

Dealing with Sand Moving & Reclaiming



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Acknowledgements

- Andrew Wedel
 - Sand Solutions – McLanahan Corporation
- Bill Bickert
 - Michigan State University
- Numerous dairy producers who have shared their experiences
- NRCS / consultants / industry may use design procedures and equations

Sand in Freestalls

- Clean
- Comfortable
- Lower Bacteria
- Cost
- Handling





Basics of Sand Separation

- Separation based on Density
 - Water – 62 lbs / cubic foot
 - Sand – 120 to 150 lbs / cubic foot
- Mixing of ingredients
 - Water – Manure – Sand
- Suspension of mixture
 - Dilution & High Velocity
- Change velocity of suspended mixture
 - Sand settles out if done correctly

Why are some sand recovery systems successful?

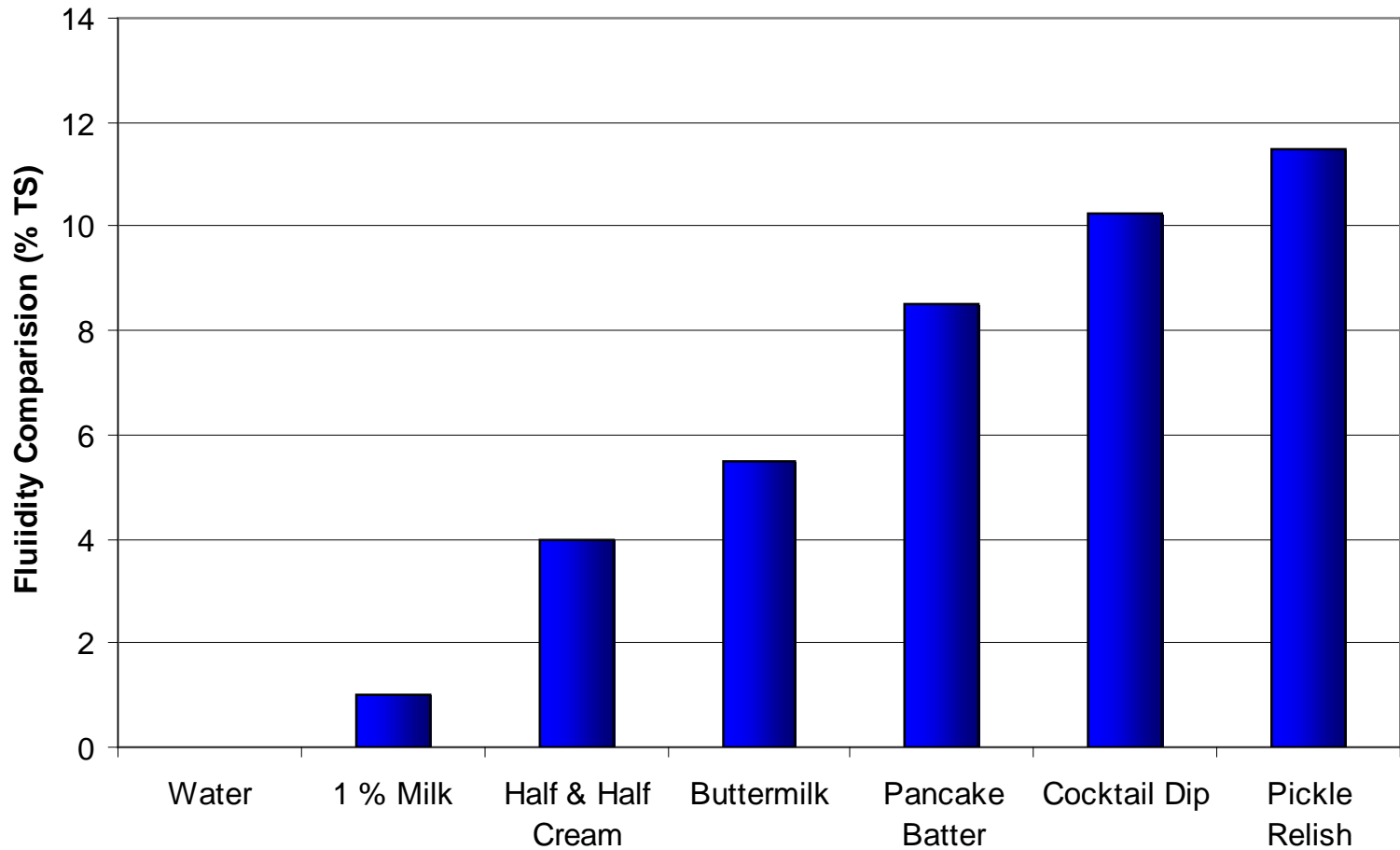




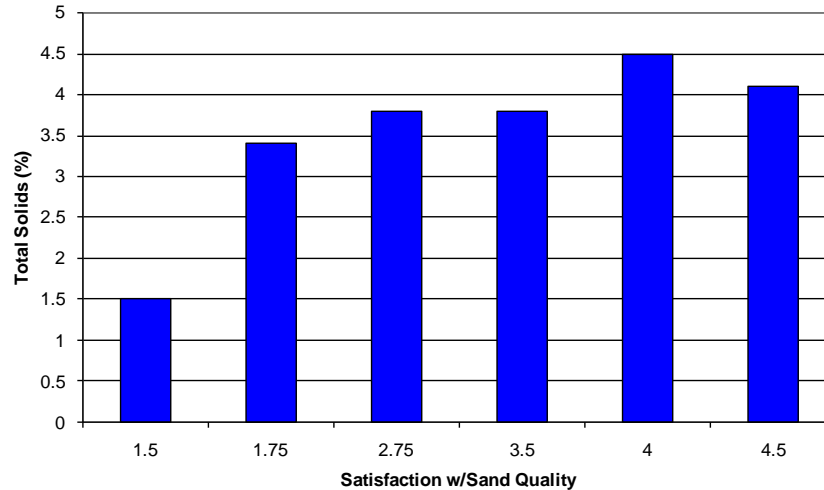
Reclaiming sand requires water – the more the better

- Total solids content of recycled water
 - One website – 1 % total solids
 - 3 % realistic
 - 5 % trouble
- Sources
 - Rainwater
 - Roof / Extraneous
 - Pasture Ponds
 - Milk Parlor / Sprinkler System

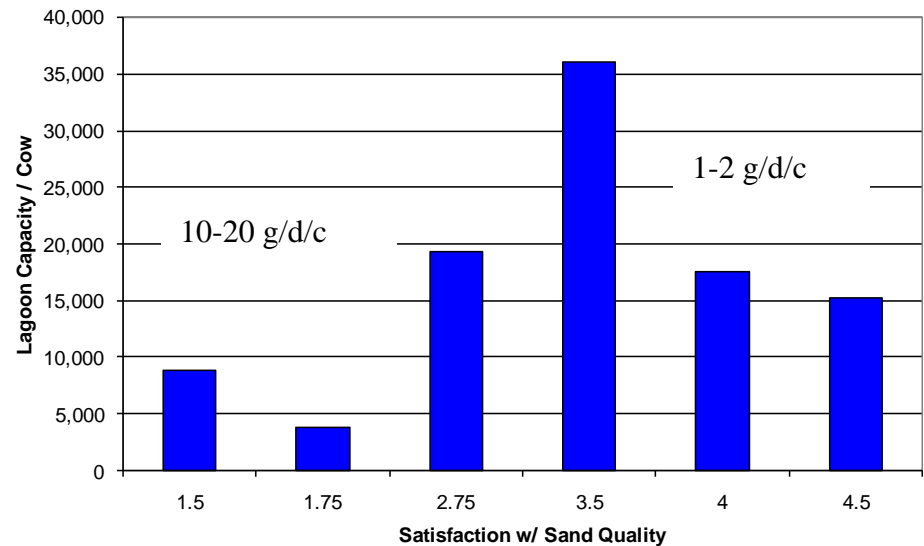
Impact of Total Solids



WI Dairy Producers



As the solid contents in recycled water increased, satisfaction with sand quality decreased proportionally





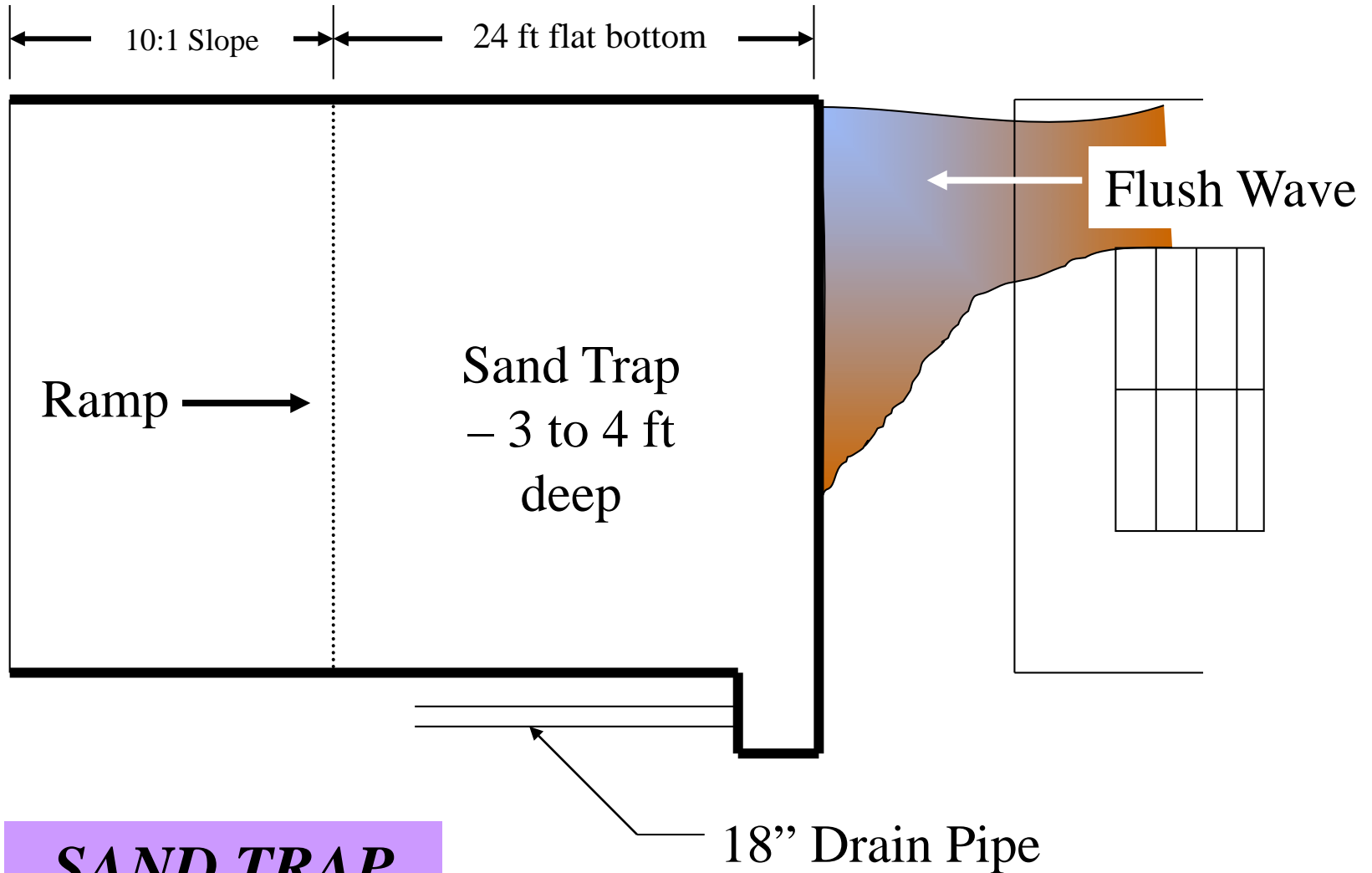
Gravity Sand Recovery

- Reduce velocity to 1 to 2 fps
- Large volume of water
- Change velocity quickly at exit
- Drying period required
- Dirty water only
- Rewash "dirty" sand



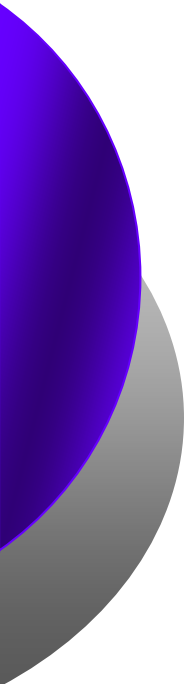
Sand Trap

- 40 ft wide, 40 ft long, 3 to 4 ft deep
- Sand storage basin (7 to 21 days)
- Manure storage when scraping
- Outlet pipe design critical
- Sand will have <3 % organic matter
- Sand may be more moisture

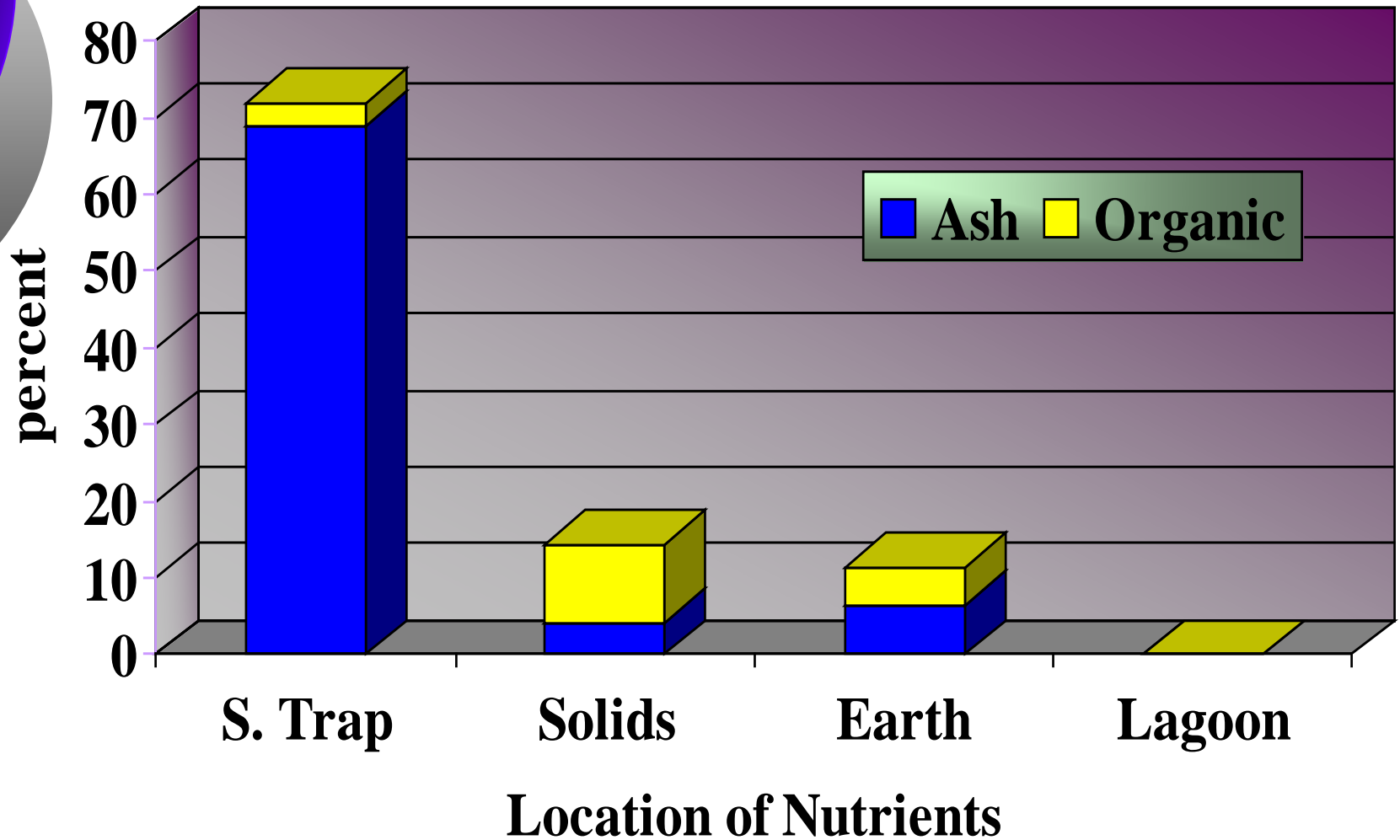


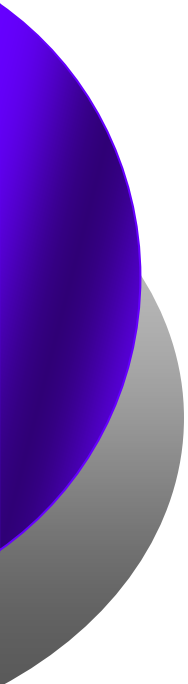
SAND TRAP





Organic Matter vs Ash (sand)

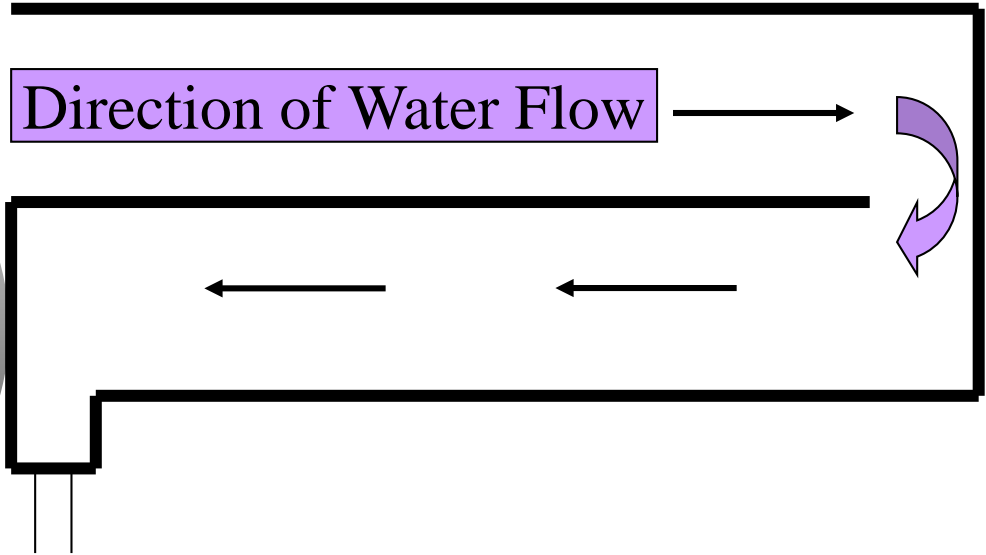






Sand Lane

- 12 ft wide, >150 ft long, 1 ft deep
- 1/10 to ¼ % slope
- Sand storage (<7 days)
- Redistribute dirty sand
- Slope & flush volume critical
- Sand will have <1 % organic matter



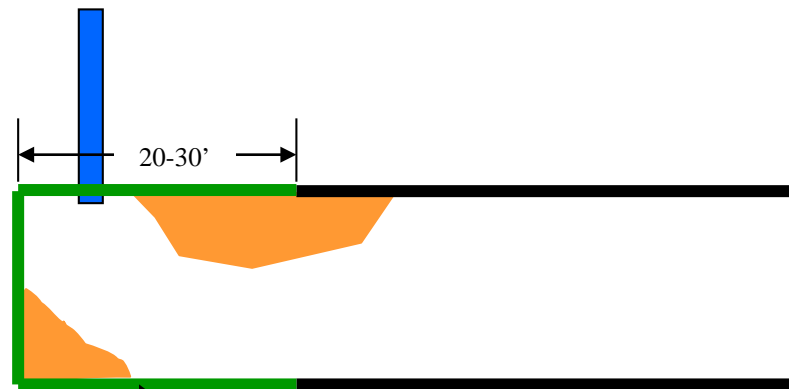
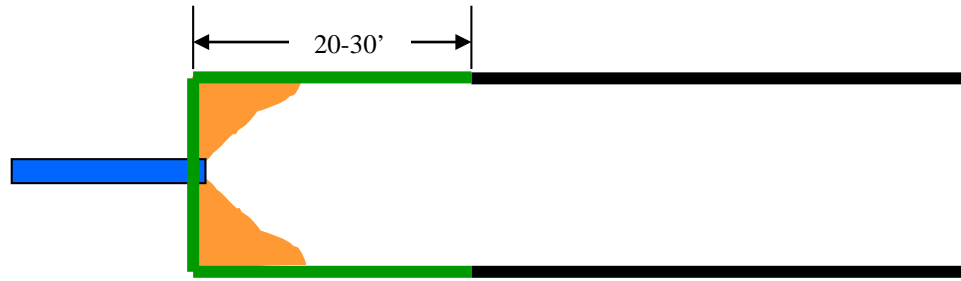
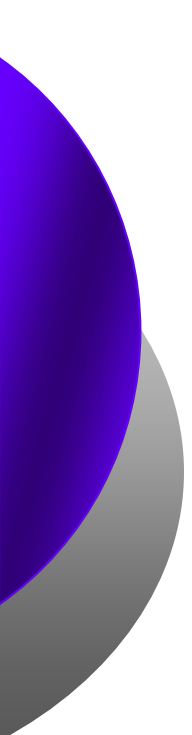
Direction of Water Flow

Sand Lane Considerations -

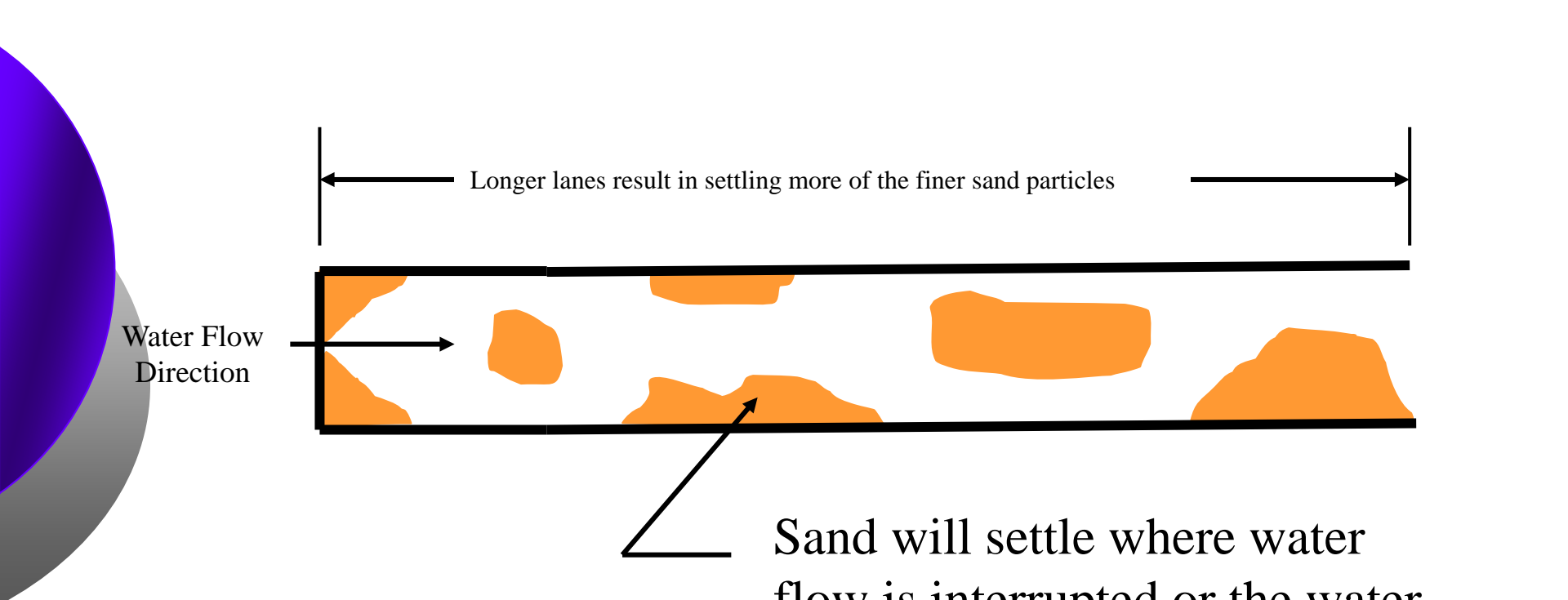
- ✓ Length vs width
- ✓ Existing components
- ✓ Ease of cleaning
- ✓ Stack pad location
- ✓ Proximity to freestalls



Direction of Water Flow



4 ft Splash Walls

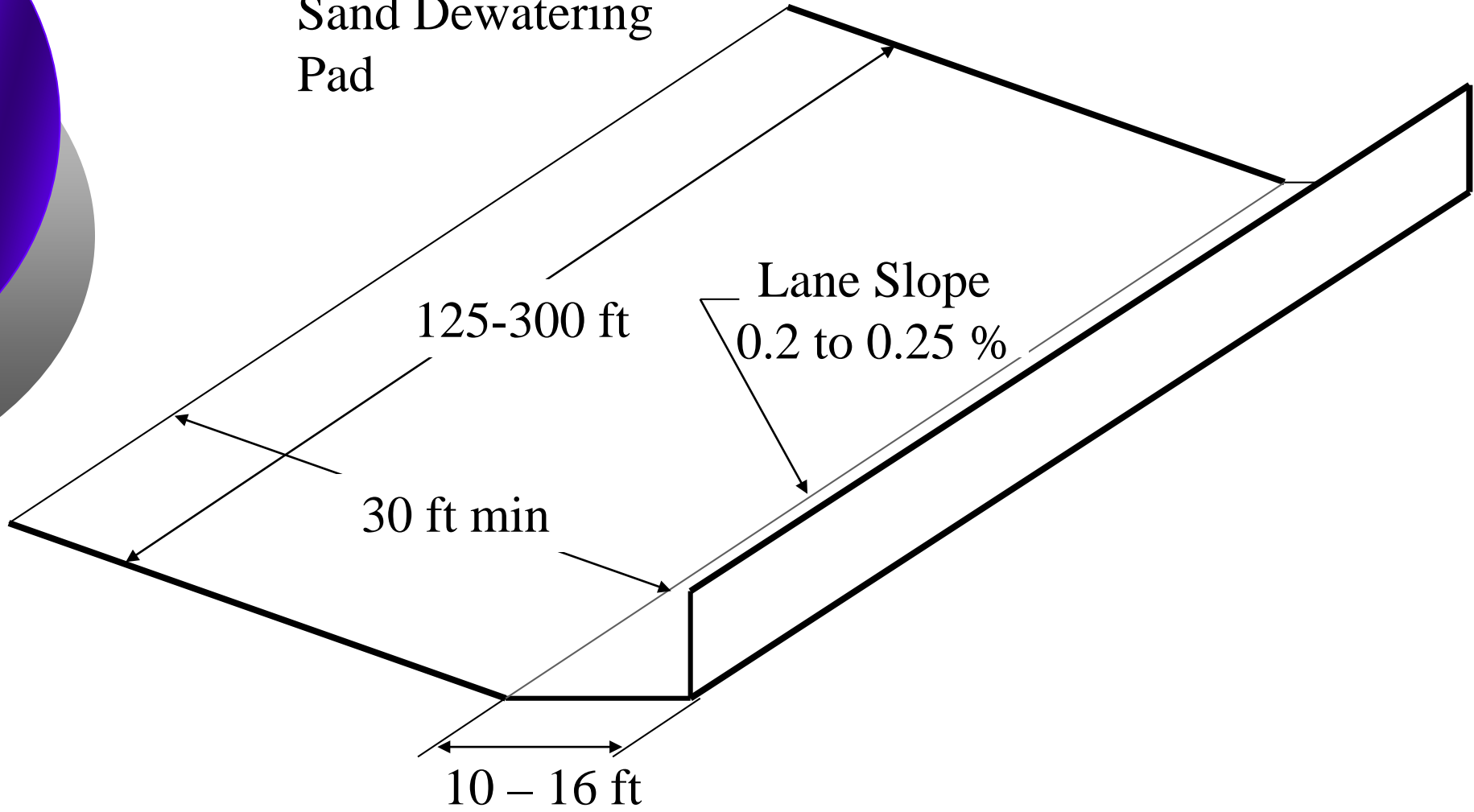


Longer lanes result in settling more of the finer sand particles

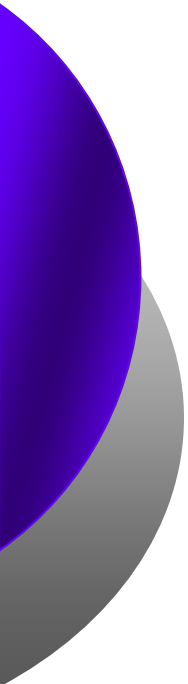
Water Flow
Direction

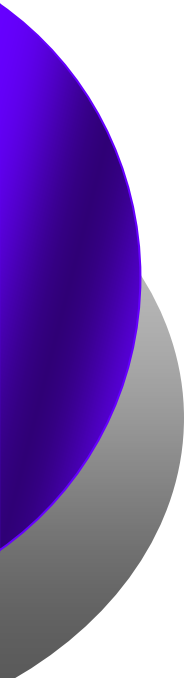
Sand will settle where water flow is interrupted or the water velocity is reduced. Design flow velocity is 1-2 fps – less than 1 fps results in organic matter settling.

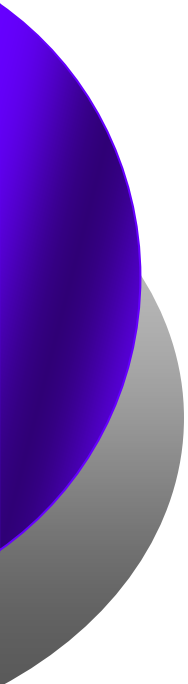
Sand Dewatering Pad



Width based on
inlet water volume



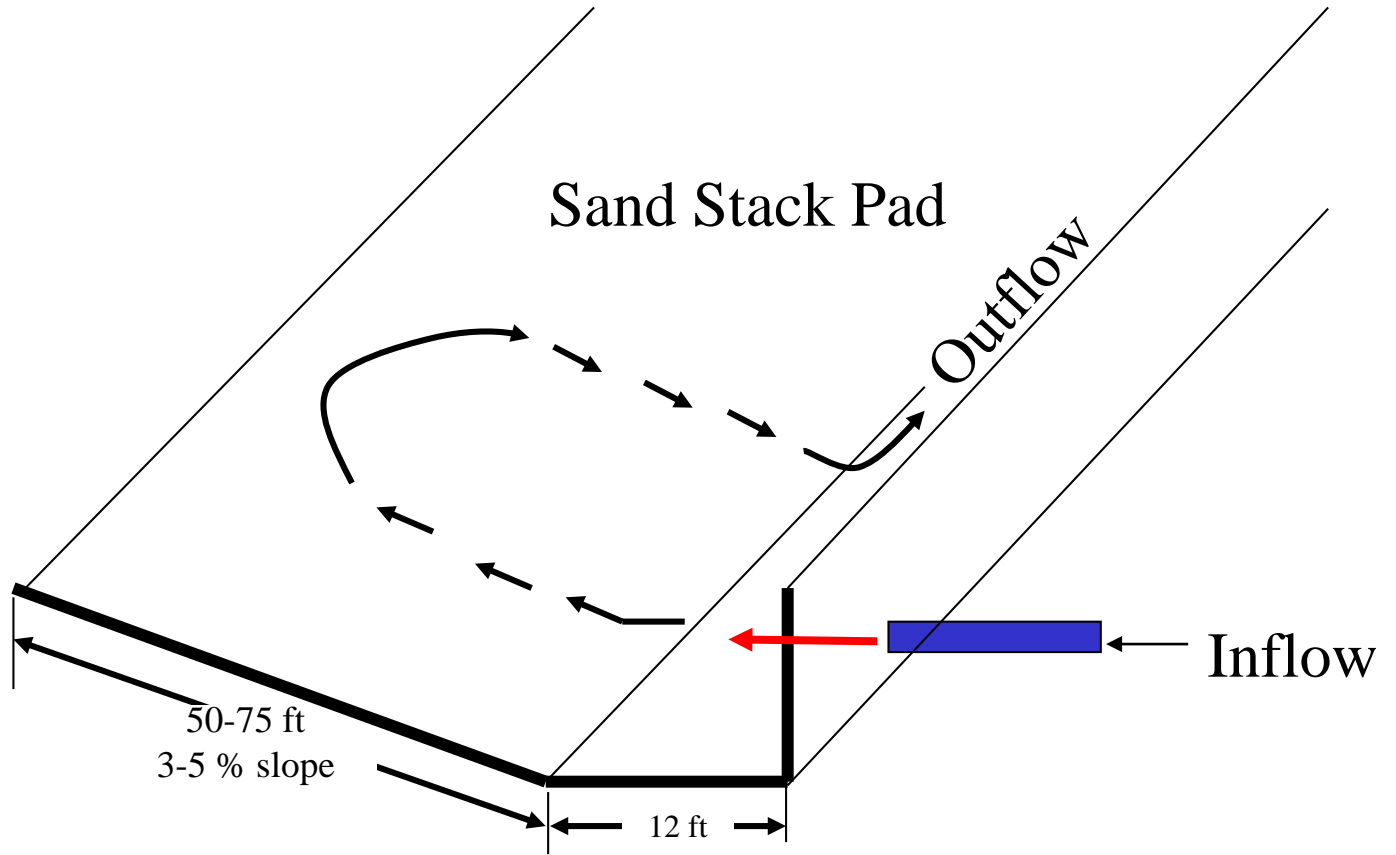




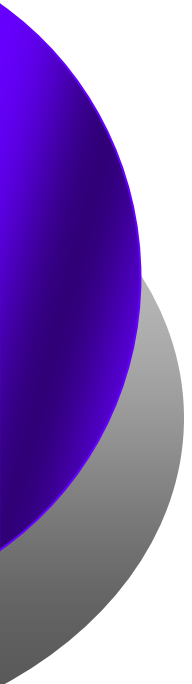


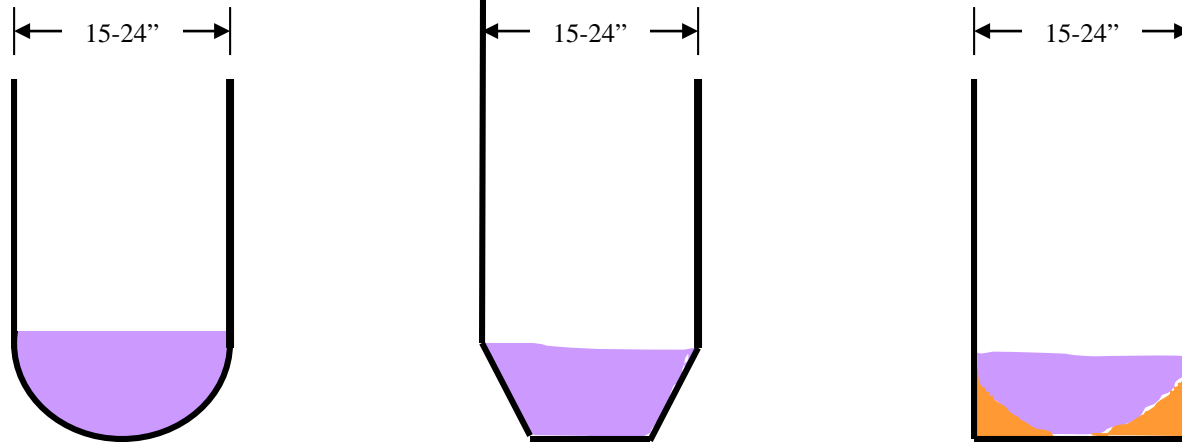
Sand Beach

- Variable width, length and depth
- 1/10 to 1/4 % slope
- Sand storage (<45 days)
- Redistribute dirty sand
- Counter slope critical
- Sand will have <1 % organic matter



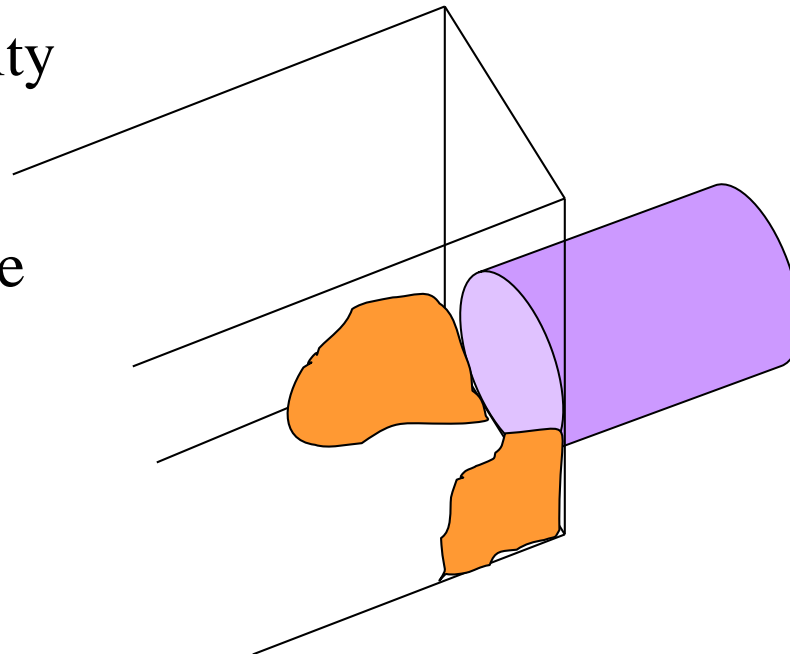
SAND BEACH



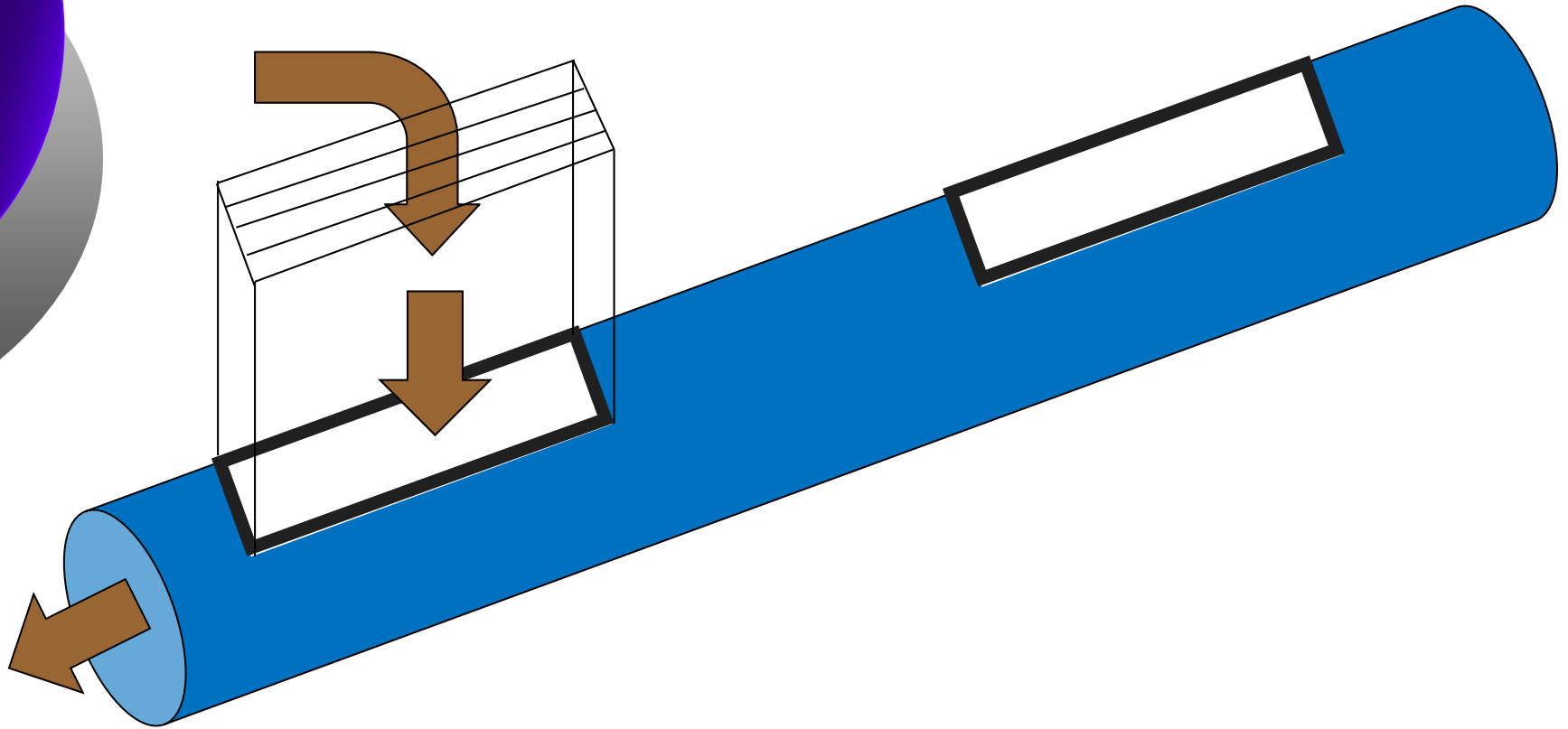


Flush Plume – Width is a function of water velocity and channel slope

Transition from square to round tube causes sand to settle at entrance due to change in velocity



Simple Flush Flume Installation



Common approach is to lay pipe,
Cut openings in pipe at alley locations &
Form manure drops on top of pipe opening



Solid Separation

- 150 lbs/cow/day @ 87 % M.C.
 - 20 lbs solids & 130 lbs liquid
- 20 % T.S. Removal & 60 % M.C.
 - 10 lbs removed -- 140 lbs to lagoon
- 60 % T.S. Removal & 80 % M.C.
 - 60 lbs removed – 90 lbs to lagoon





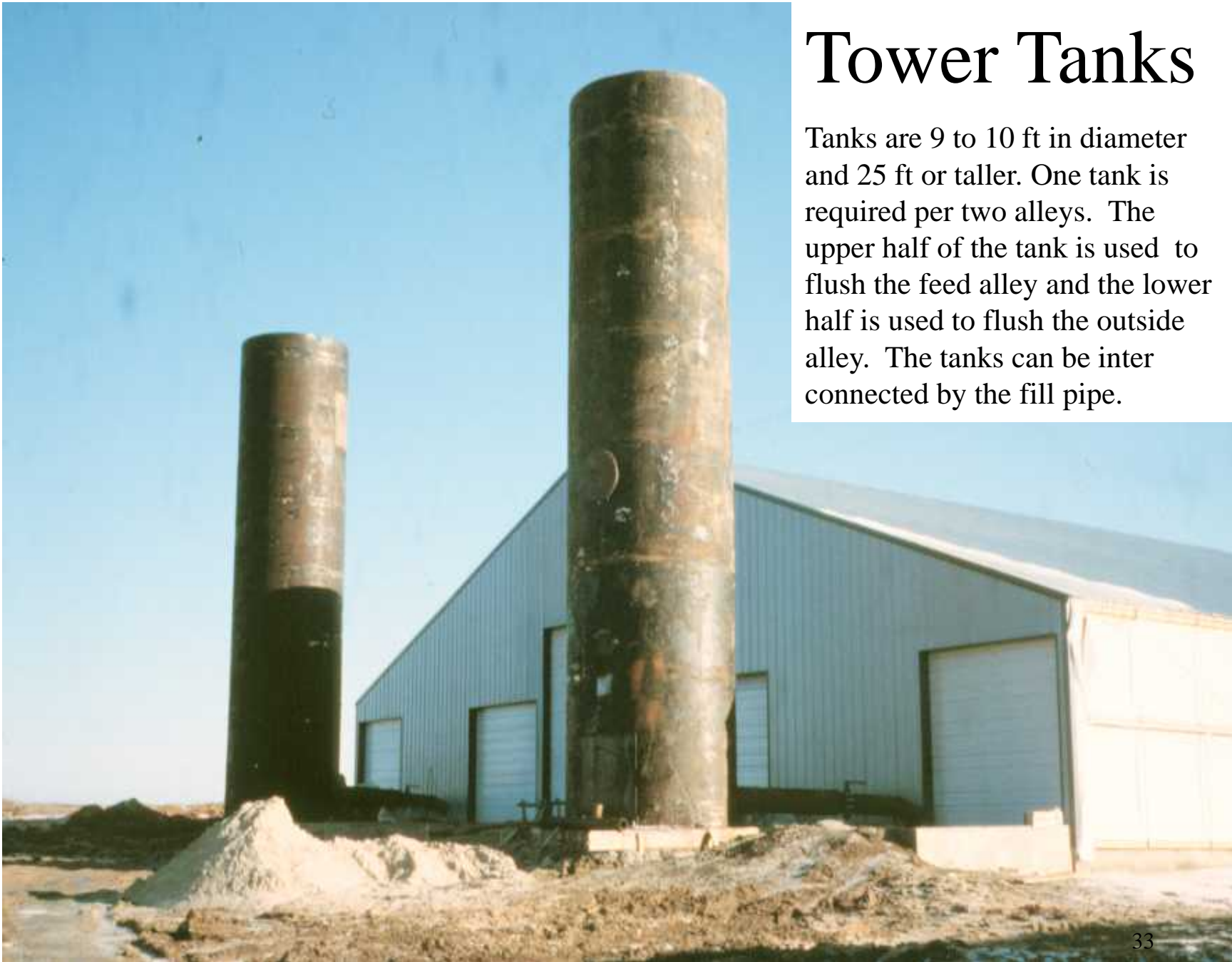
QUESTIONS ??

High Velocity Flush System For Transferring Sand



Tower Tanks

Tanks are 9 to 10 ft in diameter and 25 ft or taller. One tank is required per two alleys. The upper half of the tank is used to flush the feed alley and the lower half is used to flush the outside alley. The tanks can be inter connected by the fill pipe.



Desired Characteristics of a Flush System

- Flush wave contact time of 10 seconds
- Flush wave depth of 3 to 4 inches
- Length of flush wave equal to $\frac{1}{3}$ building length or a minimum of 150 feet.
- Flush wave velocity of 5 ft per second (fps) or greater with 7 to 10 fps preferred
- Release rate of 30-60 seconds depending on building length

Flush Design — Minimum Parameters

Assumptions —

5 f/s, 3" depth, 14 ft wide alley, 1/3 building length

$$\text{Flush Volume} = 8.75 \times \text{B. Length}$$

Flush volume in gallons

$$8.75 = 3''/12 \times 1/3 \text{ B.L.} \times 14 \text{ ft} \times 7.48 \text{ g/cf}$$

$$\text{Time of Flush} = 0.001 \times \text{B. Length}$$

Time of flush in minute

$$0.001 = 1 / (60 \text{ s/min} \times 5 \text{ fps} \times 3) \text{ where 3 is BL factor}$$

$$\text{Flush Release Rate} = \text{F.V.} / \text{T. of F.}$$

Flush release rate in gallons per minute

Flush Design — Minimum Parameters

Assumptions – 600 ft long building

5 f/s, 3” depth, 14 ft wide alley, 1/3 building length

Flush Volume = $8.75 \times \text{B. Length} = 5,250 \text{ gal}$

Flush volume in gallons

$8.75 = 3''/12 \times 1/3 \text{ B.L.} \times 14 \text{ ft} \times 7.48 \text{ g/cf}$

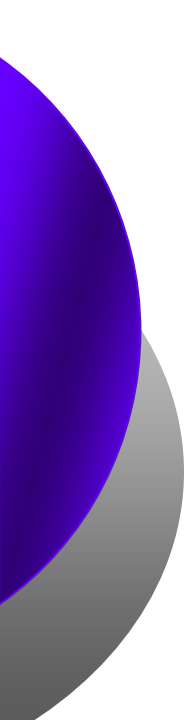
Time of Flush = $0.001 \times \text{B. Length} = 0.6 \text{ min}$

Time of flush in minute

$0.001 = 1 / (60 \text{ s/min} \times 5 \text{ fps} \times 3)$ where 3 is BL factor

Flush Release Rate = $\text{F.V.} / \text{T. of F.} = 8,750 \text{ gpm}$

Flush release rate in gallons per minute



Building Characteristics for Flushing Systems

- Maximum building length of 1,000 feet
- Building slope of 2 percent
- Alleys have $\frac{3}{4}$ -1 inch slope towards freestall curb
- Design layout to avoid flushing between groups if possible
- Freestall curbs 8 to 12 inches high

A photograph of industrial piping. A large, horizontal, rusted metal pipe is the central focus. To its left, a blue manual valve is visible, mounted on a vertical pipe. The main pipe is supported by a concrete structure. The background shows a white wall and some metal railings. The floor is made of wooden planks.

Manual valve is shown, this valve can be replaced by a automated valve.

12 inch pipe

16 inch pipe exits tank



The water is being released at 10,000 gpm along the curb. The alleys have a 1 inch slope towards the curb and 2% slope end to end. The valve is only opened for 30 seconds.



Moving sand and manure away from the curb is the main challenge in removing sand laden manure from the barn. Often the ally has a 1 inch slope towards the curb or a blade is used to scrape this material away from the curb. Once SLM is in the alley, the flush wave can normally move it away from the alleys.

Flushing characteristics with valve 90 degrees open

Initial Hd (ft)	Wave Velocity (fps)	Release Rate (gpm)
> 30	11.5	9,700
26-30	10.8	8,600
21-25	9.4	7,800
16-20	8.3	7,400
11-15	7.6	5,900
6-10	6.7	5,000

Flushing characteristics with valve 90 degrees open

Initial Hd (ft)	Flow Depth (in)	Contact Time (s)
> 30	3.6	11.2
26-30	3.6	11.9
21-25	3.0	13.4
16-20	3.3	15.4
11-15	3.0	16.3
6-10	2.5	20.0



Remember flushing sand laden manure (SLM) requires moving 30 to 70 lbs of sand per cow per day as well as 120 lbs of manure. The sand tends to accumulate along the curb. Using a high velocity flush system requires about 30 to 40 lbs of flush water per pound of sand. Daily grooming of the stalls is one method to reduce sand usage.

Sand accumulation along the curb - leading edge of the wave is directed along the freestall curb.



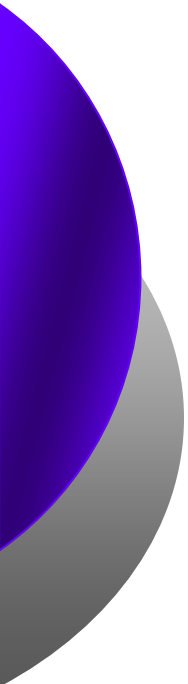
Alleys can be flushed until the flush water begins to freeze on the concrete. Normally, the outdoor air temperature has to be below 10 F for several days before ice accumulates on alley.

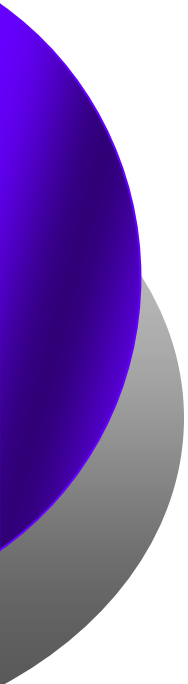


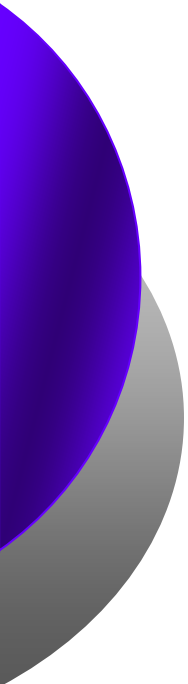
Clean 420 ft cow alley after flushing

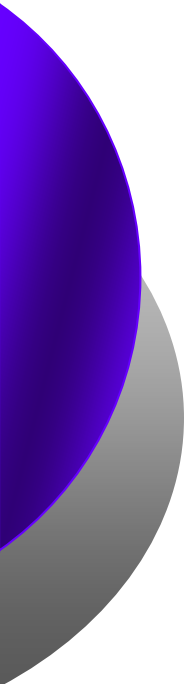
This lane has just be flushed. Longer flush times or more frequent flushing will help improve the situation. Designing a system correctly helps avoid having a flush and scrape system

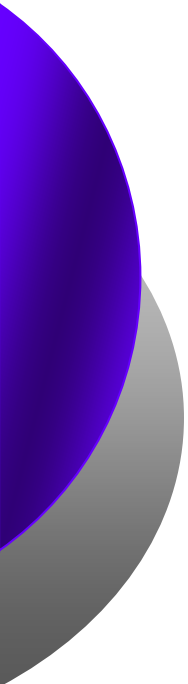












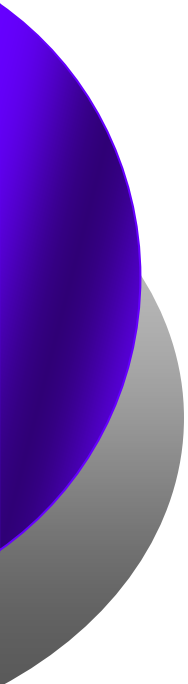




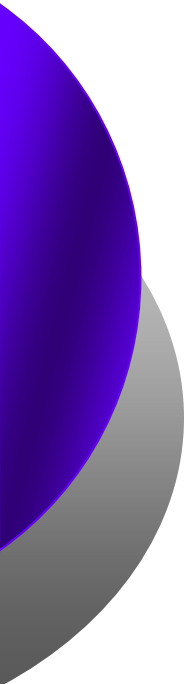












Flush Wave Velocity = 100 ft / time (sec)



100 ft



Excellent < 10 sec
Acceptable 10 to 20 s
Problems > 20 sec



Additional Water Required If 100 % of Waste Stream is Diluted

Solids in Recycle Water %	Separator Efficiency		
	0*	30/60*	60/80*
1	204 g/d/c	139 g/d/c	78 g/d/c
2	95	63	34
3	58	37	20
4	40	25	12
5	29	17	8

*Percent solids recovered and solids moisture content

500 Cow Dairy

Solids in Recycle Water %	Annual Water Volume		
	0*	30/60*	60/80*
Manure	3,100,000	2,800,000	1,900,000
Separator	0	310,000	1,200,000
1	40,500,000	28,100,000	8,000,000
3	13,900,000	9,500,000	5,500,000
5	8,600,000	5,800,000	3,300,000

*Percent solids recovered and solids moisture content

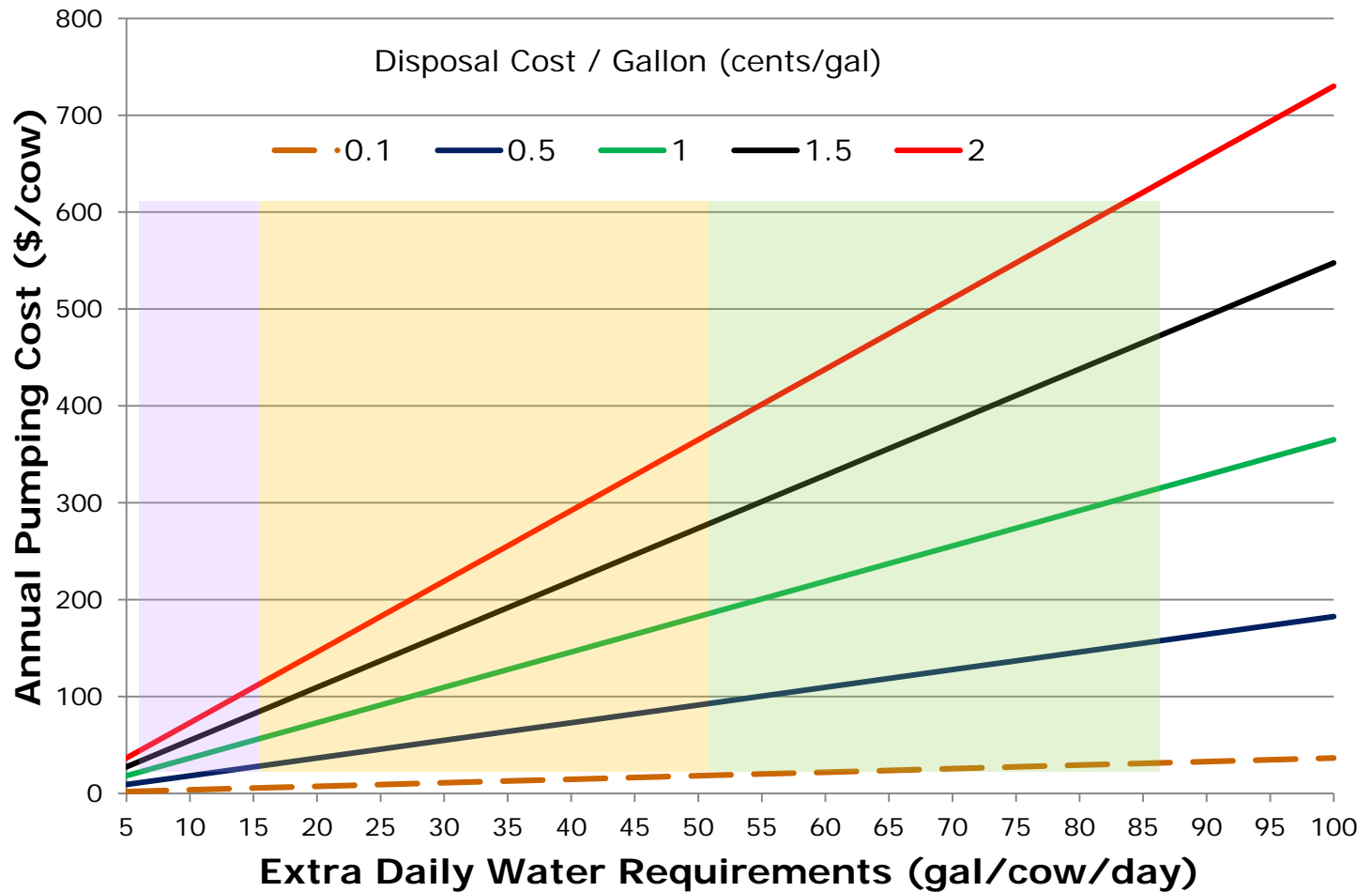
Disposal Cost / Cow / Day

Solids in Recycle Water %	Daily Pumping Cost/Cow		
	0*	30/60*	60/80*
Manure	\$0.17	\$0.15	\$0.10
Separator	0	0.03	0.13
1	2.19	1.53	0.44
3	0.76	0.52	0.30
5	0.47	0.32	0.18

*Percent solids recovered and solids moisture content

Assume \$0.01/gal of liquid disposed \$0.02/gal of solids

Impact of Additional Water





Design Considerations

- Water Quality & Quantity
- Solid Separation System
- Elevation (top floor to top storage)
- Flume / Pipe Elevation Drop (1 %)
- Flume Flow Rate / Partial Pipe Flow
- Pump Selection
- Sand Lane Design (open channel)
- Sand Length (settling equations)
- Sand Stack Pad (30 to 60 days)
- Additional Water Supply

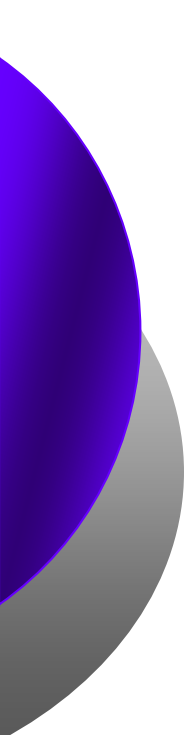
Engineering Tips

- Sand Lane – longer better
 - Open Channel Flow Equation x 1.5
 - 1.5 (1 to 2) fps
- Flush Flume – no obstructions
 - Partial Pipe Flow Equation
 - > 5 fps (7.5 fps desirable - \$\$)
 - Assume pipe 50 % full
- Recycled water
 - < 3 % total solids
 - Extra water is required
- Cold weather
 - Assume 30 – 45 days of new sand



Summary

- Do not confuse cow performance with sand recovery – benefits from sand
- Sand recovery requires extra water and cost must be considered
- Do not forget sand replacement cost – it won't last forever
- Best guess investment must be less than $\$25 \times \text{sand cost/ton/stall}$ for system to recover cost in < 4 yrs



THANK YOU -- QUESTIONS

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