Introduction to PetWin

EnviroSim ASSOCIATES LTD.

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Introduction to PetWin

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Overview

Introduction to PetWin

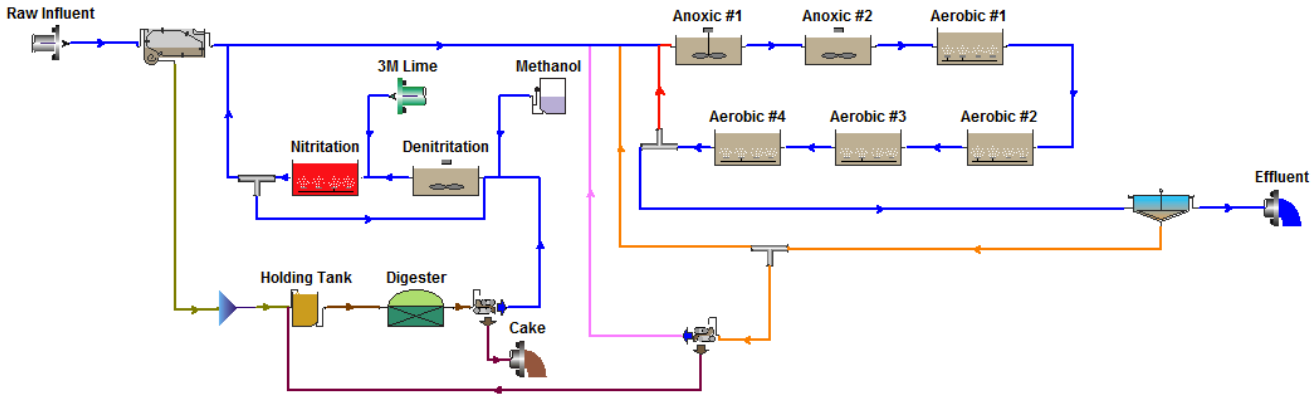
- PetWin is a significant extension of the BioWin process simulator
- BioWin applicable to many industrial wastewaters *i.e.* food processing, but…
  - PetWin provides built-in capability for additional inhibitory influent components (*i.e.* BTEX), and additional reactions (*i.e.* for sulfur modeling)
- Although built-in parameters reflect petroleum/petrochemical wastewaters, these can be modified for other applications

Main Purposes for Process Simulation

- For process design
  - To evaluate unit sizes and operating ranges
- For process analysis
  - As an optimization tool
- For process operation
  - To answer “What if… ?” questions
- For operator training

Understand Interactions in Complex Plants

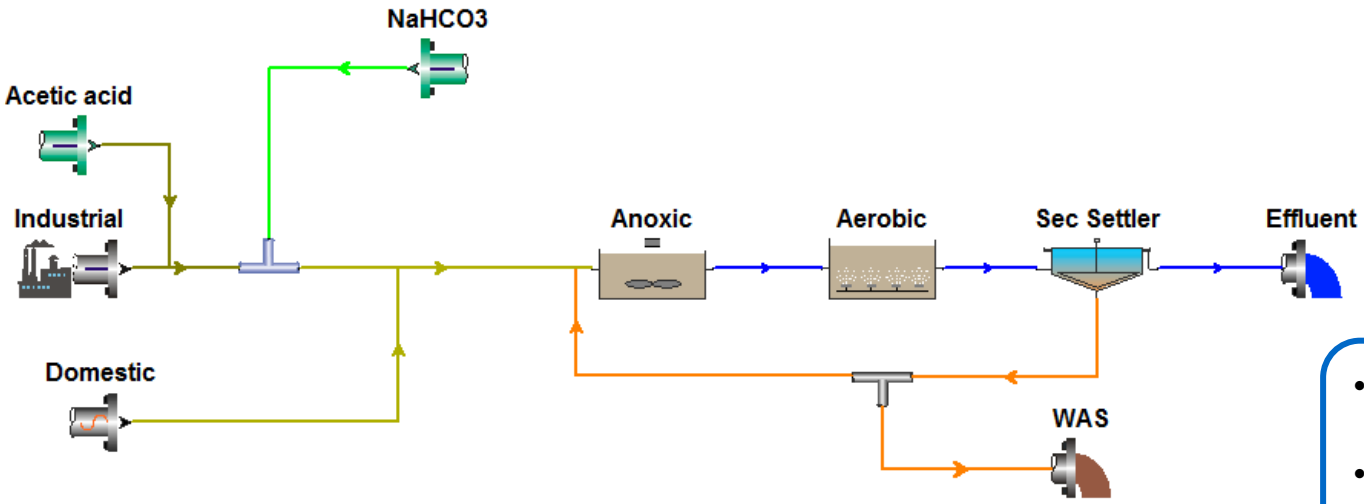
- New generation of WWTPs are complex
  - More complex biological processes
  - Physical/chemical interactions
  - Return streams



Simulation allows us to understand the interactions in the **WHOLE** plant.

Industrial/Municipal Wastewater Treatment

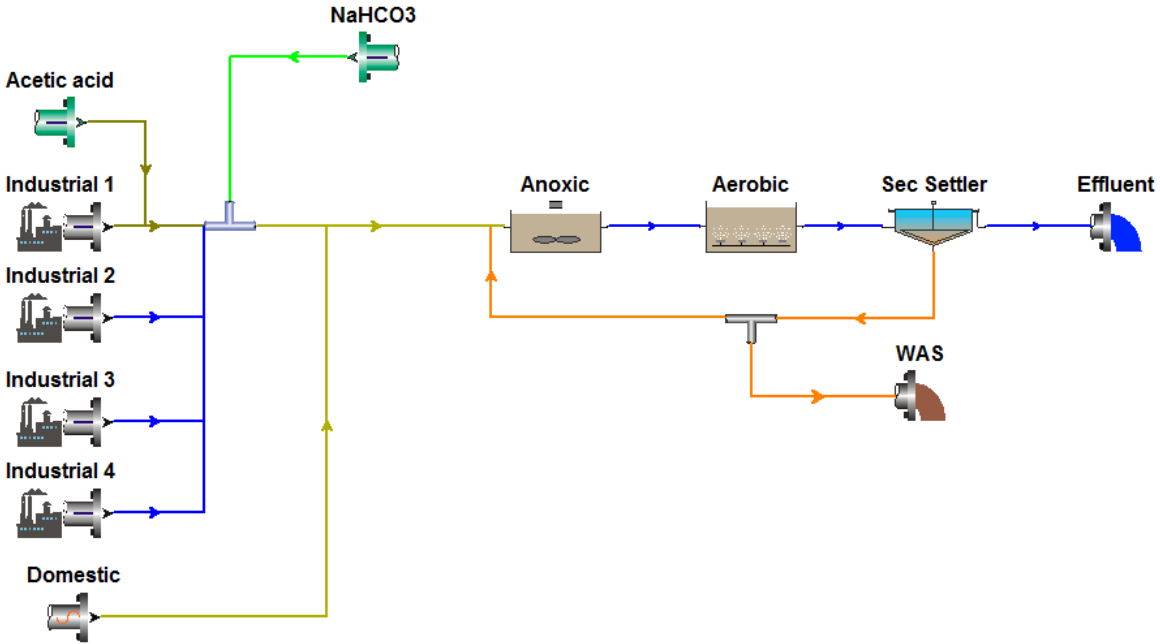
- Industrial Wastewater Treatment will have added complexity, *i.e.*:



- Mixed industrial / domestic influent
- Requirement for alkalinity and/or nutrients, *etc.*

Industrial/Municipal Wastewater Treatment

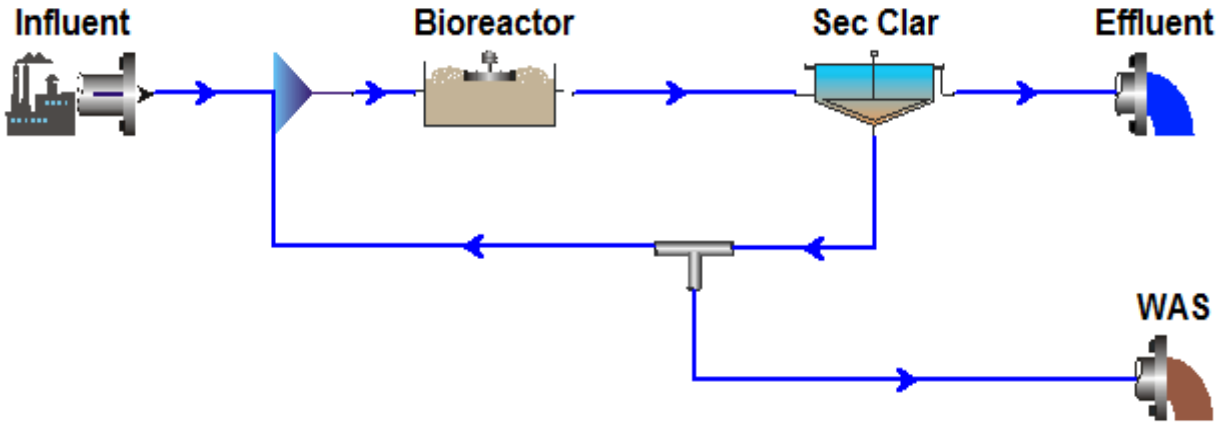
- Industrial Wastewater Treatment will have added complexity, *i.e.*:



Potentially multiple streams with different characteristics.

Industrial/Municipal Wastewater Treatment

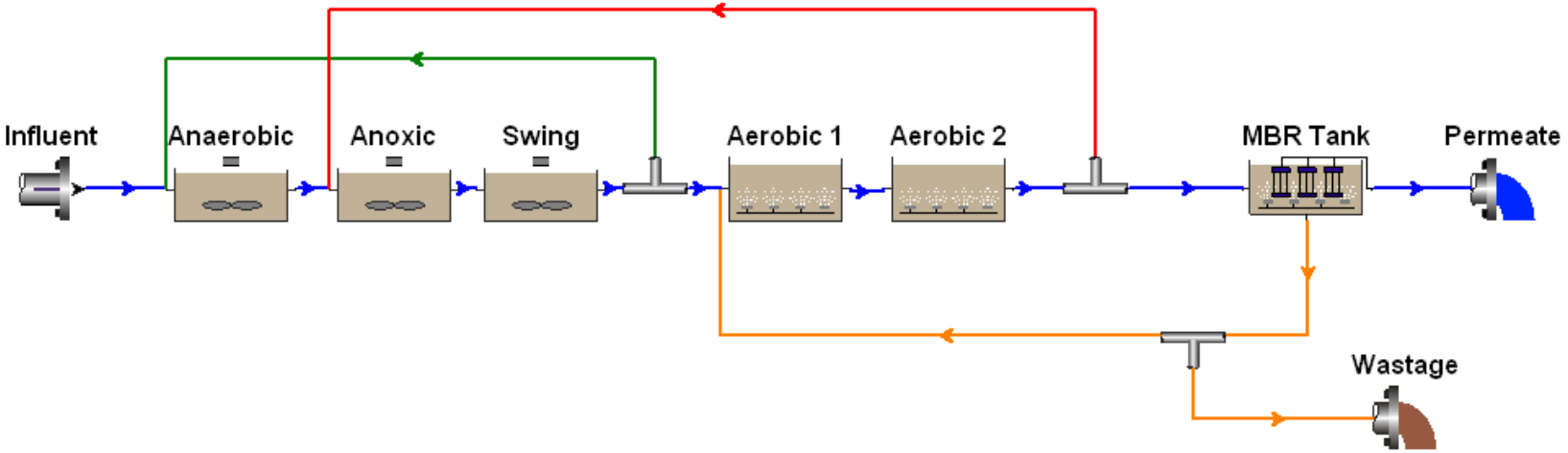
- Stripping of volatile organics could be substantial



Special considerations for mechanically aerated plants.

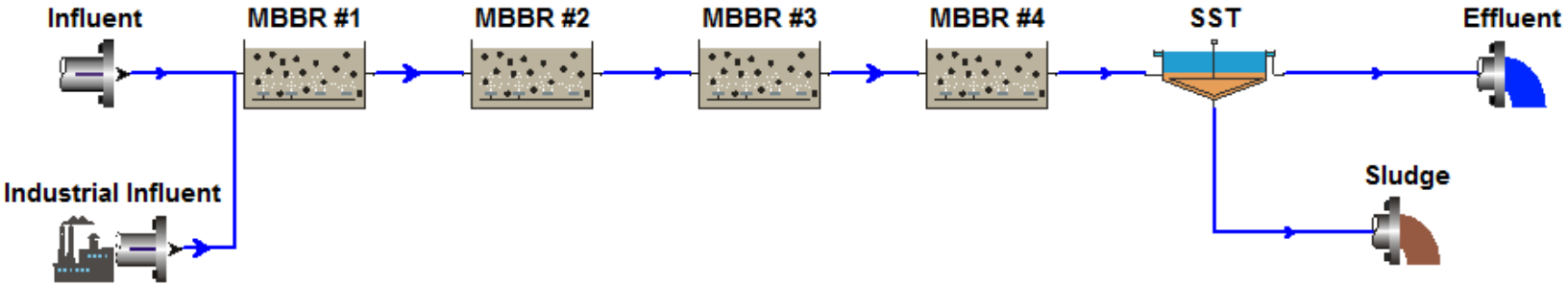
Example – Membrane Bioreactor (MBR) Process

- Simulate MBR processes when water re-use may be considered



Example – Moving Bed Bioreactor (MBBR) Process

- Applications in treatment of petrochemical/petroleum refinery wastewaters
- Simulate stability advantages of MBBRs with inhibitory influents



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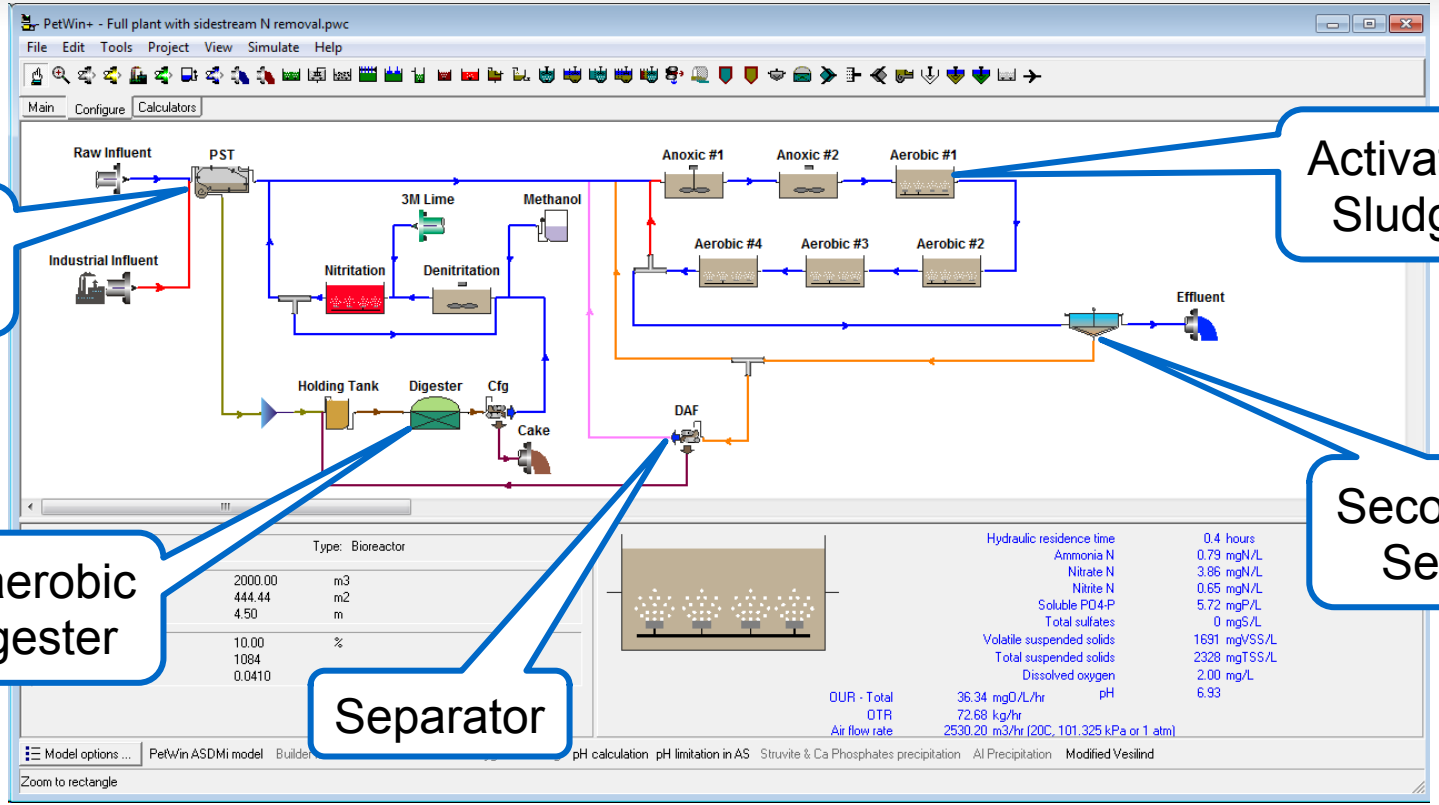
PetWin Model

Models in PetWin



Primary Settler

Activated Sludge

Anaerobic Digester

Separator

Secondary Settler

Activated Sludge – Anaerobic Digestion Model

- Carbonaceous material removal
- Nitrification
- Denitrification
- Sulfur oxidation
- Sulfur reduction
- Biological phosphorus removal
- Fermentation
- Methane production
- Chemical precipitation [pH]

Industrial Version

ASDMi

Biomass Components

- Non-polyP heterotrophs
- PolyP heterotrophs
- Anoxic methanol utilizers
- Nitrifiers (AOBs and NOBs)
- Propionic acetogens
- Acetoclastic methanogens
- Hydrogenotrophic methanogens
- Anammox organisms
- Endogenous residue

Industrial Version

ASDMi

Sulfur-related Biomass Components

- Sulfur oxidizing organisms
- Sulfur-reducing acetogens
- Sulfur-reducing acetotrophs
- Sulfur-reducing hydrogenotrophs

Industrial Version

ASDMi

Other Components #1

- Organics
  - soluble/particulate, biodegradable/unbiodegradable
- Industrial Organics
  - Industrials #1-3 – soluble, biodegradable, volatile
  - Soluble hydrocarbon
  - Adsorbed hydrocarbon
- Nitrogen
  - ammonia, nitrite, nitrate, soluble/particulate organic N

Industrial Version

ASDMi

Other Components #2

- Phosphate
  - soluble and precipitated phosphate, organic P
- Inorganic suspended solids
  - ISS = TSS - VSS
- Sulfur
  - Reduced sulfur
  - Oxidized sulfur

Industrial Version

ASDMi

Other Components #3

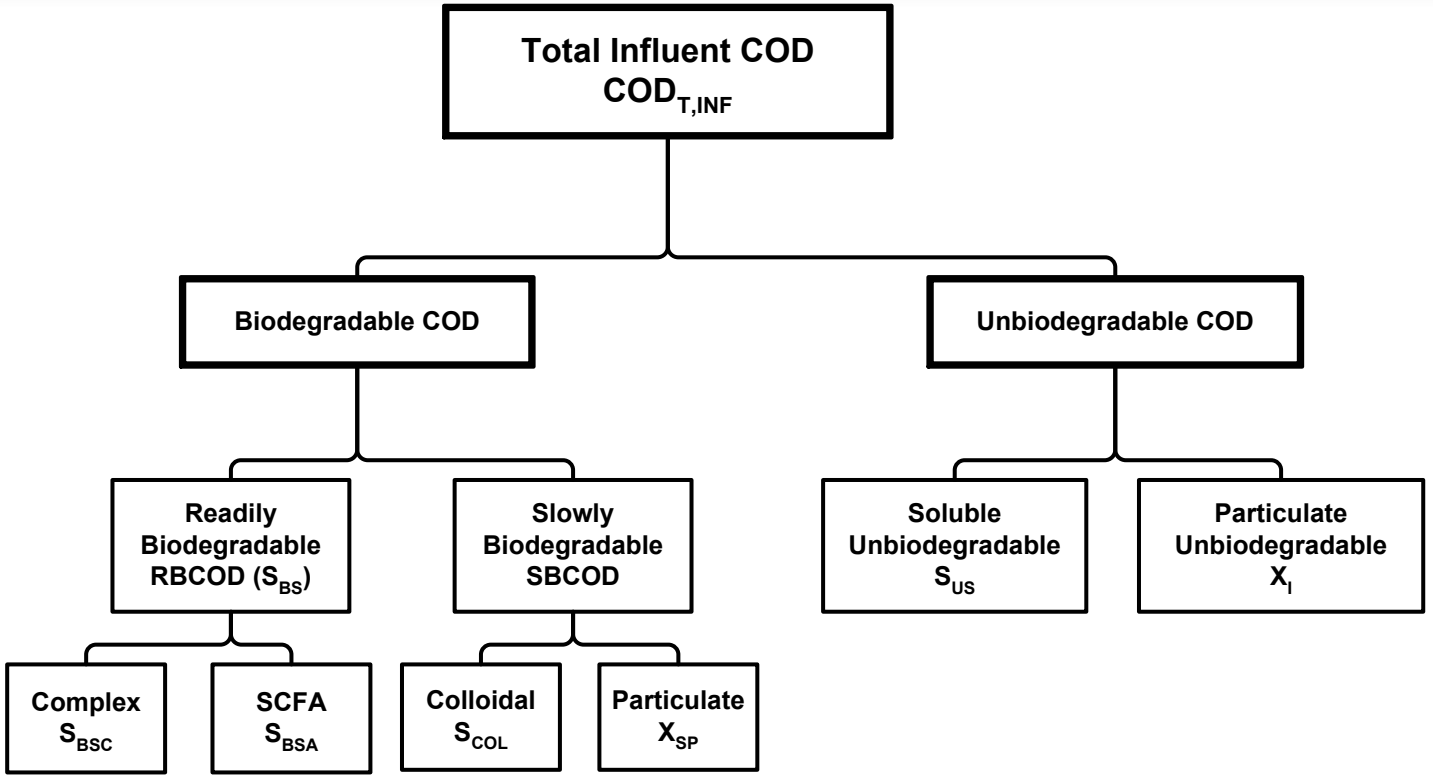
- Metals
  - Ca, Mg, Fe, Al
- Other Cations / Anions
- Precipitates
  - Struvite, HAP, HDP, metal-P
- Oxygen
- Other gases
  - carbon dioxide, nitrogen, hydrogen, methane, ammonia, volatile industrial components, hydrogen sulfide

Industrial Version

ASDMi

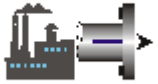
Influent Organics - Domestic

COD Influent



Influent Organics - Industrial

Industrial COD Influent



Model Processes

- Aerobic heterotrophic growth using complex substrate, acetate, propionate, methanol, industrial components #1-3, adsorbed hydrocarbons
- Anoxic heterotrophic growth on nitrate and nitrite using complex substrate, acetate, propionate, industrial components #1-3, adsorbed hydrocarbons
- Anaerobic fermentation of complex substrate, propionate and methanol
- Growth of bio-P microorganisms and storage of polyphosphate
- Various hydrolysis, ammonification and colloid flocculation reactions
- Assimilative nitrate and nitrite reduction
- Anoxic growth of methylotrophs on nitrate and nitrite
- Growth of ammonia and nitrite oxidizer biomasses
- Growth of Anammox microorganisms
- Growth of autotrophic and heterotrophic methanogens

Industrial Version

ASDMi

Model Processes, cont'd

- Aerobic heterotrophic growth using complex substrate, acetate, propionate, methanol, industrial components #1-3, adsorbed hydrocarbons
- Decay of all nine (9) active biomasses in different environments
- pH estimation based on the phosphate, carbonate, ammonia, acetate and propionate systems, including strong acids and bases, plus other relevant reactions
- Precipitation of various calcium, magnesium, aluminum and iron complexes (struvite, HDP, HAP, *etc.*)
- Gas transfer of O_2, CO_2, N_2, NH_3, H_2 and CH_4 gases
- Inorganic suspended solids fixation during polyphosphate storage and heterotrophic growth

Industrial Version

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Model Processes – Additional for Industrial

- Aerobic heterotrophic growth using industrial components #1-3, adsorbed hydrocarbons
- Anoxic heterotrophic growth on nitrate and nitrite using industrial components #1-3, adsorbed hydrocarbons
- Anaerobic growth on industrial components #1-3, adsorbed hydrocarbon
- Adsorption of soluble hydrocarbons
- Volatilization of industrial components #1-3
- Sulfur oxidizer growth and decay
- Growth of acetogenic, acetotrophic and hydrogenotrophic sulfur reducing organisms
- Decay of all sulfur reducing organisms

Industrial Version

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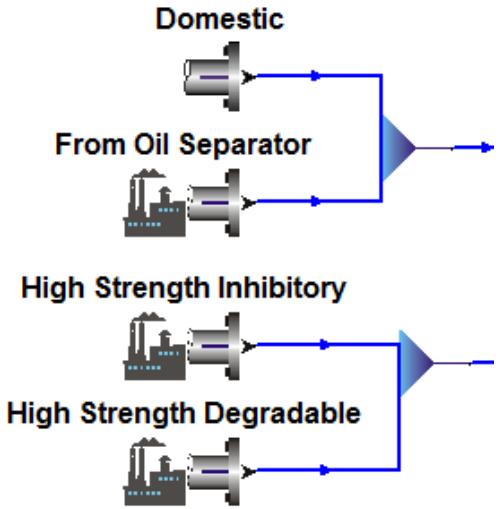
Industrial Influent Discussion

Closer look at industrial influents…

- Default model parameters in PetWin mimic the following components:
  - Soluble hydrocarbon – Ethylbenzene (or Xylene)
  - Sind1 – Phenol
  - Sind2 – Benzene
  - Sind3 – Toluene

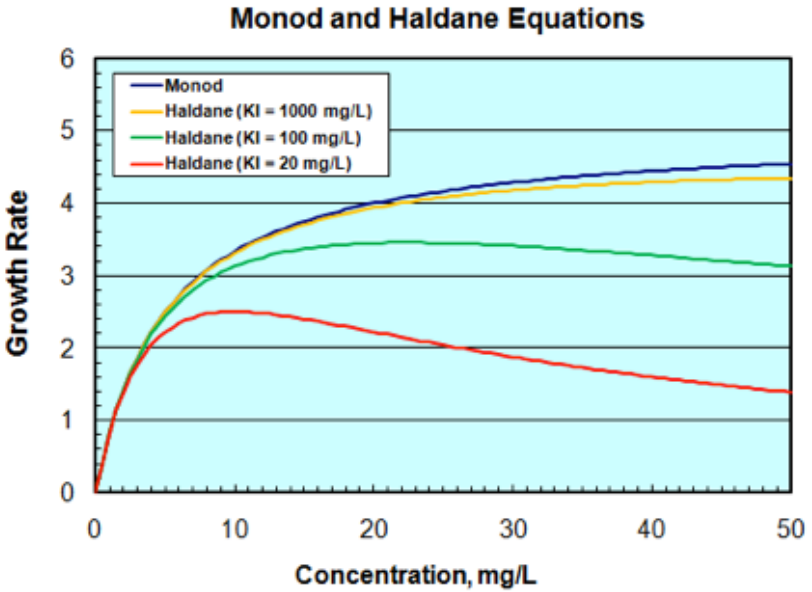


Growth on Sind (1-3)

- Based on Haldane equation:

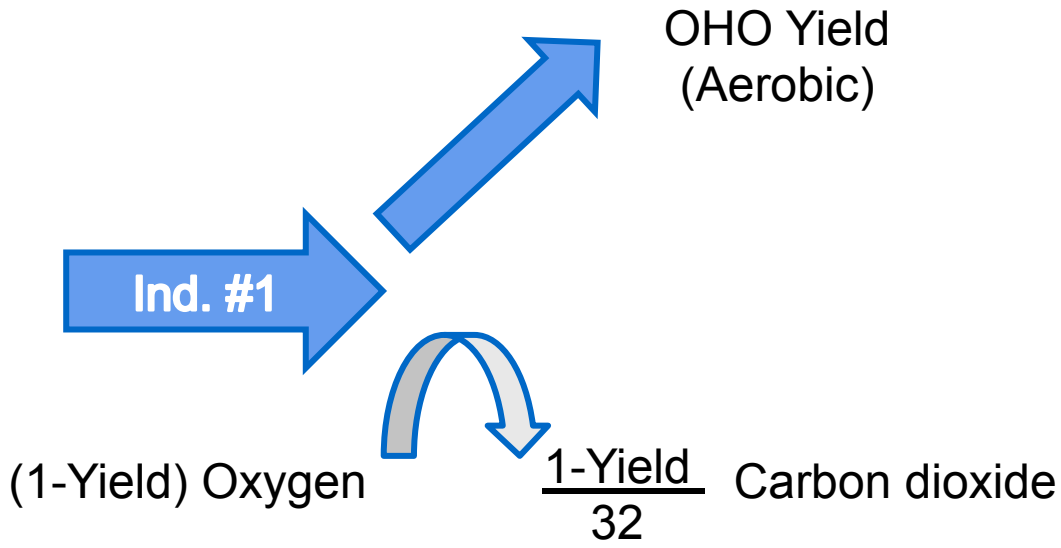
$$\mu = \mu_{max} \cdot \left[\frac{S}{K_S + S + \frac{S^2}{K_I}} \right]$$

- Sind1: K_i = 60 (moderate inhibition)
- Sind2: K_i = 3000 (negligible inhibition)
- Sind3: K_i = 60 (moderate inhibition)



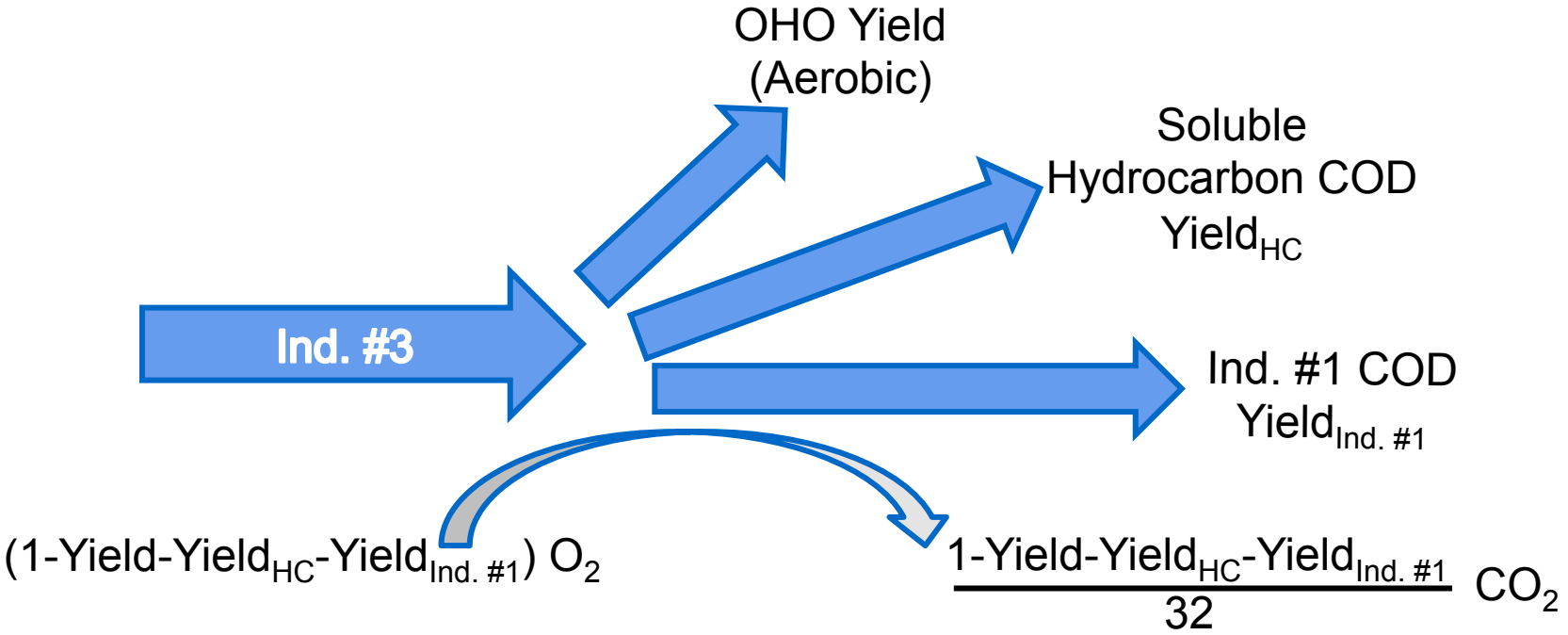
Growth on Industrial Components

- Fate of industrial components – aerobic growth on Sind1, Sind2, Adsorbed Hydrocarbon



Growth on Industrial Components

- Fate of industrial components – aerobic growth on Sind3



Stripping of Sind (1-3) – Varying Volatility

- Sind1: $k_L = 0$ (non-volatile)
- Sind2: $k_L = 0.5$ (moderately volatile)
- Sind3: $k_L = 0$ (non-volatile)

Applying PetWin

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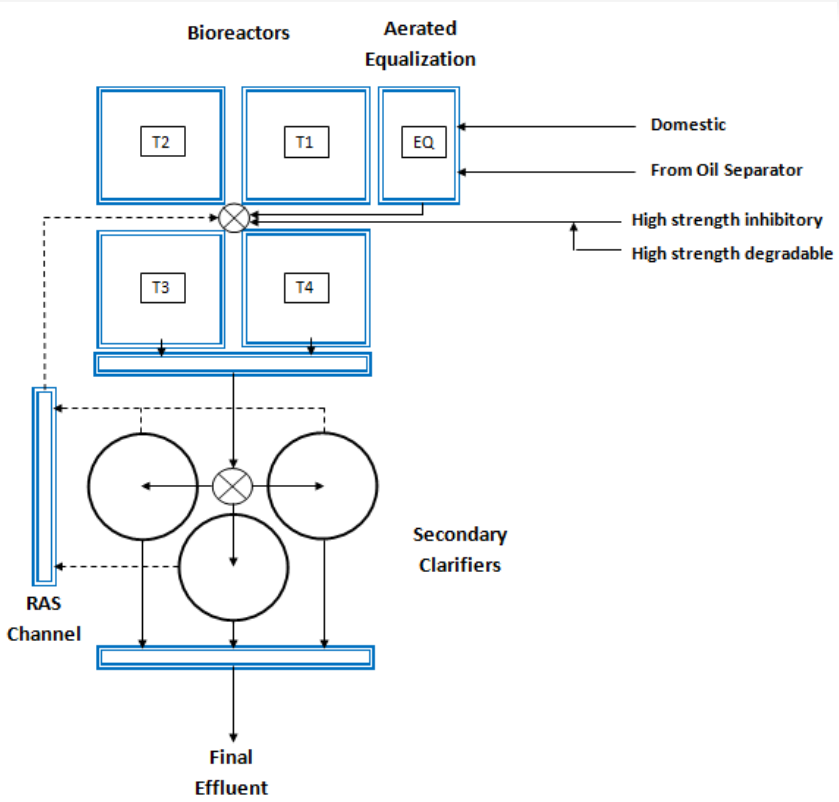
Plant Simulation for Optimization

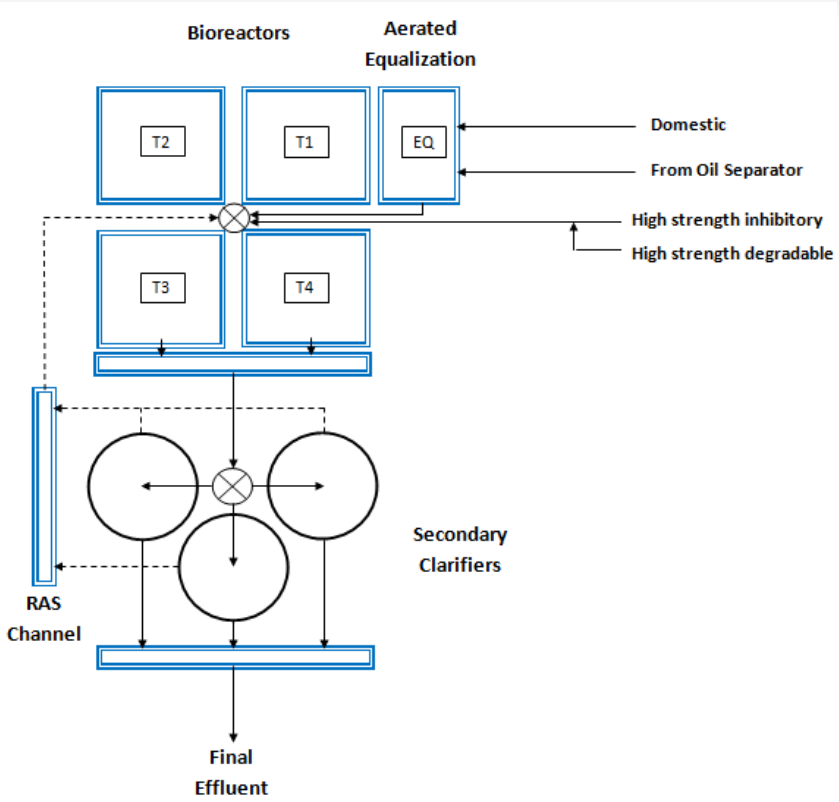
The existing plant…



Process Details

- Activated sludge process
- Various industrial streams + domestic
- Different tank arrangements possible

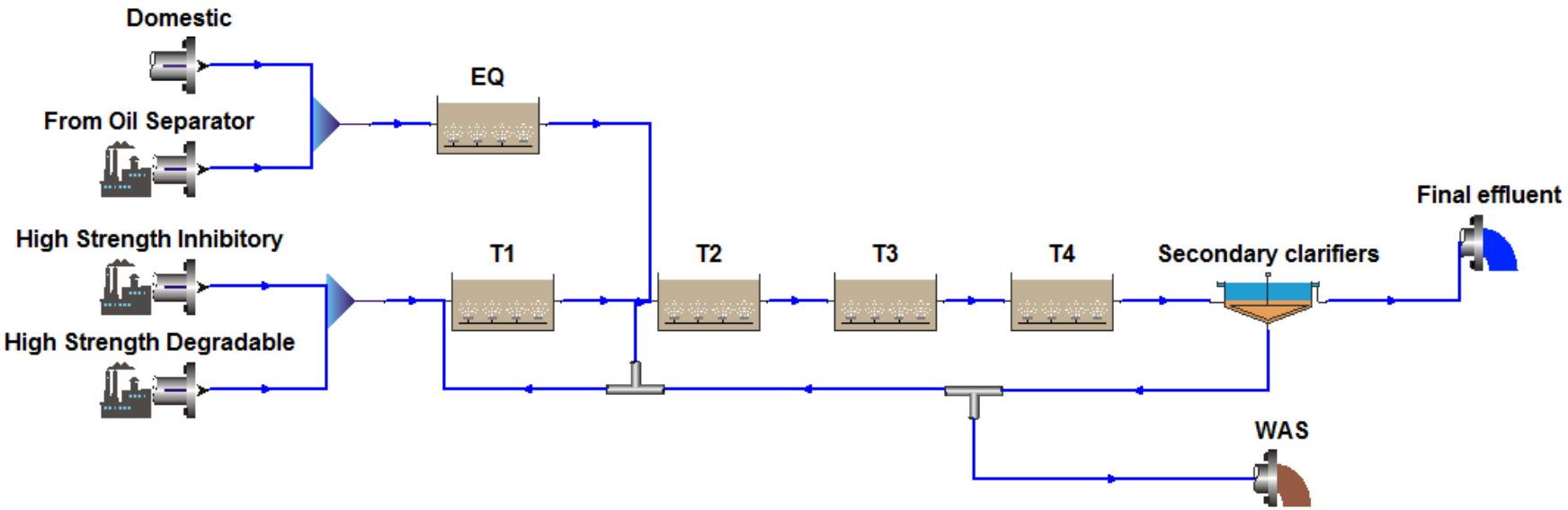
The challenge…



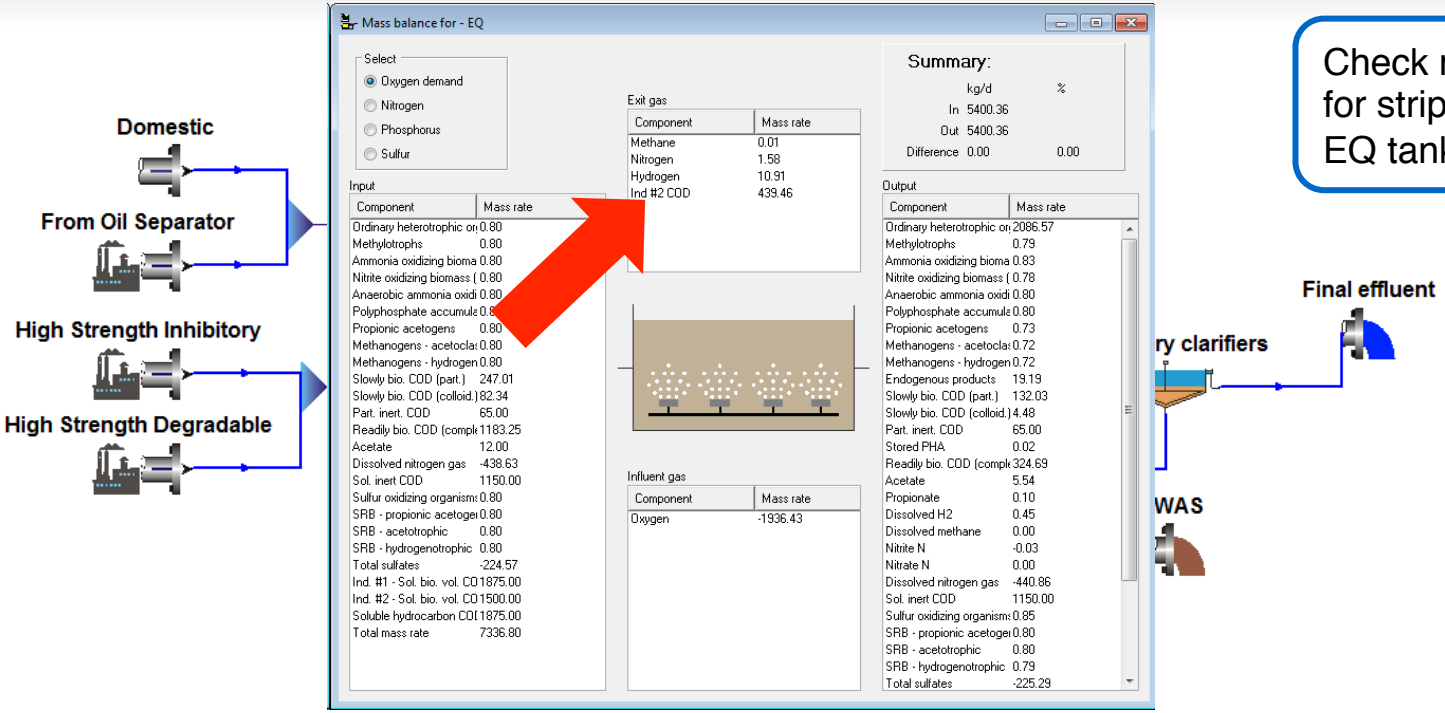
Areas of Investigation

- Different process arrangements
- Nutrient requirements
- Possible pre-treatment

Existing Plant – Current flow configuration in PetWin

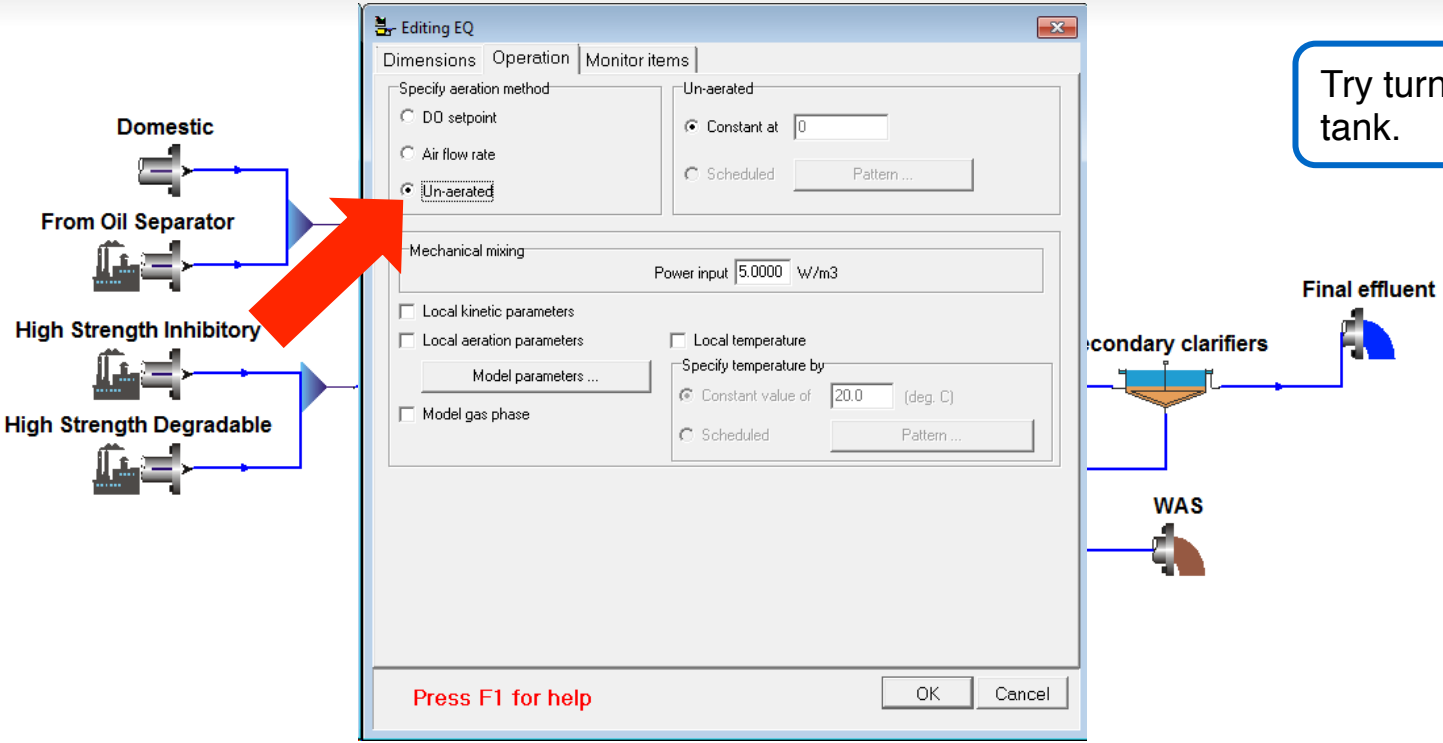


Can we reduce stripping of volatile organics?



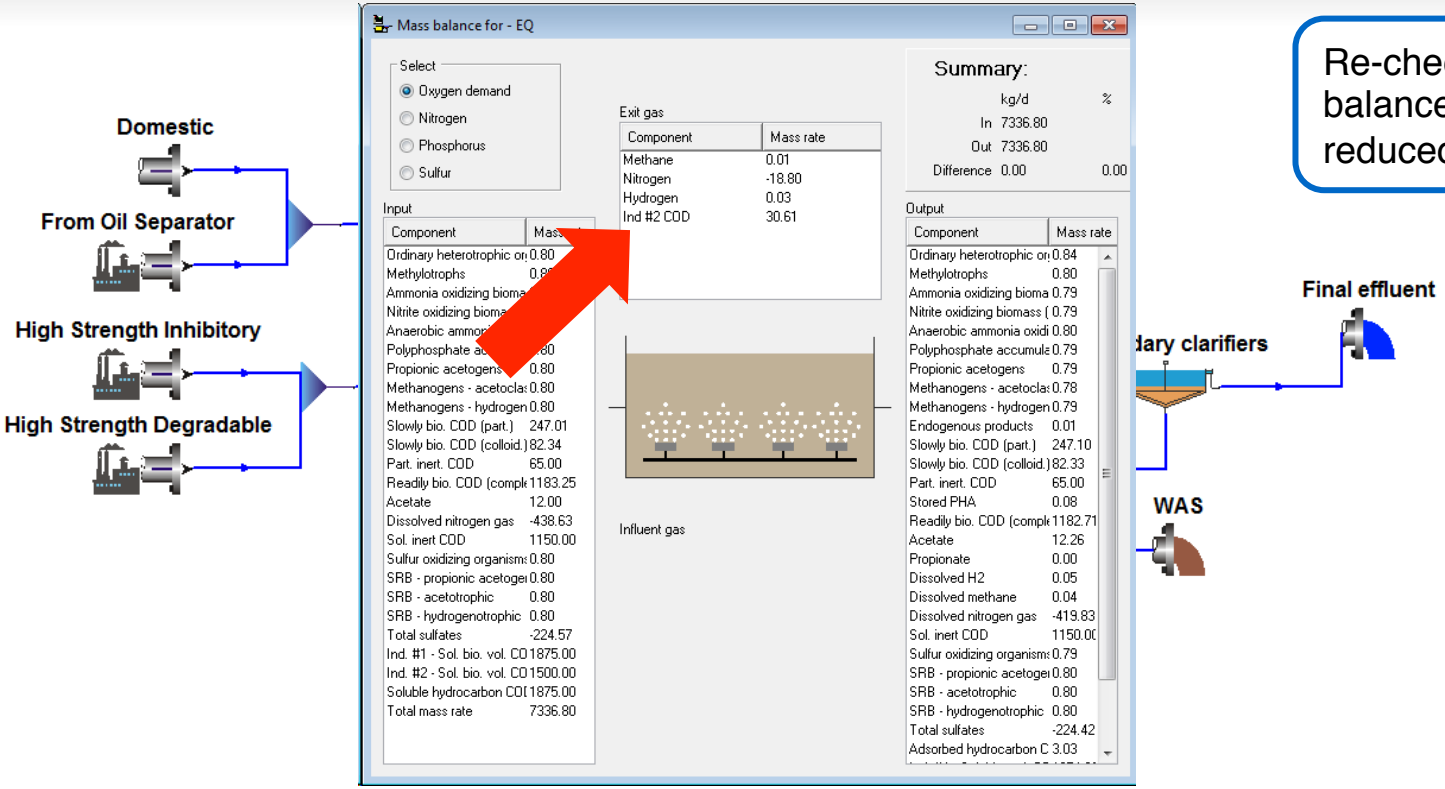
Check mass balance for stripping in aerated EQ tank.

Can we reduce stripping of volatile organics?



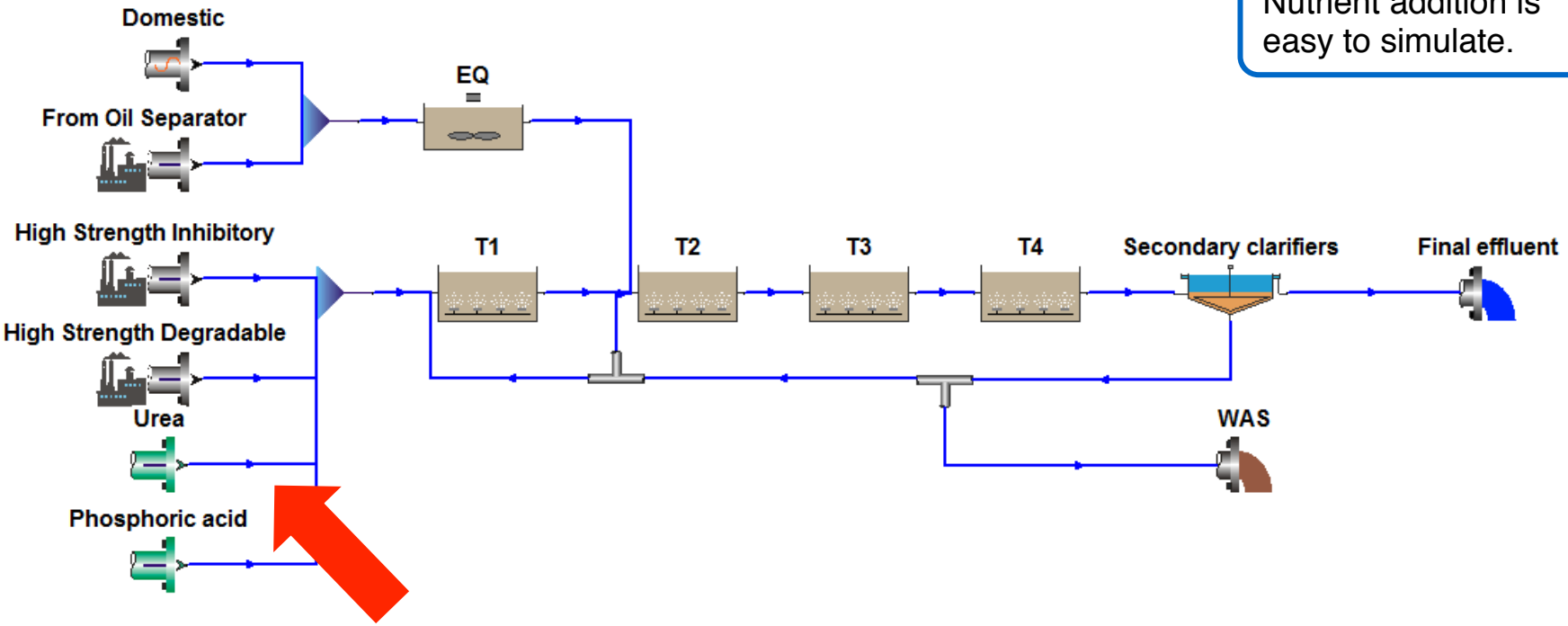
Try turning off air in EQ tank.

Can we reduce stripping of volatile organics?



Re-check mass balance…stripping reduced substantially.

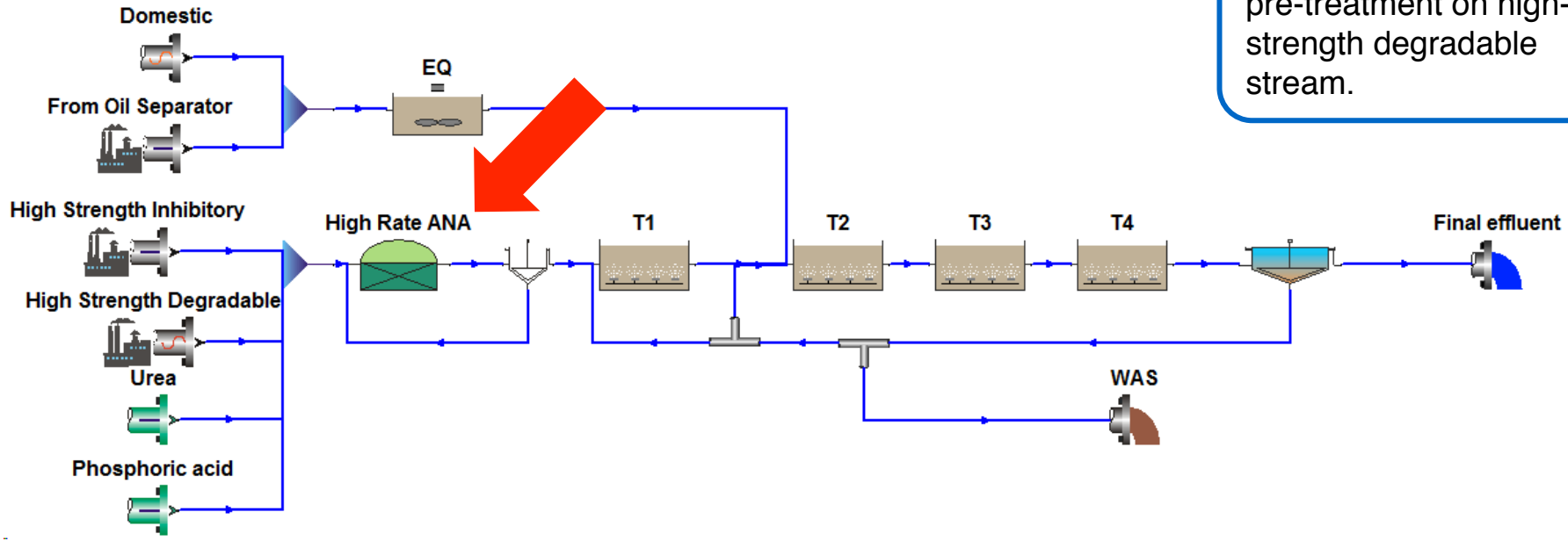
Nutrient limitations?



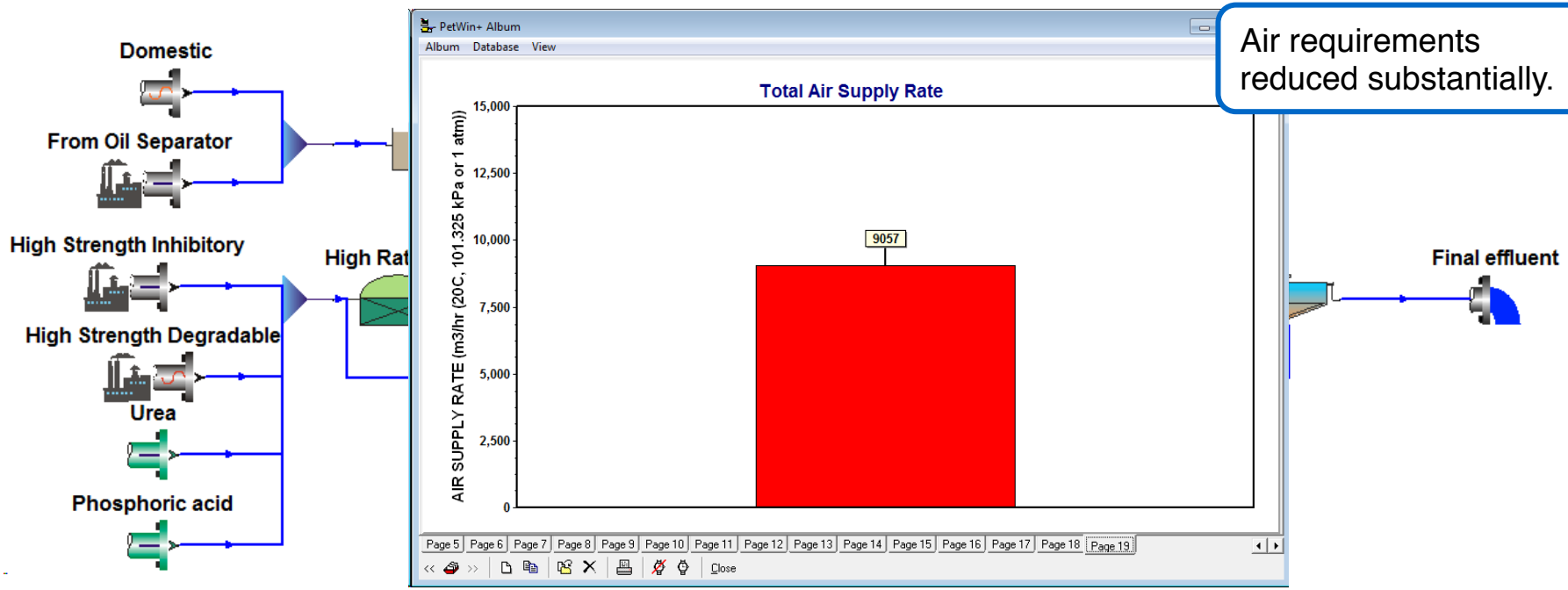
Nutrient addition is easy to simulate.

Pre-treatment options?

High-rate anaerobic pre-treatment on high-strength degradable stream.



Pre-treatment options?



Air requirements reduced substantially.

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Concluding Remarks

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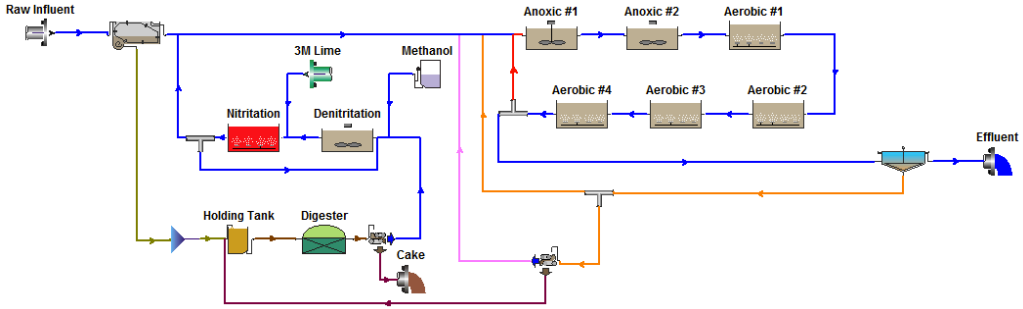

- Simulation objectives
  - Design
  - Analysis and optimization
  - Operator “what-if?” questions
  - Understanding complex interactions
- “Safety Factors” replaced by deterministic predictions of plant performance
- More robust design / operation