CONNECTING THE DOTS:

UNINTENDED IMPACTS OF WATER CONSERVATION ON WASTEWATER CONVEYANCE, TREATMENT AND REUSE

Southern California Alliance of POTWs
MAY 31, 2018
No good deed goes unpunished....
Dealing with the paradigm shift of water conservation in wastewater conveyance, treatment and reclamation
Challenges of the Triple Nexus

Stress

Strain

Pressure
Stress

Resource Management

- Increased demand for energy & chemicals
- Increased energy density – kWh per mgd
- Decreased energy potential – digestion and gas production
- Increased labor attention – process & maintenance
- Increased process monitoring
- Increased laboratory support
Reliability

- Asset performance, availability and reliability
- Increased wear and tear on equipment
- Loss of redundancy
- Overload equipment design capacity
- Increased rate of failure
- Reduced expected life
- Increased replacement rate
- Increased labor burden – reactive vs. predictive
Infrastructure Planning

- Loss of infrastructure integrity
- Increased community impacts – odor and rates
- Loss of treatment capacity and function
- Change in CIP schedule
- Increased engineering load
- Shift in financial plan and resource demand
- Loss of co-gen output
- Increase in energy purchase
INTEGRATING ISSUES AND EFFORTS THROUGH SITUATIONAL AWARENESS AND CULTURE SHIFT
CONNECTING THE DOTS

- ENERGY IMPACTS
- PROCESS IMPACTS
- ASSET IMPACTS
CONNECTING THE DOTS

CONSERVATION IMPACTS

COLL SYS IMPACTS

PROCESS IMPACTS

ENERGY/GHG IMPACTS

COMPLIANCE IMPACTS

ASSET IMPACTS
OPTIMIZATION AT THE NEXUS

REQUIRES A MAJOR SHIFT IN THINKING, PLANNING AND CULTURE

FIND THE BEST FIT CURVE OF RESOURCE MANAGEMENT

... OUR INDUSTRY NEEDS TO FIT THE NEW CURVE!
ESTABLISHING A NEW BASELINE

Aggressive water conservation is challenging infrastructure integrity, conditions of sewage conveyance, reliability and economy of treatment.

It is seriously challenging the ability of many facilities to meet stringent discharge requirements and maintain reuse water quality.
BREAK
WYATT TROXEL

*EnerVention Strategies*

**PROCESS IMPACTS OF WATER CONSERVATION – THE CASCADE EFFECTS**
ESTABLISHING A NEW BASELINE

OUR FIRST STEPS IN MEETING A NEW CHALLENGE:
1. UNDERSTANDING WHAT HAS CHANGED.
2. THE IMPACTS ON COLLECTION AND TREATMENT PROCESSES.
3. THE IMPACTS ON DESIGN, OPERATIONS, ENERGY AND PLANNING.
4. STARTING A DIALOGUE AND SHARING INFORMATION.
5. DEVELOPING OPTIONS AND ALTERNATIVES.
IMPACT OF WATER CONSERVATION

FLOW

NEW SERVICES
CHANGE IN COLLECTION SYSTEM BIOLOGY

FLOW

AMMONIA
SOLUBLE BOD
PARTICULATE BOD
WWTP ENERGY PROFILE

FLOW

ENERGY DEMAND

ENERGY POTENTIAL
KPIs FOR NEW NORMAL

ENERGY DENSITY = \frac{KWH}{MGD}

ENERGY DENSITY
CAPACITY COMPLIANCE
CHANGING CONDITIONS

- WATER CONSERVATION
- PROCESS COMPLIANCE
- ENERGY USAGE
- EQUIPMENT FAILURE
- TECHNOLOGY

STEP CHANGE
CLIMATE CHANGE WEATHER FORECAST

2005
WINTER RAIN

2008
REDUCED RAIN

2010
DROUGHT

2015
PROLONGED DROUGHT

“THE NEW NORMAL”
VOLATILE WEATHER
CONNECTING THE DOTS

ENERGY IMPACTS

PROCESS IMPACTS

ASSET IMPACTS
PROCESS CONTROL ISSUES
THE CASCADE EFFECT
PROCESS CONTROL ISSUES
THE CASCADE EFFECT

WHAT HAPPENS IN THE SEWER...

DOESN’T STAY IN THE SEWER...

AFFECTS EVERYTHING
PROCESS CONTROL ISSUES
THE CASCADE EFFECT

■ MAIN CULPRITS:
  - HIGH CONCENTRATION (BOD, TSS, TDS, TKN, Ammonia-N, etc.)
  - TIME
  - TEMPERATURE
  - DECOMPOSING PROTEIN
■ HYDROGEN SULFIDE
■ VOLATILE ACIDS (SOLUBLE BOD)
■ AMMONIA FROM TKN (PROTEIN)
PROCESS CONTROL ISSUES
THE CASCADE EFFECT

COLLECTION SYSTEM
HEADWORKS
PRIMARY SEDIMENTATION
THICKENING & DIGESTION
SECONDARY TREATMENT
TERTIARY FILTRATION
EFFLUENT DISINFECTION
RECYCLING & REUSE
COLLECTION SYSTEM ISSUES
PIPING AND PUMP STATIONS

REDUCED FLOW RATES AND HIGHER CONCENTRATIONS

INCREASED SULFIDE GENERATION

INCREASED ODORS, TOXICITY & CORROSION

OVERSIZED PUMPS AND INCREASED CYCLING

INCREASED ENERGY CONSUMPTION

INCREASED RISK OF FAILURES AND SPILLS
PROCESS CONTROL ISSUES
HEADWORKS

CREASED SULFIDE ODOR,
CORROSION,
CHEMICALS

IMPACTS FROM
SLOUGHING SOLIDS

PERIODIC
OVERLOAD OF
GRIT SYSTEM

CREASED MAINTENANCE
PROCESS CONTROL ISSUES
PRIMARY SEDIMENTATION
GROWTH AND ODORS OF SULFUR FIXING BACTERIA

- BOD REMOVAL EFFICIENCY
- TSS REMOVAL EFFICIENCY
- SLUDGE SETTLING & GASIFICATION

- HEALTH/SAFETY AND CORROSION PROTECTION
- LOSS OF DIGESTION & ENERGY PRODUCTION
- PRODUCTION AND CARRY-OVER OF VFA, HS & NH₃
PROCESS CONTROL ISSUES
PRIMARY SLUDGE THICKENING

- ADDITIONAL HS PRODUCTION
- POOR GT SETTLING AND SOLIDS RECIRCULATION TO HEADWORKS
- EXCESS WATER AND REDUCED TS MASS TO DIGESTION
PROCESS CONTROL ISSUES
ANAEROBIC DIGESTION

- REDUCED GAS PRODUCTION AND ENERGY RECOVERY
- REDUCED VSR & CHALLENGES TO CLASS B QUALITY
- IMPACTS ON DIGESTER CLEANING CYCLES
- INCREASED PUMP & COMPRESSOR ATTENTION

CO-GEN
PROCESS CONTROL ISSUES
SECONDARY TREATMENT

INCREASED ENERGY DEMAND
INCREASED TF SLOUGHING AND POOR BOD EFFICIENCY
INCREASED BLOWER AND DIFFUSER ATTENTION
POOR PERFORMANCE DUE TO HS TOXICITY
NITROGEN REMOVAL FAILURE & BREAKTHROUGH
PROCESS CONTROL ISSUES
BIOLOGICAL NUTRIENT REMOVAL

- OVERLOAD & REDUCED TREATMENT CAPACITY
- pH SHIFT & ELEVATED SVI DUE TO POLYSACCHARIDES
- MLE FAILURE DUE TO IMLR OVERLOAD
- LOSS OF REDUNDANCY
- INCREASED EFFLUENT TIN
- INCREASED IMLR & RAS PUMPING ENERGY
- INCREASED MAINTENANCE ATTENTION

Diagram:
- RAS
- ANAER
- ANOXIC
- AERATION
- POST-ANOXIC
- REAER
- MLR
PROCESS CONTROL ISSUES
BIOLOGICAL NUTRIENT REMOVAL

HIDDEN REASON FOR BNR FAILURES

In the MLE Process
Mixed Liquor Return (MLR) pumping can’t handle increased ammonia concentration

\[ Q_{mlr} = (Q_{inf})(N_i/N_e) - Q_i - Q_r \]
PROCESS CONTROL ISSUES
BIOLOGICAL NUTRIENT REMOVAL

MLR sizing based upon ammonia concentration

Influent flow = 30 mgd
Effluent TIN = 7 mg/L
RAS @ 100% = 30 mgd
MLR @ 4Q design = 120 mgd

<table>
<thead>
<tr>
<th>Influent NH3-N</th>
<th>MLR Capacity</th>
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<tbody>
<tr>
<td>25 mg/L</td>
<td>47 mgd</td>
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<tr>
<td>35 mg/L</td>
<td>90 mgd</td>
</tr>
<tr>
<td>45 mg/L</td>
<td>133 mgd</td>
</tr>
<tr>
<td>55 mg/L</td>
<td>176 mgd</td>
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</table>
PROCESS CONTROL ISSUES
SECONDARY CLARIFICATION

- INCREASED SLR
- INCREASED BLANKET LEVEL
- INCREASED RAS PUMPING
- INCREASED HOUSEKEEPING
- FOAMING

- REDUCED TSS CONTROL
- REDUCED CAPACITY RATING
PROCESS CONTROL ISSUES
TERTIARY FILTRATION

- INCREASED LOADING
- INCREASED ENERGY & RECYCLES
- INCREASED TURBIDITY
- DECREASED THROUGHPUT
- INCREASED COAGULANT DOSE
PROCESS CONTROL ISSUES
CHLORINE DISINFECTION

- INTERRUPTED EFFICIENCY
- INCREASED CHEMICAL DOSE & COST
- INCREASED COLIFORM
- INCREASED $SO_2$ DEMAND
PROCESS CONTROL ISSUES
UV DISINFECTION

- REDUCED UV TRANSMITTANCE
- INCREASED ENERGY DEMAND
- INCREASED CLEANING AND BULB MAINTENANCE
WANTED: SITUATIONAL AWARENESS

NEW TECHNOLOGIES, BETTER INFORMATION, & SUPPORT FOR NEW STRATEGIES

WHEN LOTS OF THINGS CHANGE, EVERYTHING NEEDS TO CHANGE

THIS WILL TAKE MORE THAN BETTER TOYS (OR TOOLS)
RELIABILITY IN DROUGHT CONDITIONS

- Optimize maintenance based on new conditions
- Use opportunity to improve maintenance and operation strategies
- Craft new operational strategies to deal with changing concentration load and hydraulic conditions
- Changes design & type of equipment/processes
OPTIMIZATION AT THE NEXUS

REQUIRES A MAJOR SHIFT IN HOW & WHYS OF PROCESS AND ENERGY USE

FIND THE BEST FIT CURVE OF ENERGY USE TO WORK PERFORMED ...

... OUR INDUSTRY NEEDS TO TAKE ACTION - FIT THE NEW CURVE!
ASSESSING CONDITIONS

Knowing how and why energy and process objectives are connected (interconnectedness)

- What needs to be done?
- How is it being done?
- Can it be done better?
- Does it change risk of failure?

- Functional analysis
- Condition assessment
- Technology gap analysis
- Risk analysis
What’s Next?
Alternative Solutions in the New Paradigm

- Increased Monitoring & Awareness
- Collection System Management
- Enhanced Source Control Management
- Bio-chemical Pretreatment
- Modified Primary and Anaerobic Treatment
- Modified Secondary Treatment
  - Chemical Augmentation
  - Biological Augmentation
  - Modified BNR Design
- TDS Management Plan
  - System Audit
  - Treatment Plant Audit
END

THANK YOU!
RESERVE SLIDES
CASE STUDIES: WWTP #1 OPPORTUNITIES

- MODIFIED COLLECTION SYSTEM MANAGEMENT PLAN
  - *CHEMICAL & BIOLOGICAL MITIGATION*
- HEADWORKS AND PRIMARY SULFIDE CONTROL
- MODIFIED BNR PROCESS STRATEGY
  - AMMONIA-BASED BLOWER & MLR CONTROL
  - SIMULTANEOUS NITRIFICATION/DENITRIFICATION
  - SEQUENCED LARGE BUBBLE MIXING
CASE STUDIES: WWTP #1 APPROACH

■ ROOT CAUSE ANALYSIS
■ PROCESS OPERATION STRATEGIES TO MEET CURRENT CONDITIONS
■ CHEMICAL USE OPTIMIZATION TO REDUCE COSTS
■ ENERGY OPTIMIZATION TO REDUCE COSTS
■ RELIABILITY CENTERED MAINTENANCE TO IMPROVE ASSET PERFORMANCE
CASE STUDIES: WWTP #1
LESSONS LEARNED

- USE CURRENT DATA
- ANALYZE DATA TRENDS
- DESIGN FOR FUTURE CONDITIONS
- UPGRADE AWARENESS OF MODERN TECHNOLOGIES
- FOCUS ON MONITORING AND CONTROL
- USE ON-GOING CONDITION ASSESSMENT FOR DECISIONS
CASE STUDIES: WWTP #2
FAST FACTS

• LOCATION: CENTRAL CALIFORNIA
• DESIGN: BIOLOGICAL NUTRIENT REMOVAL SYSTEM
• FLOW: 100,000 GPD DESIGN FLOW, DECREASED TO 5,000 GPD
• HISTORICAL DETAILS:
  • RECENT PLANT EXPANSION AND UPGRADE IN 2008
  • PERIODIC SEASONAL PROCESS UPSETS
  • GOLF COURSE COMMUNITY RAN OUT OF WATER
  • MAJOR UPSET IN 2015
  • VIOLATION OF TIN, BOD, TSS
CASE STUDIES: WWTP #2

CHALLENGES

• HISTORIC DROUGHT CONDITIONS
• PROPERTY VALUES DECREASED SIGNIFICANTLY
• A GHOST TOWN - MOST OF THE PROPERTY OWNERS ABANDONED THEIR HOMES
• GOLF COURSE FACILITIES HAVE BEEN CLOSED
• LOW FLOW CONDITIONS IMPACTED COLLECTION SYSTEM DETENTION TIMES
• LIFT STATION OPERATIONS IMPACTED
• LACK OF CARBON AT THE HEAD OF THE PLANT IMPACTED BNR PERFORMANCE
• NITRIFICATION AND SETTLEABILITY IMPACTED
CASE STUDIES: WWTP #2
OPPORTUNITIES

• COMMUNICATE WITH THE REGIONAL BOARD – SHOW THEM THE DROUGHT IMPACTS
• CONVINCE THE REGIONAL BOARD TO RELAX ON THE PERMIT REQUIREMENTS
• NEGOTIATE NOVs AND FINES BASED ON CONDITIONS
CASE STUDIES: WWTP #2

APPROACH

• INVITE THE BNR OEM FOR A VISIT
• LOOK FOR OPPORTUNITIES TO MODIFY THE OPERATIONAL STRATEGIES FOR DROUGHT
• CONVINCE THE BOARD TO MOVE THE PERMIT POINT DOWNSTREAM OF THE STRAINERS
• UTILIZE THE STORAGE PONDS FOR EVAP AND AVOID DISPOSAL
• AS A LAST RESORT CONSIDER USING A CARBON SUPPLEMENT (MICRO-C)
CASE STUDIES: WWTP #2
LESSONS LEARNED

• LISTEN CLOSELY TO THE OPERATORS – THEY’RE YELLING AT YOU FOR A REASON

• INVOLVE THE REGIONAL BOARD – THEY’RE HERE TO HELP US

• GET YOUR VENDORS INVOLVED – THEY HAVE A LOT AT STAKE

• USE PROCESS EXPERTS LIKE WYATT
CASE STUDIES: WWTP #3
FAST FACTS

LOCATION: CENTRAL CALIFORNIA
REGIONAL FACILITY UNDERGOING UPGRADE DESIGN
DESIGN: BIOLOGICAL NUTRIENT REMOVAL SYSTEM
FLOW: 140-180 MGD
HISTORICAL DETAILS:
  CURRENT PLANT EXPANSION UNDER DESIGN
  IMPLEMENTING BNR WITH 2010 DATA
  POTENTIAL PROCESS CAPACITY FAILURE & CONSTRAINTS
  CONCERN OVER VIOLATION OF TIN & AMMONIA
CASE STUDIES: WWTP #3

CHALLENGES

- CONTINUED DROUGHT CONDITIONS
- LOW FLOW CONDITIONS IMPACTED COLLECTION SYSTEM DETENTION TIMES
- PRIMARY SEDIMENTATION IMPACTED
- NITRIFICATION/DENITRIFICATION CAPACITY IMPACTS
- SECONDARY SETTLEABILITY IMPACTS
- OPERATORS NOT EXPERIENCED WITH BNR & CHLORINE DISINFECTION IMPACTS
CASE STUDIES: WWTP #3
OPPORTUNITIES

- RE-EVALUATE DESIGN CRITERIA
- RE-EVALUATE BASIC TECHNOLOGIES
- IMPROVE MONITORING AND CONTROL FOR OPERATIONS
- IMPLEMENT RELIABILITY CENTERED MAINTENANCE OF CRITICAL ASSETS
- TRAIN STAFF IN BNR TECHNOLOGIES
- AVOIDED NOVs AND FINES
CASE STUDIES: WWTP #3

APPROACH

• EVALUATE POTENTIAL FOR COLLECTION SYSTEM STRATEGY TO REDUCE AMMONIA LOAD
• LOOK FOR OPPORTUNITIES TO MODIFY THE OPERATIONAL STRATEGIES FOR DROUGHT
• EVALUATE ALTERNATIVE BNR CONTROL TECHNOLOGIES
• INVESTIGATE OPPORTUNITIES FOR DESIGN CHANGES PRIOR TO CONSTRUCTION
CASE STUDIES: WWTP #3
LESSONS LEARNED

• USE CURRENT DATA
• ANALYZE DATA TRENDS
• DESIGN FOR FUTURE CONDITIONS
• UPGRADE AWARENESS OF MODERN TECHNOLOGIES
• FOCUS ON MONITORING AND CONTROL
• USE ON-GOING CONDITION ASSESSMENT FOR DECISIONS
CASE STUDIES: WWTP #4

FAST FACTS

LOCATION: INLAND EMPIRE

DESIGN: INTERNAL MLR TO RECOVER LOST CAPACITY

FLOW: 28 → 30 MGD

- NEED CAPACITY FOR RECYCLED WATER DEMAND

- HISTORICAL DETAILS:
  - TREATMENT CAPACITY DOWNGRADED DUE TO BNR CONSTRAINTS
  - REDUCED BNR FLOW TO COMPLY WITH TIN LIMITS
  - INFLUENT AMMONIA HAS INCREASED OVER 30% IN RECENT YEARS
  - NO AUTHORITY OR CONTROL OF COLLECTION SYSTEMS
CASE STUDIES: WWTP #4

CHALLENGES

• CONTINUED DROUGHT CONDITIONS
• LOW FLOW CONDITIONS IMPACTED COLLECTION SYSTEM DETENTION TIMES
• PRIMARY SEDIMENTATION IMPACTED
• NITRIFICATION/DENTIRIFICATION CAPACITY IMPACTS
• SECONDARY SETTLEABILITY IMPACTS
• OPERATORS NOT EXPERIENCED WITH DESIGN CONSTRAINTS
CASE STUDIES: WWTP #4

OPPORTUNITIES

• RE-EVALUATE DESIGN CRITERIA
• RE-EVALUATE BASIC MASS BALANCE & TECHNOLOGIES
• IMPROVE MONITORING AND CONTROL FOR OPERATIONS
• IMPLEMENT RELIABILITY CENTERED MAINTENANCE OF CRITICAL ASSETS
• AVOIDED NOVs AND FINES
• INCREASE RECYCLED WATER PRODUCTION
CASE STUDIES: WWTP #4

APPROACH

• Evaluate potential for collection system strategy to reduce ammonia load

• Look for opportunities to modify the operational strategies for drought

• Evaluate alternative BNR/MLR control technologies
CASE STUDIES: WWTP #4
LESSONS LEARNED

• USE CURRENT DATA
• ANALYZE DATA TRENDS
• DESIGN FOR FUTURE CONDITIONS
• PERFORM MASS-BALANCE ANALYSIS OF TIN CONTROL
• UPGRADE AWARENESS OF MODERN TECHNOLOGIES
• FOCUS ON MONITORING AND CONTROL
• USE ON-GOING CONDITION ASSESSMENT FOR DECISIONS
DEVELOPING SOLUTIONS (ROUND TABLE)
NEW TECHNOLOGIES
NEW TECHNOLOGIES

• AMMONIA SENSING AND CONTROL TECHNOLOGIES
  • BLOWERS
  • ML RECYCLE PUMPING
  • CHEMICAL FEED FOR DISINFECTION
NEW TECHNOLOGIES

• SEQUENTIAL, LARGE BUBBLE MIXING
  • WET WELL MIXING
  • ANOXIC MIXING
  • ENHANCED SOTE IN OXIC MIXING
NEW TECHNOLOGIES

• FACULTATIVE BIO-AUGMENTATION
  • SEWER CONTROL OF BIOLOGY AND PRODUCTS
  • ENHANCED CONTROL OF SULFIDE, AMMONIA, & VOLATILE ACIDS
NEW TECHNOLOGIES

• ORGANIC RANKIN-CYCLE POWER GENERATION
  • ELIMINATE FLARES AND ICE CO-GEN ISSUES
  • CONTINUOUS POWER PRODUCTION
  • WASTE HEAT RECOVERY AND DIGESTER HEATING