Better Plants
U.S. DEPARTMENT OF ENERGY

Webinar #3 for IAC Directors: Using the Bio-Tiger Model in DOE MEASUR – Case Studies

Larry W. Moore, Ph.D., P.E.,
WEF Fellow

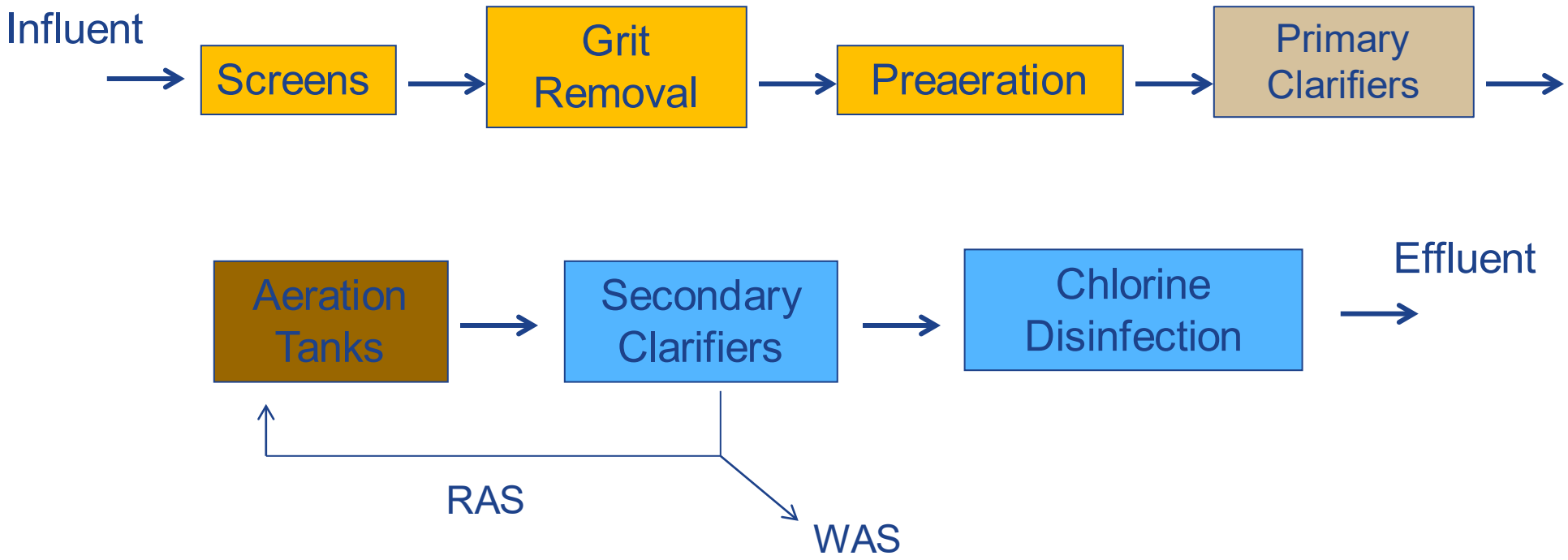
September 23, 2021

U.S. DEPARTMENT OF ENERGY

Accessing the Bio-Tiger Model in MEASUR

- Go to the DOE MEASUR website
- Download MEASUR on your computer
- Go to “Create Waste Water Assessment” and click on it
- Type an “Assessment Name” identifying this assessment
- Click “Add Assessment” to begin

Case Study #1: Military Base WWTP



*Aeration basin diffusers are flexible-membrane, fine-bubble diffusers (tapered aeration in each plug-flow reactor).

Design Parameters for Military Base WWTP: Conventional Activated Sludge Design

Flow rate	=	2.5 mgd (ave. daily)
$CBOD_5$	=	250 mg/L (ave)
TSS	=	350 mg/L (ave)
TKN	=	45 mg/L (ave)
Ammonia-N	=	25 mg/L (ave)

Summer NPDES Limits for Military Base WWTP

$CBOD_5$	=	12 mg/L (mo. ave)
TSS	=	30 mg/L (mo. ave)
Ammonia-N	=	3 mg/L (mo. ave)

*Winter limits are secondary treatment limits (25/30/20).

Existing Conditions: Military Base WWTP

Total average daily flow rate	0.58 mgd (half to each aer tank)
Aeration volume in service	0.66 mil gal (0.33 mil gal each)
Sec. influent BOD_5 concentration	90 mg/L
Sec. influent BOD_5 mass loading	435 lb/day
Sec. influent TSS mass loading	484 lb/day (100 mg/L)
Type of activated sludge process	Conventional plug flow (design)

Existing Conditions: Military Base WWTP

Type of Aeration System	Fine bubble diffusers
Type of blower	Positive displacement (no VFD)
Horsepower of blower	60 hp
MLSS	3500 mg/L
MLVSS	2600 mg/L

Existing Conditions: Military Base WWTP

Existing Conditions: Military Base WWTP

One 60-hp PD blower runs 22 hrs/day for aeration basin

One 75-hp PD blower runs 24 hrs/day for aerobic digesters

TSS in activated sludge effluent	19 lb/day (4 mg/L)
VSS destroyed in aerobic digesters	390 lb/day
Oxygen required for aerobic digestion = (2.3 x VSS destroyed)	900 lb/day

Existing Energy & Chemical Use: Military Base WWTP

Total Energy Use	**86,000 kWh/mo**
Total Energy Use	**4,900 kWh/mil gal**
Typical activated sludge energy use	1,800 kWh/mil gal
Energy use vs. typical	172% more
Potential for energy savings	Excellent
Soda ash addition for alkalinity	$15,000/yr

Existing Conditions: Military Base WWTP

Total Oxygen Supplied by aer. basin blower	**1,400 lb/day**
Mixing intensity in aeration tanks with 60 hp	91 hp/mil gal
DO in aeration basins (average)	4.5 mg/L
RAS flow rate	0.66 mgd (114%)
WAS flow rate	0.0018 mgd
RAS TSS concentration	6500 mg/L

Existing Conditions: Effluent Quality

$CBOD_5$ Concentration	3 mg/L
TSS Concentration	4 mg/L
Ammonia-N Concentration	0.1 mg/L
NO_x Concentration	30 mg/L (145 lb/day)
TKN Concentration	1 mg/L
Total Nitrogen concentration	31 mg/L

Energy Conservation Measure #1: Use Only One Aeration Basin and Run the Blower Only 16 Hours/Day

Total average daily flow rate	0.58 mgd (all to one aeration tank)
Aeration volume in service	0.33 mil gal (one basin)
Sec. influent BOD_5 concentration	90 mg/L
Sec. influent BOD_5 mass loading	435 lb/day (total)

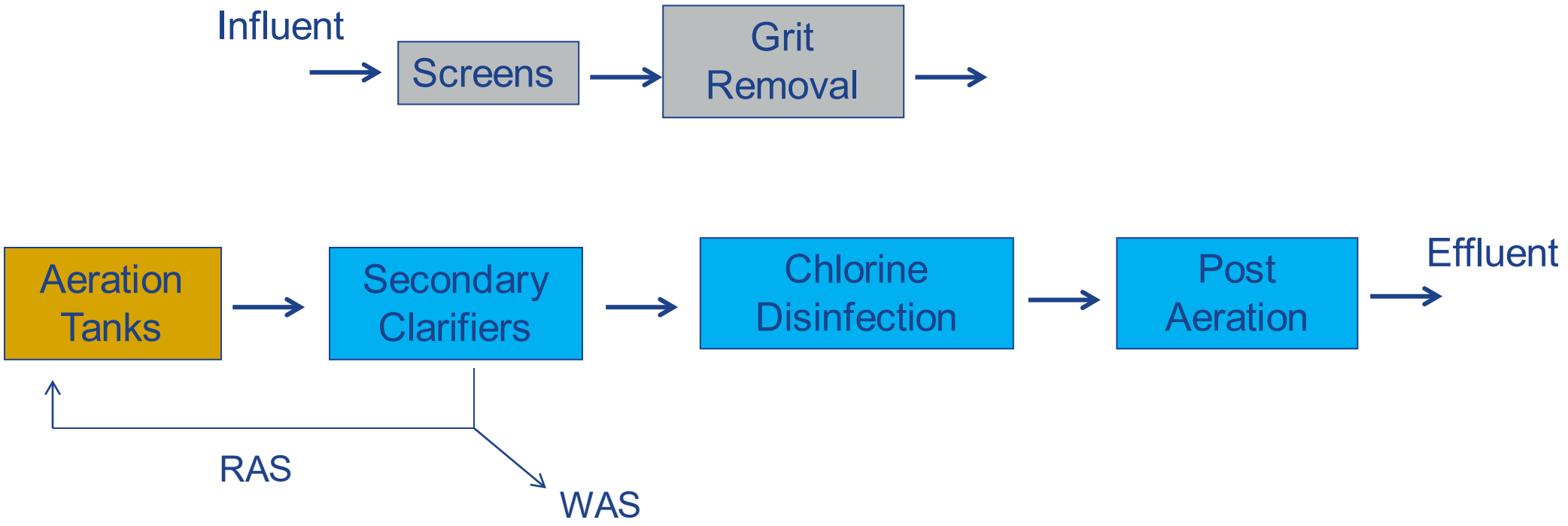
Energy Conservation Measure #2: Use Only One Aeration Basin; Run Blower 16 Hours/Day at 60% Speed; Reduce MLSS to 2,500 mg/L

Total average daily flow rate	0.58 mgd (all to one aeration tank)
Aeration volume in service	0.33 mil gal (one basin)
Sec. influent BOD_5 concentration	90 mg/L
Sec. influent BOD_5 mass loading	435 lb/day (total)

Energy Conservation Measure #3: Run the Aerobic Digester Blower Only 12 Hours/Day … Energy Savings ≈ 17,000 kWh/mo

Current digester blower use	24 hrs/day full speed
Primary sludge VSS destroyed	390 lb/day
O_2 needed for digesting prim. sludge	900 lb/day
O_2 needed for digesting waste act. sludge	0 lb/day
Digester blower O_2 transfer rate	26 lb/hp-day
O_2 supplied by digester blower	1950 lb/day
Blower run time = 900 lb/1950 lb/day	0.46 day (11 hours)

Case Study #2: Municipal WWTP



*Each of two aeration basins has six 75-HP high-speed surface aerators.

Design Parameters for Municipal WWTP: Extended Aeration Activated Sludge Design

Flow rate	=	4.5 mgd (ave. daily)
$CBOD_5$	=	200 mg/L (ave)
TSS	=	200 mg/L (ave)
TKN	=	35 mg/L (ave)
Ammonia-N	=	20 mg/L (ave)

NPDES Limits for Municipal WWTP

$CBOD_5$	=	25 mg/L (mo. ave)
TSS	=	30 mg/L (mo. ave)
Ammonia-N	=	10 mg/L (mo. ave)

Existing Conditions: Municipal WWTP

Total average daily flow rate	1.5 mgd (half to each aeration tank)
Aeration volume in service	6.8 mil gal (3.4 mil gal each)
Influent BOD_5 concentration	150 mg/L
Influent BOD_5 mass loading	1,880 lb/day
Influent TSS mass loading	2,500 lb/day (200 mg/L)
Type of activated sludge process	Extended aeration

Existing Conditions: Municipal WWTP

Type of aeration system	High-speed mechanical aerators
Number of aerators	Twelve (75 HP each)
Total aeration horsepower	900 HP (450 HP in each reactor)
MLSS	3,000 mg/L
MLVSS	2,000 mg/L

Aerial View of Municipal WWTP

Existing Conditions: Municipal WWTP

340 HP of aeration runs 16 hrs/day; some aerators are running at all times

TSS in activated sludge effluent	100 lb/day (8 mg/L)
RAS flow rate	1.8 mgd (120%)
WAS flow rate	0.024 mgd
RAS TSS concentration	5,500 mg/L
Anoxic time	0 hours per day

Existing Energy Use: Municipal WWTP

Total Energy Use	**213,000 kWh/mo**
Total Energy Use	**4,700 kWh/mil gal**
Typical extended aeration energy use	2,700 kWh/mil gal
Energy use vs. typical	74% more
Potential for energy savings	Excellent

Existing Conditions: Municipal WWTP

Total Oxygen Supplied by surface aerators	**4,200 lb/day**
Mixing intensity in aeration tanks with 340 HP aeration and four 40-HP mixers	74 HP/mil gal
DO in aeration basins (average)	4.6 mg/L
Field O_2 transfer rate of aerators	0.76 lb/(HP-hr)

Existing Conditions: Effluent Quality

$CBOD_5$ concentration	3 mg/L
TSS concentration	8 mg/L
Ammonia-N concentration	0.05 mg/L
NO_x concentration	10 mg/L (125 lb/day)
TKN concentration	1 mg/L
Total Nitrogen concentration	11 mg/L

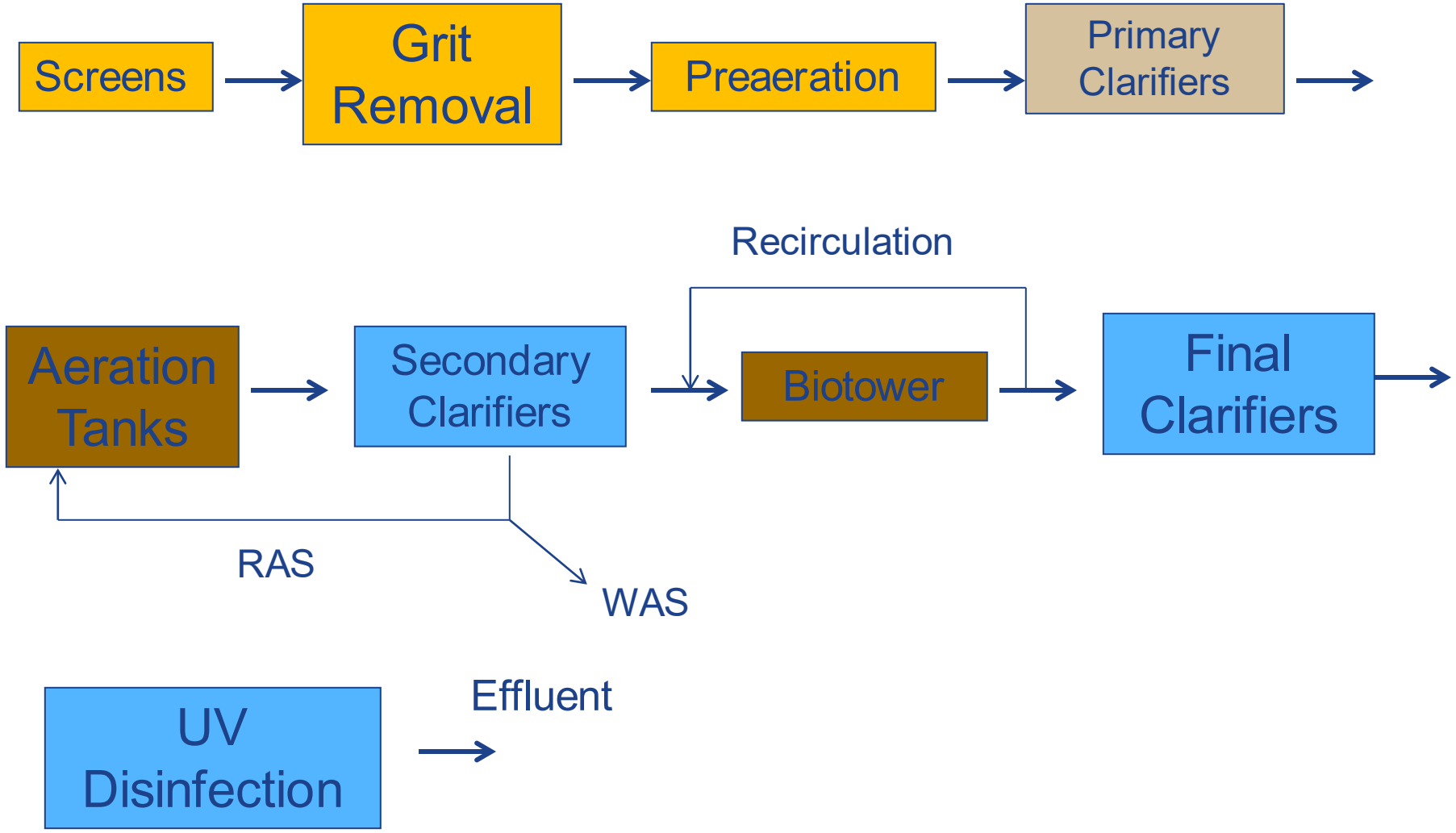
Energy Conservation Measure #1: Use Only One Aeration Basin and Run 150 HP of Aeration 18 Hours/Day

Total average daily flow rate	1.5 mgd (all to one aeration tank)
Aeration volume in service	3.4 mil gal (one basin)
Sec. influent BOD_5 concentration	150 mg/L
Sec. influent BOD_5 mass loading	1,880 lb/day (total)
Anoxic time	6 hours per day

Energy Conservation Measure #2: Use Only One Aeration Basin; Run 150 HP 18 Hours/Day; Reduce MLSS to 2,100 mg/L

Total average daily flow rate	1.5 mgd (all to one aeration tank)
Aeration volume in service	3.4 mil gal (one basin)
Sec. influent BOD_5 concentration	150 mg/L
Sec. influent BOD_5 mass loading	1,880 lb/day (total)
Anoxic time	6 hours per day

Case Study #3: Municipal WWTP



NPDES Effluent Limits: Municipal WWTP

	Summer Conditions
Total BOD_5	30 mg/L
Suspended Solids	30 mg/L
Ammonia-N	5.0 mg/L
Total Nitrogen	N/A
Total Phosphorus	N/A

NPDES Effluent Limits: Municipal WWTP

	Winter Conditions
Total BOD_5	30 mg/L
Suspended Solids	30 mg/L
Ammonia-N	5.0 mg/L
Total Nitrogen	N/A
Total Phosphorus	N/A

Case Study #3: Biological Process Design Information

- There are four aeration tanks at this facility. Each aeration tank has a volume of 0.625 mil gal. Only two aeration tanks are in operation currently. The aeration tanks are equipped with fine bubble diffusers.
- The average daily design flow rate for this WWTP is 14 mgd, with a peak daily design flow rate of 28 mgd.
- The design influent BOD_5 loading is 32,000 lb/day.
- The biotower is primarily designed to remove ammonia-N from the activated sludge effluent.

Aeration Units in Operation

- There are two 450-hp Turblex blowers supplying air to the activated sludge reactors and to aerobic digesters. One blower runs at full speed, and the other runs at half-speed.
- The aeration system provides oxygen for the activated sludge process and four aerobic digesters (each with volume of 0.38 mil gal). Two digesters currently are in operation. Sludge detention time in the digesters is 1 to 2 days. Site elevation is 650 feet.
- Blower air output is divided equally to activated sludge and to aerobic digesters.
- DO levels in the aeration basins typically are 4.0 to 8.0 mg/L.

Case Study #3: Municipal WWTP

Total average daily flow rate	4.0 mgd (half to each aer tank)
Aeration volume in service	1.25 mil gal (0.625 mil gal each)
Sec. influent BOD_5 concentration	71 mg/L
Sec. influent BOD_5 mass loading	2400 lb/day (total)
Biomass inventory (MLVSS)	11,000 lb (in aeration tanks)

Case Study #3: Municipal WWTP

Biomass inventory (MLSS)	16,000 lb (in aeration tanks)
F/M ratio	0.22 lb BOD_5/(lb MLVSS-day)
Solids Retention Time	8 days
MLSS	1500 mg/L
MLVSS	1050 mg/L

Case Study #3: Municipal WWTP

TSS Sludge Production	1700 lb/day (intentional wastage)
TSS in activated sludge effluent	330 lb/day (unintentional wastage)
Oxygen Requirements for Act Sldg (actual)	4000 lb/day
Oxygen required for aerobic digestion = 2.2 x VSS destroyed	1200 lb/day
Total Oxygen Requirements (actual)	**5200 lb/day**

Case Study #3: Municipal WWTP

Total Oxygen Supplied (DO = 2 mg/L)	**30,000 lb/day**
Mixing intensity in aeration tanks with 337 hp	270 hp/mil gal
Mixing intensity in aerobic digesters with 337 hp	440 hp/mil gal
RAS flow rate	4.0 mgd (total)
WAS flow rate	0.065 mgd
RAS TSS concentration	3000 mg/L

Importance of Diffuser Flux Rate

- The diffuser flux rate is the rate of airflow per unit surface area of the diffuser.
- A minimum flux rate is needed to ensure a uniform distribution of air throughout the perforated area of the diffuser and to prevent diffuser fouling.
- For diffused air systems, the operator should observe the distribution of air at the aeration tank surface and the size of air bubbles. These conditions indicate how well the tank is being mixed and possible problems with the diffusers and/or the air supply.

Dr. Moore's Recommendation

Turn off the 450-hp blower that is running at half speed.

Thank you!

For Questions or Comments please reach out to the following:

Dr. Larry Moore
mlarry@bellsouth.net

Thomas Wenning
Oak Ridge National Lab
wenningtj@ornl.gov