Winery and Brewery Wastewater Production and Management

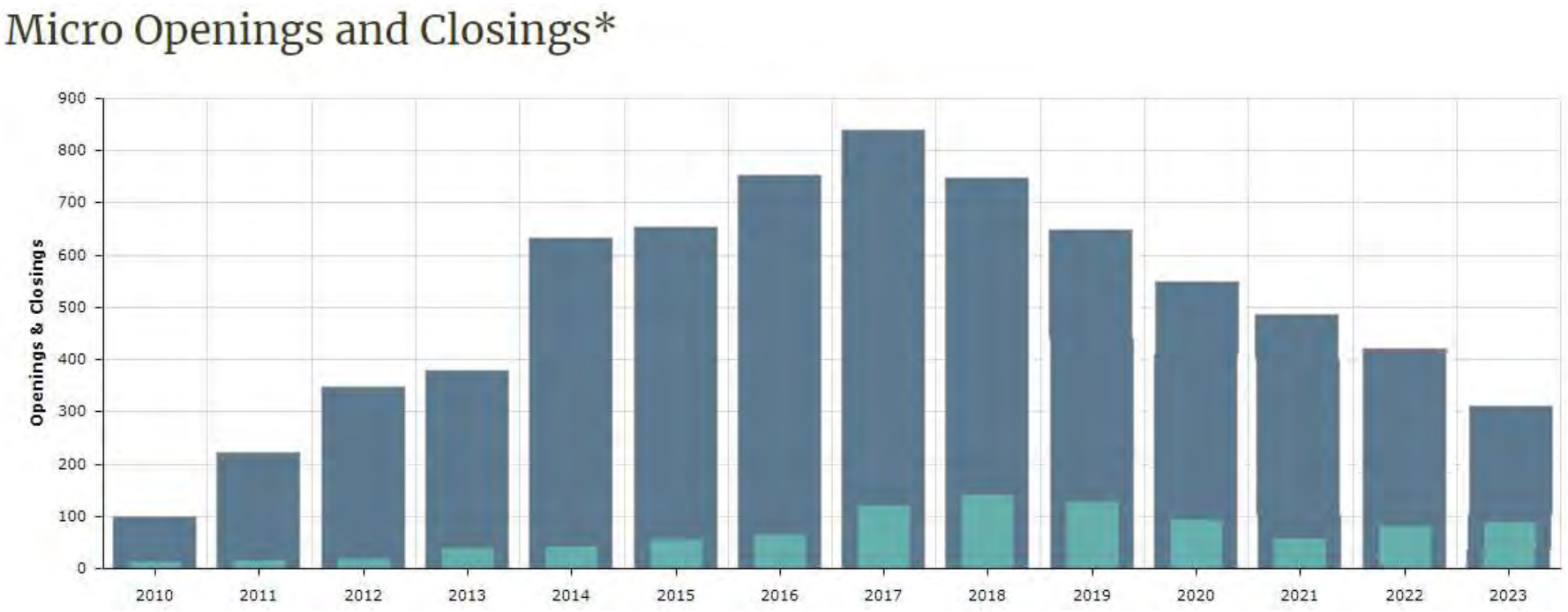
Brett M. Converse P.E., Ph.D. Senior Wastewater Engineer

J·U·B ENGINEERS, INC.

Outline

- Beer
- Wine
- Flows and Loads (Equivalent Dwelling Units)
- Treatment/Disposal
  - On-site
  - Discharge to Municipality
- Impacts
- Mitigation Strategies
- High Strength Surcharge

Beer


Micro Openings and Closings*
Openings & Closings
900
800
700
600
500
400
300
200
100
0
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023

Still Growing

Recent U.S. Brewery Count

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2022 to 2023 % Change
Craft	**4,803**	**5,713**	**6,661**	**7,618**	**8,419**	**8,921**	**9,210**	**9,675**	**9,761**	**0.9%**
Regional Craft Breweries	178	186	202	230	240	220	223	261	257	-1.5%
Microbreweries	2,684	3,319	3,956	4,518	1,917	2,003	2,007	2,132	2,092	-1.9%
Taprooms					3,091	3,389	3,643	3,771	3,910	3.7%
Brewpubs	1,941	2,208	2,503	2,870	3,171	3,309	3,337	3,511	3,502	-0.3%
Large/Non-Craft	44	67	106	107	138	171	174	149	145	-2.7%
Total U.S. Breweries	**4,847**	**5,780**	**6,767**	**7,725**	**8,557**	**9,092**	**9,384**	**9,824**	**9,906**	**0.8%**

2023 Sales Volume

Making Beer, Off-Site

- Good water – Municipal, Groundwater
- Agricultural Crop:
  - Barley (mostly)
  - Oats
  - Rice
  - Corn
  - Wheat
  - Hops
- Malting prep the grain
- Kiln
- Roasting
- Transportation to site, material and customers
- Transportation from site

Why Malt

- Grain stores energy for growth as starch
- Grain has enzymes to convert the starch to usable food
- Malting starts the growth process.
- Stops the growth process after enzymes are prepped
  - Diastatic power – measure of enzymes
- Enzymes convert starch to fermentable sugar
- Yeast convert sugar to ethanol

Malting and Roasting

- Seep, Dry, Seep, Dry
- Small Root will Grow
- Germinate
- Keep in cool moist place
- Internal leaflet grow
- Stop germination
- Dry, clean – you have pale malted Barley
  - Pale beers
- Roast as desired
  - Brown and dark beer

Roast

http://blog.brewingwithbriess.com/a-colorful-look-at-the-journey-of-barley-to-beer/

Making Beer – On Site

- Mashing
- Lautering / sparging
- Boiling
  - hops (bitter, flavor, aroma)
- Fermenting, the magic
- Bottle / Keg
- Storing
- Cleaning and Sanitizing (a lot)
- Serving

Mashing

- The grain has a lot of starch molecules
- Enzymes naturally in the grain
- Enzymes convert starch into plant food (sugar)
- Amylase (A and B)
- We highjack that sugar and ferment into alcohol

Mashing

- Done in a specific vessel
- Spent grain (2.2 to 5 wet-lb per gallons)
  - Raked out of mash vessel into wheel cart
  - Dumpster (not down the drain)
  - Leachate – pH 4.8 to 6
- Cleaning mash vessel
  - Clean in place with high pressure water
  - High pH, caustic cleaner
  - 130 degree water
  - Rinse

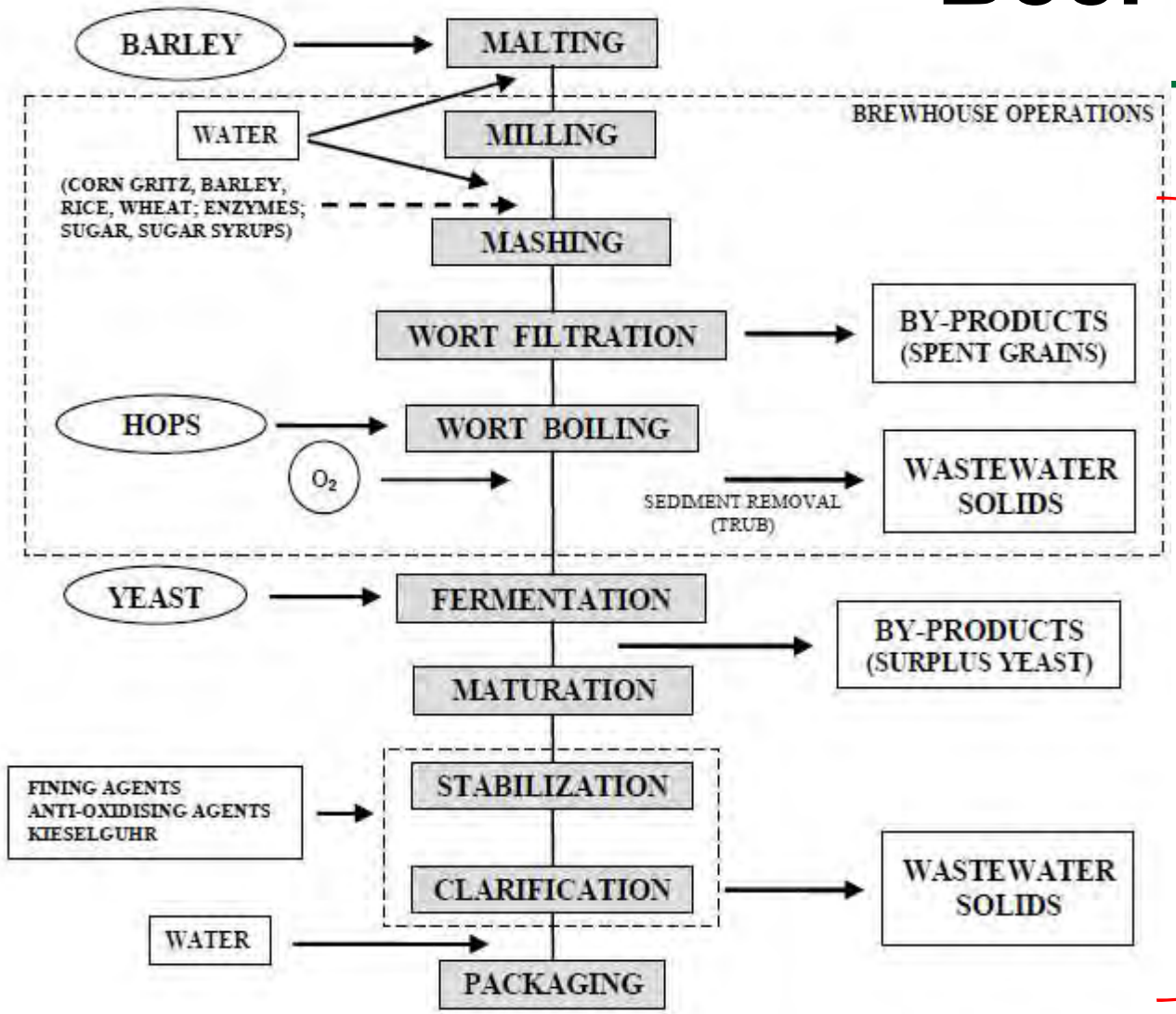
Boiling Sweet Wort

- Sweet Wort move to Boil Kettle
- Boiled for 60 minutes (sanitize)
  - Bittering hops (60-minute boil)
  - Flavor hops (15-minute boil)
  - Aroma hops (5-minute boil)
- Now you have hopped wort, moved to fermenter
- Clean Boil Kettle
  - Spent hops, rake from kettle - dumpster
- CIP, hot, high pH

Fermenting

- Wort cooled to ~<70 degrees
  - Pumped to fermenter through heat exchanger
  - Clean Heat Exchanger
- Wort in fermenter
- Yeast “making beer”
- Beer now in fermenter
- Transferred to bottles, cans, kegs
  - Clean and Sanitize serving containers
- Clean fermenter,
  - CIP, High pH, Low pH sanitizer, yeast

Beer Making



4:1, ww:beer

Varnam and Sutherland 1994, adapted

J·U·B ENGINEERS, INC.

Making Beer Summary

- Growing Barley, off-site by farmer
- Malting, off-site by maltster
- Roasting, off-site by roaster
- Mashing, Starch to Sugar
- Boiling - Hopping
- Fermenting
- Bottle / Keg (more cleaning)
- Odor - ?
- 4 gallons of WW per gallon of Beer

Beer Wastewater

- 1 gallon of Beer (3-5) gallons of WW
- BOD_5 (biochemical oxygen demand after 5 days)
  - 1,500 mg/l, Low
  - 4,500 mg/l, average (large SD)
  - 35,000 mg/l, Dump bad batch (3.5%)
  - 55,000 mg/l, Imperial (9%)
- TSS
  - Function of solids capture (target 200<TSS<1000)
- pH < 3 ranges ph>10
- N & P, 30 to 100 mg/l
- Heat
- Anytime, Year-round, can store ingredients
- Grains & Hops can't go down the drain

Impacts - Beer, Smallish

- 3 Barrel Brew House
- 375 gallons of ww per brew
  - 1.65 EDUs – hydraulic load just for brew
- BOD = 4,500 mg/l
  - 14 lb of BOD (~1 hp of air)
  - Load equal to 24 to 31 homes
- Grains don't go down the drain!
- 3 batches per day !

EDU at $50/month

- 3-barrel brew house
- 1.65 EDUs – hydraulic load
  - $82 / month
  - $0.11 per pint
- 24 EDUs – organic load
  - $1,220 / month
  - $1.64 per pint
- The day discharged, not the next
- 80 pounds of biomass (17.5%)

Impacts - Beer, Larger

- 10,000 Barrels per year
- 21 EDUs - hydraulic
- 310 EDUs – organic
- 4 to 7 days per week
- Moses Lake

Fear Beer

- Concerned ? (Yes, but address)
  - Relative flow and load
    - 10,000 barrel/yr, 310 EDUs – YES
    - 3-barrel batch, 24 EDUs (day of) - Maybe
  - Existing capacity and ability
  - Growth, domestic and beer
- What to charge?
- Be fair - Charge for service

Addressing Flow and Load

- Pre-treatment
  - pH adjustment
  - Flow equalize
    - Over days, over hours
    - Break up discharge to minimize impact.
  - Source separation
    - High strength – manage separately
    - Low strength – to sewer with surcharge fee?
- Actual treatment – get to later

Addressing Flow and Load

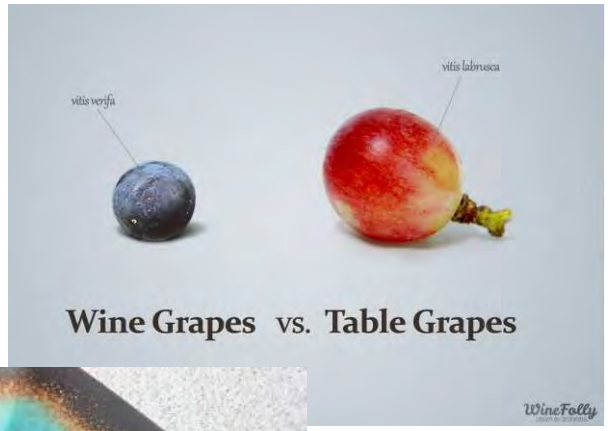
- Source separation
  - High strength – manage separately
- Bad Batch?
  - 3 barrel @ 5% ABV
  - 91 equivalent dewing units (up from 24)

Wine


PACIFIC RIM
TRAMBOISE
DRY RIESLING
COLUMBIA VALLEY
RIESLING
COLUMBIA VALLEY
SWEET RIESLING
COLUMBIA VALLEY
PACIFIC RIM
White Flowers

Wine

- Wine Grape
  - Smaller than table grapes
  - Seeds
  - More sugar
  - More juice
  - Thicker skins



J·U·B ENGINEERS, INC.

Grape Harvest

- Harvest, what comes into the winery
  - Grapes (sugar already in grapes)
  - Stems
  - Seeds
  - Pulp
  - Skins
  - Fresh Water
  - Chemicals, cleaning, pH adjustment, O_2 scrubbing

Grapes

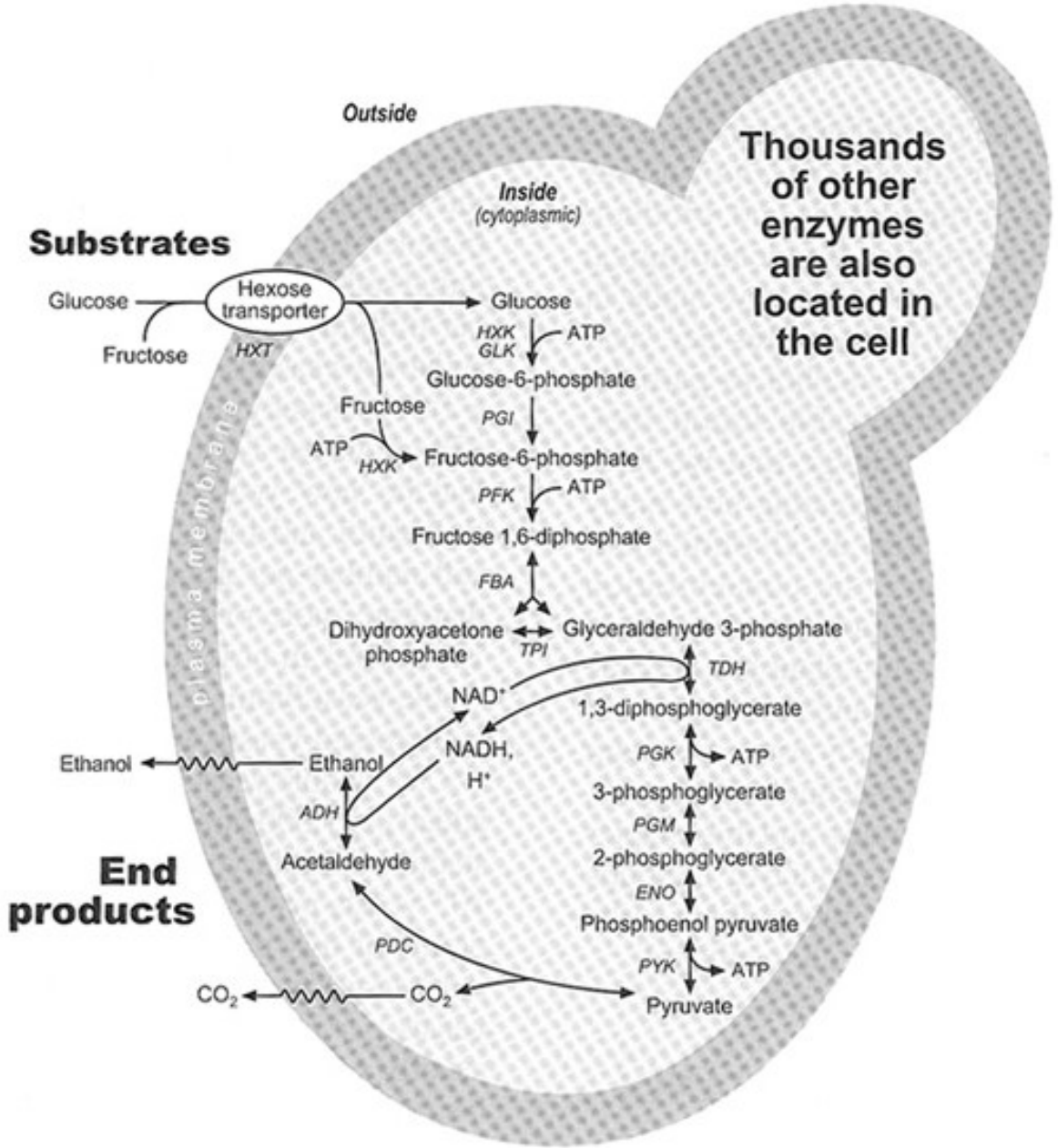
- What Winery Keeps
  - Grapes, relieved of Juice converted to wine
    - Must (Fresh Juice with skins, seeds, stems
    - Pomace = Solids
  - ~~Stems~~
  - ~~Seeds~~
  - ~~Pulp~~
  - ~~Skins~~

Grapes

- What Leaves the Winery
  - Wine
  - Lees (yeast cells, skins, other particles)
  - Wastewater
    - Chemical cleaning waste
    - Sanitation chemicals
  - Carbon dioxide

Making Ethanol

- Glycolysis
- Glucose (Sugar) into pyruvate (1:2)
- And so on to Ethanol
- Complete pathway, 10 reactions
  - 1 molecule of glucose (6 carbons), into
  - 2 molecules of Ethanol (each with 2 C), and
  - 2 molecules of carbon dioxide (each with 1 C)



Boulton et al., 1006; Pretorious, 2000

J·U·B ENGINEERS, INC.

Making Wine (with apologies)

- Grape Juice
  - 22% sugar
    - (22 grams sucrose in 100 grams juice)
  - $C_{12}H_{24}O_{12} \rightarrow 4C_2H_5OH + 4CO_2$
  - (100g → 51g)
  - 22% sugar turns into ~11% alcohol in wine

Making Wine (with apologies)

- Remove Stems
- Crush (more like breaking)
- Pressing (get all the juice)
- Clarification of must
- Condition must
- Ferment (red w/ red skins)
- Press
- Tank
- Barrel
- Filter (clarified/stabilized)
- Bottle
- Age

Clean

And

Sanitize

Throughout

The

Process

Waste

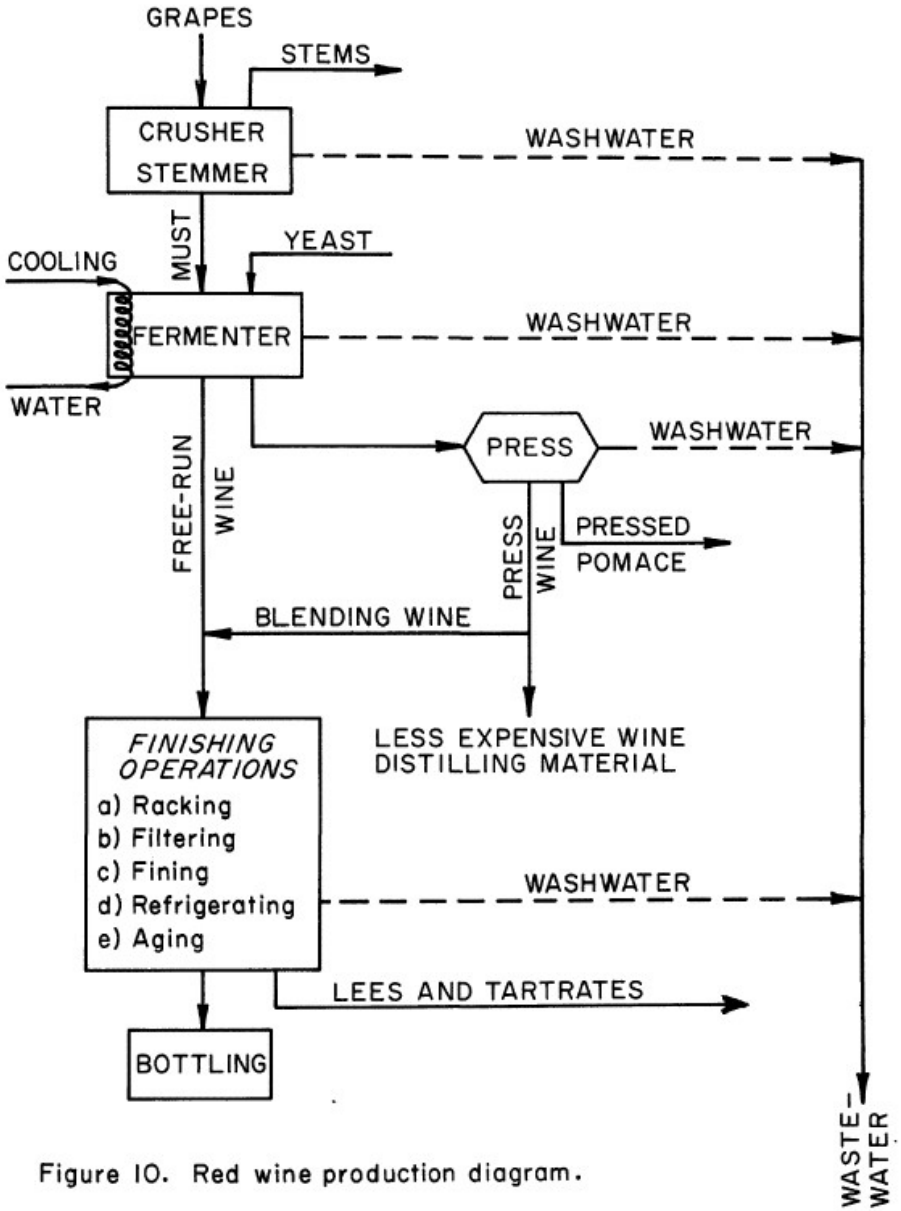


Figure 10. Red wine production diagram.

EPA-600/2-77-048

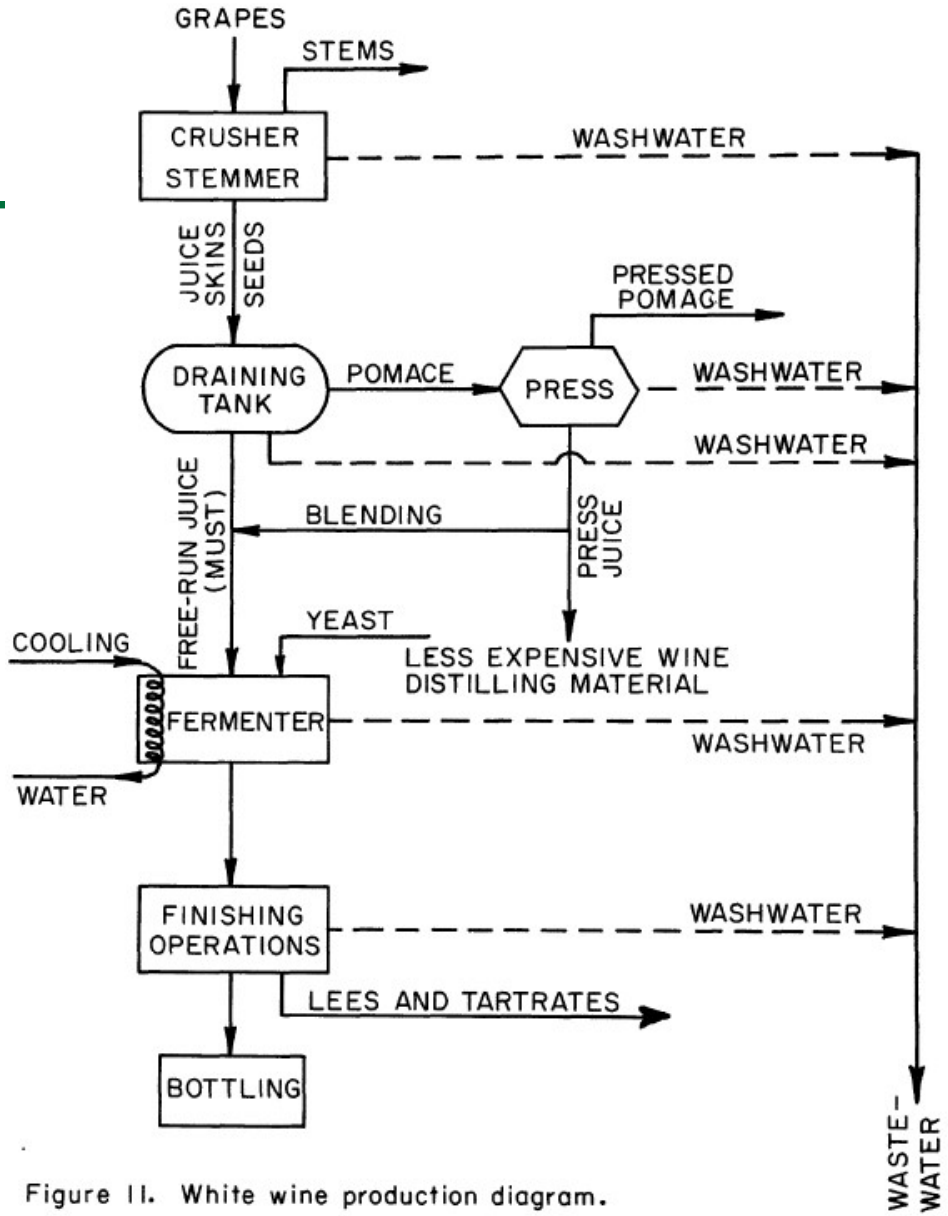
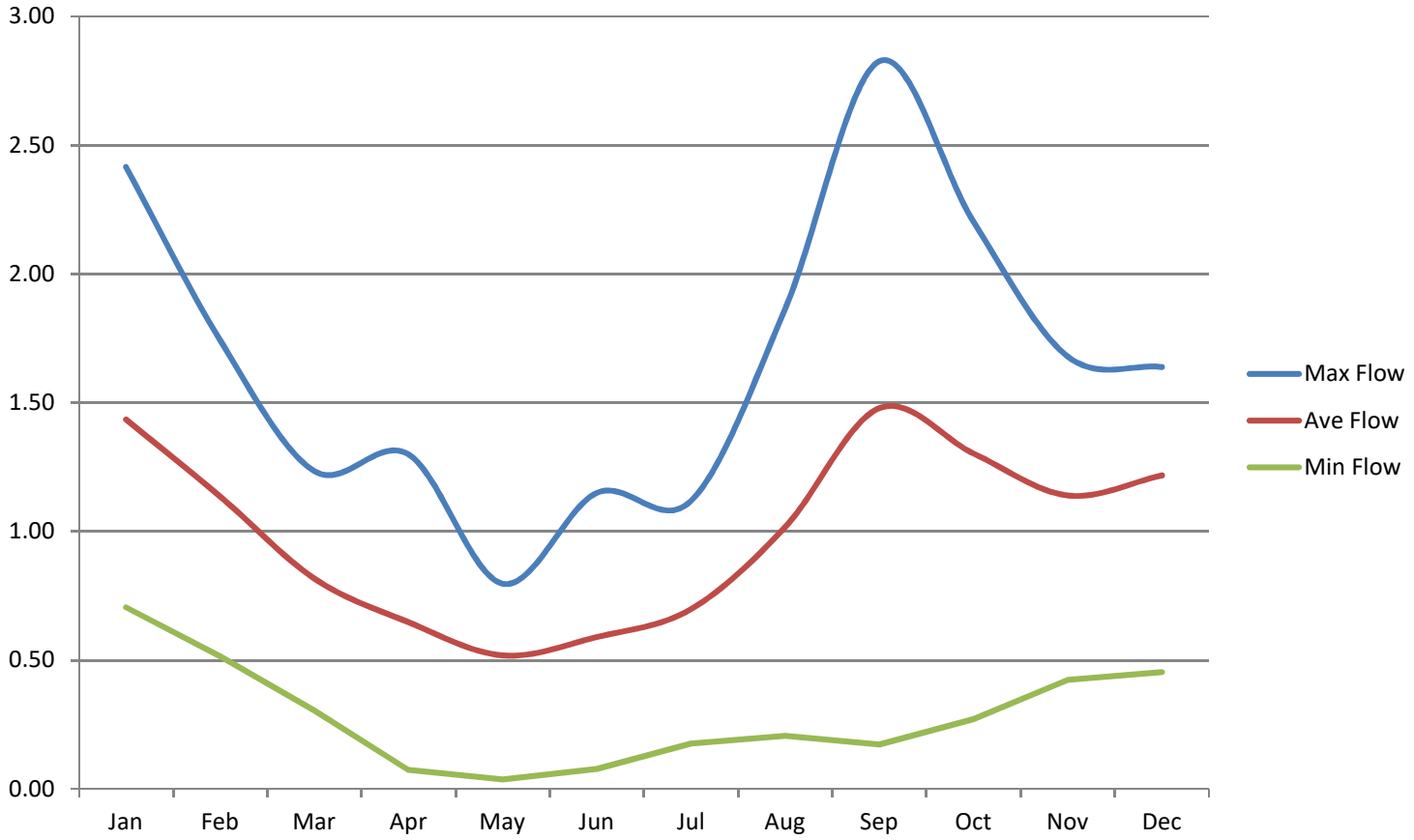


Figure 11. White wine production diagram.

Summary of Production

- Grapes are an Annual Crop; the industry is cyclic based on the season and winery activity
- Can not store grapes
- Different winemaking processes produce different wastewater
- Seasonal wastewater flows and loads

Normalized Flow



Characteristics

Characteristic[a]	Units	Crusher Wash[b]	Pomace Conveyor Wash	Fermentation Tank Wash	Press & Area Wash	Storage & Bottle Wash	Storage Tank Floor Wash	Cooling & Refrigeration Blowdown & Misc.
pH	--	3.85	4.20	4.08	3.80	6.6	7.13	6.65
Suspended Solids	mg/l	3,220	3,050	2,440	1,046	290	108	4
BOD_5	mg/l	27,300	4,650	8,300	1,540	1,130	2,800	373
Portion of Daily Flow	%	2.5	5	10	7.5	50	10	15

EPA 600/2-77-048 (60/124)

Characteristics

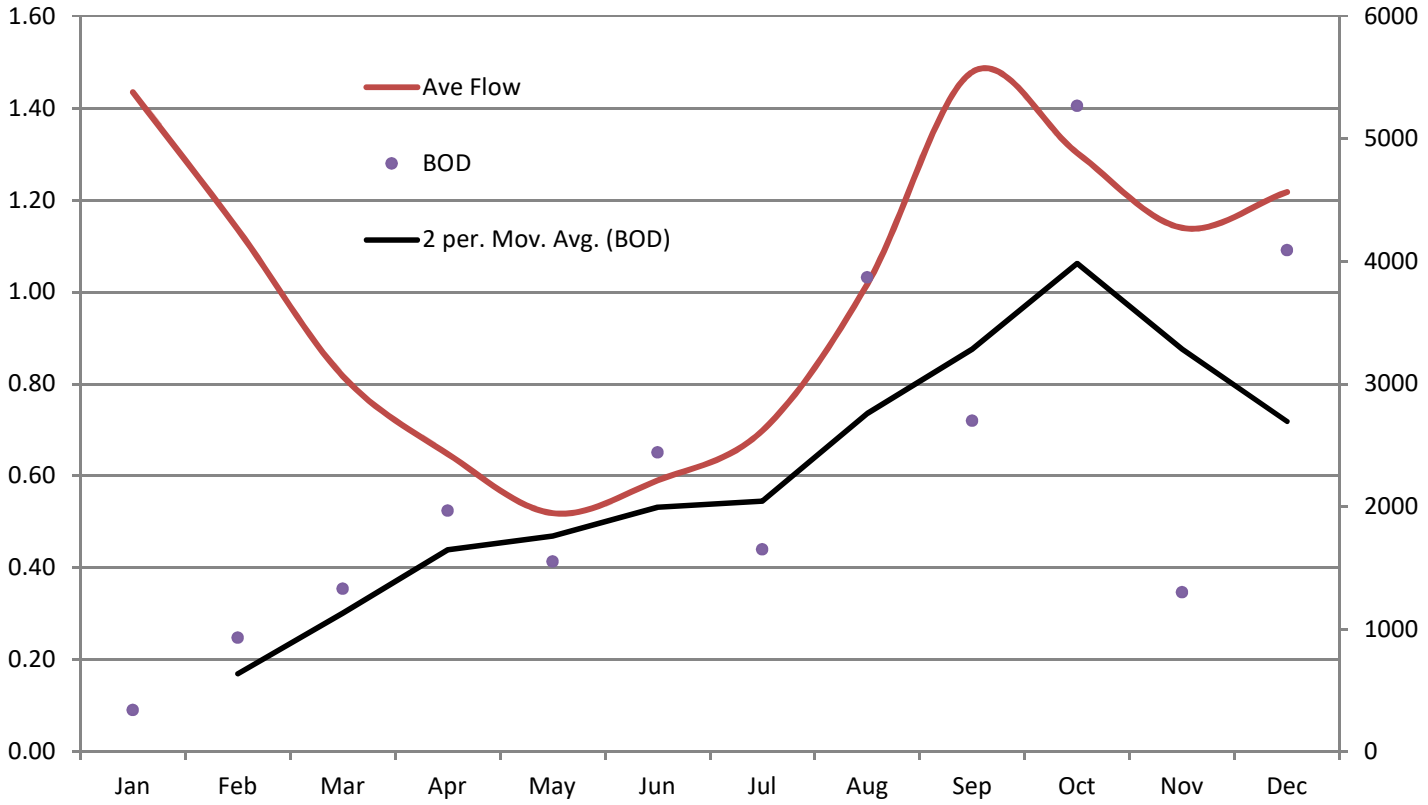
Characteristic[a]	Units	Crusher Wash[b]	Pomace Conveyor Wash	Fermentation Tank Wash	Press & Area Wash	Storage & Bottle Wash	Storage Tank Floor Wash	Cooling & Refrigeration Blowdown & Misc.
pH	--	3.85	4.20	4.08	3.80	6.6	7.13	6.65
Suspended Solids	mg/l	3,220	3,050	2,440	1,046	290	108	4
BOD_5	mg/l	27,300	4,650	8,300	1,540	1,130	2,800	373
Portion of Daily Flow	%	2.5	5	10	7.5	50	10	15

27,300 mg/l

8,300 mg/l

EPA 600/2-77-048 (60/124)

Normalized Flow and BOD_5 mg/l



Trends in Industry

- Recover liquid waste, valuable
  - Juice (SBOD)
  - Alcohol (SBOD) Could be distilled
- Technology allows Separation
  - centrifuge, membrane, vacuum systems…
- Strength could be Dropping
- TSS managed on-site, dryer due to separation of liquid (valuable)

Lesson

- Could be Function of Scale
  - Small facility 1 wine : 5 wastewater
  - Large facility 1 wine : 1 wastewater
- Confirm Process
  - How much
  - How strong
  - When

Wastewater Production, Small

- 20,000 cases
  - 9 liters per case, (12 bottles per case, 0.75 liters/bottle)
  - 3:1 wastewater : wine (typical to high)
- 142,000 gallons per year
- 22,000 gallons in September
  - 20 pounds of BOD_5 / day
- 57,000 gallons in October
  - 70 pounds of BOD_5 / day (280 People)
- 22,000 gallons in November
  - 17 pounds of BOD_5 / day
- 41,000 gallons the rest of the year
  - 2.5 pounds of BOD_5 / day

Wastewater Production, Medium

- 300,000 cases
- 2.1 MG gallons per year
- 320,000 gallons in September
  - 300 pounds of BOD_5 / day
- 860,000 gallons in October (28,000 gpd)
  - 1,000 pounds of BOD_5 / day (4,300 People)
- 320,000 gallons in November
  - 250 pounds of BOD_5 / day
- 41,000 gallons the rest of the year
  - 40 pounds of BOD_5 / day (August) (170 People)

Winery Wastewater

- Seasonal Flow
- Seasonal Load
- Load Increases Rapidly
- Confirm
  - Small, not economical to maximize liquid recovery and manage solids
  - Large, economical to recovery

Now What ?

- Wine Maker and Brewer
  - Just want to make product
  - Want the wastewater to go away
  - Maybe, some municipal systems take it
  - Others cannot
- Municipality
  - The City - Welcome here
  - WWTP - Don’t cause any issues

Mitigation

- Applicable To:
  - Beer
  - Wine
  - Hard Cider
  - Cheese
  - Yogurt
  - Restaurants
  - Super Stores

Warning !

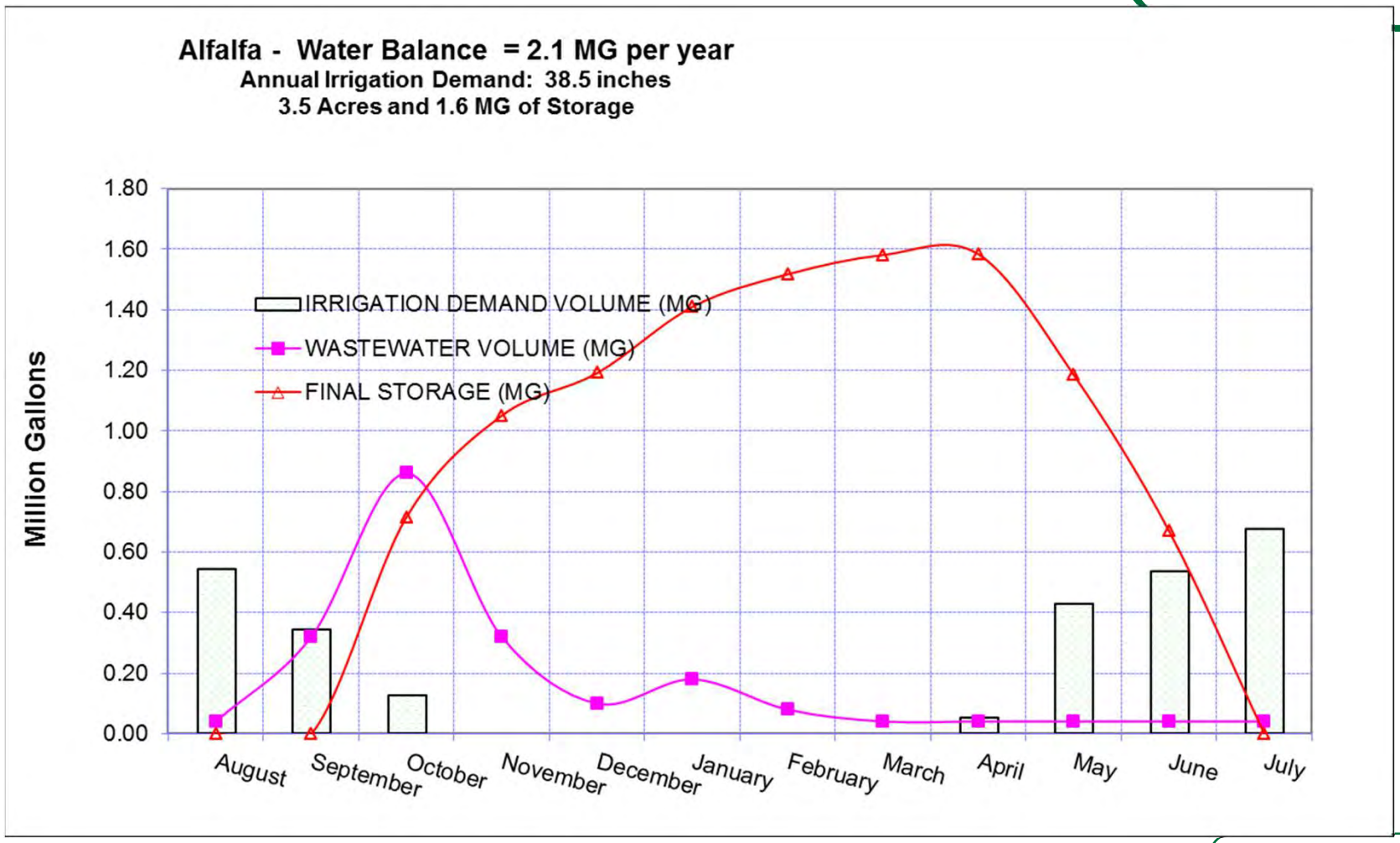
- Heavy Industry (potato, onion, fruit *etc*.)
  - Study specifically
  - Get independent help
- Data Center
  - Study specifically
  - Get independent help
  - Low strength
  - 75 degrees
  - 1.3 MGD per center

Treatment and Disposal

- Disposal, Answer this First
- The answer will control level of treatment
  - On site (very little, manage odors)
    - Store and Irrigate, crop, landscaping
    - Drain-field, and other subsurface options
    - Evaporation
  - Off site
    - Surface water discharge (highly treated)
    - Industrial treatment facility (maybe none)
    - Municipal treatment facility (pre-treatment)
    - Irrigation someone else's crop (very little)

On-Site

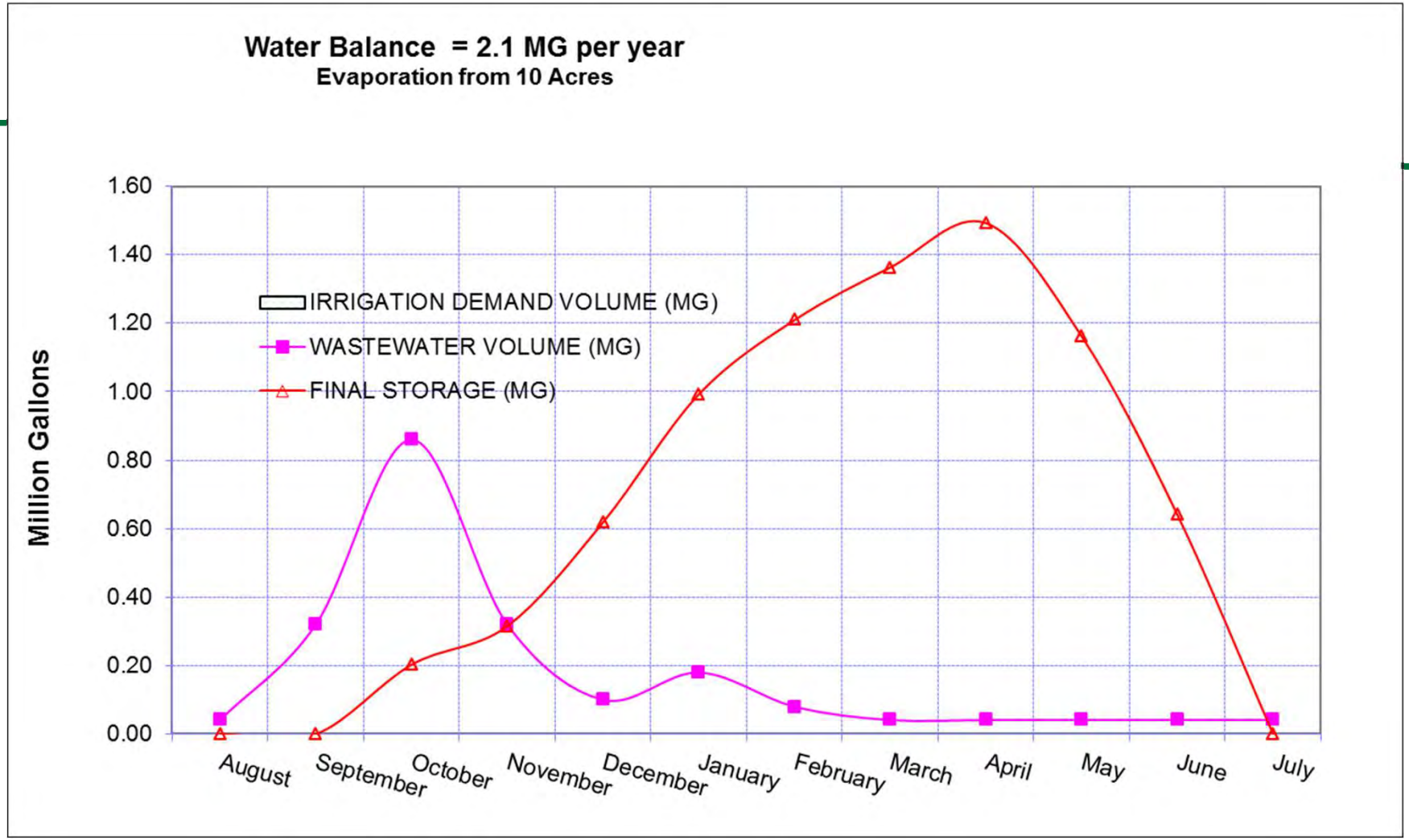
- Irrigation, Medium Size 2.1 MG/year
  - Seasonal Discharge, irrigation season
  - Winter Storage
  - 3.5 Acres of Crop
  - 1.6 MG of Storage
  - Manage TDS
  - Industrial discharge
  - Facultative pond for treatment, settling basin
  - Aeration for odor control



J·U·B ENGINEERS, INC.

On-Site

- Evaporation, Medium Size 2.1 MG/year
  - 10 Acre Evaporation Pond
    - Mechanical Evaporation → 2.5 Acres (location)
  - Settling basin to capture solids
    - Dredging plan
  - Aeration for odor control


Water Balance = 2.1 MG per year
Evaporation from 10 Acres
Million Gallons
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
IRRIGATION DEMAND VOLUME (MG)
WASTEWATER VOLUME (MG)
FINAL STORAGE (MG)
August
September
October
November
December
January
February
March
April
May
June
July

Treatment for Disposal to a Municipal Sewer

- Local Limits
- BOD < 300 mg/l (match domestic)
- Surcharge
  - Limit BOD < 300 mg/l
  - Not to exceed BOD < 1500 mg/l
  - Pay XX $/ pound discharged
    - $0.30 per pound of TSS
    - $0.35 per pound of BOD_5

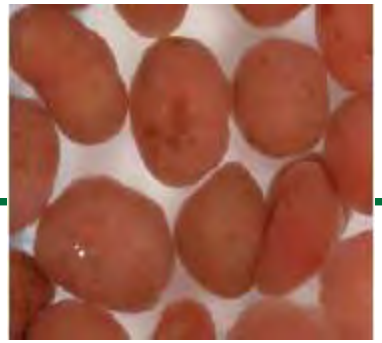
Treatment for Disposal to a Municipal Sewer

- Aerobic facultative lagoons
- Anaerobic
  - Granular Sludge ?
  - Followed by Aeration
- Activated sludge – Conventional, SBR and MBR
- Fixed film bioreactors
- Moving bed Bioreactors
- Direct Discharge to a Municipality

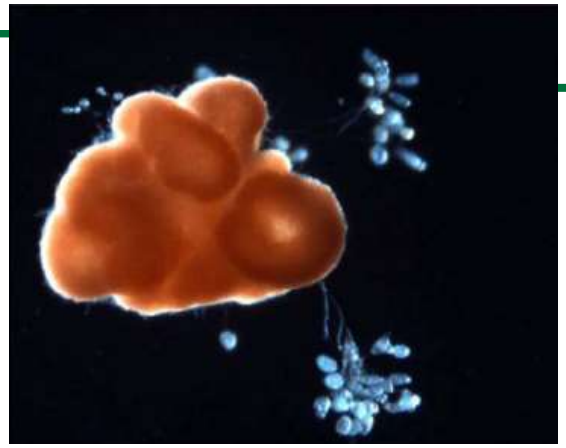
Treatment for Disposal to a Municipal Sewer (most likely ?)

- Anaerobic
  - Granular Sludge
  - Followed by Aeration
- Activated sludge

- Direct Discharge to a Municipality

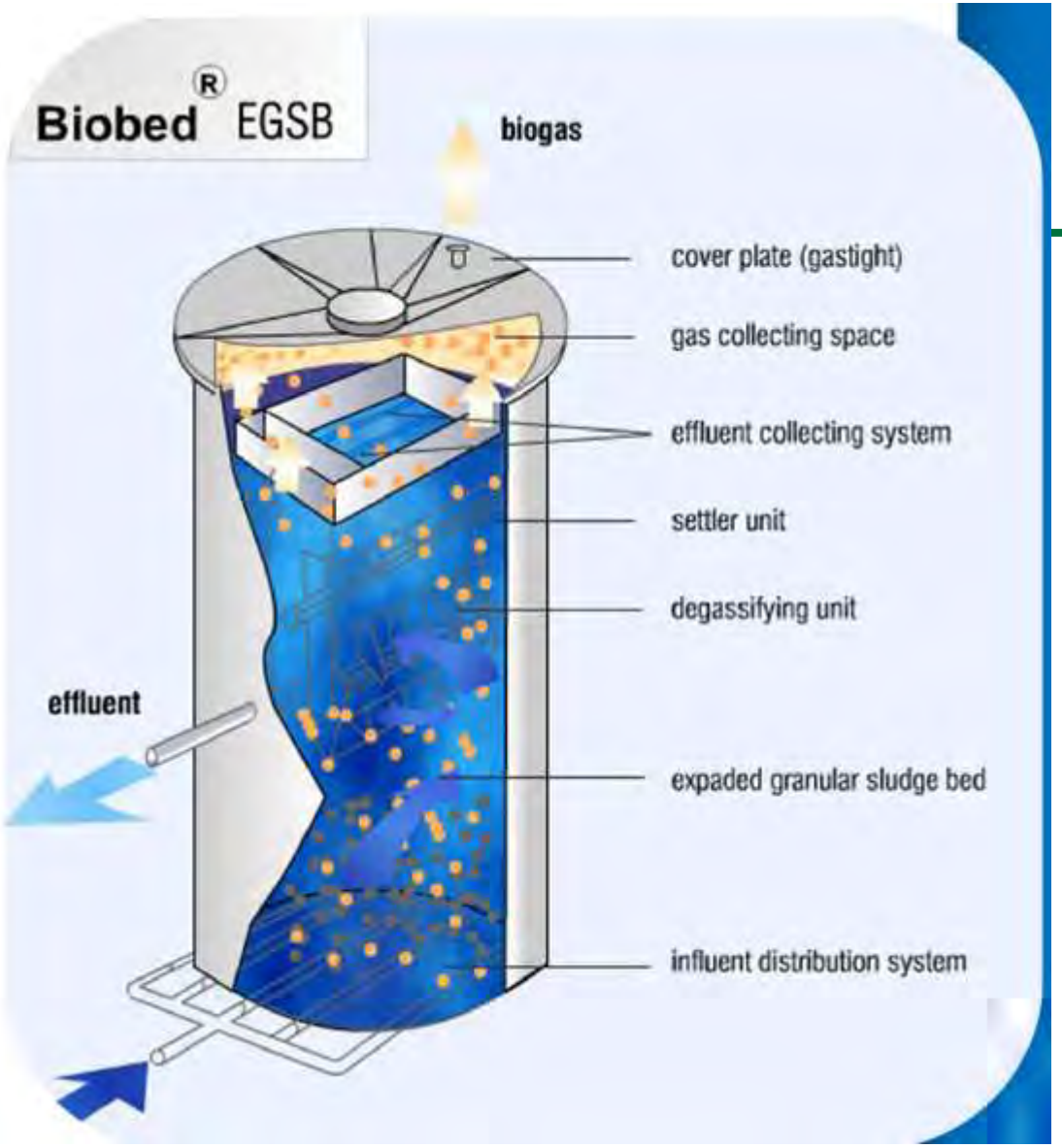


Granular Sludge



- Granular sludge
- Settles fast
- Expanded granular sludge bed
- High loading rates are lowering capital cost for digestion.
- Followed by aeration
- Can survive periods without food ? Yes.

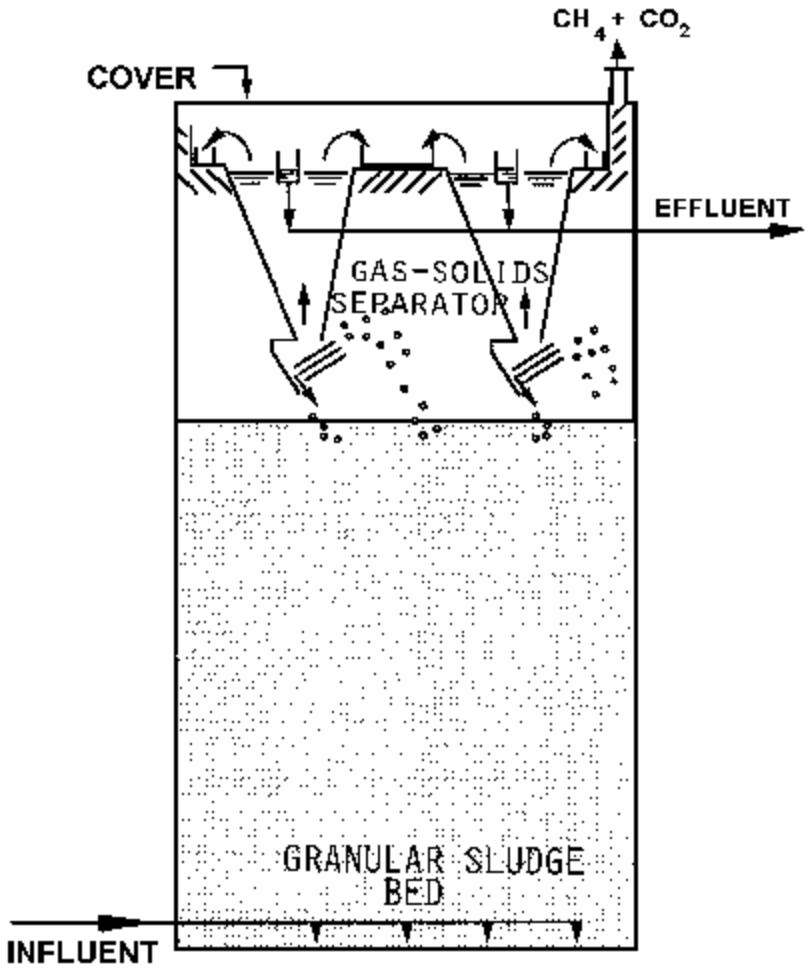
Biothane
Expanded Granular Sludge Bed



Up flow
Velocity

Settling
Velocity

J·U·B ENGINEERS, INC.



EGSB REACTOR (Biothane)

Package MBR

- Activated sludge – Package MBR
- 5,000 gallons per day
- 100,000 gallons per day
- 2 mm screen before package MBR (included)

Package MBR

- Concentrated Oxygen, dense biology
- High quality reuse water
- Seeded with WAS (discharge to sewer)

Package MBR
City of West Richland

Pre-Engineered Metal Building

Overview of Site

Entire plant fits neatly inside one building!

50,000 gpd
Re-use Ready

Direct Discharge

- Direct Discharge to a Municipality
- Minimum pre treatment
  - Lower TSS, skins settle in the sewer pipe
  - Adjust pH, concrete pipe, neutral pH, (dilution)
  - Generally easy to manage on-site
- What about BOD_5

Direct Discharge

- Example
- Medium Winery (300,000 cased)
- 860,000 gallons in October (28,000 gpd)
  - 1,000 pounds of BOD_5 / day
  - (4,300 People)

Biology to Treat, Approximate

- Biomass needed for 1,000 pounds of BOD_5 / day
- 6850 pounds of biomass, about
- Increase in MLSS
  - 0.5 MG reactor → from 2000 to 3640 mg/l
  - 2.58 MG reactor → from 2000 to 2320 mg/l
  - 6 MG reactor → from 2000 to 2140 mg/l
- 55,000 gallons of RAS/WAS (at 1.5%)
- 65 pounds of O_2 per hour
- 45 horsepower aeration

Managing Winery WW at WWTP

- Can you come up with the biology?
- Can you provide the air?
- Can you manage the extra biosolids?

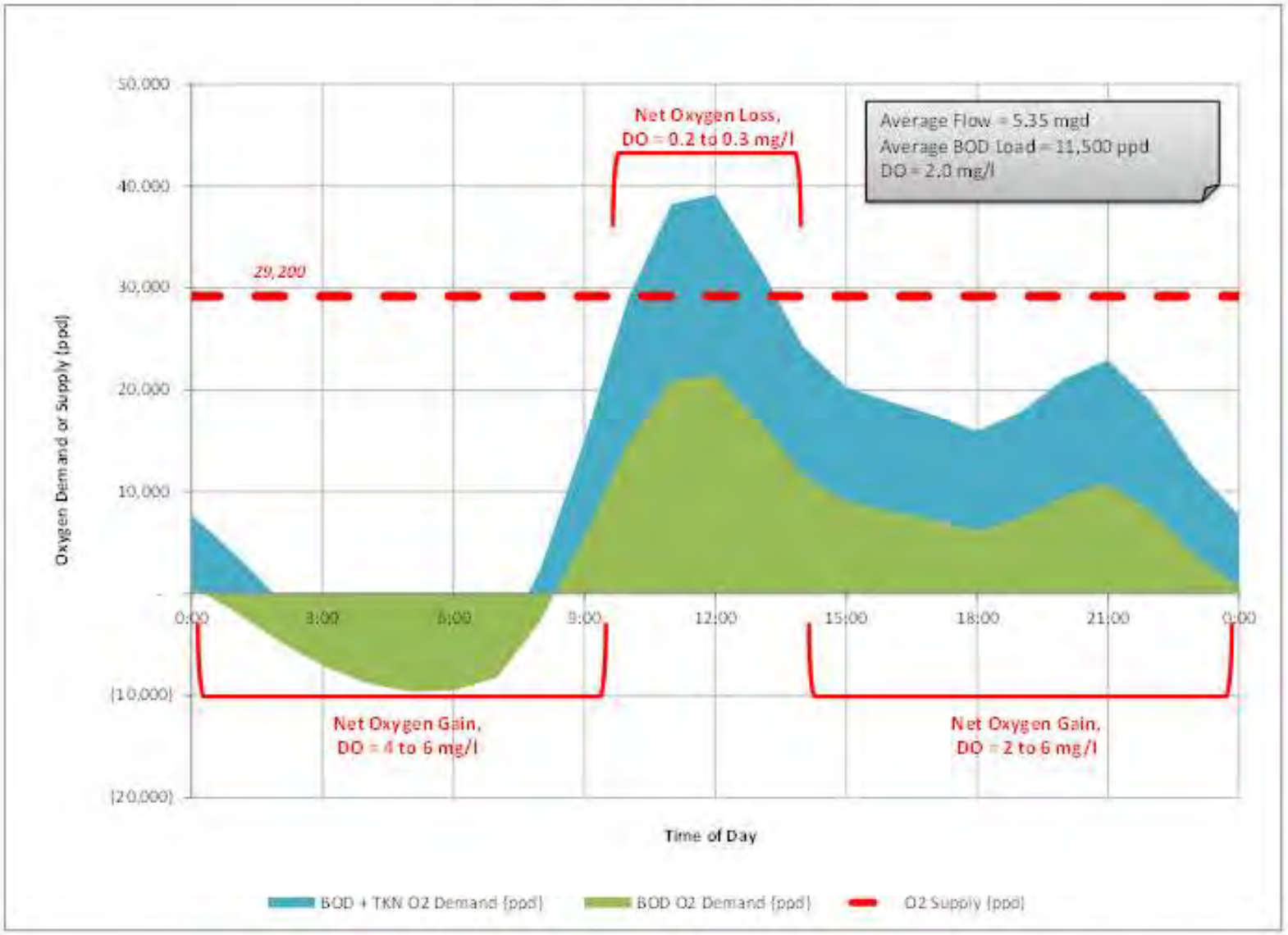
Managing Winery WW at WWTP

- Can you come up with the biology?
  - Likely, depending on time of day
- Can you provide the air?
  - Likely, depending on time of day
- Can you manage the extra biosolids?
  - 600 to 800 pound per day, dry
  - 2.3 tons per day of dewatered biosolids
  - maybe

Flow Equalization, Load Shift

- Large WWTP, Small initial winery flow
- pH adjustment tanks large enough to provide flow equalization on-site
- Meter discharge into sewer
- As flow increased evaluate performance and the need for pretreatment
- And bank fees

Diurnal Oxygen Demand



High Strength Surcharge

- Uniform Cost for Uniform Service
- Pay a fee for extra service in lieu of pre-treatment
- Discharge at night for a lower fee

Questions


SIGNATURE BREWS
BEND BREWING CO.
High Desert Hefeweizen
Pinnacle Porter
Metolius Golden Ale
Outback Old Ale
Elk Lake IPA