Aeration Basics – the Bug's Eye View

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Why Do We Aerate?

- Supply process oxygen:
  1. Oxidation of organics (BOD)
  2. Endogenous respiration
- Suspend mixed liquor solids

Biochemical Oxygen Demand ("BOD")

BOD has two components:

1. Carbonaceous BOD ("CBOD") is oxygen required for oxidation of carbon:

   $$C_xH_yO_z + \mathbf{O_2} \rightarrow CO_2 + H_2O$$

   Carried out by heterotrophic bacteria … relatively rapid process

2. Nitrogenous BOD is oxygen required for oxidation of ammonia to nitrate:

   $$NH_3 + \mathbf{O_2} \rightarrow NO_2 + \mathbf{O_2} \rightarrow NO_3 + H_2O$$

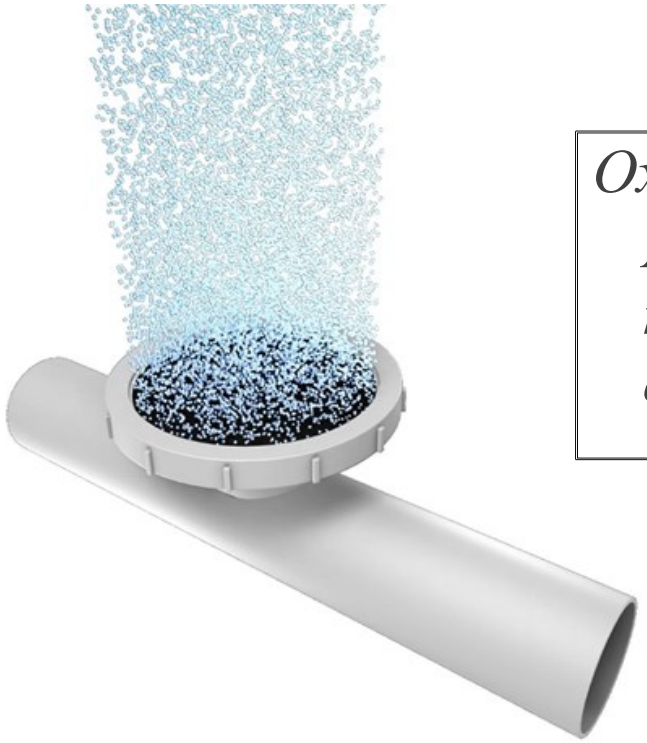
   Carried out by "nitrifiers" … slow growing, relatively sensitive bacteria

Endogenous Respiration

Without wastewater organics for food:

- Bacteria coast and respire “endogenously” (resting rate)
- Bacteria eventually die, rupture (lysis), and provide food for their relatives
- This is the main process in aerobic digestion, but it also is important in aeration basins, especially if they are organically underloaded

TCEQ Chapter 217 Design Criteria for DO



Oxygen Requirements (O_2R) of wastewater:

An aeration system must be designed to provide a minimum dissolved oxygen concentration in the aeration basin of 2.0 milligrams per liter (mg/L).

Note:

This is at the max design loading in the future.

Mixing

Keep mixed liquor solids in suspension:

Air flow rate must be

- > 20 scfm/1000 cu ft for course bubble diffusers,
- > 0.12 scfm/sq ft for fine bubble diffusers

Mechanical mixing must provide

- > 0.75 hp/1000 cu ft

Swing zone can be aerated or just mixed

How Much Oxygen is Necessary?

Depends mainly on:

- Wastewater flow rate, cBOD & ammonia concentrations
  → organic loading rates

Other factors:

- Characteristics of BOD: degrades readily or slowly?
- Solids retention time (sludge age)
- Basin configuration -- selectors?

Why Aeration is Expensive

1. Even highly efficient aeration is not very efficient in actually transferring oxygen into solution.
2. Besides pushing oxygen into the aeration basin, we also have to pressurize the accompanying nitrogen.

Example: with 33% O_2 transfer efficiency:

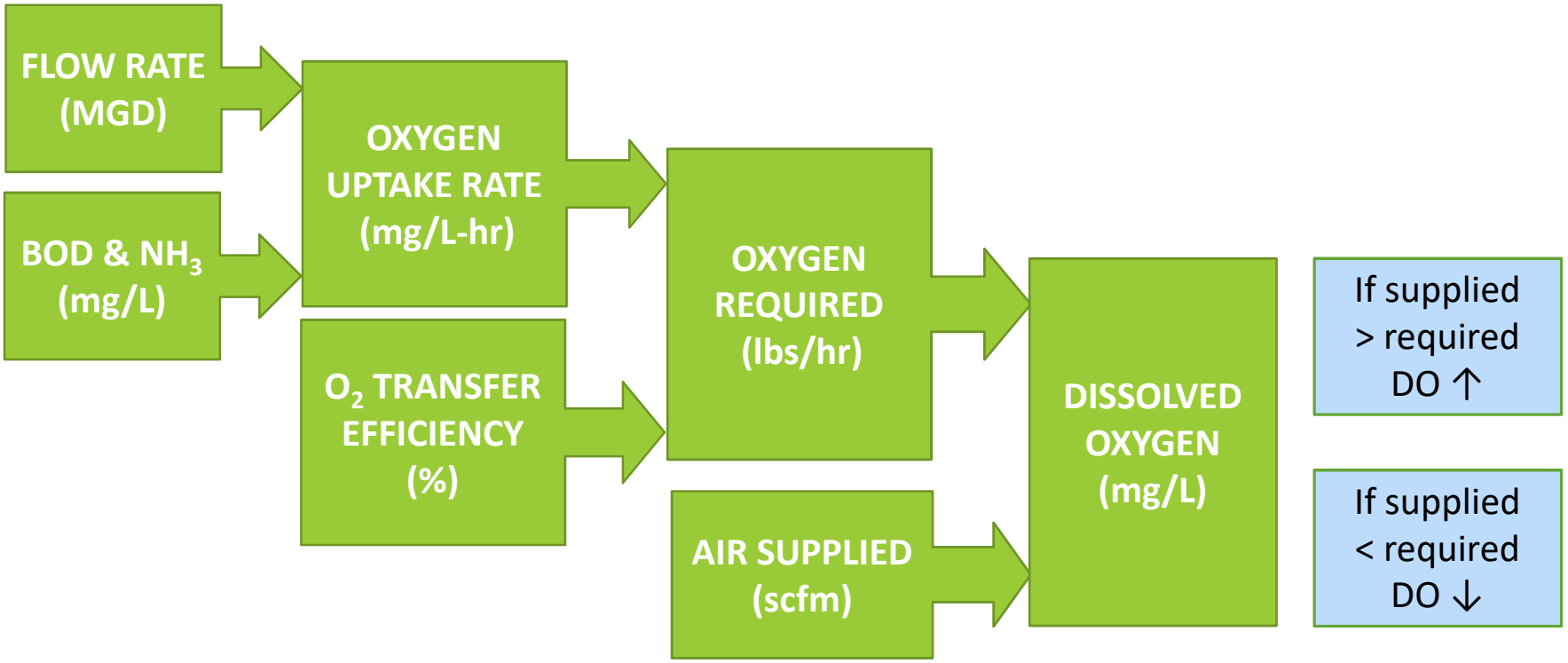
- 1 lb O_2 transferred requires 3 lb O_2 applied
- 3 lb O_2 applied carries 11 lb nitrogen
- Total air required to transfer 1 lb O_2 = 14 lb

How Much Air is Necessary?

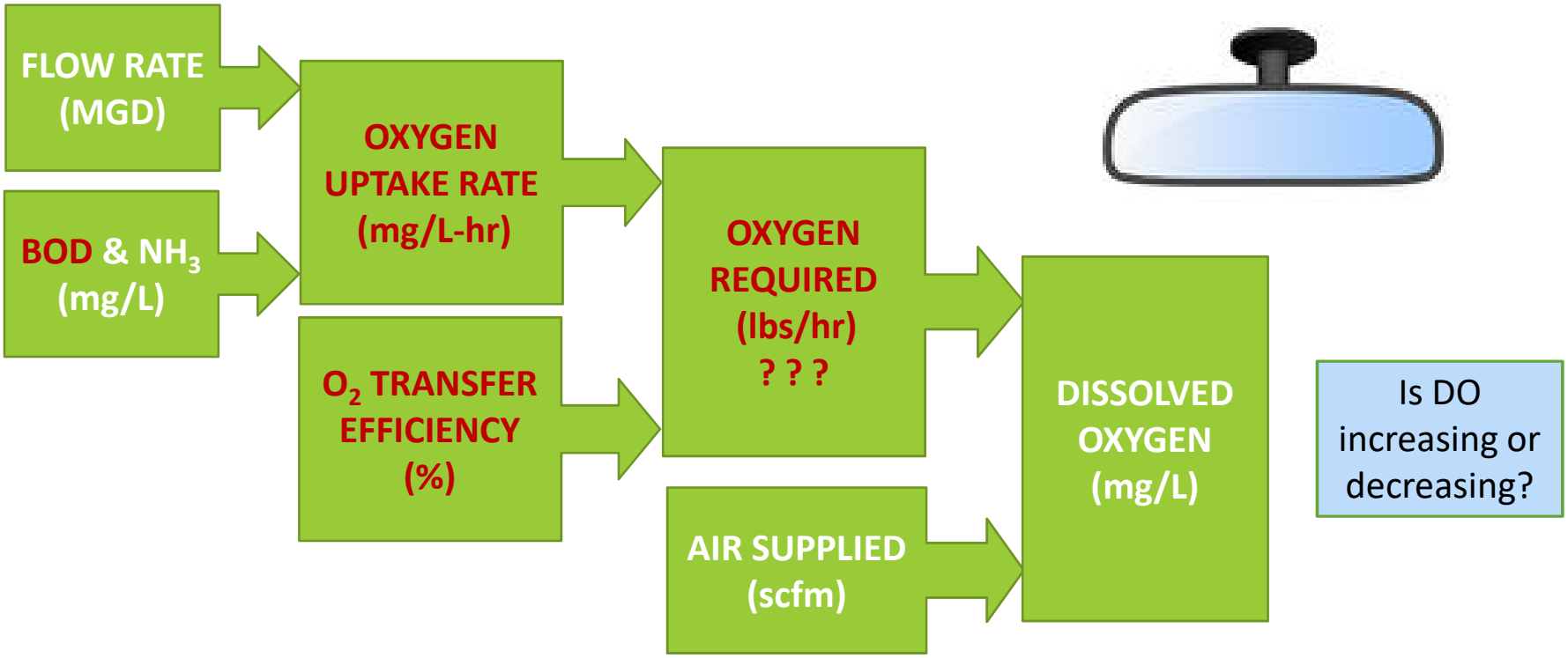
- Depends mainly on:
  - Wastewater flow rate, BOD & ammonia concentrations → loadings
- Other factors:
  - Characteristics of BOD: readily or slowly degradable
  - Solids retention time (sludge age)
  - Transfer efficiency of diffusers
  - DO concentrations
  - Wastewater temperature
  - Presence of surfactants and/or grease
  - Basin configuration (selectors?) and AB volume
  - Air temperature and humidity

WHAT CAN YOU CONTROL?

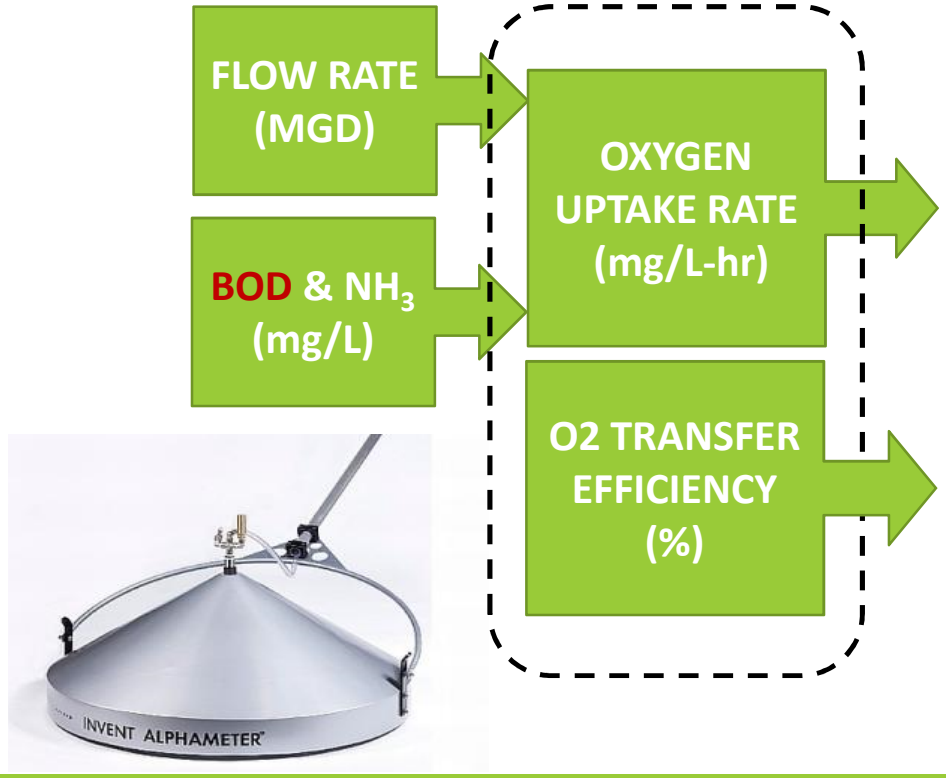
Aeration Control Overview (simplified)



Aeration Control Overview (simplified)



Possible Game-Changing Technology



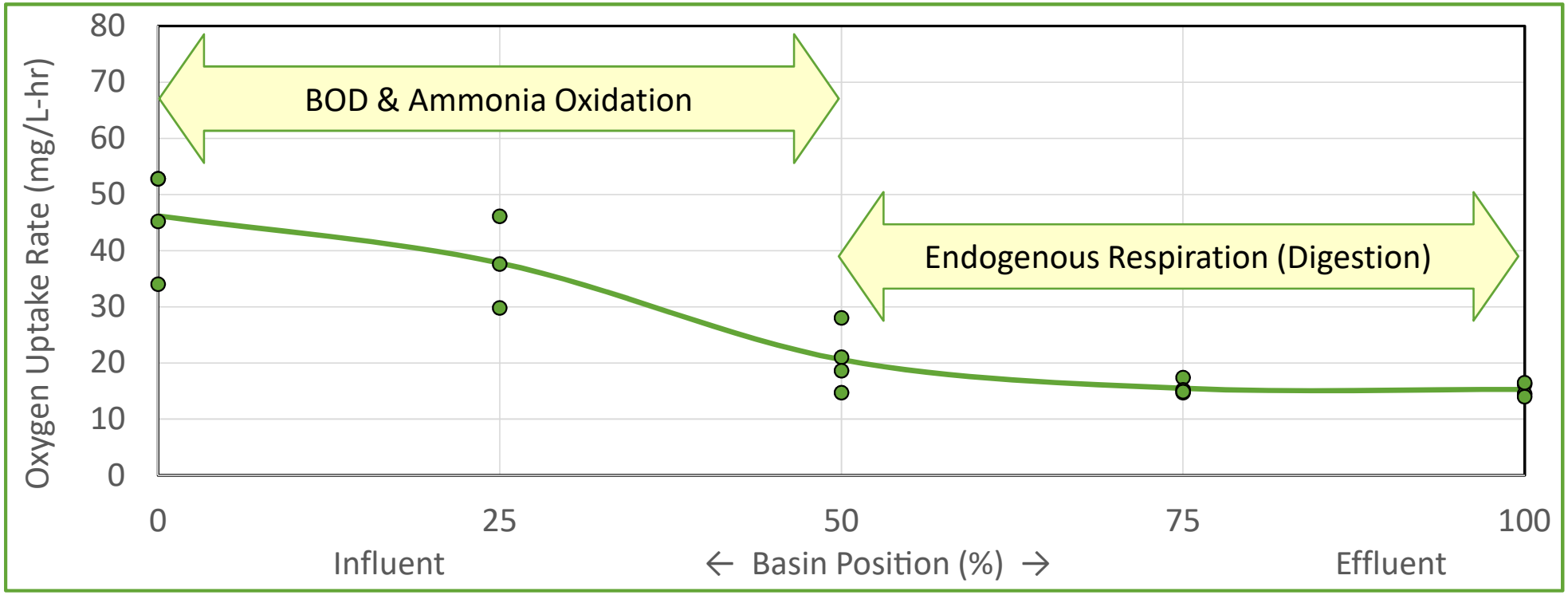
Floating hood collects off-gas and analyzes residual O_2 and CO_2 content. Calculates:

- Oxygen Uptake Rate (OUR)
- Oxygen Transfer Efficiency

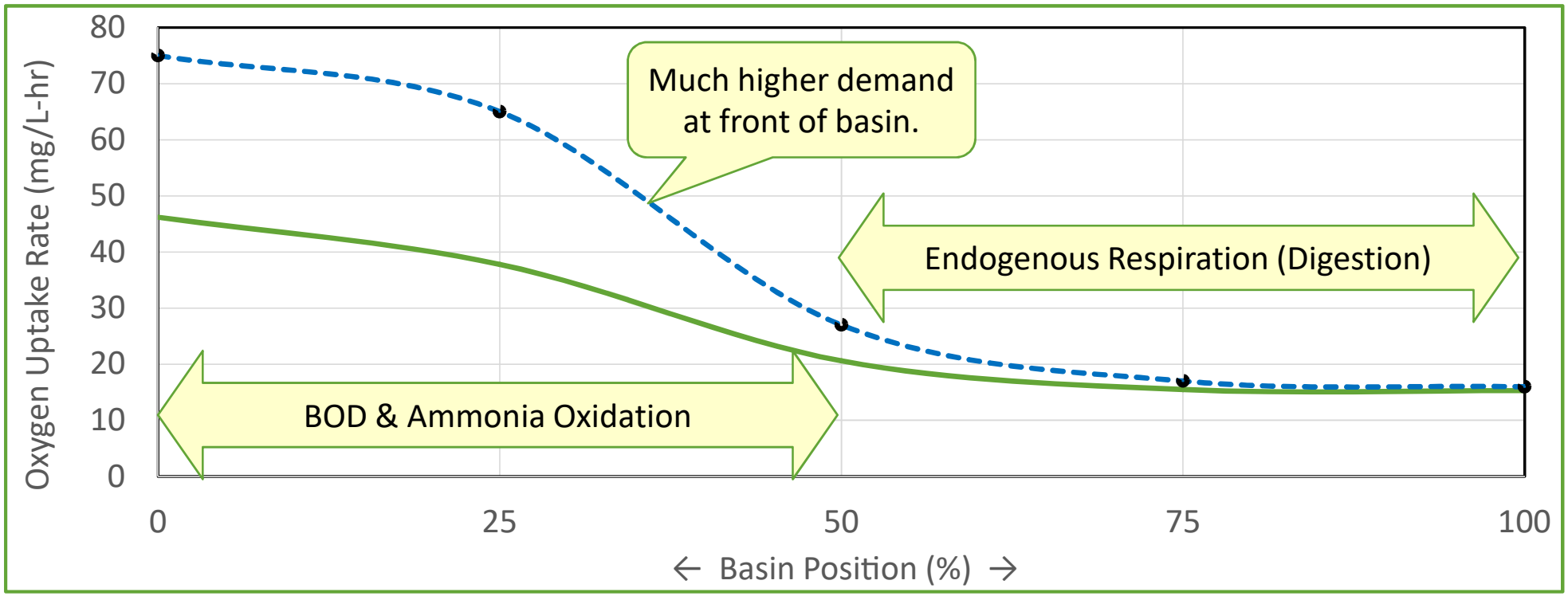
Expensive … no units in Texas at this time.

Example AB Oxygen Uptake Patterns

(Dallas Water Utilities Central Plant – B Complex)



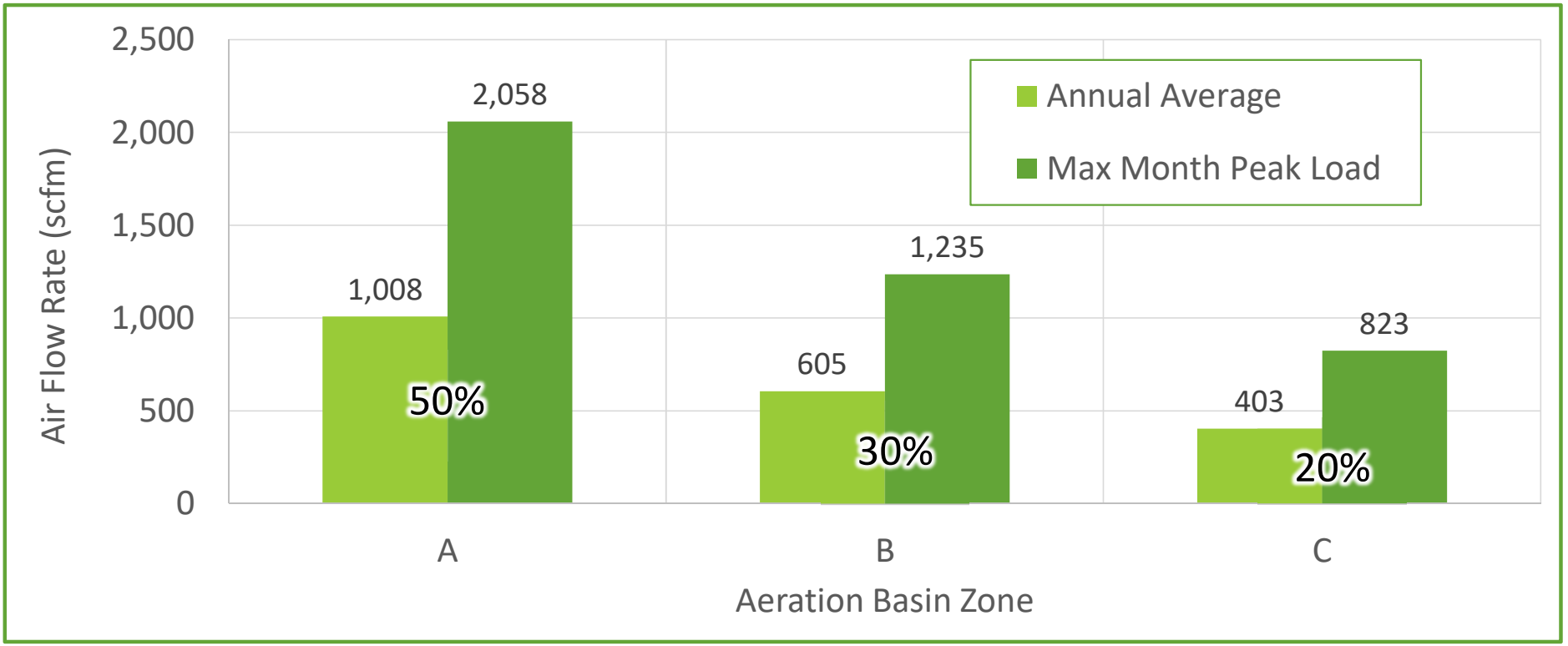
More Typical AB Oxygen Uptake Pattern



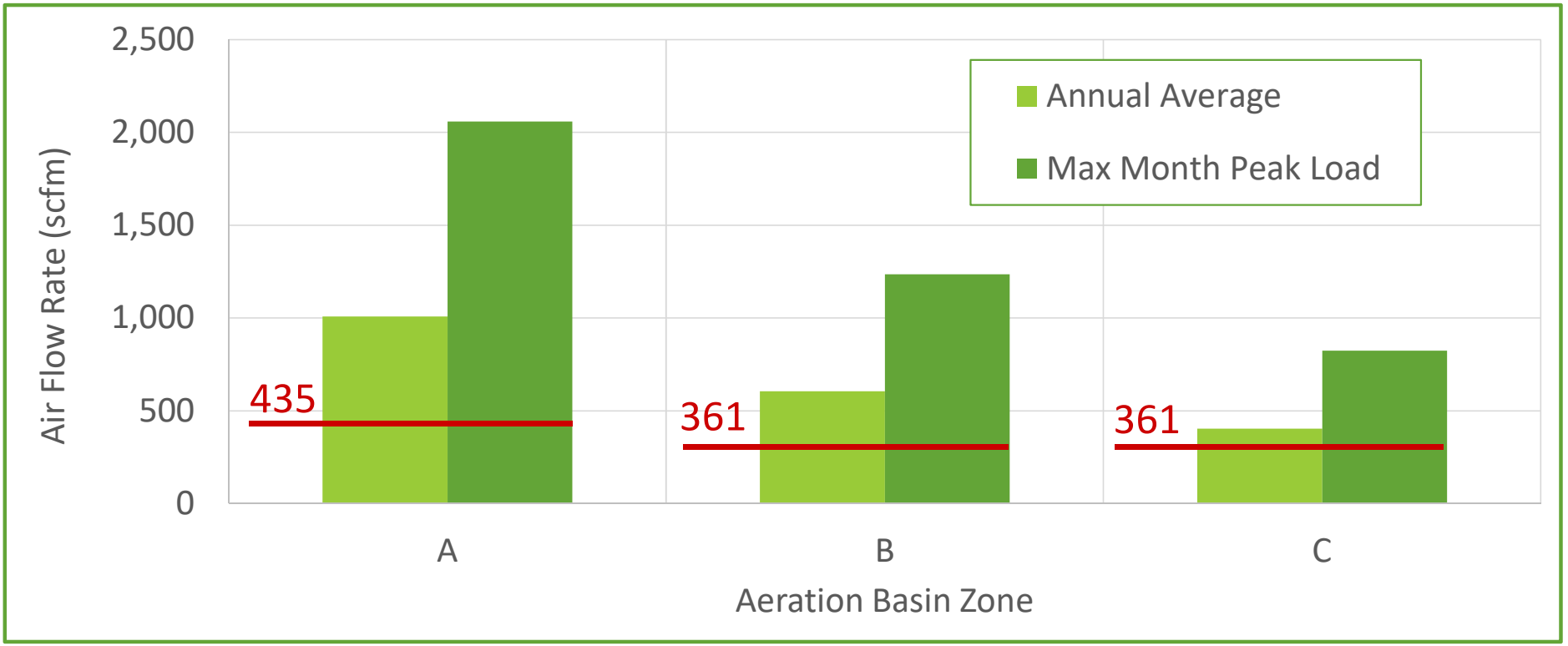
Tapered Aeration

Install diffusers in zones to match oxygen uptake pattern – higher density at influent end of basin.

Example Air Flow Distribution: Leon Creek



Leon Creek Minimum Air Flow Rates

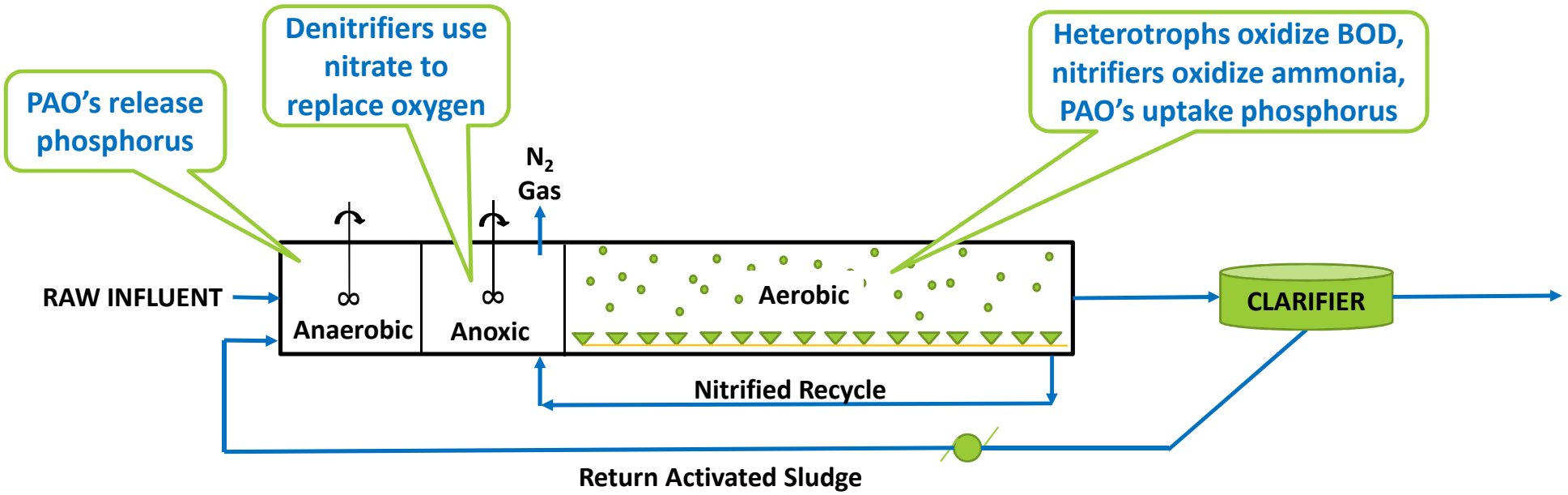


Non-Aeration: Anoxic and Anaerobic Zones

"Anoxic" – with very little, if any, oxygen present. Heterotrophic bacteria substitute nitrate for oxygen in degrading BOD ... Can reduce aeration by 15-20%.

"Anaerobic" – with no oxygen and no nitrate present. Phosphorus Accumulating Bacteria (PAO's) release phosphorus, then take up extra phosphorus in the aerobic zone … biological phosphorus removal.

Anoxic/Anaerobic Zones for BNR



Anoxic/Anaerobic (BNR) Effects on Aeration

- Can reduce oxygen, and aeration, demand by 15-20%.
- Recycle will even out uptake rate along length of basin.
- Important to minimize returning dissolved oxygen to an anoxic zone.
- Critically important to avoid returning dissolved oxygen to an anaerobic zone.

The “Perfect” Aeration Strategy?

Supply just enough air to meet process requirements – no air “wasted” on mixing.

RISK CONTINUUM

Supply enough air to meet process requirements by mid-basin, use last zone(s) as a safety cushion.

Final (Process) Thoughts …

1. Every plant has large aeration fluctuations – hourly, daily, seasonally – you'll never reach "perfection".
2. Compliance is priority #1, even if you have to waste some air.
3. Be diligent about monitoring/maintaining the DO probes.
4. Make aeration changes gradually.
5. Turndown may require taking AB's out of service.
6. DO control may be more important for BNR than for saving energy.

Thank You!

Questions / comments:

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