Streamlining Commercial Wastewater Treatment Design using Innovative Engineered Solutions with an Integrated Systems Approach

Edward F. Gelsone, M.S., P.E.

Agenda

- Treatment Basics
- Design Example
- Case Studies
- Q & A

Perspectives from the restaurant industry…

- For many current and potential restaurant owners onsite treatment is the only choice.

- Depending on the size of the facility, the menu, and the practices in the kitchen, wastewater strength can range between 2 and 10 times higher than residential strength wastewater.

- Why?
  - A lot of organic material goes down the drain.
  - Rarely are there washing machines or showers to help dilute the wastewater

- Many designers and regulators lack experience in high strength wastewater system design.

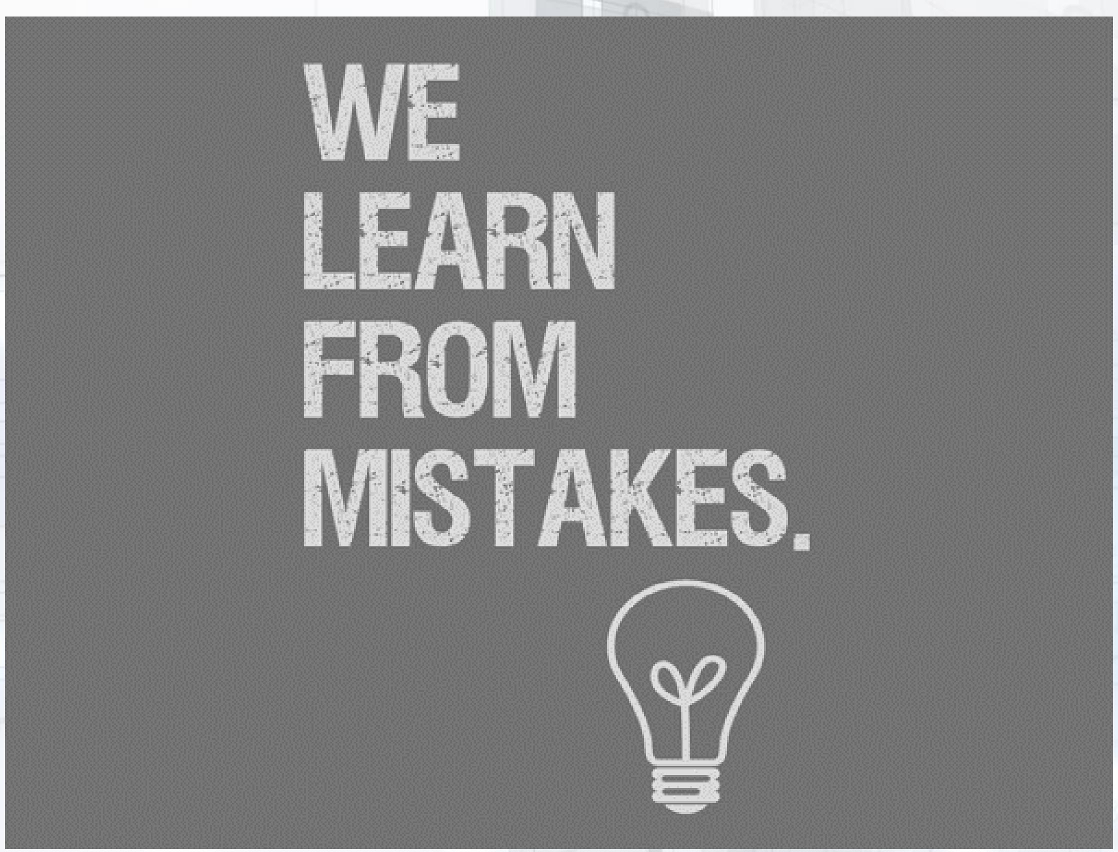
- With every other challenge that comes with a running a restaurant or other high strength application, improper treatment and discharge design can be avoided.

Critical Program Requirements

- According to the EPA in 2005
  - ✓States must consider special characteristics and requirements of commercial, industrial and large residential systems
  - ✓States need to implement technical guidelines for site evaluation, design, construction and operation/maintenance.
- O & M and routine sampling are key elements
- While costly, knowing that these may be requirements for high strength systems may make some entrepreneurs to think twice about opening a restaurant or other high strength application
- This presentation will focus primarily on technical guidelines for designing and reviewing commercially available wastewater treatment systems.

What happens if you don't understand?

- Owner may be working with untrained engineers or designers to understand what is needed. We are all stakeholders.
- There is a propensity to use soil or residential aerobic system designs and simply add a grease trap or interceptor.
- Systems that are put in are not reliable or sustainable and lead to catastrophic failures and/or repair costs.
- This can lead to financial hardship and even ruin for the people who counted on someone to understand.



The Basics

- Biochemical Oxygen Demand or BOD_5 (BOD)
  - The amount of organic material requires aerobic microorganisms to break down the waste
  - This will be our focus in this presentation
  - We will assume that all other parameters have been accounted for in the design such as grease trap/interceptor requirements; additional screening or settling for high solids; nitrogen removal requirements.
- Three main design components
  - Determining the expected BOD loading in pounds per day
  - Determining the aeration capacity for BOD removal of a pre-engineered system
  - Sludge production and management

Basic Ingredients

- Sugars
- Milk Products
- Fats Oils Grease (FOG)
- Proteins
- Blackwater

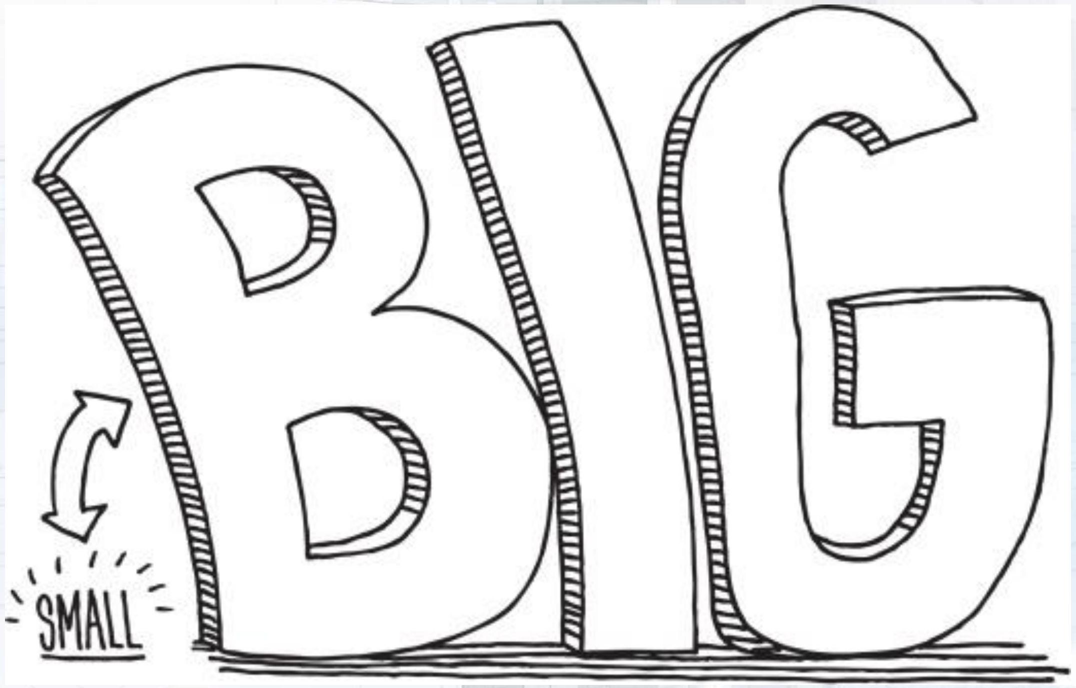
**Put these in a tank with just enough water to make it liquid.

What does this recipe produce…

- Not Chocolate Cake!
- Wastewater that:
  - Requires 2 – 10 times more oxygen to treat the wastewater = Increased Cost
  - Creates 2-10 times more sludge – Where does this go?
  - May have a Fats, Oils, and Grease component that can make treatment more difficult.

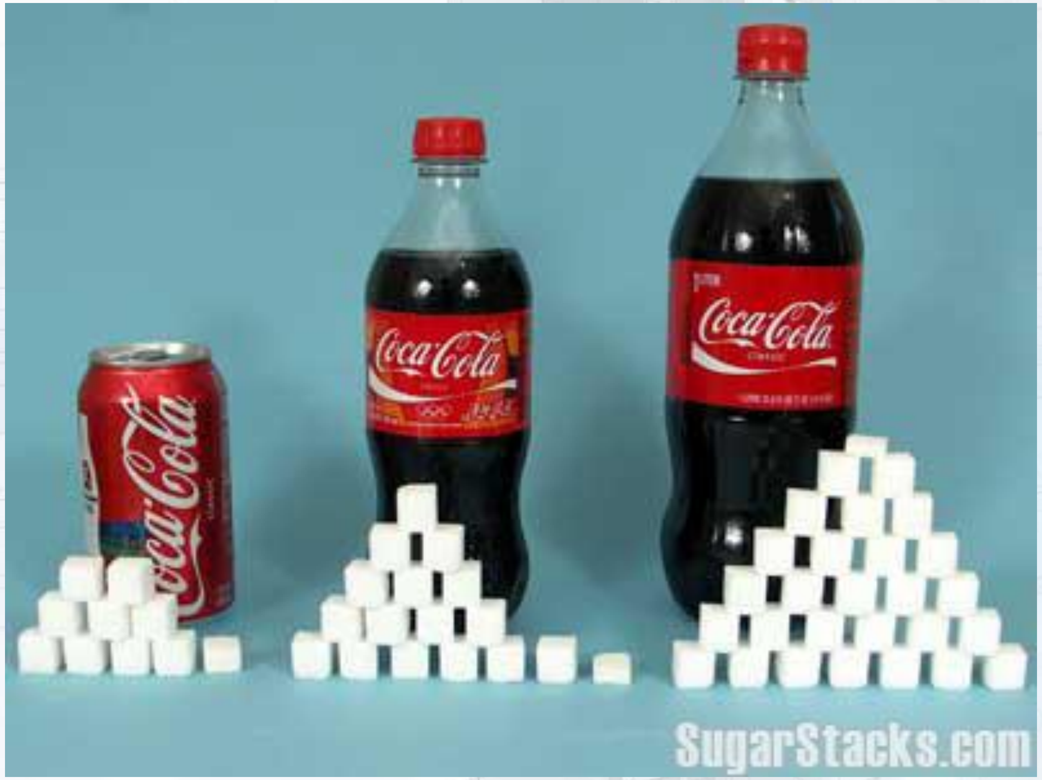
How big can the BOD_5 get?

- **Typical Strength of Ingredients**
  - Sugars – 105,000 – 108,000 mg/L
  - Milk Products – 104,000 mg/L
  - FOG – 1800 – 2000 mg/L
  - Proteins – 22,000 mg/L
  - Blackwater – 500 - 800 mg/L
  - Alcohol – 21,000 mg/L – 35,000 mg/L
  - Blood – 100,000 mg/L



Perspective?

- Sugars – 105,000 – 108,000 mg/L
- 44oz Coke * 1gal/128oz * 108,000 mg/L * 8.34 / 1,000,000 = 0.3 lbs/d
- 1 ATU treats 0.6 to 1.6 lbs/d depending on location and temperatures
- Imagine what is dumped down the drain?!?



BOD Strength

- A study performed by Lesikar in 2004 in Texas showed:
  - 75% of wastewater samples from 28 different kinds of restaurants were 1400 mg/L or less with an average of 1000 mg/L.

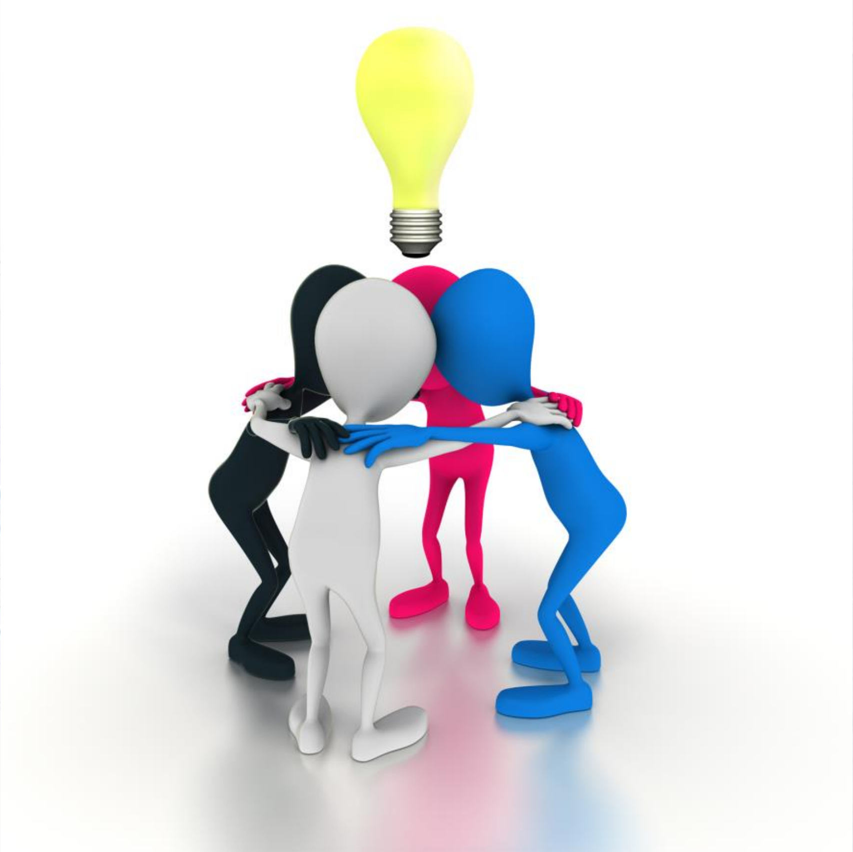
Type of Restaurants	Number of Systems in Group	Average BOD mg/L
Fast Food/Burgers	6	974
Pizza	1	1856
Chinese	4	1364
Mexican	9	1254
American	1	1063
American Buffet	1	792
Steakhouse	2	601
Seafood	3	555

BOD Strength

- Most restaurants in the study had BOD’s in the 800-1000 mg/L range
- Some types of food produced higher BOD’s like Mexican and Chinese
- A menu review would be helpful when sizing a system
  - Sauces, sweets, etc.
  - Alcohol service
  - Grease
- Practices in the facility are good to know too
  - Single service versus full plate service
- Sampling of actual facilities
  - Take more than one sample just after busy periods

BOD Strength

- Rely on studies like Lesikar's, menu review, sampling, and experience to make an assumption
- If you don't have the experience there are those that do and you should contact them!



Flows

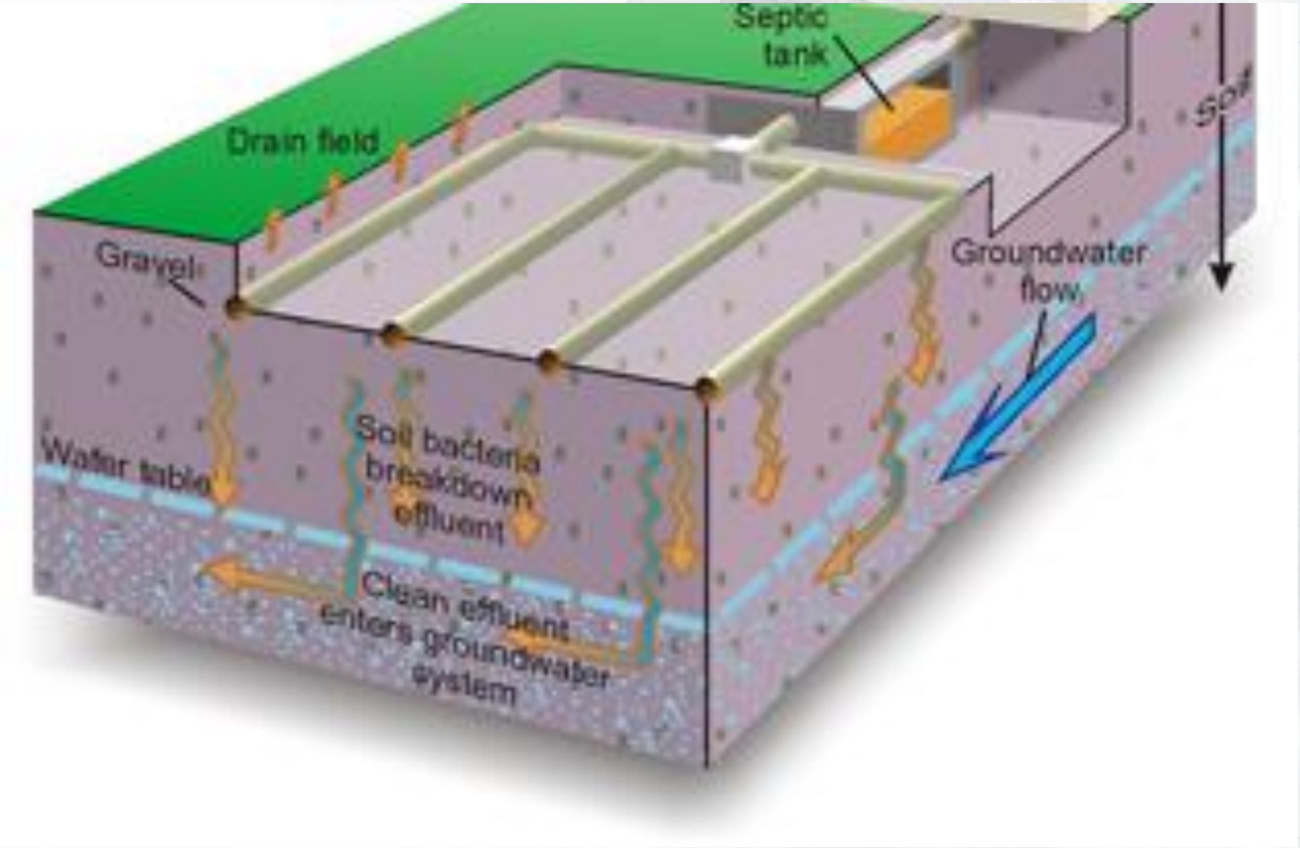
- Often dictated by regulation and conservative
- You may be able to assume a lower BOD value (10-30%) if the flows dictated are based on higher flow fixtures
- Most restaurants will never reach design flows, especially on a daily basis
- Actual flows are helpful if it is a chain restaurant or if there is a similar restaurant
- If flow equalization is in the plan then average flows taking into account the days and hours of operation can and should be used

Designing a Treatment Train

- It takes more than just a septic tank.
- Grease interceptors/traps
- Flow Equalization and Dosing
- Supply enough oxygen to meet the pounds of BOD_5 requirement as well as to treat excess FOG.
- Can this be done with a larger drainfield?

Soil treatment

- Soil properties vary
- Some soils cannot handle high BOD_5 loadings period. Silty Sands or Clays are examples.
- IF a soil can treat the wastewater the footprint could be very big and sometimes the land is not there.
- Multiple fields are a good option
- Seasonal facilities may work better
- Very high BOD's and/or high FOG the soil is not a good medium for treatment.



If soil won't work…then what?

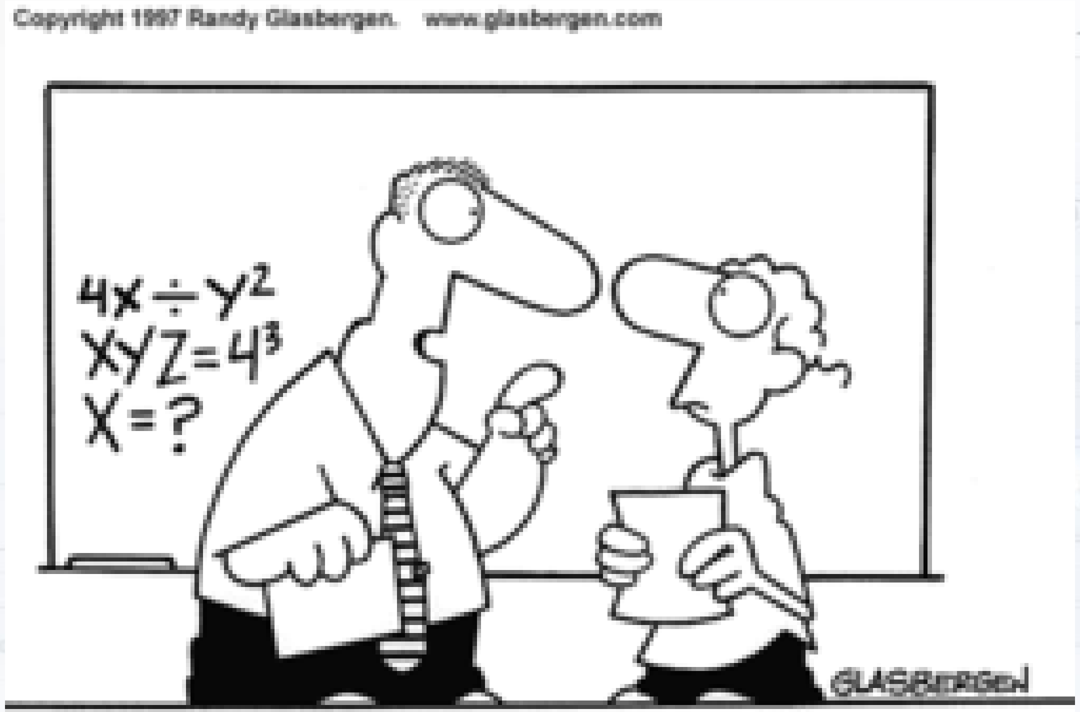
- Add treatment equipment
- Treatment adds air to the wastewater in some fashion to provide the necessary oxygen to treat the wastewater.
- Partial treatment vs. full treatment
- When using treatment proper sizing and a maintenance and monitoring plans are key.

O_2

Treatment systems are not magic

- Cannot size by flow alone
- Fairly complicated process to evaluate a system for treatment from scratch.
- Designers should choose and regulators should require a system with a significant history treating high strength wastewater
- Splitting flows to multiple systems is difficult so choosing systems that make treatment in as few of boxes as possible is best

It's time to use that algebra you never thought you would use!



"Algebra class will be important to you later in life because there's going to be a test six weeks from now."

BOD Loading

- **ALL designs should characterize both flow and BOD strength to size the system!**
- **These two numbers together are used to determine the total BOD load expressed in pounds per day.**
- **This number represents what needs to be treated with oxygen**
- **Formula for BOD loading is:**

$$\frac{\text{Flow (gpd)} * \text{Influent BOD (mg/L)} * 8.34}{1{,}000{,}000} = \text{lbs/BOD/day}$$

Example

- An American restaurant with actual peak flow of 1200 gpd and a sampled influent BOD value of 825 mg/L

$$\frac{1200 \text{ gpd} * 825 \text{ mg/L} * 8.34}{1{,}000{,}000} = 8.26 \text{ lbs of BOD/day}$$

- This value is critical to the evaluation…this is what needs to be treated.

How do we treat it?

- To treat 1 pound of BOD it takes an average of 1.2 pounds of dissolved oxygen
- To treat 8.26 pounds of BOD we calculate this way:

8.26 lbs of BOD * 1.2 lbs of O_2 = 9.9 lbs O_2/day

- This is the Actual Oxygen Requirement or AOR – we will talk more about this
- Next step is to determine the aeration capacity of a proposed pre-engineered system

Standard Cubic Feet per Minute (sCFM)

- Looking for the sCFM of the proposed aeration device.
- Can be determined by the spec sheet or contacting the aeration device manufacturer.
- An actual drawing with dimensions of the proposed unit is also needed to get the depth of the air release point.
    - If the drawing does not specify this then the manufacturer should be consulted.

sCFM

Aeration Capacity

- **Treatment units typically treat with fine bubble or course bubble diffusion and this should also be available through the manufacturer.**
- **The <u>EFFICIENCY</u> of the aerator is a function of the air release depth and the type of aeration (coarse or fine bubble).**

Oxygen Transfer Efficiency (OTE)

- The air release depth and the type of aeration will give you the OTE
  - Course bubble diffusion = max 0.75%/ft
  - Fine bubble diffusion = max 3.0%/ft
- So now you have:
  - Design loading
  - sCFM for the aeration device
  - the release depth from the drawing or manufacturer
  - And the OTE which is standard in the industry and based on the type of aeration as listed above
- With these you can determine the Standard Oxygen Transfer Rate or SOR

Standard Oxygen Transfer Rate (SOR)

- The SOR is how much oxygen can be transferred into clean water at standard conditions by the aeration device being evaluated
- SOR is measured in pounds per hour or pph
- The calculation is done as follow:

SOR in pph = 1.035 * sCFM * OTE * air release depth

- Taking this by 24 hours in the day will give you the SOR in pounds per day (ppd)
- The SOR can then be used to determine the Actual Oxygen Transfer Rate (AOR) of the aeration device.

Back to Actual Oxygen Transfer Rate

- The AOR is = α*SOR
  - α = constant for efficiency of the aerator in sewage versus clean water
  - α for fine bubble diffusion is between 0.4 and 0.45
  - α for coarse bubble is between 0.5 and 0.6
- The AOR divided by 1.2 = the pounds of BOD that can be removed per day by that device.

Back to the example….

- American restaurant 1200 gpd producing 8.26 lbs/day of BOD
- Let's put a fictitious 500 gpd suspended aeration system to the test…knowing you will need 3 units to meet the flow requirement.
- A fine bubble diffusion system:
  - The AIR RELEASE DEPTH per the fictitious drawing is 66 inches or 5.5 feet.
  - The aeration system produces 0.49 sCFM at that depth per the aerator manufacturer

sCFM

Here comes the algebra…

SOR in pph = 1.035 * sCFM * OTE * air release depth

OTE is a constant for certain types of aerators

Fine bubbles maximum is 3.0%/ft

SOR in PPH = 1.035 * 0.49 * 3.0% * 5.5 ft = .084 pph

SOR in PPD = 0.84 pph * 24 h/d = 2.02 ppd

Continued…

AOR = αSOR

α is a constant….for fine bubble between 0.4 and 0.45

AOR = 0.4 * 2.02 ppd = 0.81 ppd

Removal Capacity

BOD removal capacity = AOR / 1.2 lbs O_2 per lb of BOD

0.81ppd/1.2 = 0.675 ppd

- **This is how much BOD can be removed by a single 500 gpd fine bubble system.**
- **If we size based on flow alone we would need 3 of these to meet the flow rating**
- **For three 500 gpd systems the BOD removal capacity is 0.675 ppd X 3 = 2.02 ppd BUT we needed to treat 8.26 lbs at this restaurant.**
- **We really need 12 units at least. Is this really a practical design approach?**

Sludge management

- Use the same system we just reviewed
- For every pound of BOD coming into the system about 0.6-0.7 lbs of sludge is produced
- Since the aerator was very efficient we will assume 0.7 lbs of sludge is produced per day

8.26 lbs BOD/day * 0.7 lbs of sludge/lb BOD = 5.78 lbs of sludge/day

Mixed Liquor Suspended Solids (MLSS)

- **Since activated sludge systems are completely mixed the sludge is suspended and mixed in the aeration chamber and measured by the MLSS reading in mg/L**

- **MLSS determines treatment efficiency and also indicates when sludge needs to be wasted**

- **Need to know the reaction chamber size and for this example system it is 475 gallons/unit**

- **Assuming we sized on flow alone and used 3 units that is 1425 gallons of sludge storage capacity**

- **Convert lbs of sludge produced/day to mg/L**

$$\frac{5.78 \text{ ppd} * 1{,}000{,}000}{8.34 * 1425 \text{ gpd}} = 486 \text{ mg/L of sludge accumulating in the mixed liquor}$$

When to waste sludge

- If the system is producing 486 mg/L of sludge per day in 30 days that would be 14,580 mg/L of sludge in the MLSS.
- Treatment efficiency of activated sludge systems requires the MLSS to be between 3,000 and 5,000 or the sludge will start “bulking” or not settling and leave in the effluent.
- To maintain efficiency the sludge would need to be removed every 6 – 10 days.
- Very costly to pump out and be watched to assure MLSS stays in the right range.
- Even at half the loading the system is not sustainable
- Add more units? Back to practicality.

What operational challenges can you face that affect treatment performance?

- **Multiple uninformed users**
- **Cleaning products**
  - **Dish machines**
  - **Sanitizers**
  - **Industrial strength cleaners**
  - **Degreasers**
  - **Enzymes/Bacterial additives**

Design Summary

- Determining an accurate influent BOD loading/day is critical to design
- Determining if a system specified can treat the expected loading in a sustainable way is critical to long term performance
- Using systems proven and designed for high strength wastewater removal is something that can be done but it is not inexpensive
- If the owner of a restaurant is presented with a system that will work and accepts the costs involved and that system is installed correctly and maintained it will last a long time and perform
- If the owner is not prepared to accept the costs of a correct design as a cost of doing business then they should not be allowed to put in a substandard system that will ultimately fail and could damage the environment.
- WE NEED YOUR HELP!!!

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"HIGH VOLTAGE"
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PERSONNEL ONLY


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APCO

Quote Request Form

INFILTRATOR water technologies
delta treatment systems

4 Business Park Road, PO Box 768, Old Saybrook, CT 06475
(800) 221-4436 (860) 577-7000 (860) 577-7001 FAX

Design & Quote Request Form

Wastewater Collection, Treatment, and Dispersal

Project Information RUSH REQUEST: ☐

Date: Respond By Date: ☐ Site Dwgs Available ☐ Site Pics Available ☐ Project Plans and/or Specs Available

Project Name: Funding: -None- -None- Regulatory Agency: -None-

Project Address: State: Project Zip Code:

Design Status: ☐ % Complete ☐ Permitted ☐ Approved Deliverable: ☐ Preliminary Budget ☐ Final Design Documents ☐ Quote

Installation Type: ☐ Buried ☐ Partially Buried ☐ Mounded ☐ At Grade Tank Construction: -None-

Influent Collection: ☐ Raw ☐ Grease Trap ☐ STEP/STEG ☐ Flow EQ Effluent Discharge/Dispersal Type: -None-

Influent Flow: ☐ Gravity ☐ Pumped; Flow: gpm@ -None Effluent Flow: ☐ Gravity ☐ Pumped; Flow: gpm@ -None

Influent Pumps: ☐ Sewage ☐ Grinder ☐ Effluent ☐ Multistage Effluent Pumps: ☐ Sewage ☐ Grinder ☐ Effluent ☐ Multistage

Dispersal Area Available: sf Soil Texture: Perc Rate: -None Loading Rate: gal/sf/day Soil Depth: in.

Wastewater Detail

Ownership Entity: ☐ Municipal ☐ Residential ☐ Commercial ☐ Agriculture ☐ Govt/Military ☐ Industrial ☐ Indian Reservation

Sanitary Strength: ☐ Apartments ☐ Houses ☐ Hotel ☐ Offices ☐ Institution ☐ School ☐ Mobile Homes ☐ Recreation (RV)

High Strength: ☐ Brewery ☐ Food ☐ Dairy ☐ Textile ☐ Chemical ☐ Pharmaceutical
☐ Winery ☐ Beverage ☐ Stockyard ☐ Pulp & Paper ☐ Mining ☐ Other (specify):

Wastewater Data (please provide as much wastewater data as possible; sample from an influent flow point)

DATE OF SAMPLE: **SPECIFY SAMPLE LOCATION:** ☐ Raw Influent ☐ Settled Influent

SAMPLE TYPE: ☐ Grab Sample ☐ Composite Sample ☐ Data is assumed or projected

Design Flow: GPD GPM Peak Flow: GPD GPM

PARAMETERS: Influent Effluent Requirement

Good Intel Gathering…

DATE OF SAMPLE: **SPECIFY SAMPLE LOCATION:** ☐ Raw Influent ☐ Settled Influent

SAMPLE TYPE: ☐ Grab Sample ☐ Composite Sample ☐ Data is assumed or projected

Design Flow: GPD GPM Peak Flow: GPD GPM

PARAMETERS: Influent Effluent Requirement

PARAMETERS	Influent		Effluent Requirement	
Biochemical Oxygen Demand (BOD_5)		mg/L		mg/L
Chemical Oxygen Demand (COD)		mg/L		mg/L
Total Suspended Solids (TSS)		mg/L		mg/L
Total Dissolved Solids (TDS)		mg/L		mg/L
Fats, Oils and Grease (FOG)		mg/L		mg/L
Alkalinity (ALK) as Calcium Carbonate		mg/L		mg/L
Ammonia (NH_3)		mg/L		mg/L
Total Kjedhal Nitrogen (TKN)		mg/L		mg/L
Total Nitrogen (TN)		mg/L		mg/L
Total Phosphorus (TP)		mg/L		mg/L
Disinfection: ☐ E.Coli. ☐ Fecal Coli. ☐ Total Coli.		N/100mL		N/100mL
Dissolved Oxygen (DO)		mg/L		mg/L
pH Range		-		-

Minimum Influent Water Temperature degF Power: Ph VAC Hz Elevation: ft ASL

Minimum Seasonal Air Temperature degF ☐ Low Flow Devices ☐ Garbage disposals ☐ RV/Portajon Dump Station

Maximum Seasonal Air Temperature degF ☐ Seasonal flows. Please specify:

Product Information

Collection & Dispersal Products: ☐ Influent/Effluent Pump Stations ☐ ECOFILTER ☐ Infiltrator Chambers ☐ EZflow ☐ ATL ☐ AES ☐ ECODRIP

Treatment Products: ☐ Whitewater UC/DF ATU ☐ ECOPOD ATU ☐ ECOPOD Package Plant ☐ Extended Aeration Package Plant

Notes (Design Assumptions, Site Conditions, Challenges, Constraints, Other Permit Requirements, etc.)

Processes Req'd: ☐ Primary ☐ Flow EQ ☐ Sludge Holding ☐ Chlor. ☐ Dechlor. ☐ UV ☐ Flow Metering ☐ Filtration ☐ Other (specify below):

Contact Information How did you hear about Delta Treatment Systems?: -None-

Name: E-mail:

Company: Phone:

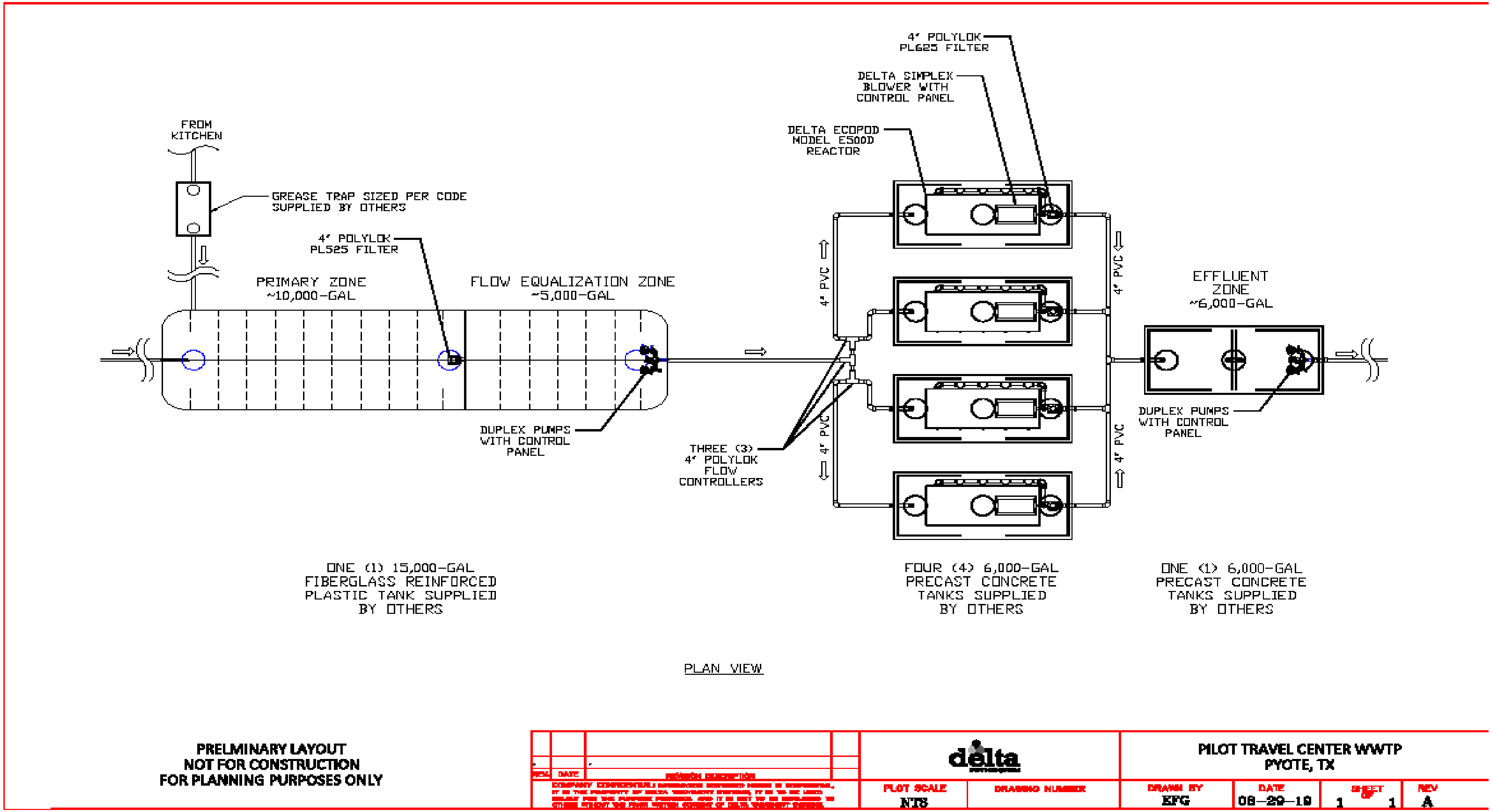
Address: Fax:

 Quote No.: www.infiltratorwater.com

…to determine options

Commercial Treatment: Pilot Travel Center

- 5,000 Gallon Per Day System
- 1500 mg/L BOD
- 62.6 lbs/d BOD Loading
- 200 mg/L TSS
- Treatment to 100 mg/L BOD or less
- 1,350 Q4 + High Chambers installed in trenches
- 1 – 15,000 Gallon Containment Solutions 2 Compartment Trash / Flow EQ Tank with Polylok Filters
- 4 – 6,000 Gallon Concrete Tanks with (4) E500D Ecopods
- 1 – 6,000 Gallon Pump Tank to pump effluent to gravity feed the chambers



FROM KITCHEN
GREASE TRAP SIZED PER CODE SUPPLIED BY OTHERS
4" POLYLOK PL525 FILTER
PRIMARY ZONE ~10,000-GAL
FLOW EQUALIZATION ZONE ~5,000-GAL
DUPLEX PUMPS WITH CONTROL PANEL
THREE (3) 4" POLYLOK FLOW CONTROLLERS
4" POLYLOK PL625 FILTER
DELTA SIMPLEX BLOWER WITH CONTROL PANEL
DELTA ECOPOD MODEL E500D REACTOR
4" PVC
4" PVC
4" PVC
4" PVC
EFFLUENT ZONE ~6,000-GAL
DUPLEX PUMPS WITH CONTROL PANEL
ONE (1) 15,000-GAL FIBERGLASS REINFORCED PLASTIC TANK SUPPLIED BY OTHERS
FOUR (4) 6,000-GAL PRECAST CONCRETE TANKS SUPPLIED BY OTHERS
ONE (1) 6,000-GAL PRECAST CONCRETE TANKS SUPPLIED BY OTHERS
PLAN VIEW
PRELMINARY LAYOUT
NOT FOR CONSTRUCTION
FOR PLANNING PURPOSES ONLY
REV.
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delta
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PYOTE, TX
PLOT SCALE
NTS
DRAWING NUMBER
DRAWN BY
EFG
DATE
08-29-19
SHEET
OF
1
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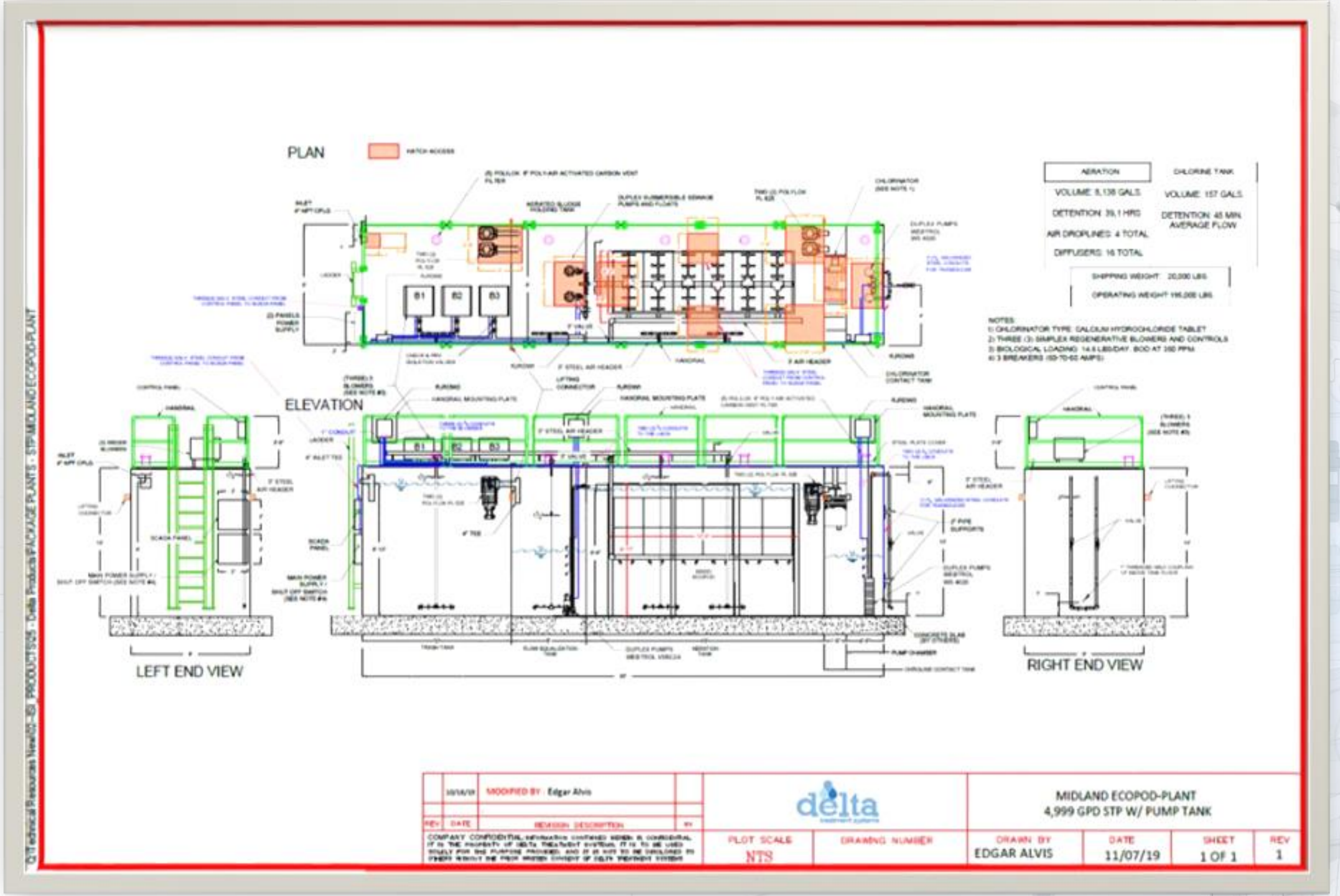
2019/04/30

Commercial Treatment: Oil & Gas Man Camp Package Plant

- 5,000 Gallon Per Day System
- 350 mg/L BOD Concentration
- 14.6 lbs/d BOD Loading
- 1 – E600D Ecopod
- Treatment to 10/10 for spray irrigation
- 1 Compartment - 5,285 Trash Tank
- 1 Compartment – 2,643 Flow EQ Tank
- 1 Compartment – 8,457 Treatment Tank
- 1 Compartment – 114 Chlorination Tank
- 1 Compartment – 1,585 Pump Tank
- Client ordered three (3) identical units
- Client planning to order twelve (12) more identical units in 2020


PLAN
ELEVATION
LEFT END VIEW
RIGHT END VIEW
AERATION
VOLUME: 5,138 GALS
AIR DROPLINES: 4 TOTAL
DIFFUSERS: 16 TOTAL
CHLORINE TANK
VOLUME: 157 GALS
DETENTION: 45 MIN. AVERAGE FLOW
NOTES:
MODIFIED BY: Edgar Alvis
REV
DATE
REVISION DESCRIPTION
MIDLAND ECOPOD-PLANT
4,999 GPD STP W/ PUMP TANK
PLOT SCALE
NTS
DRAWING NUMBER
DRAWN BY
EDGAR ALVIS
DATE
11/07/19
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1 OF 1
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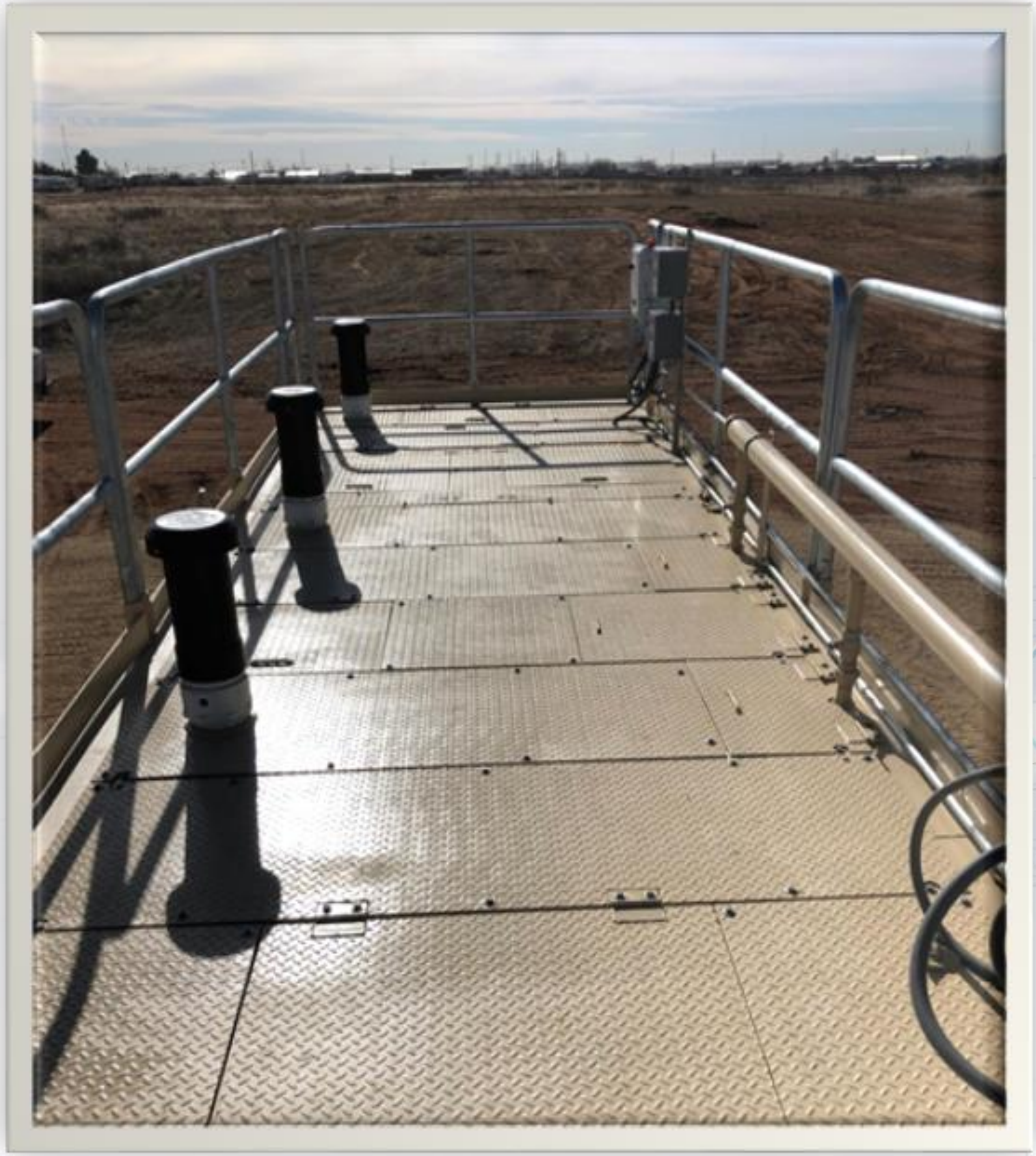
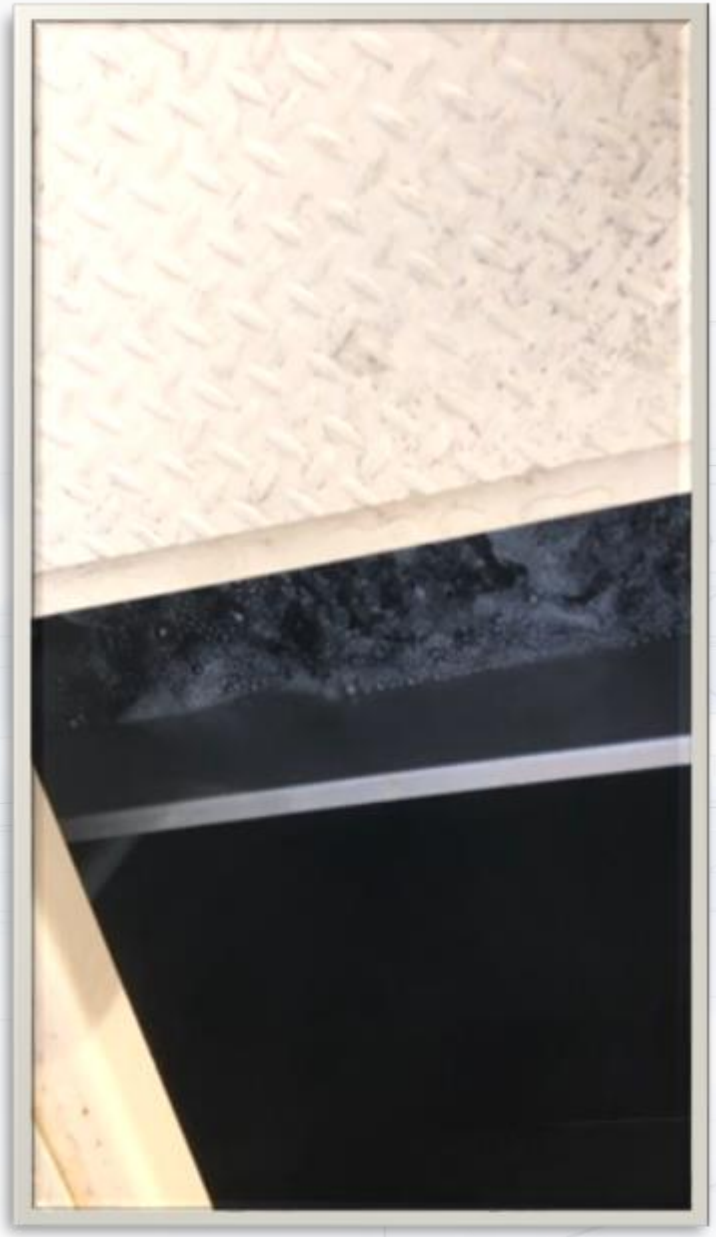




In summary…

Soil treatment

- Some soils cannot handle high BOD_5 loadings period.
  - Silty Sands or Clays are examples
- IF a soil could treat this waste the footprint could be very large.
- IF soil is used consider multiple fields and leave room for treatment to be added
- Seasonal facilities may work better
- Very high BOD's and/or high FOG the soil is not a good medium for treatment.

In summary…

If soil won't work…then what?

- Add treatment equipment
- Treatment adds air to the wastewater to provide the necessary oxygen to treat the wastewater.
- When using treatment proper sizing and a maintenance and monitoring plans are key.
- Partial treatment vs. full treatment

In summary…

Treatment systems are not magic

- Cannot size by flow alone
- Complicated process to evaluate/design from scratch.
- Use a system with a significant history treating high strength wastewater
- Splitting flows to multiple systems is difficult

In summary…

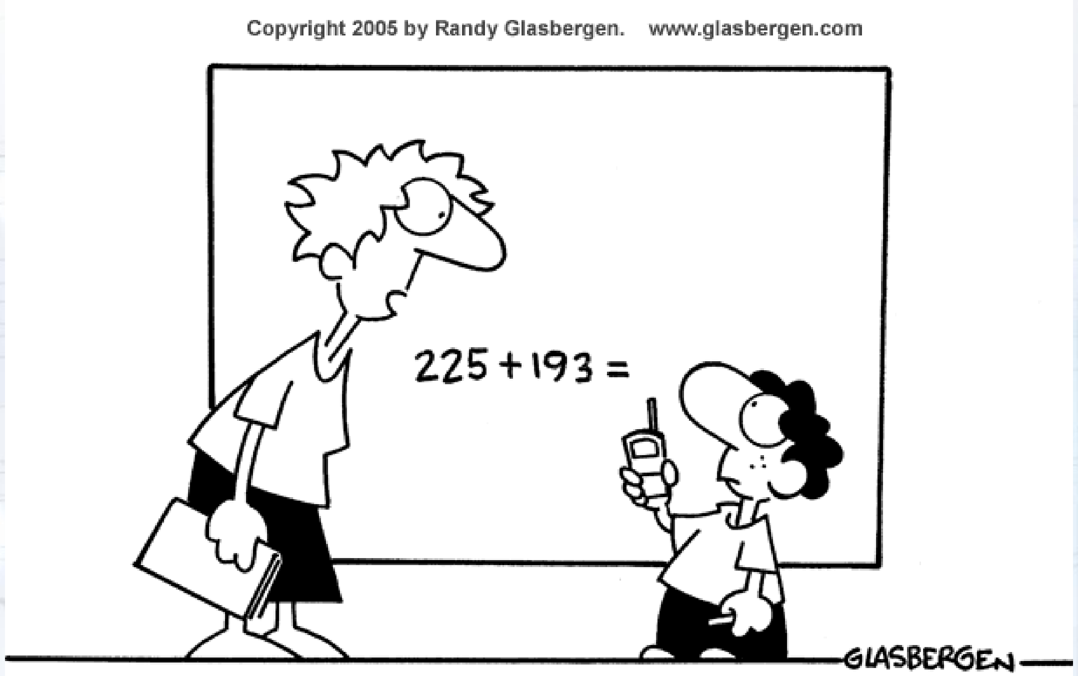
Flow (gpd) vs. Loading (lbs/day)

$$\frac{\text{Flow X BOD}_5\text{ X 8.34}}{1{,}000{,}000} = \text{lbs BOD}_5$$

Example of rest stop:

$$\frac{1{,}000\text{ gpd X 500 mg/L X 8.34}}{1{,}000{,}000}$$

$= 4.17$ lbs of BOD_5 /Day



"You have to solve this problem by yourself. You can't call tech support."

In summary…

Designing a treatment train

- More than a septic tank.
- Grease interceptors/traps
- Flow Equalization
- Supply enough O_2 to meet the pounds of BOD_5
- Can this be done with a larger drainfield?

In summary…

What some State Agencies are doing to help

- **Intensive up front reviews**
- **Show calculations**
- **Require significant data from other locations**
- **Ongoing sampling and maintenance required**

In summary...

What seems to work well

- Engineers or trained designers are typically required
- Regulatory approval of products
  - May run through a piloting/provisional program
  - Must produce significant data to show past success
- Mandatory maintenance
  - Mandatory sample collection
- Mandatory reporting
- EDUCATION, EDUCATION, EDUCATION

In summary…

It isn't easy or cheap!

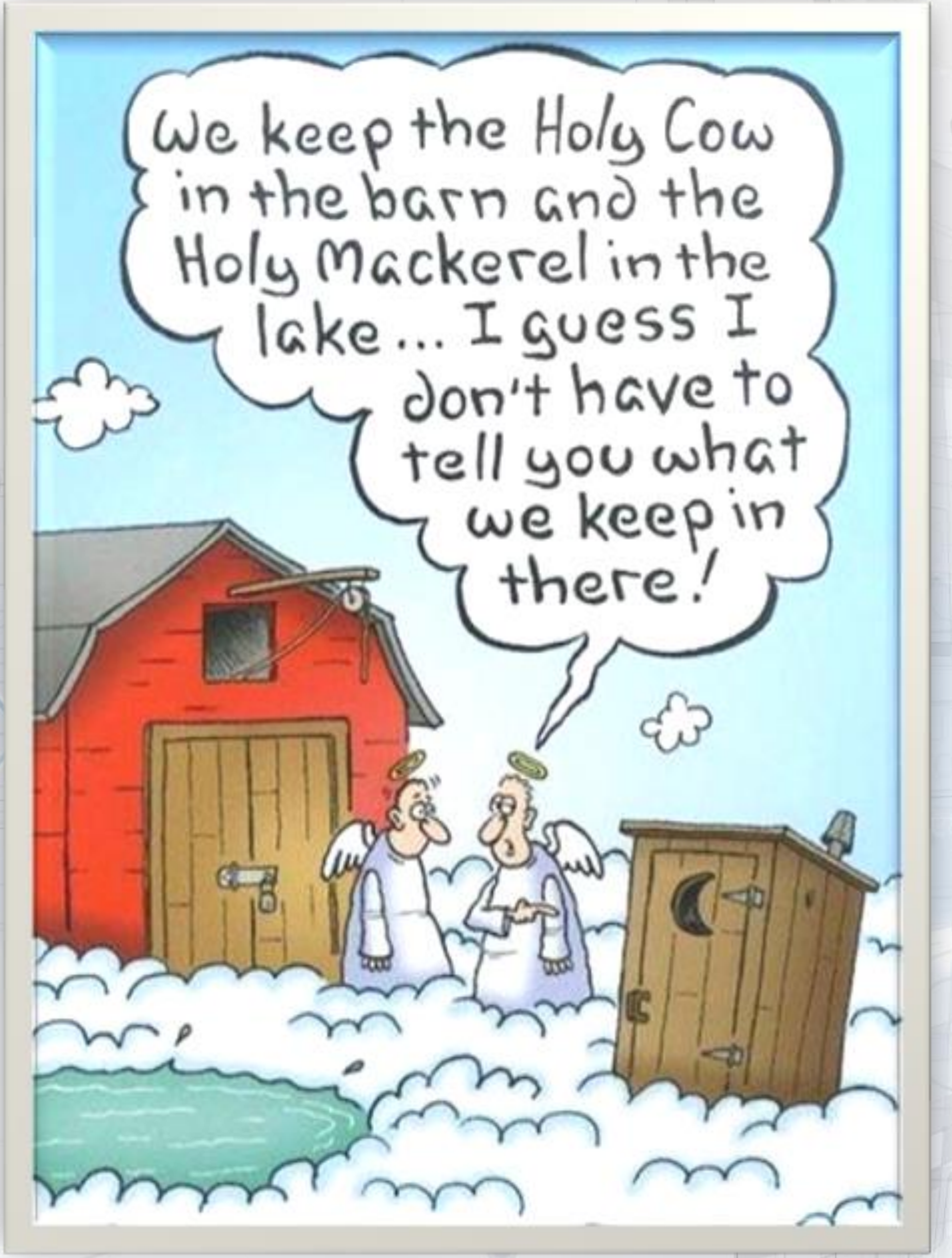
- Paying a designer is costly
- Putting in a system that will work is costly
- Annual maintenance contracts with at least semi-annual visits are costly
- Sampling wastewater effluent is costly
- Staying educated is costly
- BUT…

In summary…

What is the cost of doing it wrong?

- Relationships
- Owners
- Designer/Engineers
- State or Local Agency personnel
- Installers/Contractors
- Last but not least… Environment!!!

Questions?



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