An MRRDC Short Course: Influent Characterization for Wastewater Modeling

Thursday, January 25, 2018

1 – 3 p.m. ET

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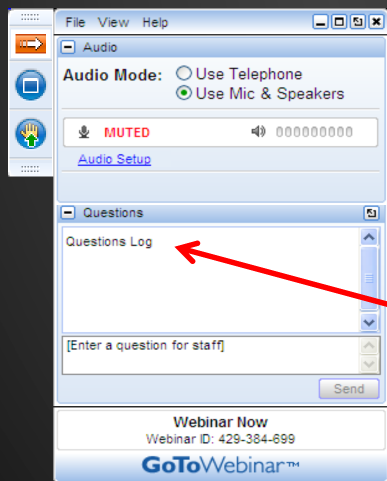
How to Participate Today



- **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.**

Today's Moderator

John B. Copp Ph.D.
Primodal Inc.
Hamilton, Ontario

Primodal
Earth Essential Technologies

Influent – Jan. 25, 2018

An MRRDC Short Course

Influent Characterization for Wastewater Modeling

- Topics:
  - Introduction to Influent Characterisation
  - Influent Characterisation Methods
  - Modelling Case Studies

Influent – Jan. 25, 2018

An MRRDC Short Course

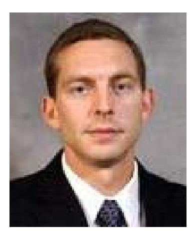
Influent Characterization for Wastewater Modeling

- Speakers:

Chris Bye
EnviroSim

Tanush Wadhawan
Dynamita

Alyssa Mayer
Hazen&Sawyer



Matt Tebow
Kimley-Horn

Christopher Bye, Ph.D., P.Eng.

Enviro Sim
ASSOCIATES LTD.

Wastewater Characterization

Introduction – Why it is Important

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Introduction

- Influent wastewater composition has a significant impact on WRRF operation and performance
  - Sludge production and disposal costs
  - Nutrient removal system performance

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Introduction

- Historically, our industry has focussed on measurement / monitoring of effluent
- Obviously, this is an important driver!
- Influent monitoring often minimal
  - Frequency (*e.g.* a few samples a week)
  - Parameters (*e.g.* BOD and TSS?)

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Why Does Influent Matter?

- Modern treatment facilities being asked to do more and more
- Trend now is to refer to WWTPs as WRRFs – **W**ater **R**esource **R**ecovery **F**acilities!
- Also a concerted effort to lower energy usage – aiming for neutrality or net-positive generation!

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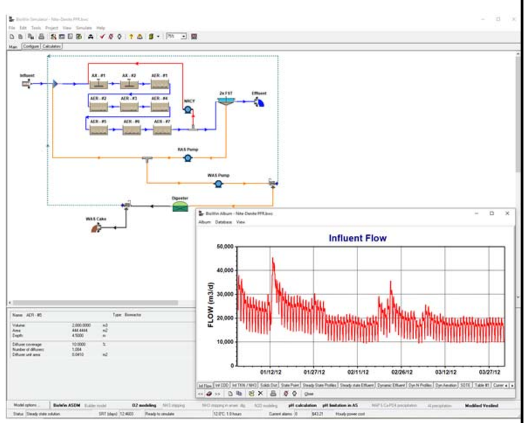
Why Does Influent Matter?

- Analysis required to achieve these goals beyond steady state design spreadsheets
- Engineers use computer modeling for analysis



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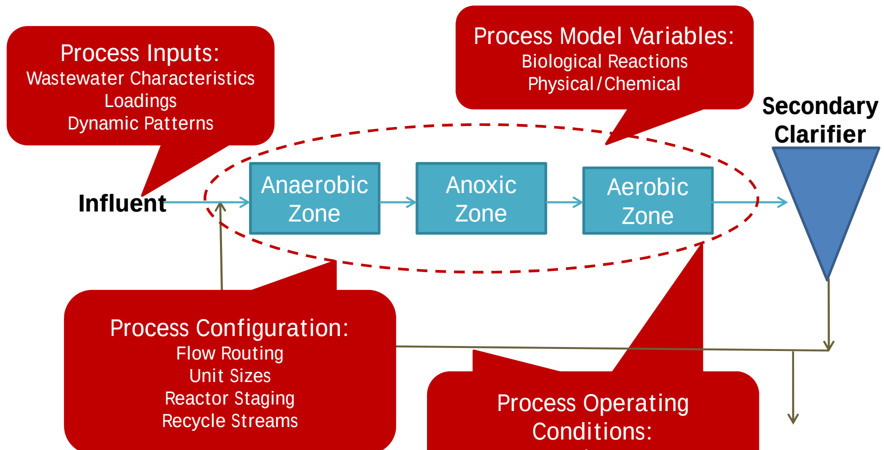
Why Does Influent Matter?

- More input than just BOD and TSS



WERF Methods of Wastewater Characterization for Activated Sludge Modeling (2003)

What's in Wastewater?

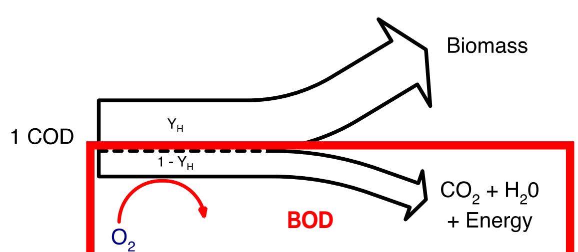
- Complex mix of organics and inorganics
- "Wastewater characteristics" refers to partitioning components into categories
- Defined according to how the components behave in / impact the activated sludge process

What’s in Wastewater?

- This discussion will focus on chemical oxygen demand (COD) rather than BOD
- Why?

What’s in Wastewater?

- BOD…
  - Only measures the organics used for respiration, ignores what is converted to bacterial biomass
  - Ignores unbiodegradable particulate



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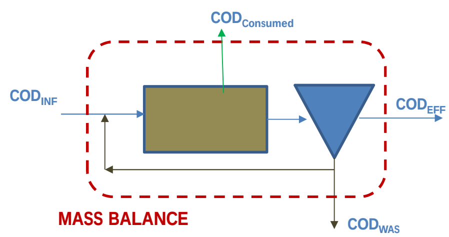
What's in Wastewater?

- COD…
  - Measures electron-donating potential of organics
  - Captures all organics, can be used in mass balance



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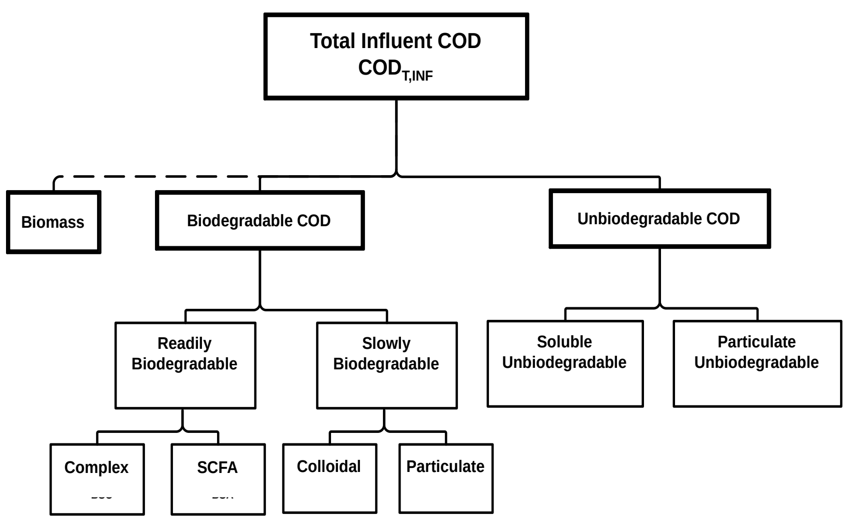
What's in Wastewater?



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First Level of Characteristics

- Is the influent organic material:
  1. Biodegradable
  2. Unbiodegradable
  3. Active biomass
- Cannot determine divisions with only BOD and TSS!

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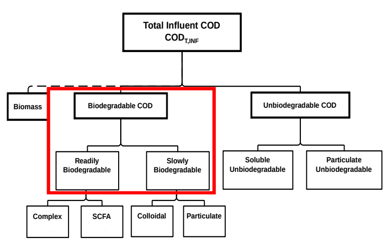
Biodegradable portion



- Subdivided into “readily” and “slowly” biodegradable

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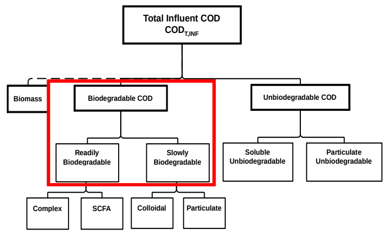
Biodegradable portion



- “Readily” portion consists of small molecules organisms rapidly take up and consume
- “Slowly” portion consists of larger molecules requiring extracellular breakdown before uptake and use

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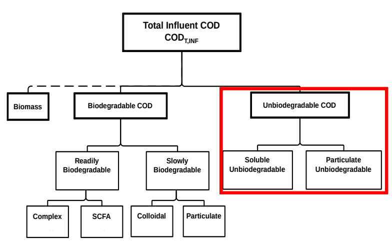
Unbiodegradable portion



- Material not degraded under conditions typically found in WRRFs

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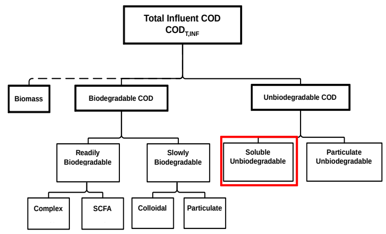
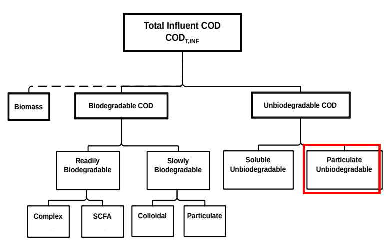
Unbiodegradable portion



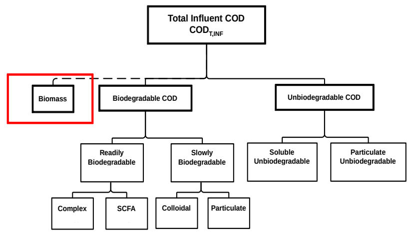
- Soluble portion passes through WRRF
  - Generally not a concern since not often a discharge limit (perhaps for industrial WW)

Unbiodegradable portion



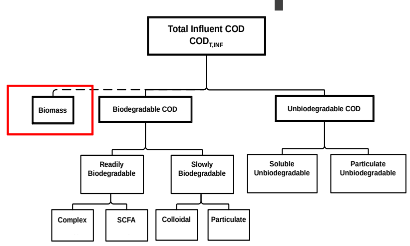
- Particulate portion forms significant portion of primary and/or or waste activated sludge
  - Impacts plant sludge production and digestibility

Active biomass portion



- Historically thought to be very low (< 2% of influent total COD)

Active biomass portion



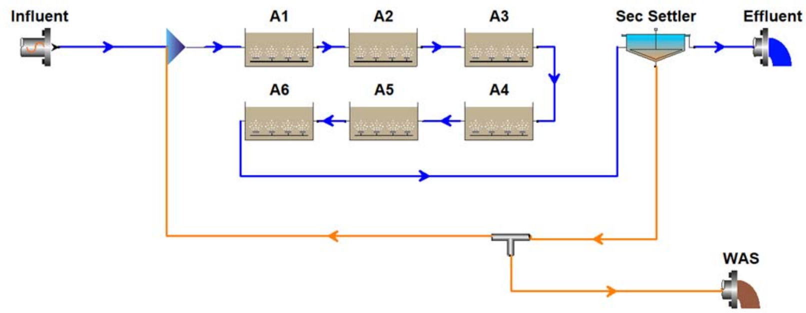
- More recent research has shown it can be significant (*e.g.* > 10%)

Dold, P.L., Omari, A., Mokhayeri, Y., Awobamise, M., Stinson, B., Bodniewicz, B., Bailey, W., Jones, R., and Murthy, S. Measuring Influent Heterotrophic Biomass Content for Modeling and Design. *Water Environment Federation 83rd Annual Conference and Exposition, New Orleans, LA, USA, October 2 – 6, 2010.*

Coleman, P., Bye, C., Chen, C., Mawani, Z., Longworth, E., and Bicudo, J. Computer Modelling to Test the Design of the Kitchener Wastewater Treatment Plant. *41st Annual WEAO Technical Symposium and OPCEA Exhibition, Ottawa, Ontario, Canada, April 22-24, 2012.*

Why Does It Matter? Examples!

- Readily Biodegradable COD Portion
- Impact on oxygen demand



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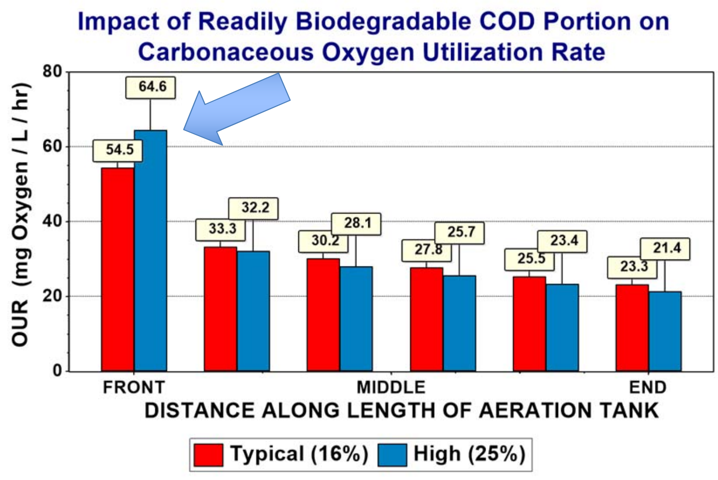
Why Does It Matter? Examples!



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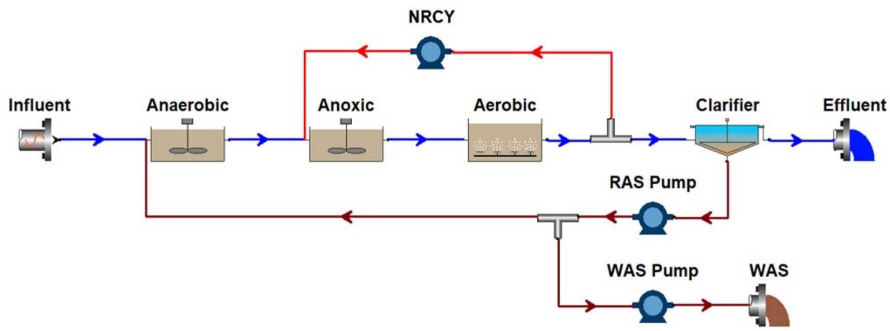
Why Does It Matter? Examples!

- Readily Biodegradable COD Portion
- Impact on bioP performance



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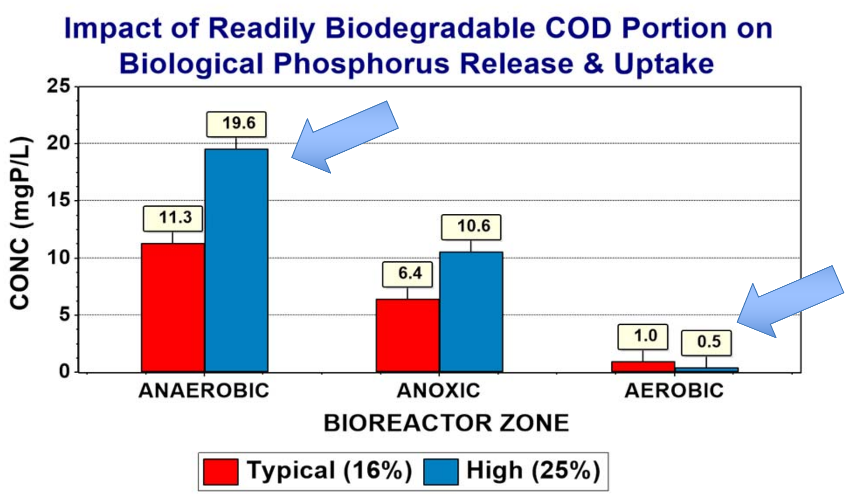
Why Does It Matter? Examples!



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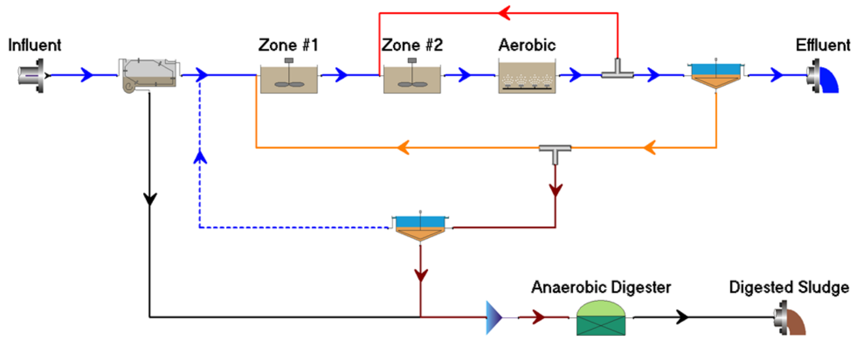
Why Does It Matter? Examples!

- Unbiodegradable Particulate COD Portion
- Impact on digester performance



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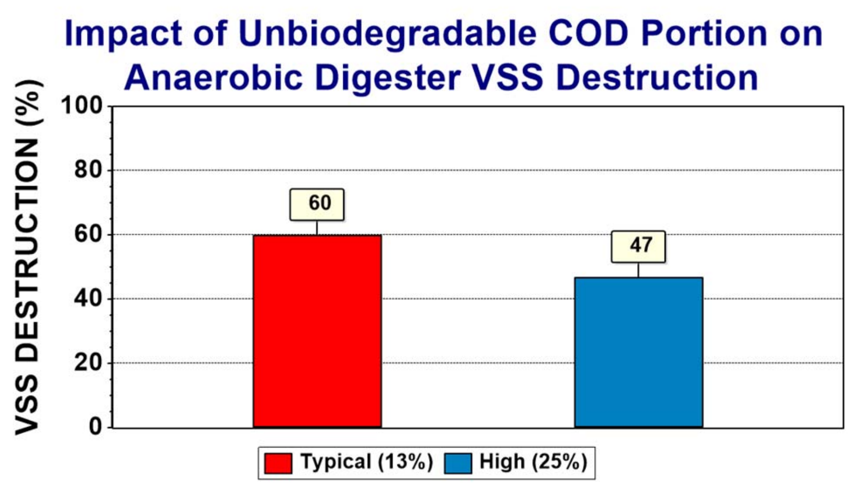

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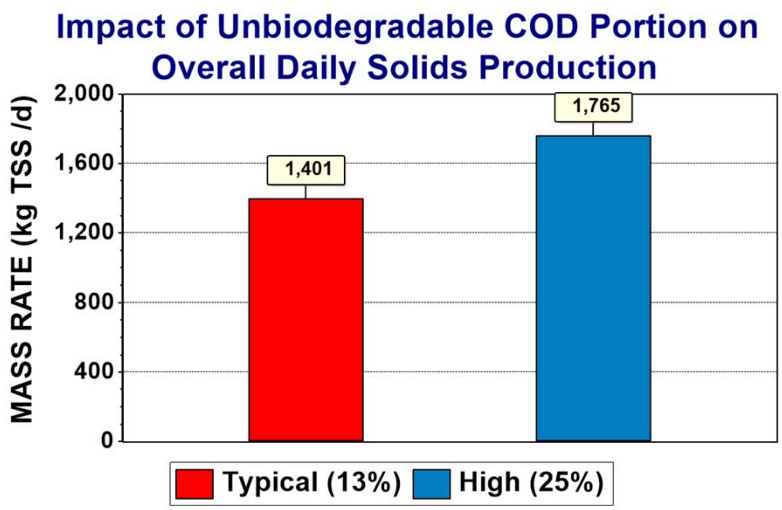

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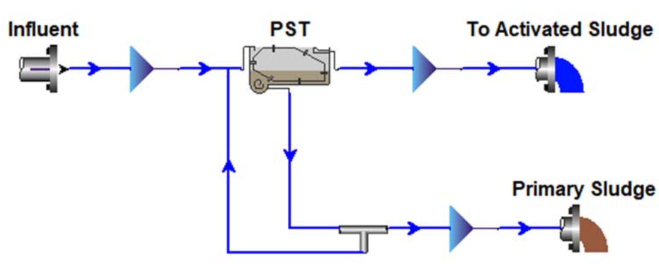
Why Does It Matter? Examples!

- Active Biomass COD Portion
- Impact on primary sludge fermenter



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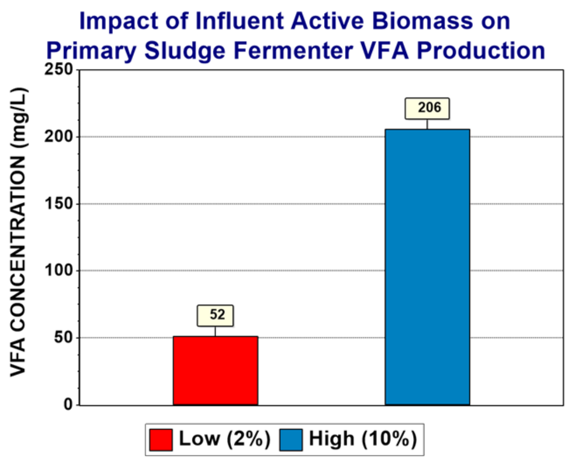
Why Does It Matter? Examples!



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Conclusions

- Influent characterization the most important part of any modeling job
- Influent composition affects everything – liquid *AND* solids trains
- Modeling 101: "Garbage in = Garbage out"

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Up Next…

- How to measure wastewater characteristics for model input
- Case studies: large plants
- Case studies: small plants

Next Speaker

Tanush Wadhawan, Ph.D.
Dynamita,
Toronto, Ontario, Canada

Methods for Wastewater Characterization in Activated Sludge Modeling

Tanush Wadhawan, PhD
Dynamita

Key outline points

- Methodologies in influent characterization
- Making sense of the measurements
- Converting measurements into model inputs

Sampling technique

- **Grab sample - A sample taken from one point and time**
  - Gives an idea of what is happening right then.
- **Composite sample**
  - Multiple samples taken from one point at multiple times and integrated together for analysis
  - Pulled from a location that provides a composite
  - Multiple grab samples at different flow periods
  - Averaging over the course of a day

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Analytical Requirements

Grab required

- Alkalinity
- Oil and grease
- pH
- Temperature

Grab or Composite

- BOD5, CBOD, COD
- Nitrogen species – TN, NO3-N, NHx-N
- Solids – TSS, VSS
- Phosphorus

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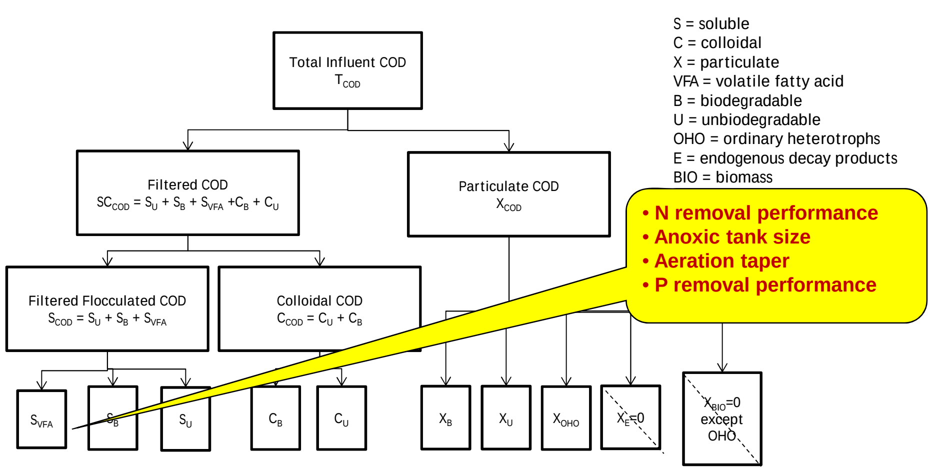
Chain of custody

- Name of person collecting sample
- Each person having custody (w/ date and time)
- Sample number and Sample description
- Qc/Qa
- Required for lab validation of results

COD fractions & their impact



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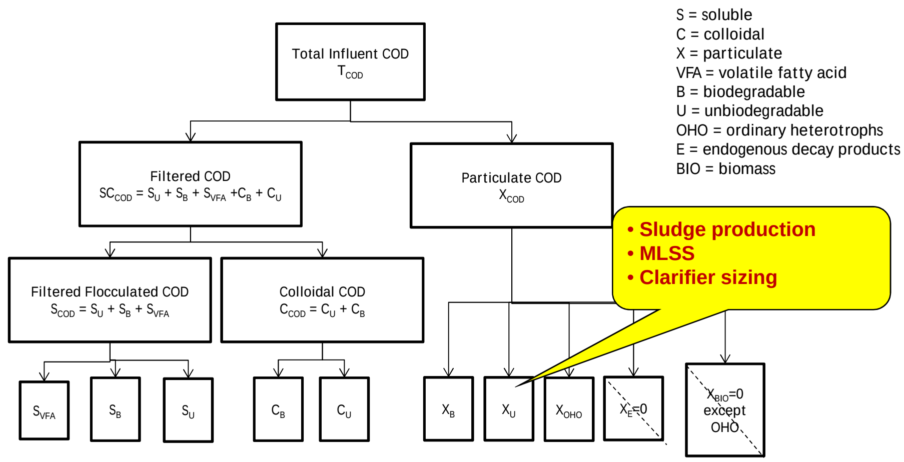
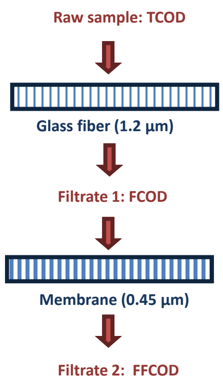
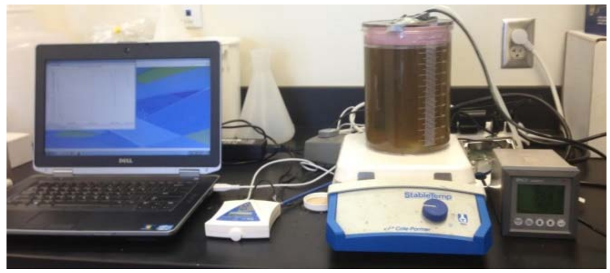


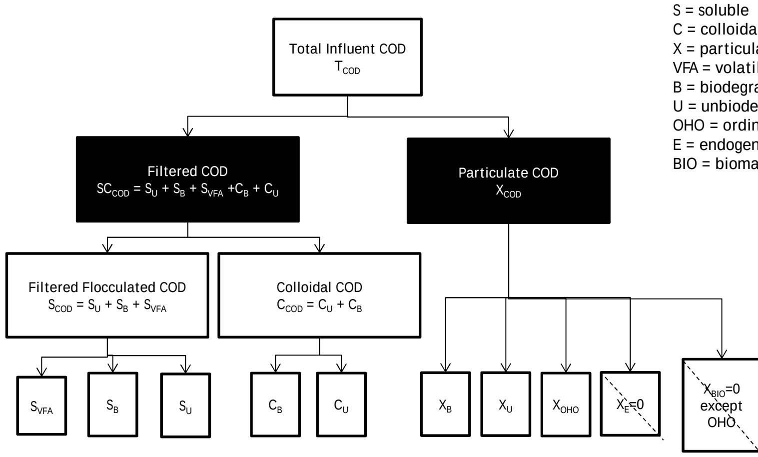
How to measure?

- **Physio-chemical method**
  - SB, SU
- **Biodegradability test approach**
  - Aerobic/Anoxic batch test & Pilots
  - Total biodegradable and unbiodegradable COD, SB, XOHO
- **Model based approach**
  - XU

Filtration vs respirometry







S = soluble
C = colloidal
X = particulate
VFA = volatile fatty acid
B = biodegradable
U = unbiodegradable
OHO = ordinary heterotrophs
E = endogenous decay products
BIO = biomass

FCOD and PCOD

Raw sample: TCOD

$X_B + X_U + C_B + C_U + S_B + S_U$

Filtration

Glass fiber (1.2 µm)

PCOD = TCOD - FCOD

$X_B + X_U$

Filtrate : FCOD

$C_B + C_U + S_B + S_U$

Key steps

- Homogenizing sample for TCOD measurement.
- Rinse drying filters
- Using same filter size (1.2-1.5 micron)

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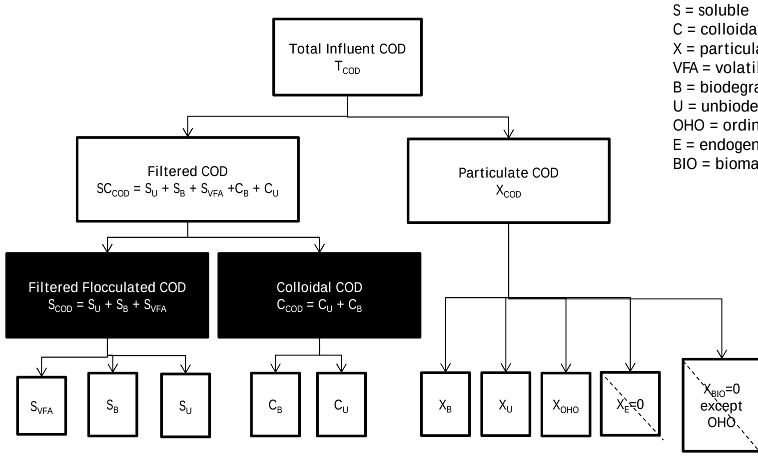

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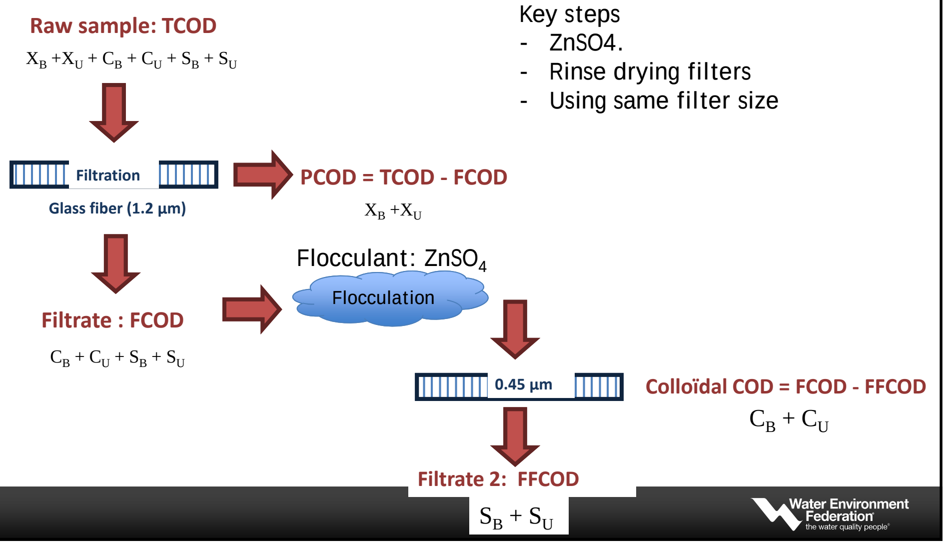
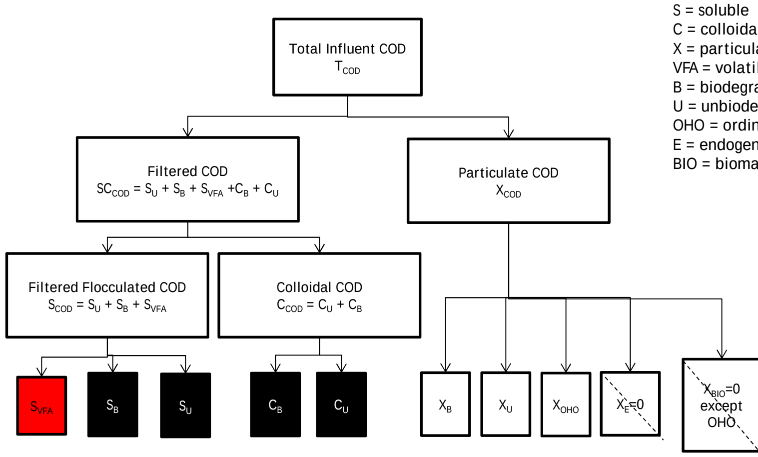
Soluble COD and Colloidal COD

Key steps
- ZnSO4.
- Rinse drying filters
- Using same filter size





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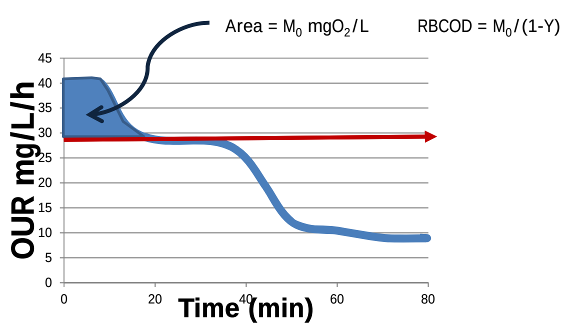
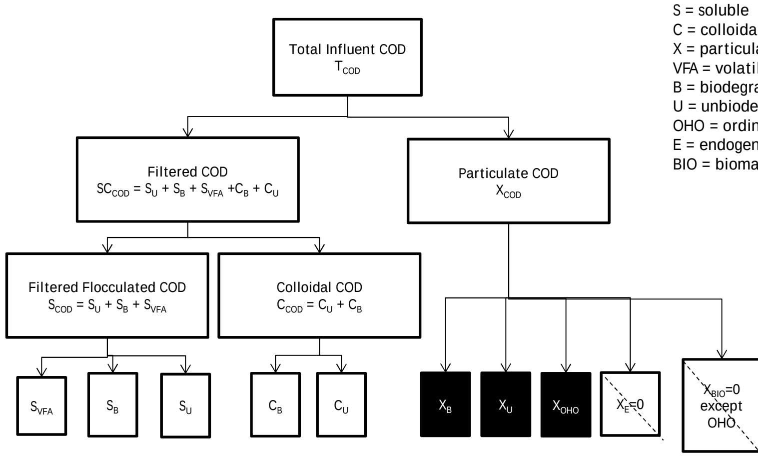
Estimating SB and SU using Filtration

- **SU**
  - Systems with SRT more than 3 days
  - Measuring plant effluent data
  - FFCOD effluent
- **SB**
  - FFCOD influent – FFCOD effluent

SB using Respirogram





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XB and XU, and XOHO

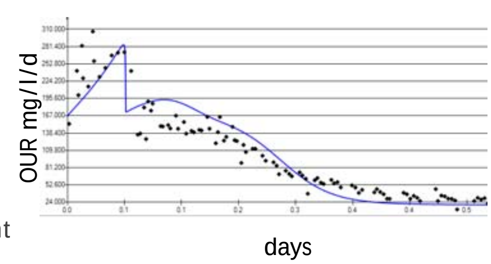
XB

- Total biodegradable COD – Filtered biodegradable COD
- BOD tests - 8-20 days
- 1st order rate constant determination

• XU

- Model calibration of a pilot plant

XOHO



OHO - 30 mgCOD/L
Mu – 8.5 d-1

Measurements to model input

Key measurements	Value	Unit
Flow	24000.0	MGD or m^3/d
TSS	185.0	mg/L
VSS	157.0	mg/L
TDM	800.0	mg/L
TKN	34.4	mg N/L
TP	4.3	mgP/L
Total Sulfur	20.0	mgS/L
Alkalinity	330.0	mg CaCO3/L
pH	7.2	-

COD - BOD	Value	Unit
Influent COD	420.0	mg COD/L
Influent filtered COD	170.0	mg COD/L
Influent filtered flocculated COD	85.0	mg COD/L
Effluent filtered COD (inert)	20.0	mg COD/L
Influent $cBOD_5$	200.0	mg BOD/L

Other influent measurements	Value	Unit
VFA	20.0	mg COD/L
Ammonia	24.0	mg N/L
Phosphate	2.5	mg P/L
Nitrite+nitrate	0.0	mg N/L

Measurements to model input

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Phosphate	2.5	mg P/L
Nitrite+nitrate	0.0	mg N/L

Convertor

Influent fractions		
Name	**Value**	**SI unit**
Fraction of VSS/TSS	84.9	%
Fraction of filtered COD (SCCOD, 1.5 µm, incl. colloids) in total COD (TCOD)	40.5	%
Fraction of flocculated filtered (SCOD, wo colloids) COD in total COD (TCOD)	20.2	%
Fraction of VFA in filtered COD (SCCOD, 1.5 µm, incl. colloids)	11.8	%
Fraction of soluble unbiodegradable organics (SU) in filtered COD (SCCOD, 1.5 µm, incl. colloids)	11.8	%
Fraction of particulate unbiodegradable organics (XU) in total COD (TCOD)	14.0	%
Fraction of heterotrophs (OHO) in total COD (TCOD)	5.0	%
Fraction of endogenous products (XE) in total COD (TCOD)	20.0	%
Fraction of colloidal unbiodegradable organics (CU) in colloidal COD (SCCOD-SCOD)	20.0	%
Fraction of NHx in total Kjeldahl nitrogen (TKN)	69.8	%
Fraction of PO4 in total phosphorus (TP)	58.1	%
Fraction of N in readily biodegradable substrate (SB)	4.0	%
Fraction of N in particulate unbiodegradable substrate (XU)	1.0	%
Fraction of P in readily biodegradable substrate (SB)	1.0	%
Fraction of P in particulate unbiodegradable substrate (XU)	0.1	%

Current commercial simulators provide tools to convert usual measurements into model inputs.

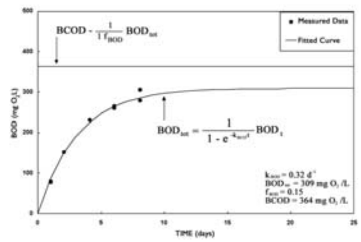
Convertor

Influent fractions from data	Default %	Calculated from data %
Fraction of filtered COD (SCCOD, 1.5 µm, incl. colloids) in total COD (TCOD)	40.5	**40.5**
Fraction of flocculated filtered (SCOD, wo colloids) COD in total COD (TCOD)	20.2	**20.2**
Fraction of VFA in filtered COD (SCCOD, 1.5 µm, incl. colloids)	11.8	**11.8**
Fraction of soluble unbiodegradable organics (SU) in filtered COD (SCCOD, 1.5 µm, incl. colloids)	11.8	**11.8**

Influent fractions to estimate	Default %	To be estimated %
Fraction of particulate unbiodegradable organics (XU) in total COD (TCOD)	14.00	14
Fraction of heterotrophs (OHO) in total COD (TCOD)	5.00	5
Fraction of endogenous products (XE) in total COD (TCOD)	20.00	20
Fraction of colloidal unbiodegradable organics (CU) in colloidal COD (SCCOD-SCOD)	20.00	20
Fraction of N in readily biodegradable substrate (SB)	4.00	4
Fraction of N in particulate unbiodegradable substrate (XU)	1.00	1
Fraction of P in readily biodegradable substrate (SB)	1.00	1
Fraction of P in particulate unbiodegradable substrate (XU)	0.10	0.1

Particulate COD/VSS ratios by component	Default	To be estimated g COD/g VSS
COD of biomass in volatile solids	1.42	1.42
COD of biodegradable substrate in volatile solids	1.80	1.80
COD of particulate unbiodegradable organics in volatile solids	1.30	1.30
COD of endogenous products in volatile solids	1.42	1.42
COD of PHA in volatile solids	1.67	1.67

COD/BOD/TSS/VSS match	Measured data	Calculated from estimated fractions	Verdict
Influent COD	420.0	**420.0**	good match
Calculated influent filtered COD	170.0	**170.0**	good match
Calculated Influent filtered flocculated COD	85.0	**85.0**	good match
Calculated influent BOD5	200.0	**183.2**	good match
TSS	185.0	**183.0**	good match
VSS	157.0	**155.3**	good match



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What can go wrong?

My model does not match data

- Data analysis is crucial for data clean up and for accurate model prediction
  - Fault detection
    - Was it sampling?
    - Sensors?
  - Sanity checks!!!

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Fault detection

- Check consistency between the sampling period of automatic samplers and the averaging periods applied in the WWTP reports
- The proper assignment of lab results to the time of sampling (Example BOD5)
- Response time of sensors or analysers including sampling and filtration.
- Often some data are missing or the measurement intervals are inconsistent.
- Depending on the objectives, data might have to be interpolated.

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Simple sanity checks

- Plausibility checks→ simple relationships
  - TN → TKN + NO3-N + NO2-N
  - TKN > NHx-N
  - Ptot > PO4-P
  - CODtot > CODfil > CODsol
  - CODtot > BOD5
  - TSS > VSS

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Simple sanity checks

- Potential outlier detection → Typical ranges
  - Their correctness cannot be confirmed
  - Causes for outliers are not evident
  - The data appear to be correct and plausible, but still are of outside typical range
  - Unusual plant condition

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Simple sanity checks

- Comparison with typical ratio

	Ratio	Unit	n[1]	Mean	*Std%* [2]	Median	Min	max
Raw influent	N_{tot}/COD_{tot}	g N/g COD	12	0.095	*17%*	0.091	0.050	0.150
	$N\text{-}NH_x/TKN$	g N/g N	13	0.684	*8%*	0.670	0.500	0.900
	P_{tot}/COD_{tot}	g P/g COD	12	0.016	*22%*	0.016	0.007	0.025
	$P\text{-}PO_4/P_{tot}$	g P/g P	12	0.603	*16%*	0.600	0.390	0.800
	COD_{tot}/BOD_5	g COD/g BOD	12	2.060	*11%*	2.050	1.410	3.000
	COD_{fil}/COD_{tot}	g COD/g COD	13	0.343	*29%*	0.350	0.120	0.750
	TSS/COD_{tot}	g TSS/g COD	12	0.503	*18%*	0.500	0.350	0.700
	COD_{part}/VSS	g COD/g VSS	11	1.690	*12%*	1.600	1.300	3.000
	VSS/TSS	g SS/g SS	12	0.740	*20%*	0.800	0.300	0.900
	BOD_5/BOD_{∞}	g BOD/g BOD	7	0.655	*7%*	0.650	0.580	0.740
	Alkalinity	Mol_{eq}/L	11	5.173	*35%*	5.000	1.500	9.000

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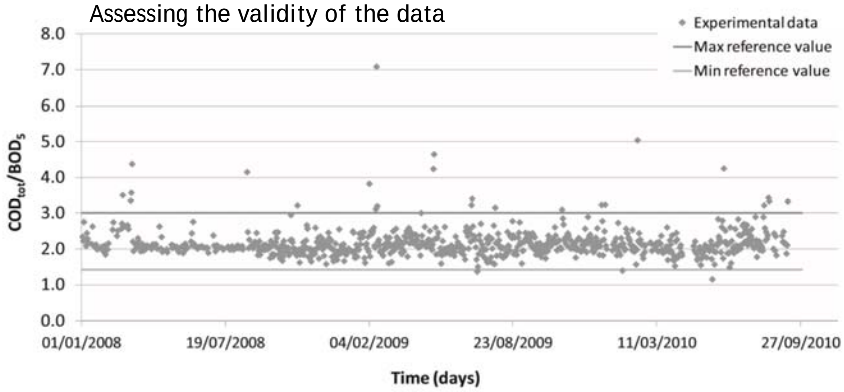
Simple sanity checks

Historical checks
Assessing the validity of the data

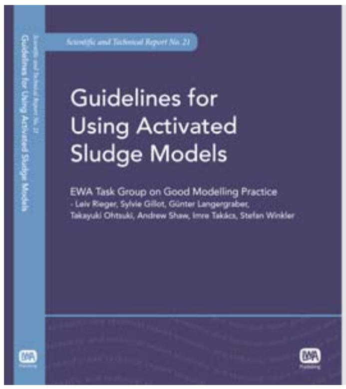


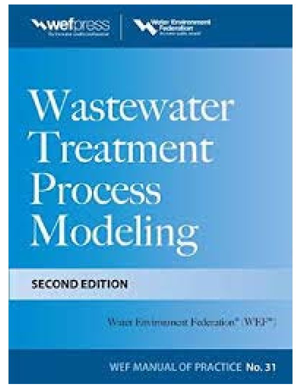
- Considerable day-to-day variations
- Should not show large fluctuation

Key highlights

- Proper sample handling is crucial.
- Performing sanity checks can help clean up data.
- Using proper measurement techniques.
  - Using correct filter
  - Homogenizing sample
- Using influent characterization tool provided by the commercial modeling software.

Reference





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Thank you!

Questions?

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Influent Characterization Case Studies

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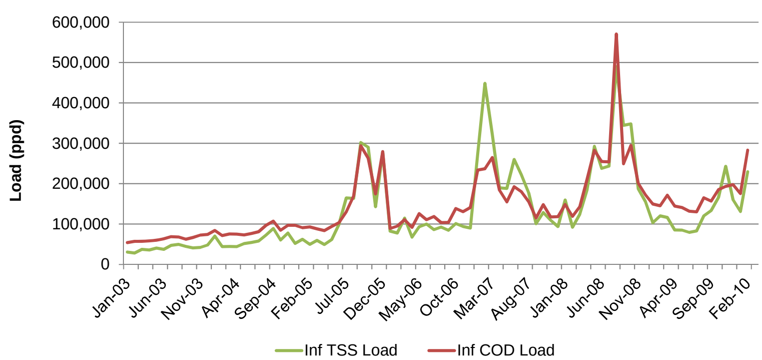
Plant A

- Biological Nutrient Removal and Tertiary Treatment
- 60 mgd Permitted Capacity (Operating at ~30 mgd)

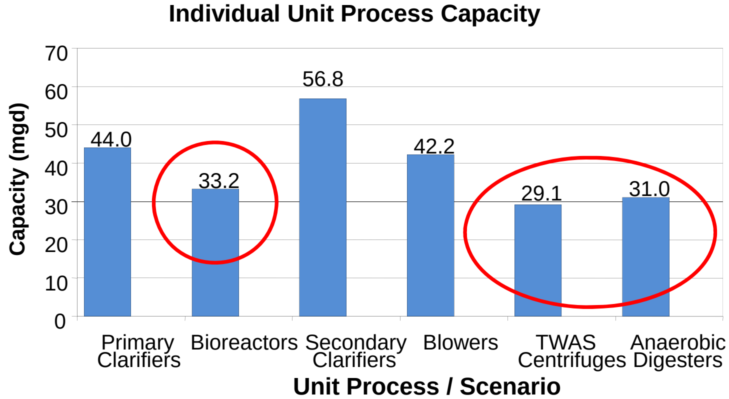
Measured Influent Concentrations Increased Significantly in Recent Years



- Increased influent loading and poor primary clarifier performance lead to concern about available remaining process capacity

Potential Capacity Crisis!

60 mgd plant is really only a 30 mgd plant



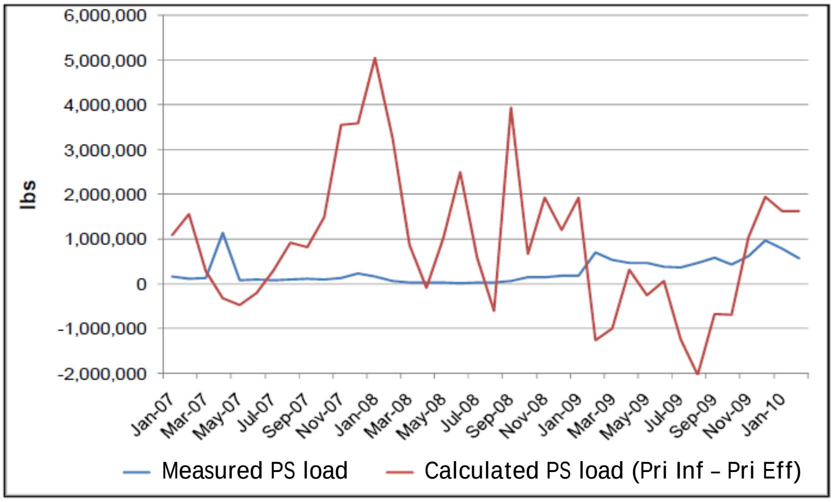
Prompted detailed study of influent characteristics, sampling locations and process performance

Historical Data Investigation

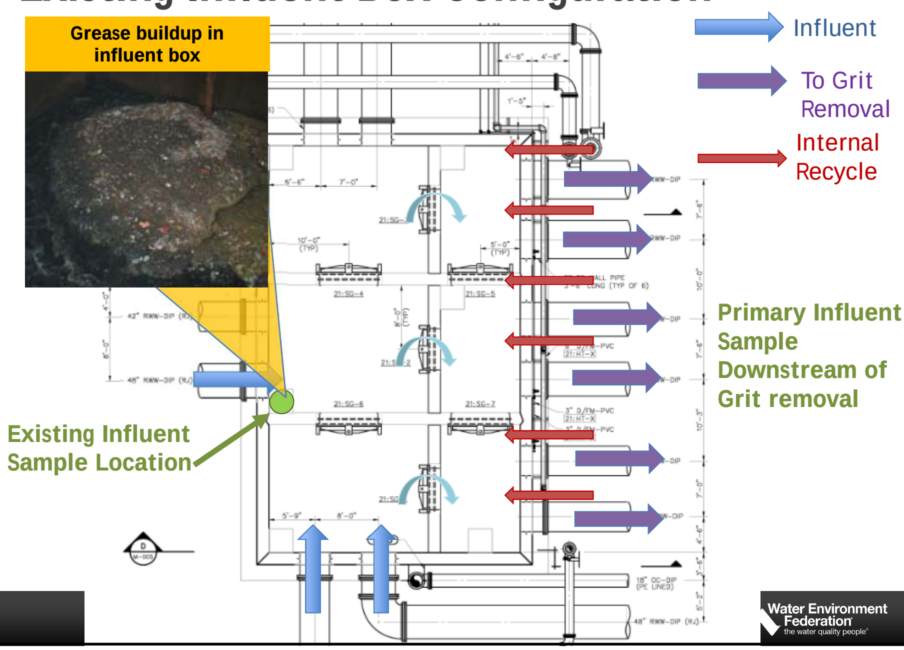
Raw Influent Data					
Year	COD mg/L	TSS mg/L	CBOD mg/L	NH3-N mg/L	TP mg/L
2004	609	430	182	24.8	7.6
2005	1021	940	237	25.6	7.3
2006	715	575	252	25.6	7.5
2007	1170	1391	297	28.6	9.6
2008	1211	1186	277	30.6	9.4

- High Influent and Primary Influent COD, TSS concentrations, but more typical CBOD, NH3-N and Phosphorus concentrations
- No major industries or significant changes in the collection system
- Data quality checks (mass balance, yield, ratios)

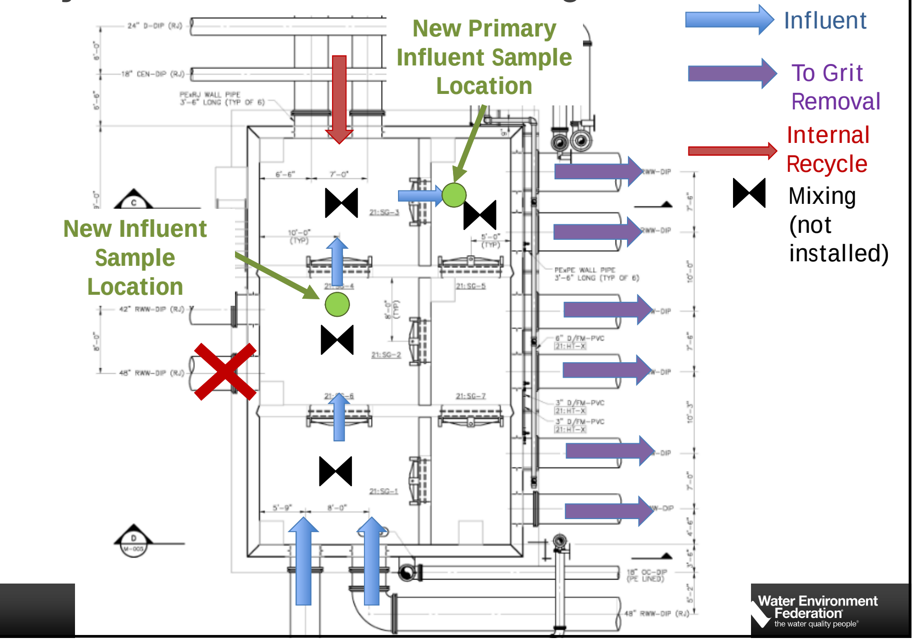
Primary Clarifier Data



Existing Influent Box Configuration



Adjusted Influent Box Configuration



Detailed Special Sampling

- New Locations:
  - Reconfigured Influent Box
  - Individual Influent Force mains
  - Adjusted Primary Influent Sampling Location
- Composite and Grab Sampling
- Detailed Wastewater Characterization using WERF methods for model calibration

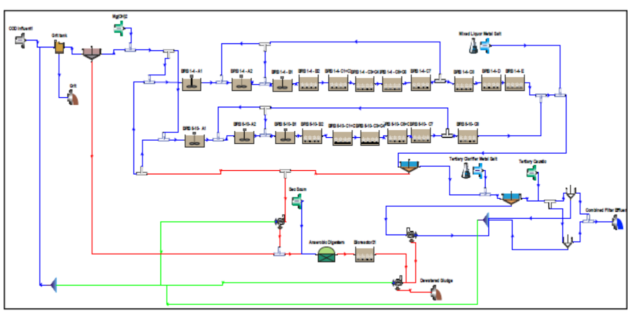
Reconciled Influent Characteristics

Influent Concentrations				
Parameter		Original Design	Historical Average	Reconciled Data
COD	mg/L	476	1,030	635
BOD5	mg/L	200	266	284
TSS	mg/L	230	1,020	365
TKN	mg/L	40	42.5	43
NH3-N	mg/L	25	27.6	28.4
TP	mg/L	8	8.5	8

Wastewater COD Fractions		
Fraction	Default	Reconciled
Readily Biodegradable Soluble	0.16	0.19
Unbiodegradable Soluble	0.05	0.03
Unbiodegradable Particulate	0.13	0.23
Slowly Biodegradable	0.66	0.55

Higher than typical inert particulate fraction

Process Model Calibration



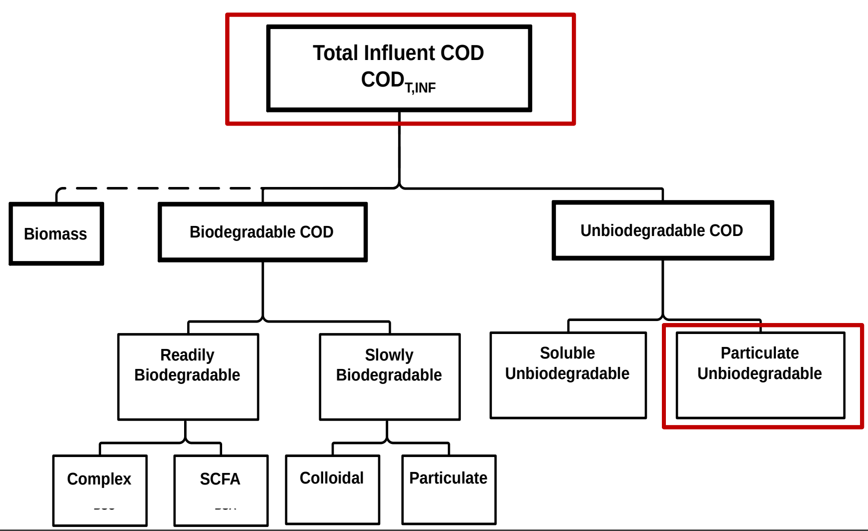
- Reconciled data used for calibration to match primary effluent, solids production, air demands, gas production
- Occasional high COD, TSS still observed; measured BOD found to be most consistent and accurate representation of load

Capacity Evaluation Completed with Reconciled Data and Updated Model Calibration

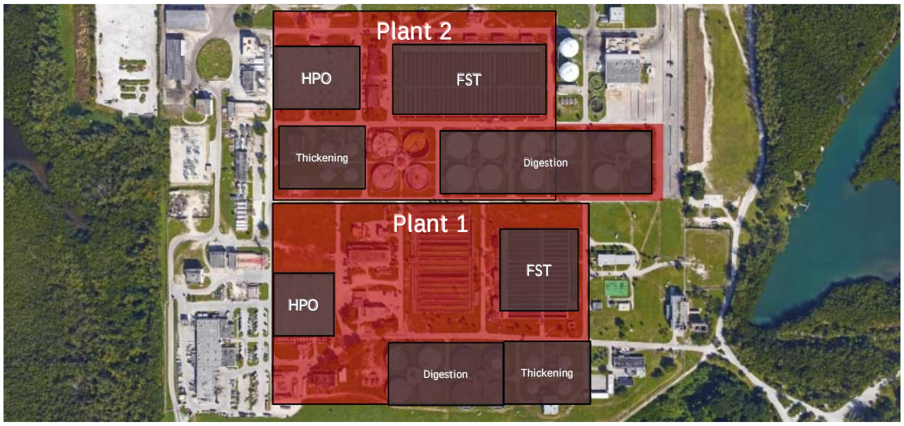
- Dynamic simulations under several combinations of temperatures, loading, and sludge settling properties
- Results:
  - Liquid Stream Processes able to maintain 60 mgd capacity
  - **Solids Handling Processes were limited <u>below</u> 60 mgd**
- Recommended Improvements included thickening improvements and some operational changes to primary sludge withdrawal, and planning for additional digester capacity

Lesson Learned: Representative Influent Sampling Key!

Important Characteristics for Plant A



Plant B



- HPOAS Plant rated for 143 mgd AA; 286 Peak
- Two separate plants (No. 1 and No. 2)

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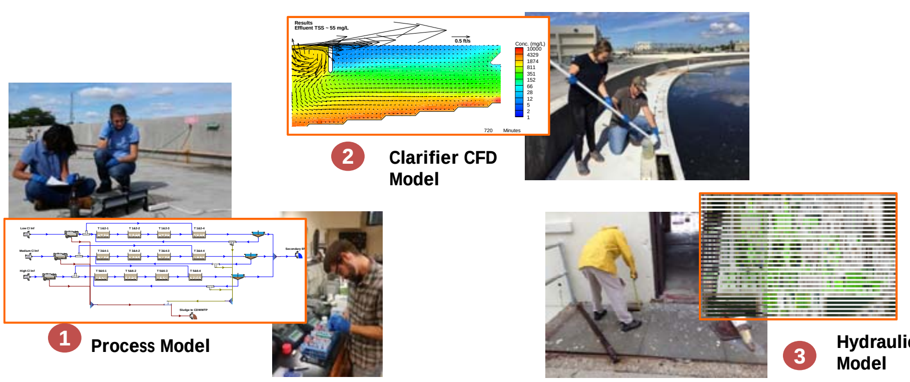
Models Created for Master Planning Efforts



Capacity Evaluation

Conceptual Design of Improvements

Peak Flow Management Strategy Evaluation

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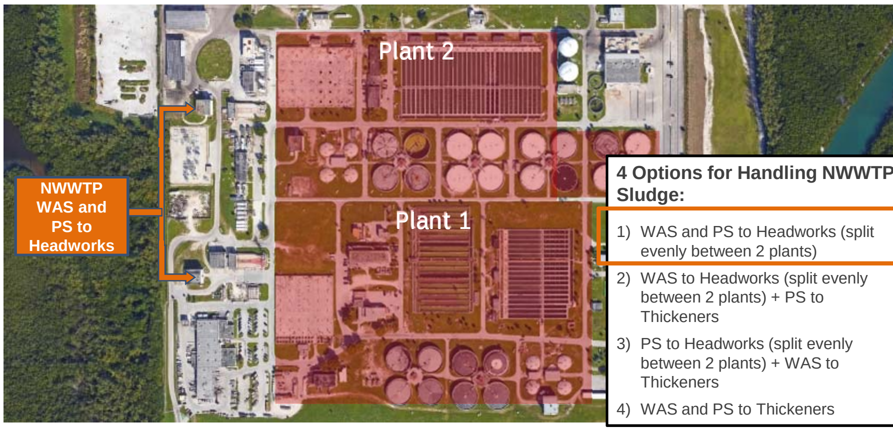
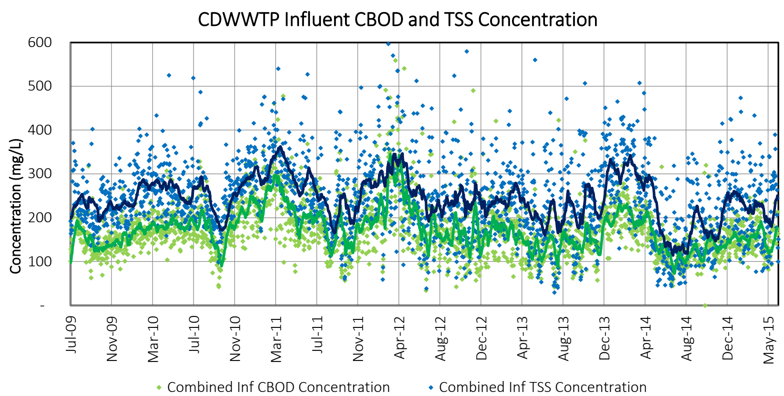
Plant B Receives Sludge from 100 mgd Neighboring Plant (NWWTP)



4 Options for Handling NWWTP Sludge:

1) WAS and PS to Headworks (split evenly between 2 plants)
2) WAS to Headworks (split evenly between 2 plants) + PS to Thickeners
3) PS to Headworks (split evenly between 2 plants) + WAS to Thickeners
4) WAS and PS to Thickeners

Significant variability in Historical CBOD and TSS concentrations



Limited record keeping of sludge transfer from NWWTP

Detailed Sampling

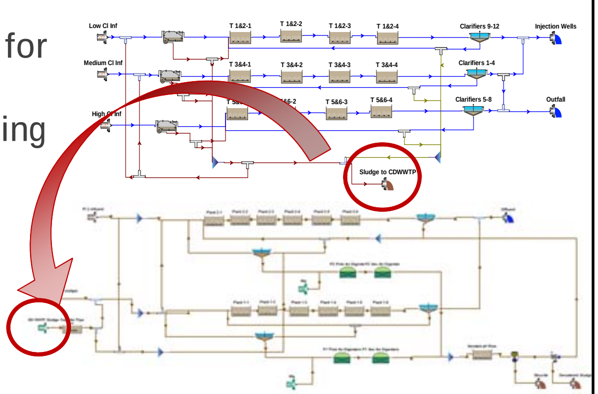
- Influent Characterization
  - Plant B Influent at Headworks
  - Raw wastewater at composite at pump station in collection system (no NWWTP sludge)
- At NWWTP
  - Primary Sludge
  - WAS

Model Calibration for Both Plants

- Modeled Separate NWWTP Sludge input
- Solids production for NWWTP key for accurately capturing impact to Plant B influent and process

NWWTP Sludge Production

Parameter	Measured	Modeled	Difference
Influent CBOD, mg/L	176	172	-2%
Primary Effluent CBOD, mg/L	116	121	4%
MLSS, mg/L	2,333	2,391	3%
Transfer Sludge, ppd	89,014	90,100	1%

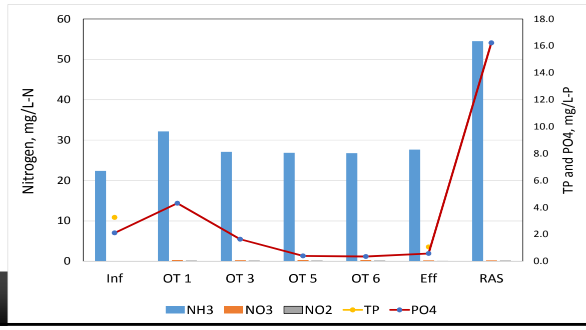


Raw Influent Characterization based on Data Collected from Pump Station No. 1

Wastewater COD Fractions		
Fraction	Default	Reconciled
Readily Biodegradable Soluble	0.16	0.25
VFA fraction of rbCOD	0.15	0.31
Unbiodegradable Soluble	0.05	0.13
Unbiodegradable Particulate	0.13	0.14
Slowly Biodegradable	0.66	0.51

Higher than typical rbCOD fraction and VFA

- Enhanced Biological Phosphorus Removal observed



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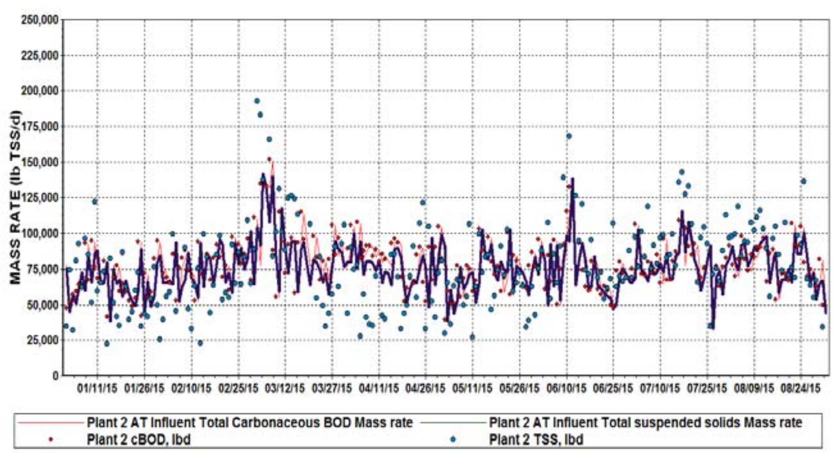
Confirmed Influent + Sludge characteristics (Measured at Plant Headworks)



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Influent Design Criteria for Planning Period

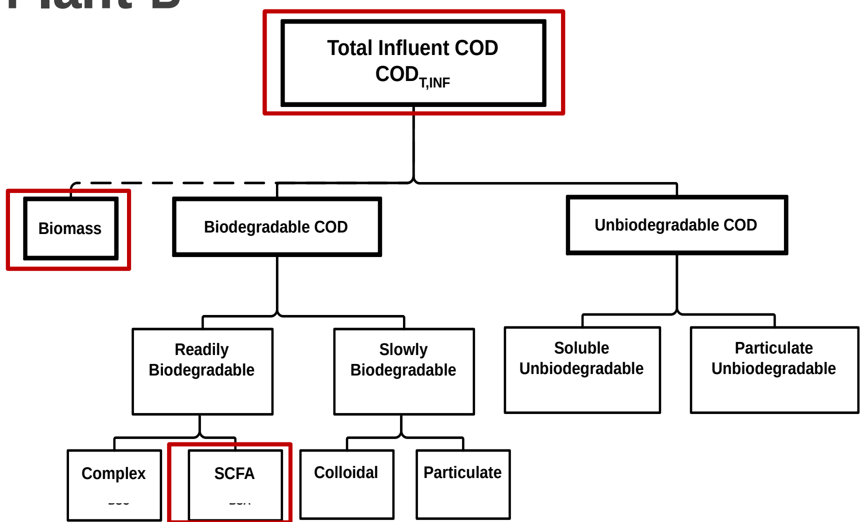
- Projected NWWTP sludge production and evaluated multiple influent conditions:

Influent Conditions	AADF (mgd)	$cBOD_5$ Load (ppd)	TSS Load (ppd)	$cBOD_5$ Concentration (mg/L)	TSS Concentration (mg/L)
All NWWTP Sludge to Influent	143	269,100	363,500	226	305
NWWTP WAS to Influent, PS to Plant 2 Thickeners	143	225,700	285,100	189	239
NWWTP PS to Influent, ND WAS to Plant 2 Thickeners	143	222,400	269,200	186	226
All ND Sludge to Plant 2 Thickeners	143	178,900	190,800	150	160

Selected Design Criteria

Design Condition	NWWTP Sludge	AADF mgd	CBOD Load ppd	TSS Load ppd	CBOD Concentration mg/L	TSS Concentration mg/L
Intermediate (2025)	WAS to Inf.; PS to Thickeners	113	188,200	245,100	200	260

Important Characteristics for Plant B



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Summary

- Influent characteristics can have significant impact on process performance and plant design
- Selecting representative sample locations is key and capturing the “pure” raw sample
- Use historical data review and additional sampling to help identify data quality issues

Next: Example Influent Characterization Studies for Small Facilities

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Influent Characterization Case Studies:

Facilities less than 5 MGD

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Why Does Influent Matter?

- Smaller treatment facilities being asked to do more with less
- Influent composition affects everything – liquid *AND* solids trains

Why Does Influent Matter?

- In an ideal world:
  - We know exactly what's coming into the process and operate perfectly sized equipment in the most optimal way
- In the real world:
  - Safety factors are considered to size process basins and equipment due to the uncertainty and provide a "cushion" against upsets and regulatory violations

Why Does Influent Matter?

- More Sampling
- Greater Certainty

Smaller Safety Factors and Potentially More Efficient Operations

Larger Safety Factors with Less Efficient Operations

- Less Sampling
- Less Certainty

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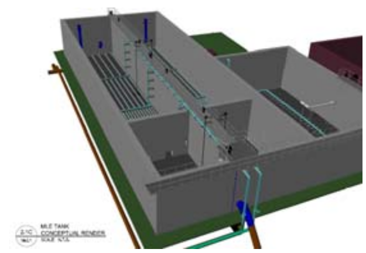
Plant A



- Design Capacity: 2.0 MGD AADF
- Regulatory Requirement:
  - Total Effluent Nitrogen less than 10 mg/L
- Public access reuse and nutrient removal facility

- Conducted review of historical flow, BOD, and TSS (*i.e.* required regulatory monitoring data)
- No existing influent characterization

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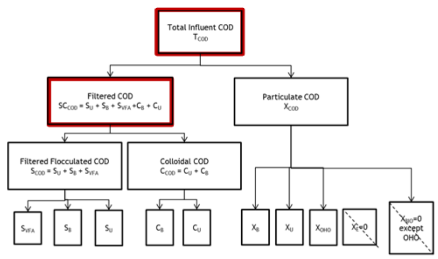
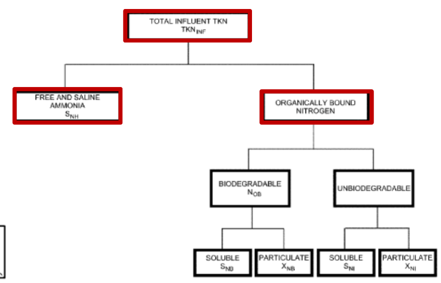
Influent Characterization

- Conducted abbreviated Influent Characterization and executed sampling plan
- Influent Characterization used with an Influent Specifier to calculate the remainder of influent wastewater fractions
- Used the Influent Characterization for process model calibration and facility design





Influent Sampling Plan

PARAMETER	METHOD	MDL	MATRIX
BASE STUDY PARAMETERS			
pH	SM4500H+-B	0.1 UNITS	WW
TSS	SM2540D	0.570 MG/L	WW
CBOD5	SM5210B	0.530 MG/L	WW
OIL & GREASE	1664A	0.992 MG/L	WW
TEMPERATURE			WW
SECOND STAGE PARAMETERS			
ALKALINITY	SM2320B	0.594 MG/L	WW
COD, TOTAL	410.4	7.04 MG/L	WW
COD FILTERED 125 um	410.4	7.04 MG/L	WW
TOT. VOLATILE SUSPENDED SOLIDS	SM2540E	1.4 MG/L	WW
TKN	351.2	CALC	WW
AMMONIA	350.1	0.012 MG/L	WW
NITRATE	353.2 - SM4500NO2B	0.05 MG/L	WW
NITRATE-NITRITE	353.2	0.004 MG/L	WW
NITRITE	SM4500NO2B	0.002 MG/L	WW
PHOSPHORUS, TOTAL	365.3	0.008 MG/L	WW
orthoPHOSPHORUS	365.3	0.002 MG/L	WW

- Approximately 500,000 gpd of existing residential wastewater being pumped to an existing WRRF
- Conducted 14-day, 24-hour flow proportional composite sampling program
- Wastewater Characterization using WERF methods for model calibration (Table 21-1)

Influent Sampling Results

Parameter	Result	Units
OIL & GREASE	32.7	MG/L
AMMONIA NITROGEN	39.3	MG/L
TOTAL KJELDAHL NITROGEN	67.3	MG/L
NITRATE NITROGEN	0.013 I	MG/L
NITRATE+NITRITE AS N	0.013 I	MG/L
ORTHO PHOSPHORUS AS P	4.69	MG/L
TOTAL PHOSPHORUS AS P	8.58	MG/L
CHEMICAL OXYGEN DEMAND	529	MG/L
CHEMICAL OXYGEN DEMAND, DISSOLVED	262	MG/L
TOTAL ALKALINITY (CACO3)	274	MG/L
TOTAL SUSPENDED SOLIDS	330	MG/L
VOLATILE SUSPENDED SOLIDS	224	MG/L

- Typical Domestic Wastewater
- However, influent TKN concentration was higher than historical data projected
- The variation in TKN and Ammonia assumed to be a function of the unique characteristics of that community

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Influent Characteristics

Influent COD fractions	Default	Estimate	Notes
Fbs	0.160	0.179	from Step 1
Fus	0.050	0.064	from Step 1
Fup	0.130	0.120	affects BOD, VSS
Fzbh	0.020	0.020	from separate method
Fxs	0.640	0.618	by difference (must be > 0!!)
Fxsp	0.750	0.750	affects VSS, scale: 0 to 1

Influent values	Measured (From Step 1)	Calculated (Based on fractions above)	Match Status
CODt	392		
Soluble COD (GFC)	157	156	Excellent
FF COD	95	95	Excellent
cBOD5	193	193	Excellent
fcBOD5 (GFC)	92	93	Excellent
VSS	150	151	Excellent
TSS	189	190	Excellent

Calculated concentrations (from CODt & fractions)		
Sus	25	
Xi	47	
Sbs (Sbsc + Sbsa)	70	
Sbsc	58	
Sbsa	12	
Xs (c+p)	242	
Zbh	8	
Xsc	61	Added to Ss for BOD calcs
Xsp	182	

- Sampled COD/TKN Ratio: 7.86 (low)
- Typically, higher ratio COD/TKN (12-16) is better for denitrification
- Influent Specifier to calculate the influent fractions not sampled

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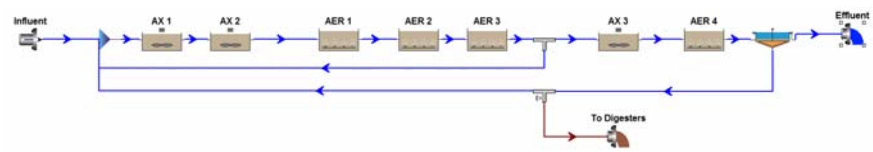
Process Model and Design



- Selected the design Safety Factors to account for TKN, Ammonia, and COD load variations
- Using Influent Characterization:
  - Steady state simulations under several combinations of flows, SRT, temperatures, and loadings
- Evaluated 4-stage BNR Bardenpho and Deep Bed Denitrification filters in addition to 2-stage MLE process
- Results: Selected 2-stage MLE with Deep Bed Denitrification Filters

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Plant B

- Permitted Capacity: 3.55 MGD TMADF
- Current Flow: 1.6 MGD
- Total Effluent Nitrogen requirements less than 12 mg/L
- Public access reuse water (reclaimed) and nutrient removal facility
- Institutional and Industrial Loading:
  - 1.0 MGD from Federal prison
  - 150,000 gpd from stainless steel fabricator

- City staff contemplated expanding the treatment process to increase capacity and maintain reclaimed water quality standards

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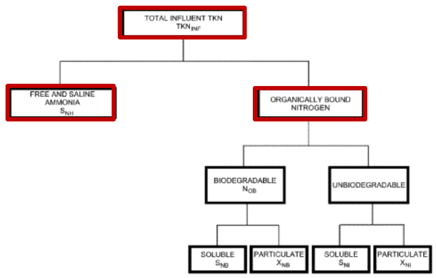
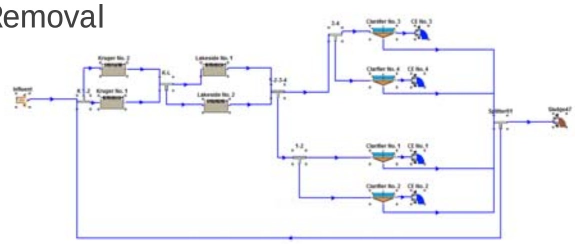
Influent Characterization



- Collection and analysis of plant operational data
- Composite and Grab Sampling
- Wastewater influent characterization results
  - Influent Nitrate concentration up to 8.20 mg/L

Process Model Calibration and Evaluation

- Used Influent Characterization to calibrate and conduct steady state simulations under several combinations of flows, SRT, temperatures considering:
  - Biological inhibition from industrial users
  - Regulatory requirements
  - Design Safety Factors
  - Nutrient Removal



Evaluation Results

- Recommendations:
  - Operational changes to the return activated sludge rate and DO control setpoints
  - Establish Local Limits for acceptable influent loadings based on revised design Safety Factors
- Results:
  - Two years after implementing the operational changes and Local Limits, the WRRF consistently meets all reclaimed water quality requirements and fully treats the institutional and industrial loadings

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Plant C

- Permitted Capacity: 1.5 MGD TMADF
- Current Flow: 0.90 MGD TMADF
- Public access reuse water and nutrient removal facility
- Total Effluent Nitrogen requirements less than 12 mg/L

- City received request from local natural gas-fired combined-cycle power generation facility to discharge cooling tower blow-down water into treatment facility

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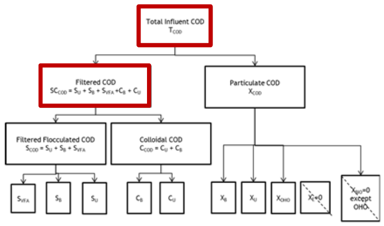
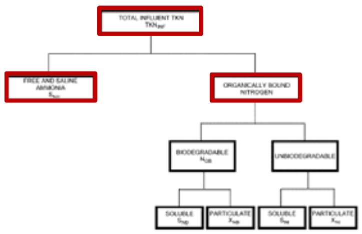
Influent Characterization





- Collection and analysis of plant operational data
- Composite and grab sampling at treatment facility and cooling tower blow-down water
- Included:
  - COD Fractions (Total/Filtered)
  - Nitrogen Fractions

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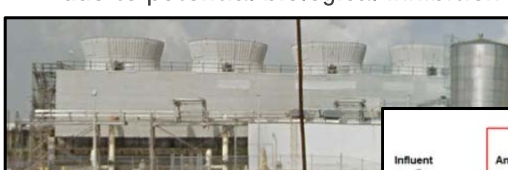
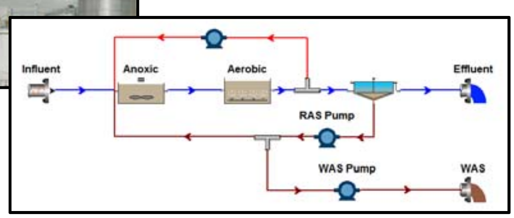
Process Model Results

- Calibration from Influent Characterization including cooling-tower blowdown water
- Refined the design Safety Factors to account for TKN, Ammonia, COD, and TDS load variations based on Influent Characterization
- Recommended the City not accept cooling-tower blowdown water due to potential biological inhibition





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Summary

- The variation in influent characteristics is unique to each facility and should be characterized based on each situation
- Influent Characterization can help identify and resolve process or capacity issues
- Influent Characterization is the first step in a cost effective way to analyze and evaluate smaller facilities

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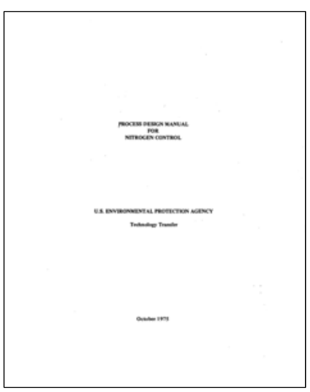
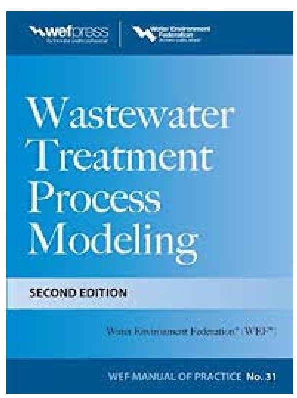
Reference





Water Environment Federation
the water quality people

Final Q & A

Influent – Jan. 25, 2018

An MRRDC Short Course

Influent Characterisation

- Final Q & A:

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