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What is new with Solid Separation?

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SOLID LIQUID SEPARATION



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- Purpose of the document
- What was done
- Document Contents
- How to find it
- How to use document





Purpose of the Document

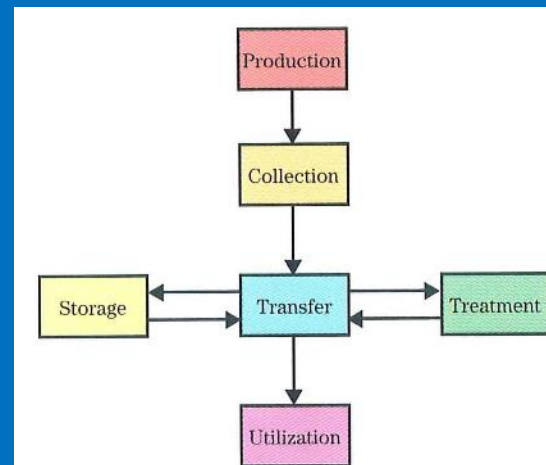
- NRCS utilized conservation practices to address resource concerns
 - More than 20 are related to waste management
 - Waste Separation Facility
 - Waste Treatment
 - Waste Storage Facility
- There was a need for a document to provide planning and design information on waste separation





Purpose of the Document

- Develop a waste separation document to covers both current and innovative technologies
- Present information on separation theory to provide a better understanding for staff and others
- Provide guidance on separation technologies to assist landowners in determining the right choice for their operation
- Show examples to illustrate various technologies and how they perform on-farm





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Purpose of the Document

- Provide information on the use of coagulants or flocculants to enhance separation performance
- Provide guidance and examples of addressing sand laden manure
- Quantify the impact of utilizing waste separation technologies on system and operational performance





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Document Contents

- Methods of Solid-Liquid Separation
 - Based on density
 - Based on particle size
- Manure Characteristics
 - Animal Housing
 - Waste Separation Benefits



Sand Settling Basin



Screw Press



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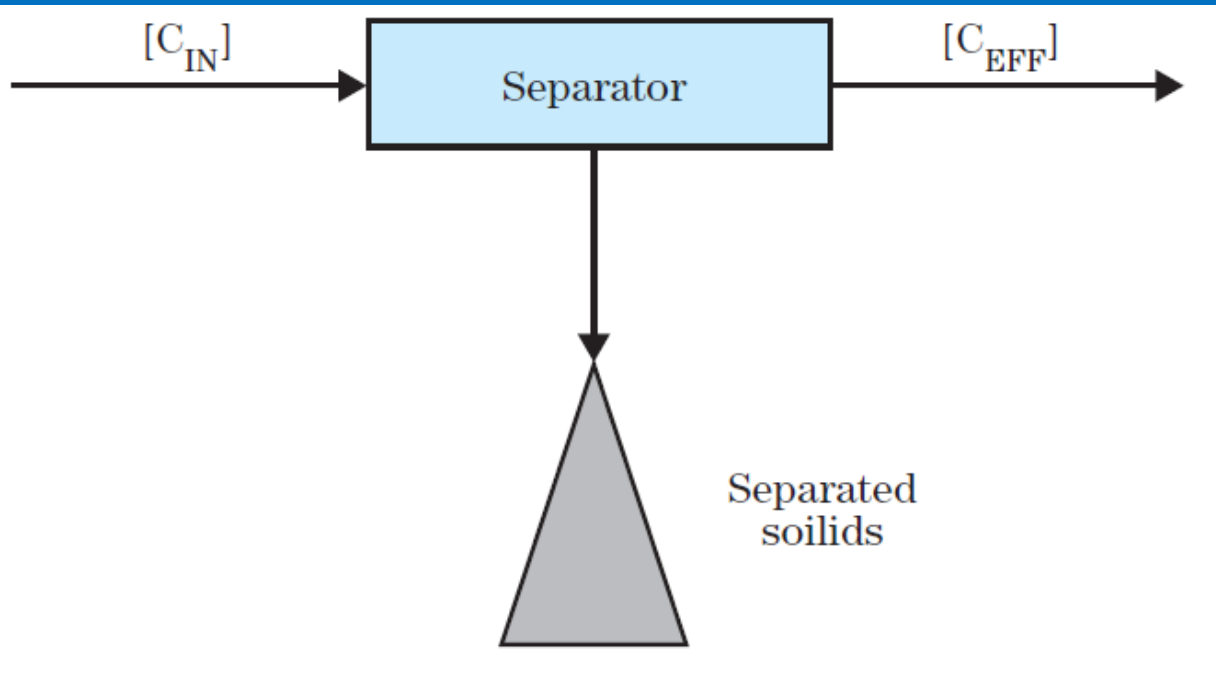
Document Contents

- Fundamentals
 - Screening
 - Settling
 - Hindered Settling
- System Performance
 - Concentration Reduction
 - Mass Removal





Concentration Reduction



Mass Removal

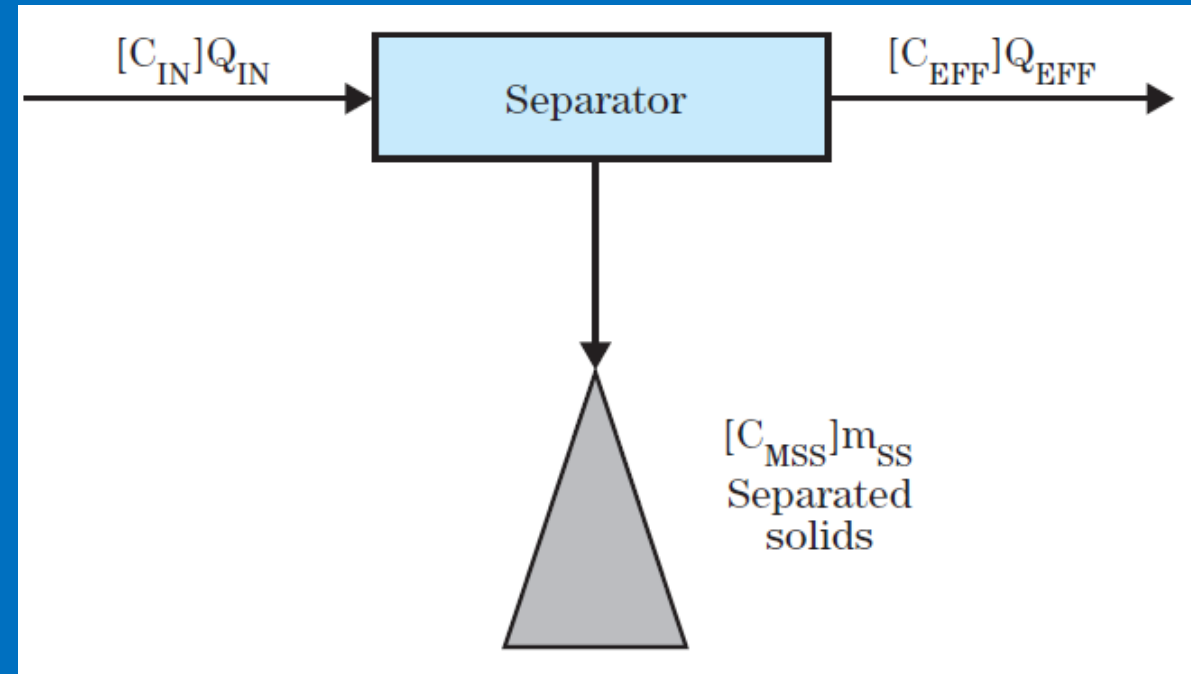




Table 4–14 Comparison of solids removed by the same brand of inclined screen separator on two dairies with different bedding practices, flush water sources and management

	South Carolina dairy ^{1/}	Missouri dairy ^{2/}
Screen size	0.060 in (1.5 mm)	0.060 in (1.5 mm)
Breed	Jersey	Holstein
Milk production level	High	Average
Alley flush water source	Fresh water from a pond	Recycled lagoon water
Bedding use	17.6 ft ³ /stall/week ^{3/} (shavings and sawdust)	Design value ≈ 1.4 ft ³ /stall/week ^{4/} (bedding type not reported)
Influent TS content	3.8%	Not reported, ≈ 2%
TS removed	60.9%	45.5%
Wet solids produced	51 lb/AU-day ^{5/}	23 lb/AU-day
Dry matter content of solids	20.3%	23.1%
Dry separated solids produced	10.4 lb DM/AU-day	5.3 lb DM/AU-day

1/ Chastain et al. (2001a)

2/ Fulhage and Hoehne (1998)

3/ Calculated from farm records

4/ Design value given by Bickert et al. (1995)

5/ AU = animal unit = 1,000 lb of average production live weight



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Table 4–15 Comparison of actual and theoretical removal of TS (TSR) for screens and presses treating swine manure

Type	Screen size (in)	Influent TS (%)	Actual TSR (%)	Theoretical TSR ^{1/} (%)	Entrainment factor ^{2/}	Reference
Incline static screen	0.0394	0.5	35	37	0.95	Shutt et al. (1975)
	0.0590	0.5	9	29	0.31	Shutt et al. (1975)
Vibrating screen	0.0041	2.9 ^{3/}	58 ^{3/}	56	1.04	Holmberg et al. (1983)
	0.0092		42 ^{3/}	50	0.84	
	0.0203		36 ^{3/}	45	0.80	
	0.0386		30 ^{3/}	37	0.81	
Belt press	0.0039	3.0	47	56	0.84	Fernandes et al. (1988)
		8.0	59	56	1.05	
Screw press	0.0098	0.89	13	49	0.27	Westerman and Arogo (2005)
	0.0197	5.5	18	45	0.40	Chastain et al. (2001b)

1/ Value from swine data given in figure 4–20

2/ See equation 4–2

3/ Mean values from cited study



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Table 4-16 Comparison of observed and theoretical removal of TS (TSR) for screens and presses treating dairy manure

Type	Screen size (in)	Influent TS (%)	Actual TSR (%)	Theoretical TSR ^{1/} (%)	Entrainment factor ^{2/}	Reference
Incline static screen	0.0219	2.8	68	42	1.62	AWMFH (2012)
	0.0591	NR	45	34	1.32	Fullhage and Hoehne (1998)
	0.0591	3.8	61	34	1.79 ^{3/}	Chastain et al. (2001a)
	0.0661	4.6	49	32	1.53	NRCS (1996)
	0.0787	2.2	26.9	30	0.90	Zhang et al. (2003)
Vibrating screen	0.0289	1.9	70	40	1.75	AWMFH (2012)
	0.0469	5.8	56	36	1.56	AWMFH (2012)
Screw press	0.0197	2.6	24.6	43	0.57	Converse et al. (2000)
	0.0295	10.0	50.5	40	1.26	Gooch et al. (2005)
	0.0940	4.9	33.1	25	1.32	Converse et al. (2000)

1/ Value from dairy data given in fig. 4-20

2/ See eq. 4-2

3/ Included large amounts of organic bedding.



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Document Contents

- High Rate Separation
 - Coagulants/flocculants
 - Final Treatment
- Other Separation Technologies
 - Sand Laden Manure
 - Weeping Walls
 - Geotextile
 - Belt Separation
 - Sand Bed Filtration





Table 4–38 Reduction in supernatant phosphorus concentrations following addition of hydrated lime milk solution to screened and unscreened milking center wastewater (adapted from Sheffield et al. 2010)

Type of dairy wastewater	Lime Milk Dose (% by Vol.)	Reduction in supernatant concentration as com- pared to control	
		TP (%)	Sol-P (%)
Screened milking center wastewater, [TS] = 1% to 2%	4.14	83	99.7
Unscreened milking center water, [TS] = 0.5% to 2.0%	5.0	78	63
Screened milking center wastewater + manure from a flushed feed alley, [TS] = 4.0% to 4.5%	10	66	66



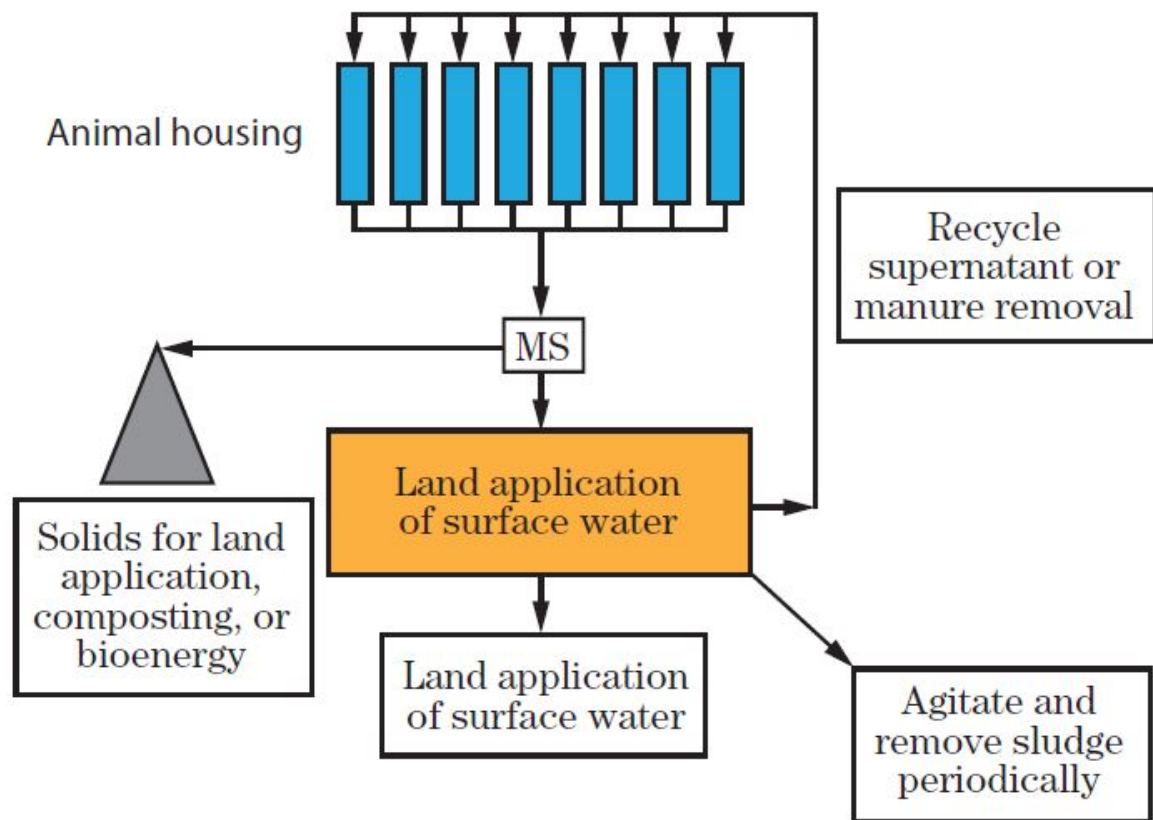
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Document Contents

- Design Consideration
 - Single Stage
 - Multiple Stage
- Cost-benefit Considerations
- Appendix
 - Demonstration Projects (FPPC)
 - Evaluation of Polymer Dosage
 - Additional Performance Data



Figure 4-69 Use of a mechanical separator (MS) to reduce the organic loading on a treatment lagoon to yield treated wastewater for manure removal





How to Find the Document

- Download document from the NRCS eDirectives web-site:
 - <https://directives.sc.egov.usda.gov/>
 - Select Handbooks
 - Select Title 210 – Engineering
 - Select National Engineering Handbook
 - Select Part 637 – Environmental Engineering
 - Select Chapter 4 – Solid-liquid Separation Alternatives for Manure Handling and Treatment





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United States Department of Agriculture

Part 637 Environmental Engineering
National Engineering Handbook

Chapter 4

**Solid-Liquid Separation
Alternatives for Manure
Handling and Treatment**



How to Use the Document

- Look for the pertinent sections in the document
- Review the parameters associated with the proposed technology or approach (know the assumptions)
- Example problems can help to understand concepts
- Separation efficiencies will be impacted by several factors ranging from animal type and age to operation and maintenance

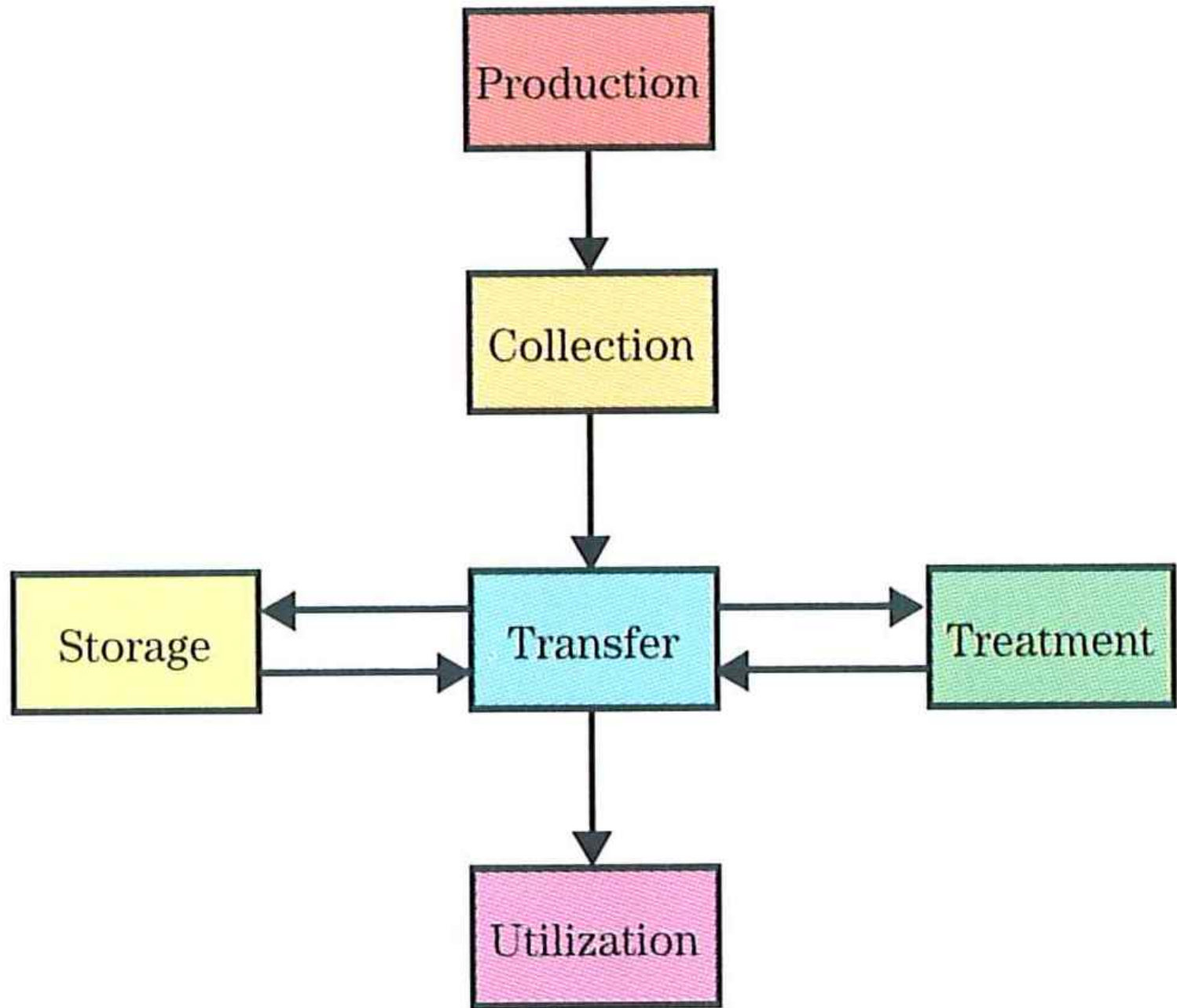
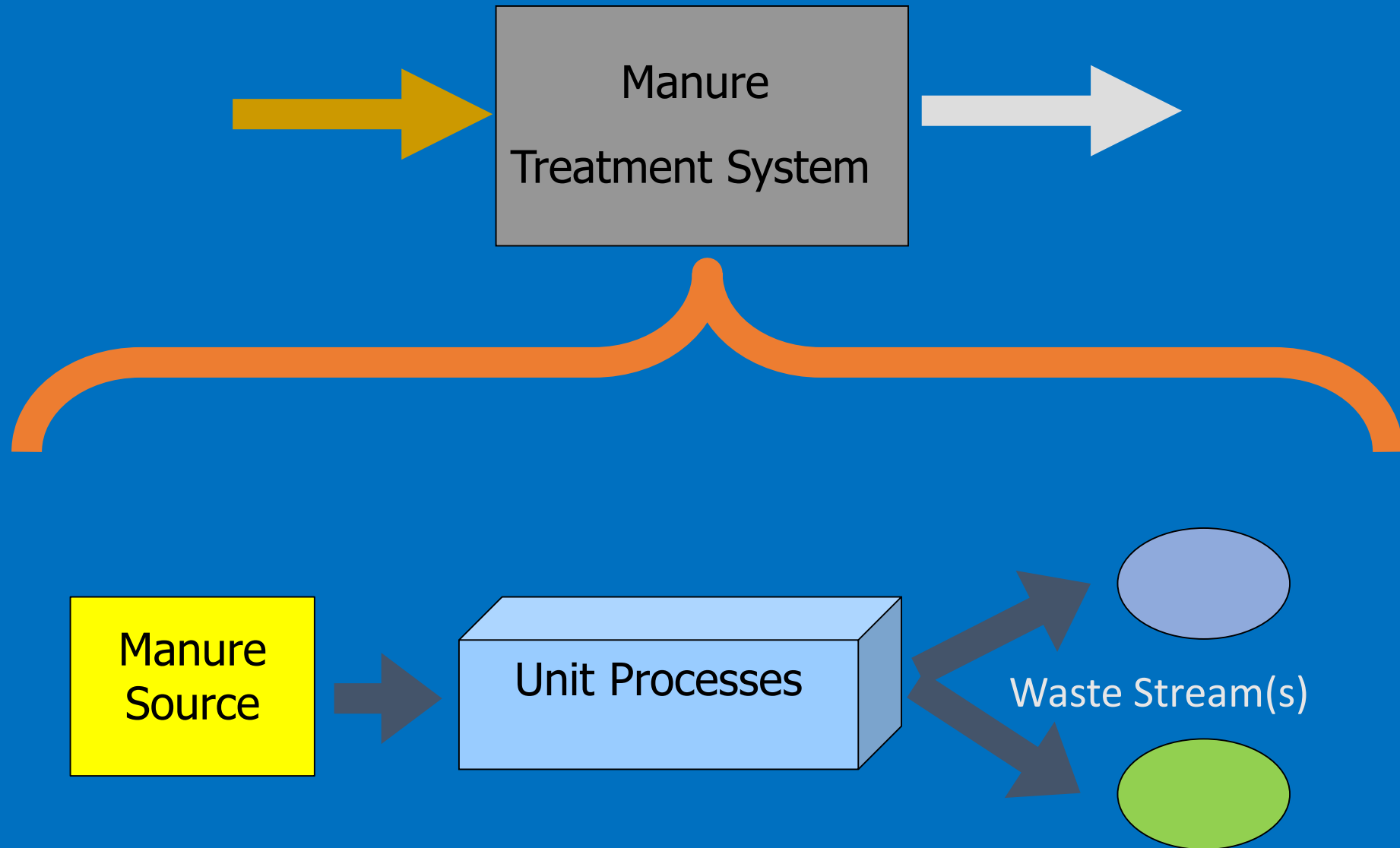


Diagram the System





Concentration Verses Mass Reduction

Table 4-28 Performance of a roller press treating scraped dairy manure, screen size unknown (data from Gooch et al. 2005)

$Q_{IN} = 5,386 \text{ gal/hr}$		$15,600 \text{ gal/day}$		$(Q_{EFF}/Q_{IN}) = 0.783$			Separated solids
$Q_{EFF} = 4,219 \text{ gal/hr}$		$12,200 \text{ gal/day}$					
Constituent	$[C_{IN}]$ lb/1,000 gal	$[C_{EFF}]$ lb/1,000 gal	CR_C %	$[C_{IN}] Q_{IN}$ lb/hr	$[C_{EFF}] Q_{EFF}$ lb/hr	MRE_C %	$[C_{MSS}]$ lb/ton
TS	859 (10.3%)	632 (7.58%)	26	4,626.6	2666.4	42.4	478 (23.9%)
VS	703	488	31	3,786.4	2058.9	45.6	438
TKN	34.4	33.3	3	185.3	140.5	24.2	8.56
TAN	16.0	15.9	5	86.2	64.1	25.6	2.75



Swine Operation

Finishing operation,
average animal weight 200
lbs. (8 buildings
approximately 700 animals
per building)

Buildings are flushed daily

Anaerobic Treatment
Lagoon is nearing capacity.

Landowner desires to
reduce loading to lagoon to
extend life of the system.

Current solids content of
flushed effluent is <1%

**What options are available
for waste separation?**

Table 4-1 Relative performance of major types of solid-liquid separators treating fresh animal manure

Type of separator	Total solids of influent manure (%)							
	≤ 1	2	3	4	5	6	8	10
Gravity settling	++++ ^{1/}	+++	++	+	NR ^{2/}	NR	NR	NR
Centrifuge	++++	++++	+++	+++	++	++	+	NR
Screen separators								
stationary	+	++	+++	++++	++++	NR	NR	NR
vibrating	+	++	+++	++++		NR	NR	NR
rotary	+	++	+++	++++	++++	NR	NR	NR
Press								
screw press	NR	NR	++	+++	+++	++++	++++	++++
belt press	NR	NR	++	+++	+++	++++	++++	++++

1/ The greater the number of plus signs, the more effective the separator will be for a given value of TS.

2/ NR = not recommended based on available data or no data exists in the literature.



Swine Operation

- Low solids and fiber content could limit the options for separation
- What percentage of solids removal is desired?
- Gravity settling or Centrifuge could be chosen as separation technologies
 - Cost/benefit, available separation area and desired moisture content of separated solids could further impact decision
- Chemical enhancements could be used to increase separation efficiency and impact the separation technology chosen

Dairy Operation

500 cow dairy

Has both freestall and bedded pack barns

Sand bedding is used in freestall barn

Building lanes are flushed twice a day at 3,000 gallons per flush (flow rate 3,000 gallons/min from barn)

Landowner desires to reuse sand to reduce operation costs and storage volume of holding pond

Size a sand lane for this operation?

Provided by Google Maps



Assumed Sand Lane Parameters

- Dilution ratio – at least 2:1 (4:1 or higher is better)
- Uniform sized sand
- Sand lane slope – 0.15 – 0.25%



Dairy Operation

- Flow rate from barn: (3,000 gallons/flush)
 - 3,000 gallons/minute = 401 cubic feet/minute)
- Contact time in settling lane:
 - 2 – 4 minutes (use 3 minutes)
 - $401 \text{ ft}^3/3 \text{ minutes} = 134 \text{ ft}^3/\text{min}$



Dairy Operation

- Calculate cross-sectional area
 - Sand settling velocity 1.5 ft/sec = 90 ft/min)
 - Area = (flow rate/settling velocity)
 - Area = $(134 \text{ ft}^3/\text{min}) / (90 \text{ ft}/\text{min}) = 1.5 \text{ ft}^2$



Dairy Operation

- Settling lane width and depth
 - Based on equipment size use a width of 12 feet
 - Depth = $1.5 \text{ ft}^2 / 12 \text{ ft} = 0.125 \text{ ft} = 1.5 \text{ inches}$
- Sand land length
 - Length = $3 \text{ min} \times 90 \text{ ft/min} = 270 \text{ feet}$
 - Distance to establish sheet flow is approximately 2 times the width (24 feet)
 - Use total length of 300 feet.



Dairy Operation

- Sand Removal Efficiency: 75 - 85 percent
- Sand recovery area is required for sand to be stored and dewatered
- Some manure solids and other material will remain in the sand
- Flush water quality can impact separation effectiveness
- Sand with excess solids can be moved to the upper end of the sand lane to remove additional solids



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The End



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