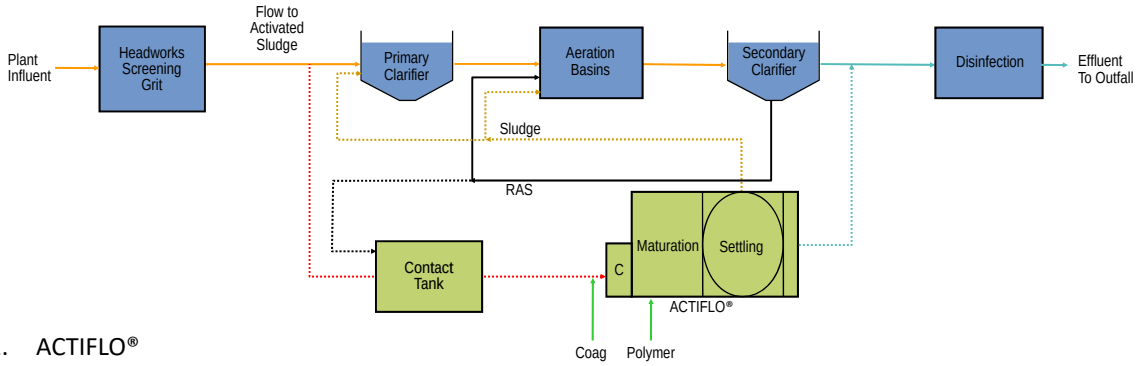
Process Overview



1. ACTIFLO®
2. BIOACTIFLO™
   - o *A biological contact tank precedes ballasted clarification*
   - o *RAS/WAS from the main treatment plant is blended with excess flows to facilitate soluble BOD uptake*
   - o *RAS/WAS and suspended solids are removed within ballasted clarification*
   - o *RAS/WAS is continuously returned to the main plant for reuse and regeneration*
   - o *Achieves > 85% BOD reductions for all wet weather flows*

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Performance in Wet Weather Applications

Configuration	TSS mg/l (% Rem)	BOD mg/l (% Rem)	Total Phosphorus mg/l	UV Transmittance % UVT	Geo Mean E. Coli after Disinfection MPN/100 ml
ACTIFLO®	< 15 (85 – 95%)	10 – 40 (40 – 65%)	0.1 – 0.3	65 - 80	< 15
BIOACTIFLO™	< 10 (90 – 98%)	5 – 10 (> 85%)*	0.1 – 0.2	70 - 85	< 15

*Note: sBOD reduction in BIOACTIFLO™ contact tank allows for this increased total BOD reduction rate.

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Experience / Benefits

- Over 18 years of Wet Weather Treatment Experience
- 26 Wet Weather installations in operation
- 5 BIOACTIFLO™ facilities in operation
  - *3 more under construction / detailed design*
- Intermittent or Continuous Use. Same Treatment train can handle variety of operating modes (Primary, Wet Weather, Tertiary)
- ACTIFLO® and BIOACTIFLO™ are cost effective solutions compared to other treatment options and provides the flexibility to handle variability in influent quality/flow
- BIOACTIFLO™ provides full secondary treatment to all wet weather flows

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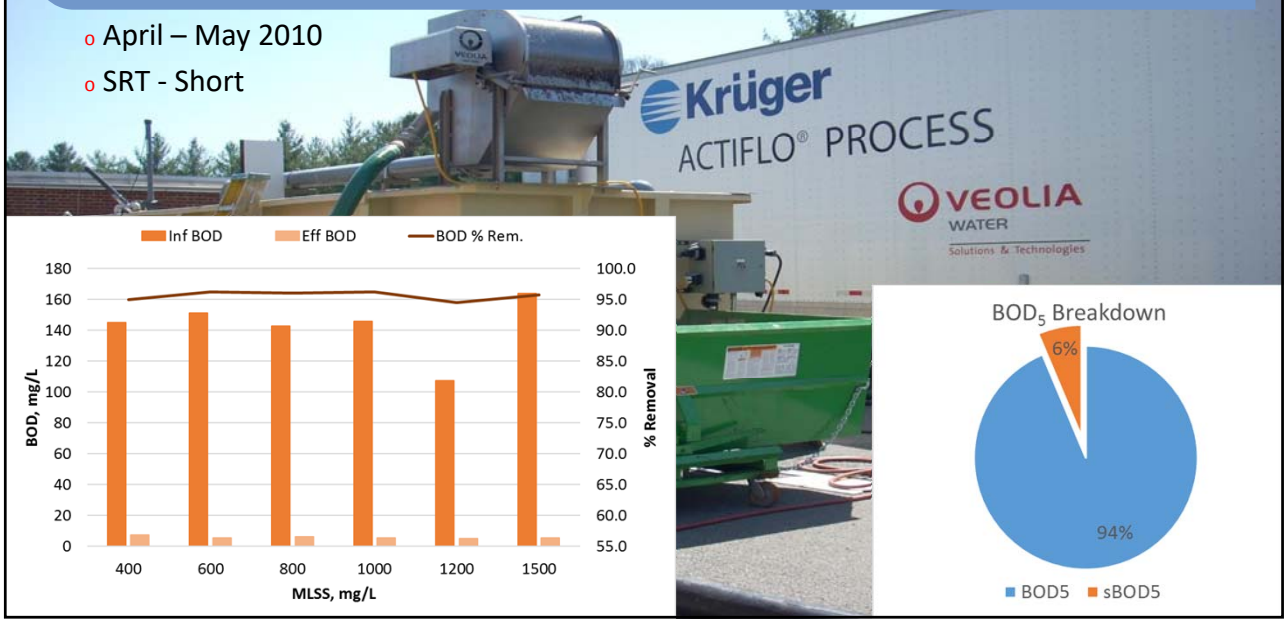
Pilot Testing – Fourth Creek WWTP

- April – May 2010
- SRT - Short



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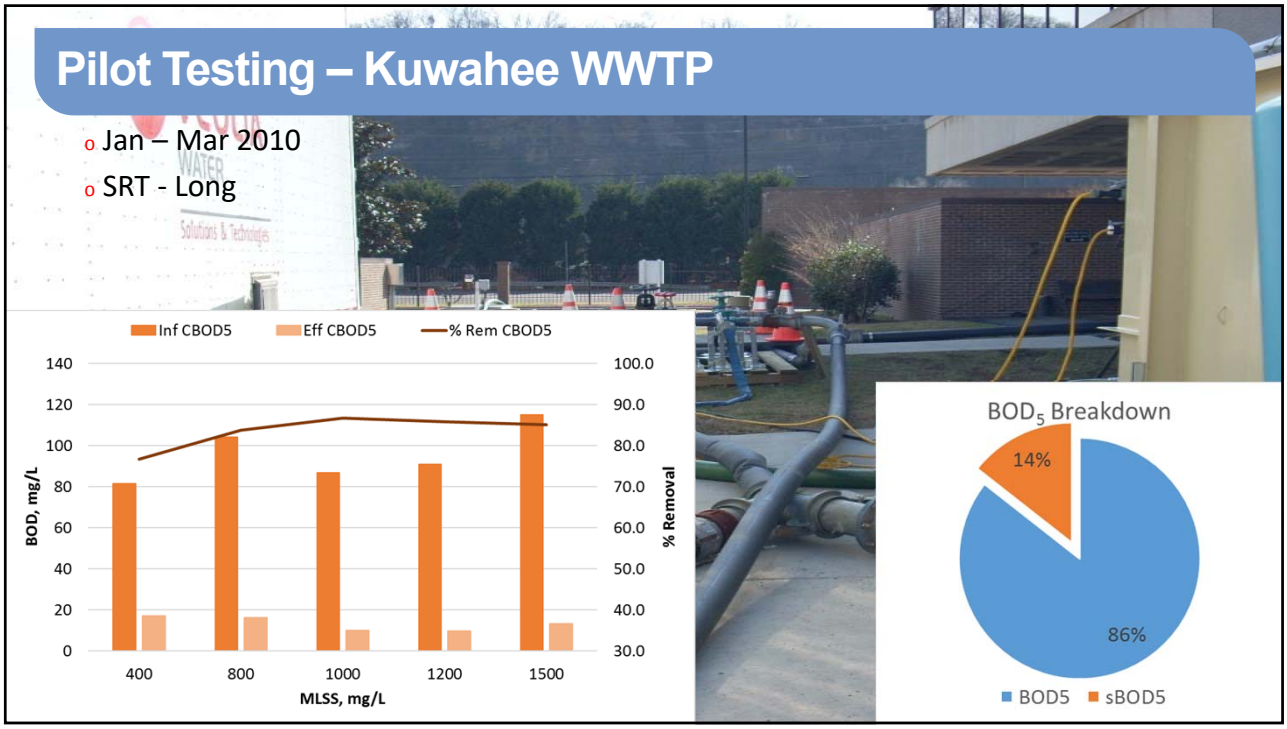
Pilot Testing – Kuwahee WWTP

- Jan – Mar 2010
- SRT - Long



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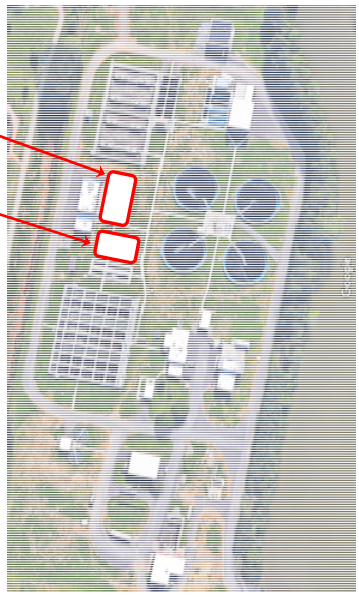
Fourth Creek WWTP – System Design

- 2 x 9.5 MGD ACTIFLO® installed and commissioned in 2014
- Converted to BIOACTIFLO™ in 2018
  - *Provisions were made in 2014 to help reduce conversion costs*
  - *Phased implementation helped identify unexpected issues and resolve them before starting KWWTP*
- Anticipated Influent Conditions
  - *BOD_5 (Avg / Max) – 141 mg/L / 230 mg/L*
  - *TSS (Avg / Max) – 130 mg/L / 260 mg/L*
- Effluent Guarantees
  - *> 85% removal of BOD_5*
  - *> 85% removal of TSS*



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Fourth Creek WWTP – Project Timeline

- Phase 1
  - *CEPT Pilot testing early 2009*
  - *BIOACTIFLO™ Pilot testing in early 2010*
  - *Design and Construction of CEPT + ACTIFLO® + Storage – 2011 to 2013*
  - *ACTIFLO® commissioning and Performance Evaluation - 2014*
- Phase 2
  - *Design and Construction of BIOACTIFLO™ – 2016 to 2018*
  - *BIOACTIFLO™ commissioning - 2018*

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Kuwahee WWTP – System Design

- 2 x 27.5 MGD BIOACTIFLO™ under construction
- Anticipated start-up – 3Q 2020
- Site Constraints
  - *Existing Pre-Aeration Tank converted into Biological Contact Tank No. 1*
  - *Retrofitted existing Intermediate Storage Basins with ACTIFLO®, Chemical Building, Biological Contact Tank No. 2 and Pump Station*
- Anticipated Influent Conditions
  - *BOD_5 (Avg / Max) – 135 mg/L / 211 mg/L*
  - *TSS (Avg / Max) – 180 mg/L / 350 mg/L*
- Effluent Guarantees
  - *> 85% removal of BOD_5*
  - *> 85% removal of TSS*

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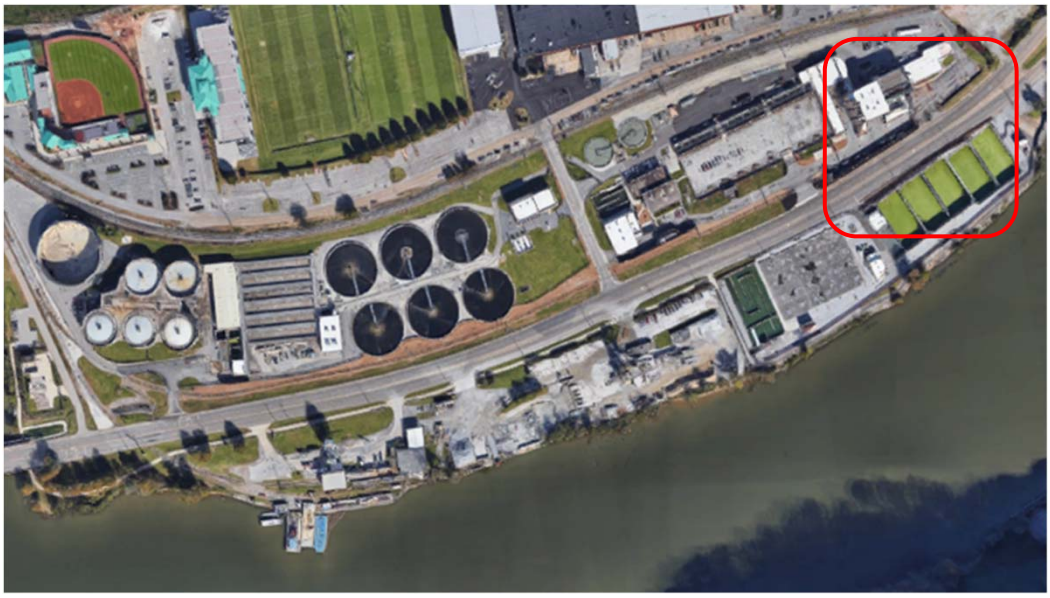
Kuwahee WWTP – System Design



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Kuwahee WWTP – System Design

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Kuwahee WWTP – Project Timeline

- Phase 1
  - *CEPT Pilot testing early 2009*
  - *Design and Construction of Storage – 2008 to 2011*
  - *BIOACTIFLO™ Pilot testing in early 2010*
  - *Design and Construction of CEPT – 2010 to 2012*
- Phase 2
  - *Design and Construction of BIOACTIFLO™ – 2018 to 2020*
  - *BIOACTIFLO™ commissioning - 2020*

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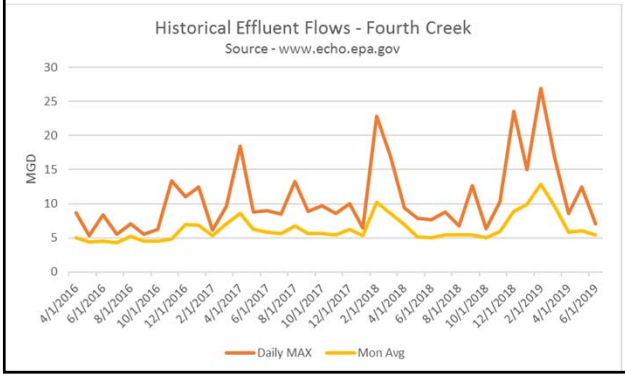
Full-Scale Operation

- Record Rainfall, I&I Issues – Late 2018, Early 2019
- Feb 2019 – Received over 13” rain (4X the 10-yr avg)
- Area wide impacts, widespread flooding lasting for days



Chilhowee Park

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Full-Scale Operation

- KUB treated over 4 billion gallons of water between Jan-Feb 2019
  - *34% increase compared to 2018*
- BIOACTIFLO™ helped Fourth Creek handle historic flows and remain in compliance
  - *1 violation due to influent dilution with inflow*

Fourth Creek WWTP	Average TSS	Average BOD_5
Influent	63.5 mg/L (27 – 150 mg/L)	56.0 mg/L (15 – 140 mg/L)
Effluent	9.1 mg/L (2 – 19 mg/L)	4.6 mg/L (2 – 9 mg/L)
% Removal	81.3% (41% – 97%)	90.5% (80% - 94%)

Note – Based on 14 events between 12/21/2018 – 3/10/2019

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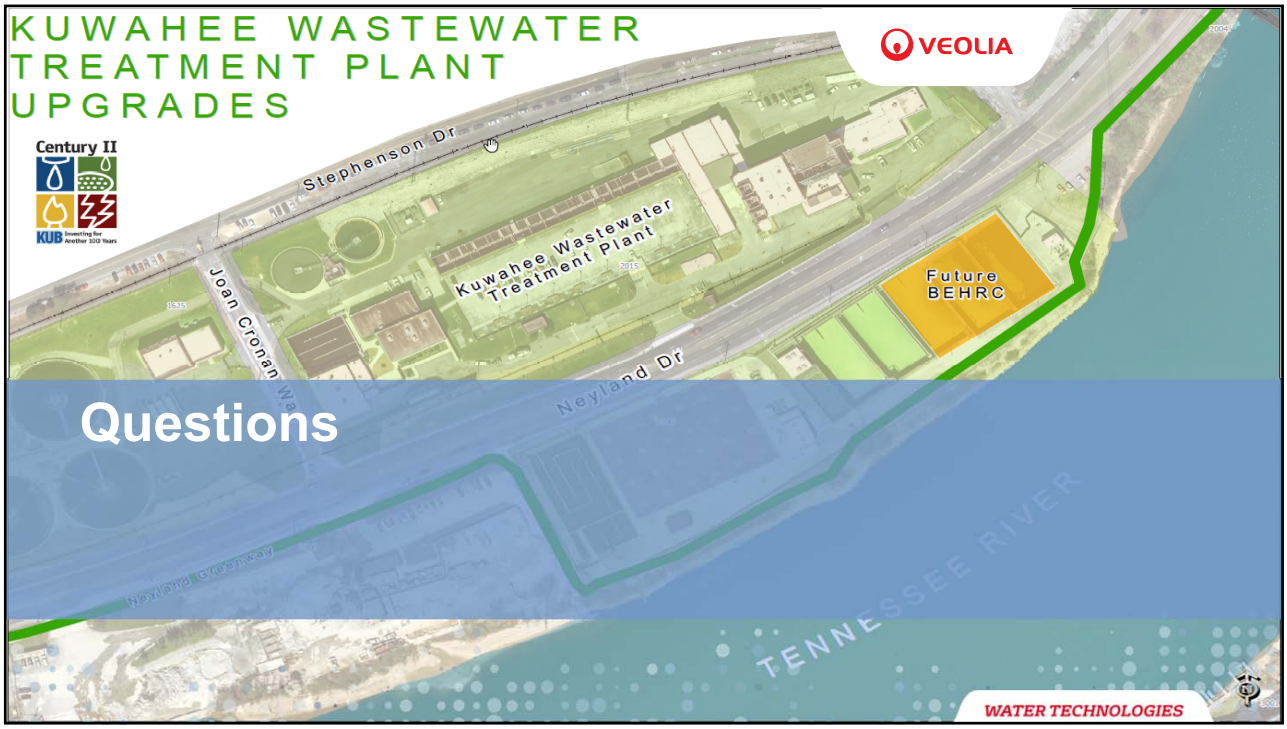
KUWAHEE WASTEWATER TREATMENT PLANT UPGRADES
VEOLIA
Century II
KUB
Stephenson Dr
Joan Cronan Way
Kuwahee Wastewater Treatment Plant
Future BEHRC
Neyland Dr
Questions
Neyland Greenway
TENNESSEE RIVER
WATER TECHNOLOGIES

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