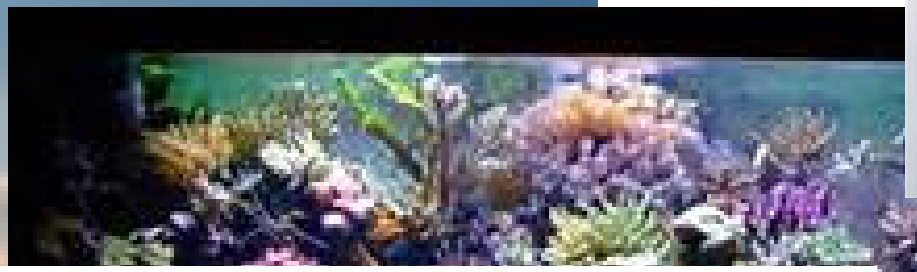
NITROGEN TREATMENT

NAWT

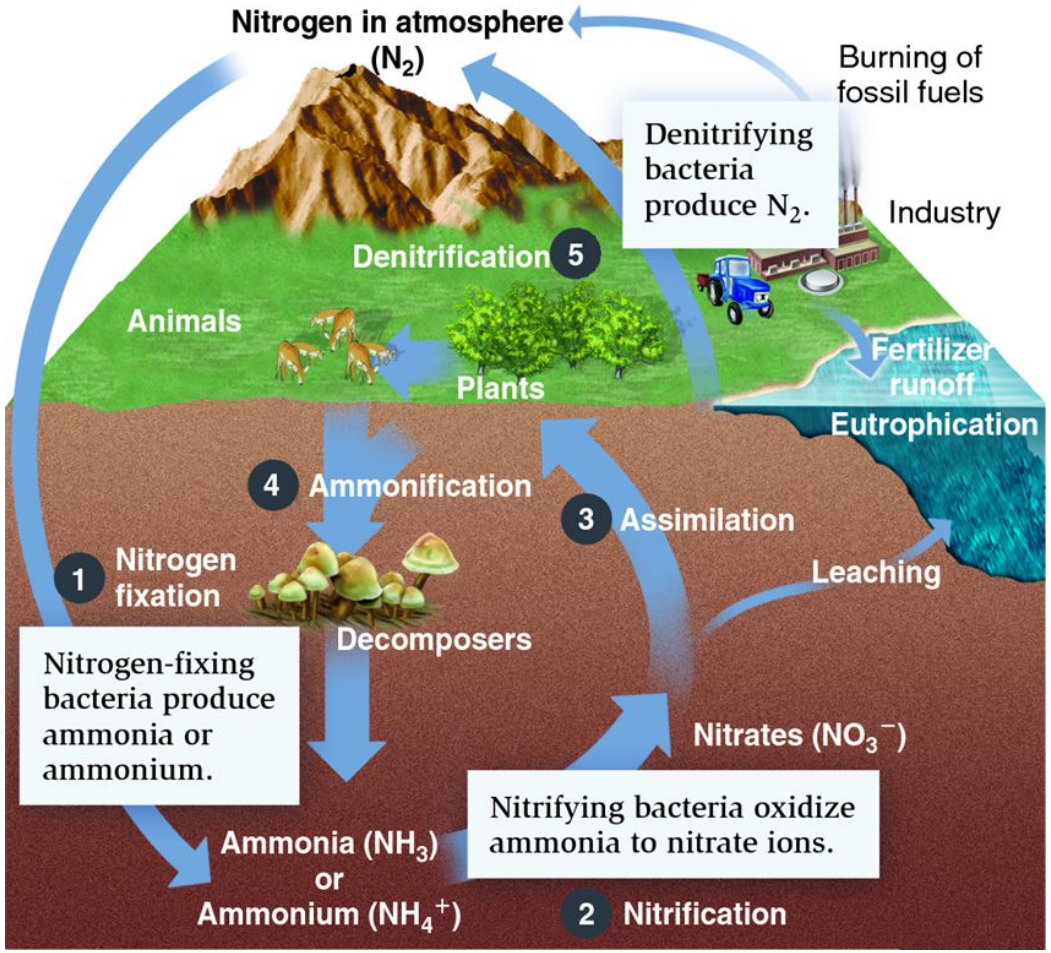
National Association of Wastewater Technicians

WHY ARE WE CONCERNED



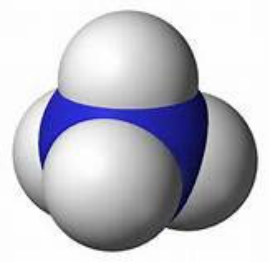
Do not drink water that have high concentration of Nitrates or Nitrites.

THE NITROGEN CYCLE



THE DIFFERENT FORMS

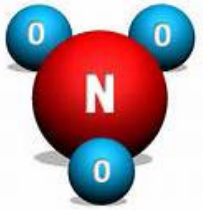
- **Organic**
- Organic N
- Ammonium



NH_4^+

- **Lab Test**
- TKN

- **Inorganic**
- Nitrite
- Nitrate



NO_3^-

- **Lab Test**
- Nitrate

Total Nitrogen = TKN + Nitrate

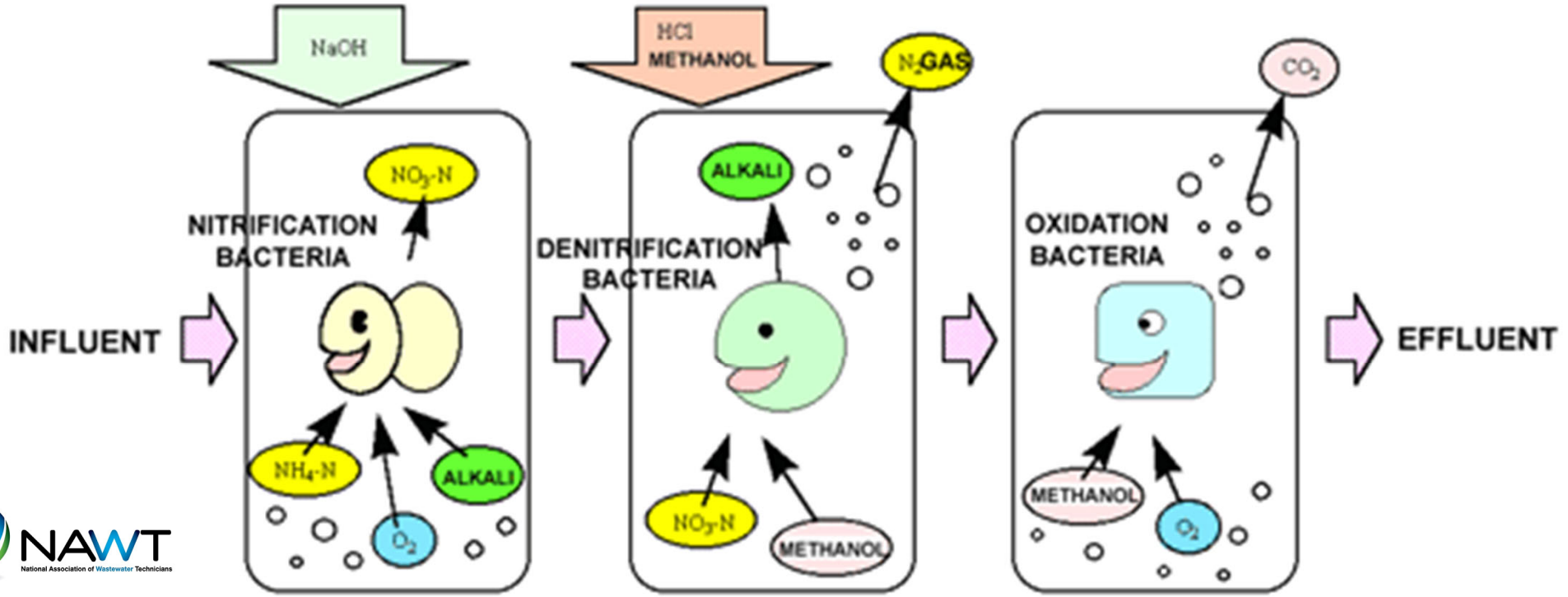
UNDERSTANDING THE STEPS

- **Nitrification**
  - Moving Organic N to Ammonia
  - Changing Ammonia to Nitrite
  - Changing Nitrite to Nitrate

- **Denitrification**
  - Moving Nitrate to Nitrogen gas

THE REMOVAL PROCESS: FULL CYCLE

CONCEPT OF NITROGEN REMOVAL



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NITRIFICATION PROCESS

Step 1: $NH^+_4 + 1.5\ O_2 \xrightarrow{\text{Nitrosomonas}} NO_2^- + 2H^+ + H_2O$

Step 2: $NO_2^- + 0.5\ O_2 \xrightarrow{\text{Nirtrobacter}} NO_3^-$

Overall Reaction: $NH^+_4 + 2O_2 \longrightarrow NO_3^- + 2H^+ + H_2O$

- **4.6 lbs O_2 needed per lb ammonia**
- **7.14 lbs alkalinity used per pound ammonia**

Uses Alkalinity to Balance or lowers pH

DENITRIFICATION PROCESS

NO_3^- + organic carbon $\xrightarrow{\text{carb. bacteria}}$ $N_2 + CO_2 + OH^- + H_20$

$CO_2 + OH^- \longrightarrow HCO_3^-$

$NO_3 \longrightarrow NO_2 \longrightarrow NO \longrightarrow N_2O \longrightarrow N_2$

- 2.86 lbs oxygen recovered per lb NO3-N
- 3.57 lbs alkalinity recovered per lb NO3-N
- ≥ 3 mg $cBOD_5$ / mg NO_3-N

NITROGEN TREATMENT

Vessel	Oxygen State	N Species
Septic Tank	Anaerobic	Ammonia
BOD Treatment Vessel	Aerobic	Nitrate
N Treatment Vessel	Anaerobic	Nitrogen gas

OPERATION & MAINTENANCE

- Maintaining System performance
  - BOD
- Testing the SYSTEM

PROPER LAB WORK

- Organic Nitrogen
  - TKN [Organic + Ammonia]
- Nitrate [Nitrite + Nitrate]
- Total Nitrogen = Organic Nitrogen + Nitrate
- O&M
  - pH
  - DO

Troubleshooting~ BOD_5

HOW MUCH & HOW DO WE MEASURE

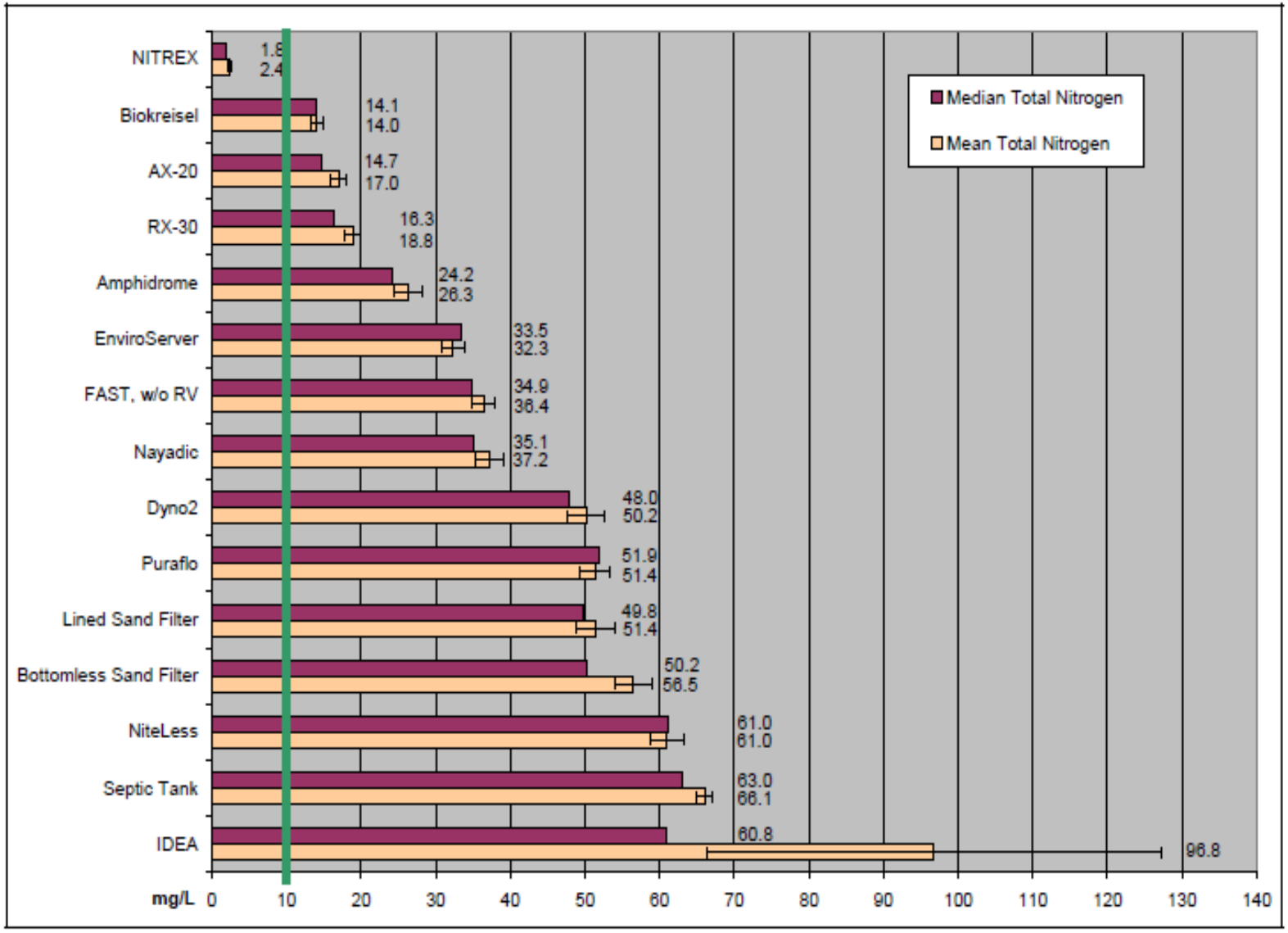
NITROGEN REDUCTION

- Depends on DO, alkalinity and pH
- Food for processing
- Standard recirc system:
  - Typically 50% reduction

20 mg/l

- Recirc through carbon source:
  - Up to 85% reduction

<10 mg/l


NITREX
Biokreisel
AX-20
RX-30
Amphidrome
EnviroServer
FAST, w/o RV
Nayadic
Dyno2
Puraflo
Lined Sand Filter
Bottomless Sand Filter
NiteLess
Septic Tank
IDEA
1.8
2.4
14.1
14.0
14.7
17.0
16.3
18.8
24.2
26.3
33.5
32.3
34.9
36.4
35.1
37.2
48.0
50.2
51.9
51.4
49.8
51.4
50.2
56.5
61.0
61.0
63.0
66.1
60.8
96.8
Median Total Nitrogen
Mean Total Nitrogen
mg/L
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

THE MATH

- Starting levels 70-100 mg/L
- 50% reduction
- **Measuring Nitrogen**
- TKN: 60 mg/L Nitrate: 10 mg/L
- After Aerobic treatment
- TKN: 10 mg/L Nitrate: 60 mg/L
- After Anaerobic cycle
- TKN: 10 mg/L Nitrate: 10 mg/L

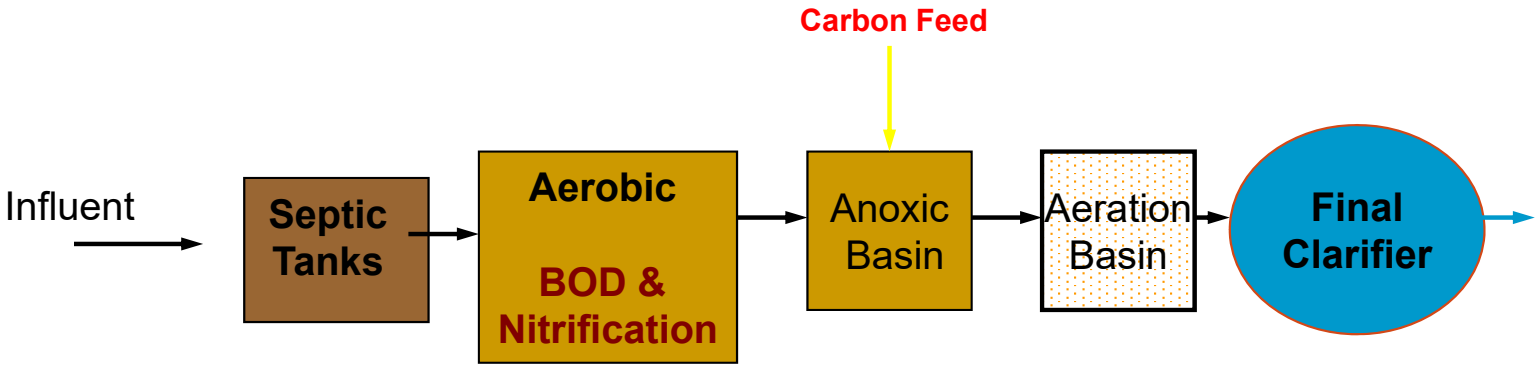
TN: 35- 50 mg/L

TN: 70 mg/L

TN: 70mg/L

TN: 20mg/L

ALTERNATIVE DENITRIFICATION SYSTEMS: POST ANOXIC



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EXTERNAL CARBON SOURCE

- Methanol – 6.6 lbs/gal
- Ethanol - 6.8 lbs/gal
- MicroC™: 9.56 lbs/gal
- Acetic Acid
- Sugar, etc.
- External carbon source should be:
  - Easy to use
  - Low cost
  - Available
  - Favorable Microbial Growth

CHEMICAL-FEED UNIT

- Supplemental food delivery system
- Application:
  - # NO_3 x Carbon
  - mg/l x Flow x 8.34 ÷ 1,000,000
  - 40 mg/l x 400 x 8.34 ÷ 1,000,000
- Ethanol - 6.8 lbs/gal
- MicroC™: 9.56 lbs/gal

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TROUBLESHOOTING NITROGEN REDUCTION

- Know the TN required by your permit
  - No requirement, 50% reduction, 10mg/L, etc.
- Know local/regional norms for ammonia, organic nitrogen, Groundwater nitrates
- Know the alkalinity of your waste source
- Understand the nitrogen reduction process and related factors

OPTIMUM NITROGEN REDUCTION REQUIRES

- Adequate alkalinity
  - lab test shows levels
- pH of 6-8
- Filtrate DO level of 2.5-8 ppm
- Influent ammonia level of ~60 mg/L
- Influent TN below 65 mg/L
- Adequate time for nitrifying bacteria to develop
- Adequate temperature
  (below 40°F slows the nitrification/denitrification process)

SIGNS OF GOOD NITROGEN REDUCTION

- Clear, odorless effluent
- Normal-looking biomat

Additional testing will show

- Low BOD_5
- Relatively <u>low</u> ammonia levels (NH_3-n)
- Relatively <u>high</u> nitrate levels (NO_3-n)

CHALLENGES OF NITROGEN REMOVAL FOR ONSITE APPLICATIONS

- Periodic and Non-uniform Influent Flow
- Adverse Impact of High and Low Loading Rates on Nitrogen Removal
- Typically Non-Optimum Influent BOD:TKN for Denitrification Process
- Potential for unexpected **toxicity** in the Influent
- Temperature limitations in our environment

INHIBITING FACTORS

- High carbonaceous demand
- Toxic compounds in wastewater
- Disinfectants
- Insufficient alkalinity or buffering capacity

TROUBLESHOOTING POOR NITROGEN REDUCTION FILTRATE ALKALINITY TOO LOW

- Available alkalinity determines degree of nitrification
- For each part ammonia that is nitrified, 7.14 parts alkalinity is consumed
- 70 mg/L x 7.14 ratio = 500 mg/L alkalinity
- If all the available alkalinity is consumed, the pH may drop too low (typically maintain about 80 ppm Alkalinity in the effluent)
- A high recirc-ratio increases alkalinity consumption

TROUBLESHOOTING POOR NITROGEN REDUCTION
FILTRATE PH TOO LOW

- Check pH level (<6 retards microbial activity)
- Check influent alkalinity level
- Check recirc-ratios; reduce if too high
- Ask system user about chemical discharges:
  - Carpet cleaners
  - Chlorides (water softener regenerate)
  - Chlorine (other disinfectants of sanitizers)
  - Photo developing agents, etc.

TROUBLESHOOTING POOR NITROGEN REDUCTION

FILTRATE DO LEVELS OUTSIDE 2.5 - 6 RANGE RETARD NITRIFICATION

- Low filtrate DO [< 2.5 mg/L]:
  - Increases potential for odor (typically sulfides)
  - Check air flow in ventilation fan assembly [Low air in RMF]
  - Check recirc-ratio; increase as necessary
- High filtrate DO [>6 mg/L]:
  - Indicates excessive recirculation
  - Indicates too little HRT in tank
  - Decrease the recirc-ratio

TROUBLESHOOTING POOR NITROGEN REDUCTION
HIGH FILTRATE AMMONIA (NH3-N) LEVELS

- Check for sufficient aeration
  - Ensure no blockage of air flow into Filter
  - Ensure no blockage in manifold causing ..
    - Hydraulic overloading, saturation
    - Short circuiting
- Check for sufficient alkalinity
  - If insufficient, consider supplemental buffering

TROUBLESHOOTING POOR NITROGEN REDUCTION

LOW FILTRATE NITRATE (NO_3-N) LEVELS

- Check recirc-ratio; reduce if necessary
  - high recirc-ratios prevent adequate denitrification
- Verify incoming Organic N [ammonia] levels
- Check recirc/blend for sufficient organic food source
  - if BOD is too low, nitrogen reduction won't occur

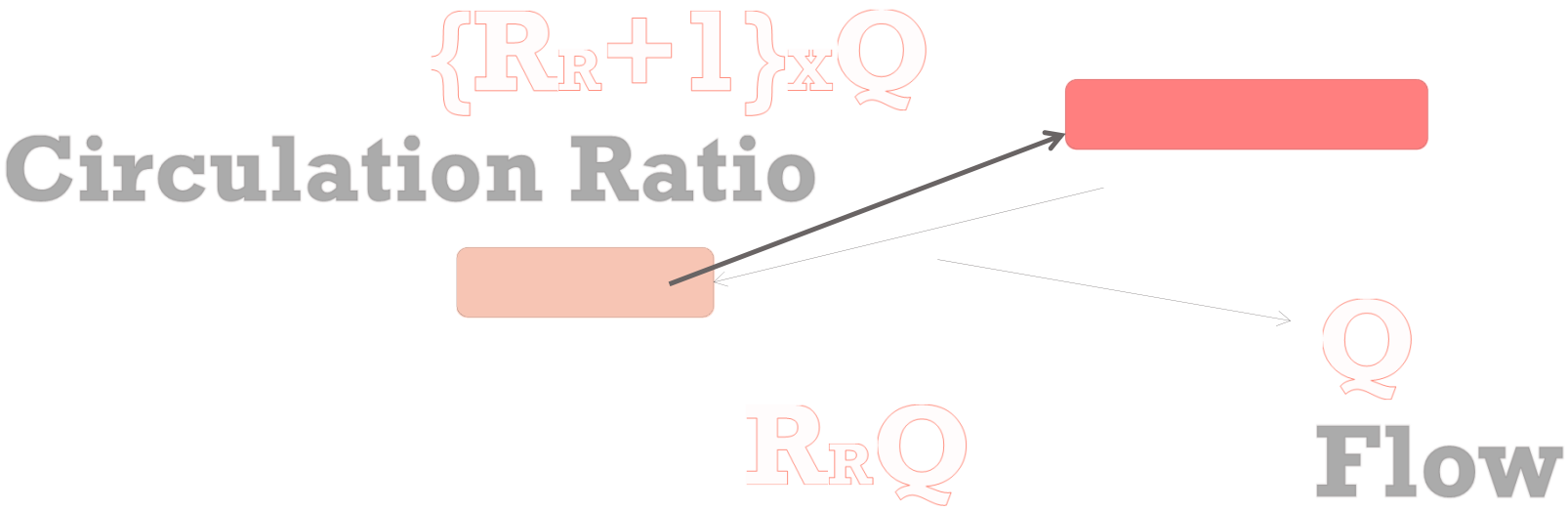
RECIRCULATION RATIO

- Is the ratio between the recirculated volume through the media and the 'forward flow'

$$\text{Recirc. Ratio} = \frac{[\text{Recirculated volume}\}-1}{\text{Forward flow}}$$

RECIRC. RATIO

$\{R_R+1\}_x Q$ ~ Amount Pumped to filter

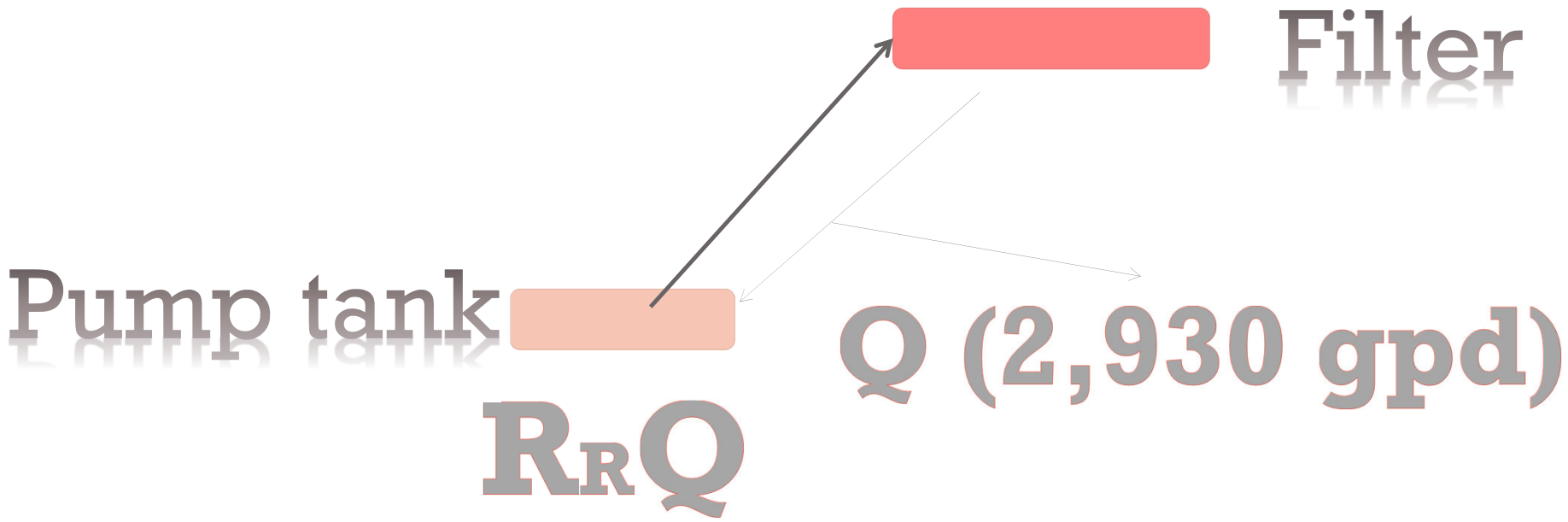


Q ~ Measured Flow
[from house:going to STA]

Recirculation Ratio

RECIRC RATIO

$\{R_R+1\}xQ$ (9,307 gpd)



CHANGING THE RECIRCULATION RATIO

- The BOD is too high?
- Solution Raise the RR

Cloudy effluent
Low performance

- If the Service provider needs to change the recirculation ratio to 4.0:1
- Increase Ratio: Recommendation

High Organic N [TKN]

Changing the Recirculation Ratio

Calculated:

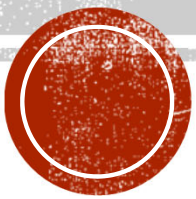
- Recirc. Ratio = 2.2:1
- Pump 'off' time = 131 minutes
- Off time x Current RR ÷ New RR

Example:

131 min x 2.2 ÷ 4.0 = 72.05 min

(New pump 'Off' time)

QUESTIONS



David Gustafson, PE
gusta002@umn.edu