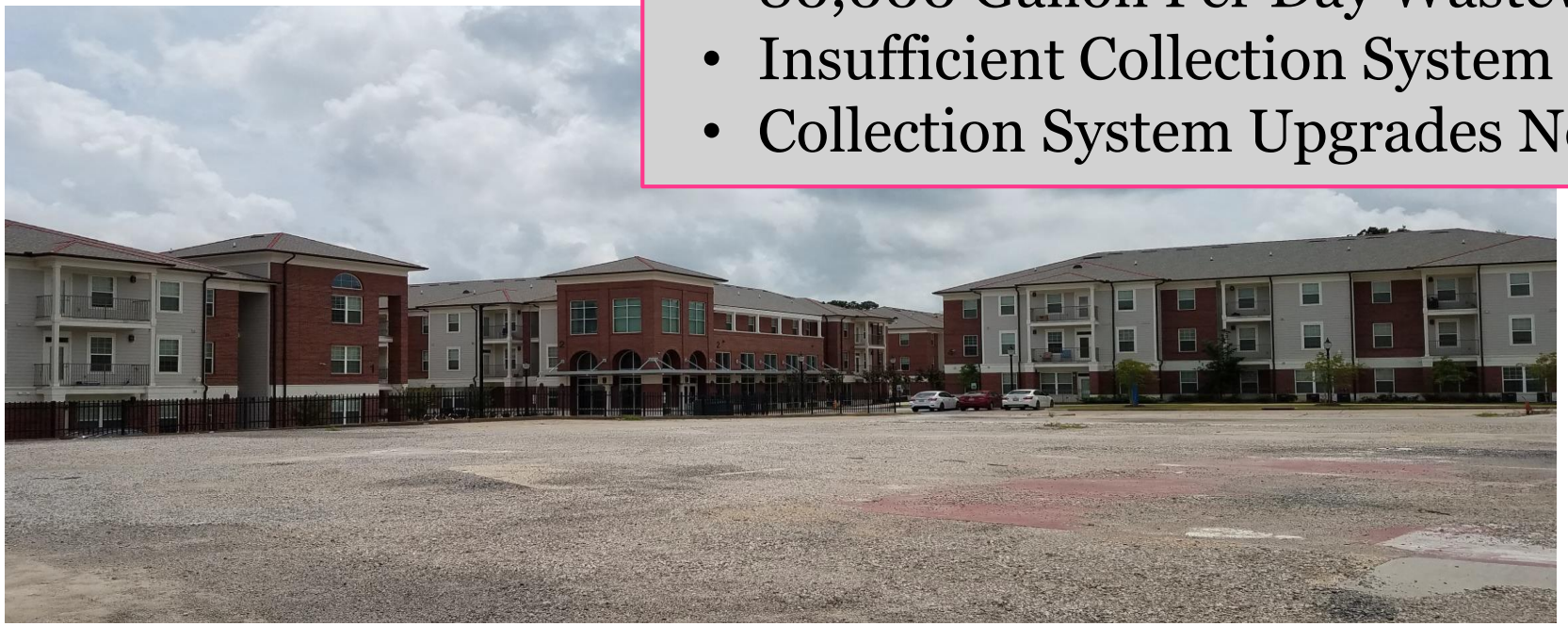
Nutrient Reduction in Neighborhood Scale Wastewater Treatment Plants

CHARLES W. CORKERN

LAFAYETTE UTILITIES SYSTEM

University Housing On Campus

- Multi-Unit / Multi-Level Complex
- 700 + Residents & Amenities
- 80,000 Gallon Per Day Wastewater Flow
- Insufficient Collection System Capacity
- Collection System Upgrades Not Feasible



Site Challenges Precast Concrete Sewage Treatment Plant By Gainey's Concrete Products

- 80,000 Gallons Per Day Treatment Capacity
- 160,000 Gallon Tankage for 24 hour Detention Time
- Extended Aeration, Return Activated Sludge Process
- Aerated Flow Equalization For Pretreatment
- Fully Adjustable, Timed Influent Dosing
- Chlorine Disinfection Of Final Effluent

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Site Challenges

- Highly Visible Location
- Close Proximity To:
  - Neighbors
  - Residents
  - Faculty & Staff
  - Classrooms
  - Operations and Maintenance Offices

Site Challenges

- Effluent Discharge To Concrete Lined Stream
- Sidewall Discharge 20 Feet Above Water Level
- Stream Flows Through Multiple Housing Units
- Classrooms
- Offices
- Parking
- Campus Daycare Center

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Operational Challenges

- Very Public, Very Visible, Highly Scrutinized
- Zero Margin For Error regarding:
  - Effluent Quality
  - Odors
  - Noise

Operational Challenges

- Heavily Loaded, Nutrient Rich Influent
- Unusual Flow Characteristics
- LDEQ Permit Limits / Monthly Monitoring
- Consistently, Inconsistent Flow Loading
- Compact Plant Footprint / Water Level Gradient
- High Sludge Generation / Wasting Frequency Requirements

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Operational Challenges

- Heavily Loaded, Nutrient Rich Influent
- BOD = 296 mg/L
- TSS = 372 mg/L
- Ammonia = 57 mg/L
- Total Nitrogen = 99 mg/L
- Total Phosphorus = 12 mg/L

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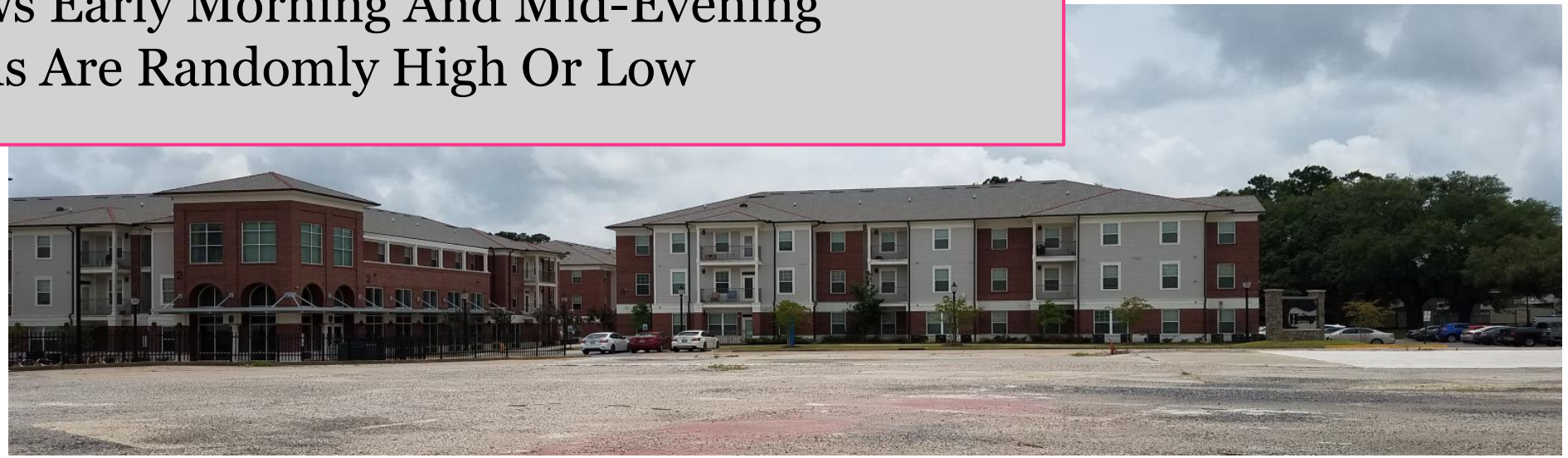
Operational Challenges

- Unusual Flow Characteristics
- College Student Housing / College Student Schedule
- Peak Flows Are Polar Opposite Of Average Timing
- High Flows At Mid-Day And Midnight
- Low Flows Early Morning And Mid-Evening
- Weekends Are Randomly High Or Low



Operational Challenges

- Consistently, Inconsistent Flow Loading
- College Student Housing / College Student Schedule
- No Load To Full Capacity: Four Days
- 90 Days Of Use / 30 Days No Use
- Intermittent Breaks. Up To 14 Days
- Random High Load Periods. 3~7 Days

Operational Challenges

- Compact Plant Footprint / Water Level Gradient
- 80,000 GPD Design Average Flow
- 25 Linear Feet. Head of Plant to Discharge
- 18”~24” Water Level Difference. Aeration Basin To
- Clarifier
- Critically Sensitive Return Sludge And Skimmer Rates
- Equally Critical Influent Dosing Rate / Timing

Operational Challenges

- High Sludge Generation / Wasting Frequency Requirements
- Heavily Loaded Influent =Heavily Loaded MLSS
- Sludge Age Critical / Older Is Better
- No Built in Sludge Holding / Digester
- Wasting To Municipal Collections System
- Ability To Waste From Each Clarifier Individually

Nutrients

- Nutrients Are Fertilizer
- Nutrients Are Concentrated In Wastewater
- Nutrients Promote Algae And Plant Growth
- Certain Nutrients Are Toxic To Aquatic Life
- Nitrogen And Phosphorus Are The Target Nutrients
- Nutrient Removal Is Essential To Meeting NPDES Limits

Nutrients

- Nutrients Are Concentrated In Wastewater
- Typical Domestic Wastewater Contains 20~85 mg/L Nitrogen As:
- Ammonia = NH_3
- Nitrate = NO_3
- Nitrite = NH_4
- Typical Domestic Wastewater Contains 4~15 mg/L Phosphorus:
- Orthophosphates
- Polyphosphates

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Nutrients

- Nitrogen And Phosphorus Are Toxic To Aquatic Life
- Nitrogen And Phosphorus Cause Algae Blooms
- Decomposing Algae And Aquatic Plants Consume Dissolved
- Oxygen
- Low Oxygen levels Kill Fish and Other Marine Life
- Ammonia above 3mg/L is Toxic to Fish
- Combined Plant And Animal Decomposition Promotes
- Eutrophication

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Nutrient Removal

- Nutrient Removal Is Essential To Meeting NPDES Limits
- Nitrogen Can Be Removed By Biological Nitrification and
- Denitrification
- Nitrification Converts Ammonia NH_3, To Nitrate NO_3
- Denitrification Converts Nitrate NH_3, To Nitrite NH_4, And
- Nitrogen gasses
- The Process Requires Little To No Oxygen (Anoxic) Conditions
- Nitrogen Gasses Are Removed By Air Stripping

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Nutrient Removal

- Nutrient Removal Is Essential To Meet NPDES Limits
- Phosphorus Can Also Be Removed By Biological Means
- Bacteriologic consumption Of Phosphorus Is Enhanced By Alternating Aerobic And Anaerobic Conditions
- Phosphorus Contained In Cell Wall Of Bacteria
- Ultimate Phosphorus Removal Occurs When Wasting Sludge

Nutrient Reduction Process

- Nutrient Concentrations Of Raw Influent
- BOD = 296 mg/L
- TSS = 372 mg/L
- Ammonia = 57 mg/L
- Total Nitrogen = 99 mg/L
- Total Phosphorus = 12 mg/L

Nutrient Reduction Process

- Three Flow Equalization Cells Receive Raw Wastewater
- First Two Cells Aerated 23 Hours A Day
- Third Cell Anoxic. Nutrient Reduction Begins At
- Pretreatment
- Timed Dosing Of Pretreated Influent Occurs At This Cell
- Head Of Plant Receives Pretreated Influent

Nutrient Reduction Process

- First Treatment Cell Receives Pretreated Anoxic Influent
- First Cell Receives Return Sludge From 3 Of 4 Clarifiers
- First Cell Simi-Anoxic, Upstream Half Aerated
- Second, Half Sized Cell Receives Return Sludge Fourth Clarifier
- Second, Half Sized Cell Anoxic
- Return Sludge Flow Ensures Mixing Of MLSS

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Nutrient Reduction Process

- Third Full Sized Treatment Cell Is Anoxic
- Downstream Air Diffusers On To Deter MLSS Settling
- Fourth Cell Is Vigorously Aerated For Nitrogen Stripping
- Fifth Cell Is Anoxic, Downstream Air To Deter Settling
- Cells 6~9 Are Aerated By Varying Degrees
- Aeration Is Essential To Treatment And Promotes Nitrogen
- Stripping

Nutrient Reduction Process

- Treatment Cell Ten Is Anoxic, Downstream Air
- Cells 11~14 Are Aerated As Usual
- Clarification And Sludge Return Occur In Cells 15~18
- Treated Effluent Leaves Cell 18 Via Adjustable Weirs
- Chlorine Disinfection Prior To CCC And Discharge

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Nutrient Reduction Results

Influent Concentration

- BOD = 296.0mg/L
- TSS = 372.0mg/L
- Ammonia NH3 + 57.0mg/L
- TN = 99.4mg/L
- TP = 11.8mg/L

Effluent Concentration

- BOD = 3.0mg/L
- TSS = 4.0mg/L
- Ammonia NH3 = 0.40mg/L
- TN = 11.6mg/L
- TP = 6.4mg/L

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Credits

All Pictures Courtesy Of:

- Charles W. Corkern With LUS
- Greg Roche With Gainey's
- Except Slide 8

http://techalive.mtu.edu/meec/module21/images/raw.jpg

Credits

Slide 15 Picture Courtesy Of:

Description	Algal bloom in village river. Taken in a small village in mountains near Chengdu, Sichuan, China.
Date	2 December 2005
Source	Own work
Author	Felix Andrews (Floybix)

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Credits

- **Module 18**
- **The Activated Sludge Process**
- **Part IV**
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