

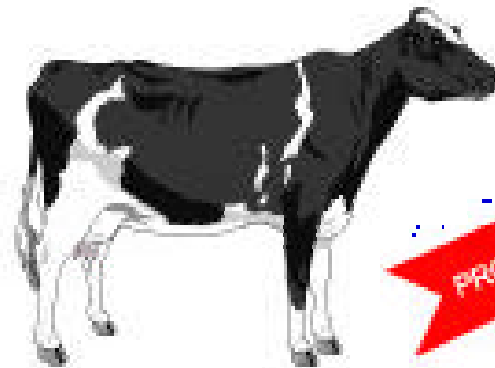
Plug Flow Digesters

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Anaerobic Digestion Systems

- ◆ **Biological**
- ◆ **Manure and Effluent Handling
Separation**
- ◆ **Gas Collection
Conditioning**
- ◆ **Engine**
- ◆ **Electric**
- ◆ **Heat**
- ◆ **Management**

Benefits

- ◆ Energy production
- ◆ Odor Reduction
 - Nutrient Management
- ◆ Solid Sales
 - Bedding use
- ◆ Liquefy Manure
- ◆ Integration with other enterprises

- ◆ Profit Center

Reasons to adopt Methane Generation in 1970s

- ◆ Energy prices went up and were expected to go higher
- ◆ Guaranteed price for electricity produced
- ◆ Technology was demonstrated successfully

Problems in 1970s

- ◆ Biological systems management on farms was primitive
- ◆ Peak energy demands on farm
- ◆ Few large farms
- ◆ High capital costs
- ◆ High maintenance costs
- ◆ Cows on pasture



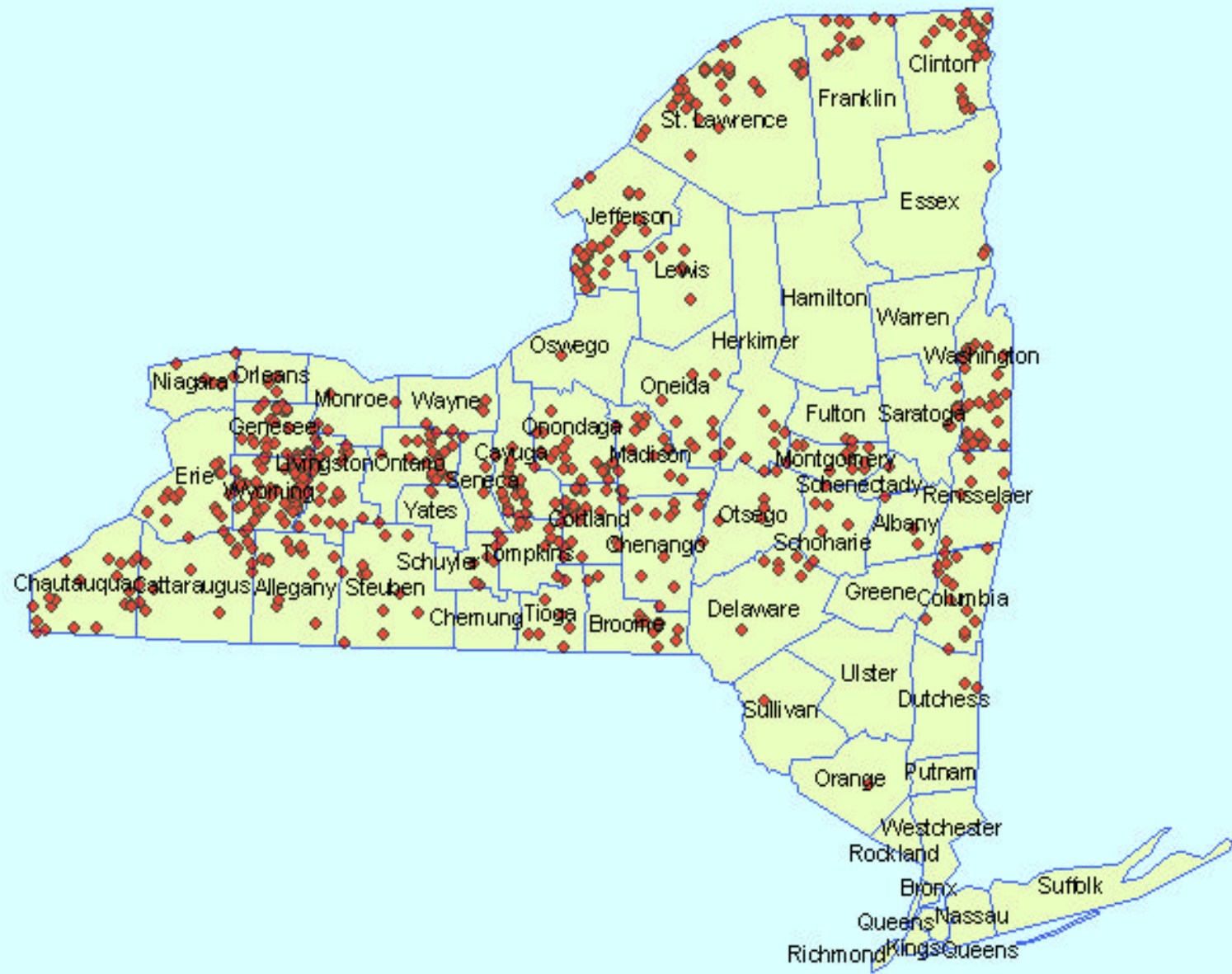


Reasons to adopt Methane Digestion in 2004

- ◆ Odor control is a real need
- ◆ More larger farms with economies of sale
- ◆ Management ability of biological systems on farms has increased
- ◆ Electric demand on some farms is continuous
- ◆ Liquid manure handling systems are more advanced
- ◆ Solid separation

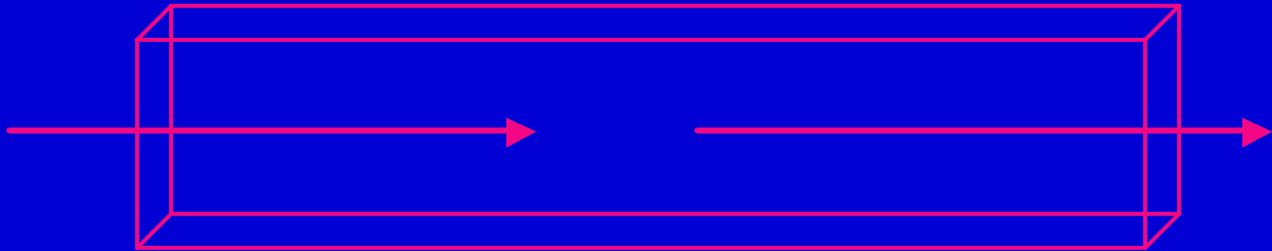
◆ Problems in 2004

- ◆ High capital costs
- ◆ Support industry not developed
- ◆ Wholesale electric price is low



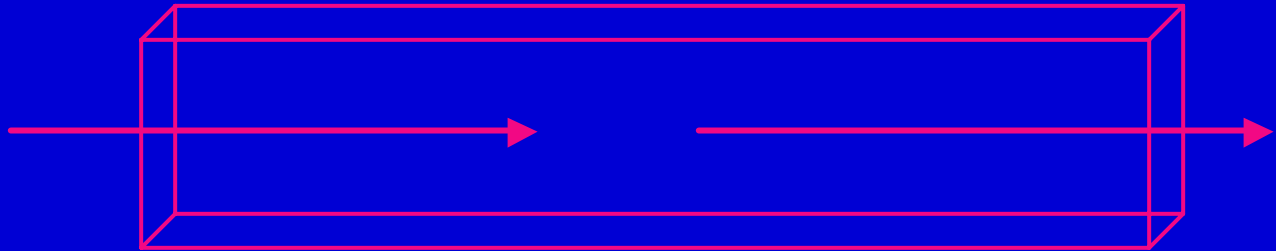
Plug Flow

- ◆ No “Mixing”
- ◆ Inflow = Outflow, $HRT=SRT$
- ◆ HRT 20-25 days



Plug Flow advantages

- ◆ Perfect for scraped dairy manure
- ◆ Many successful examples
- ◆ Slug loads?



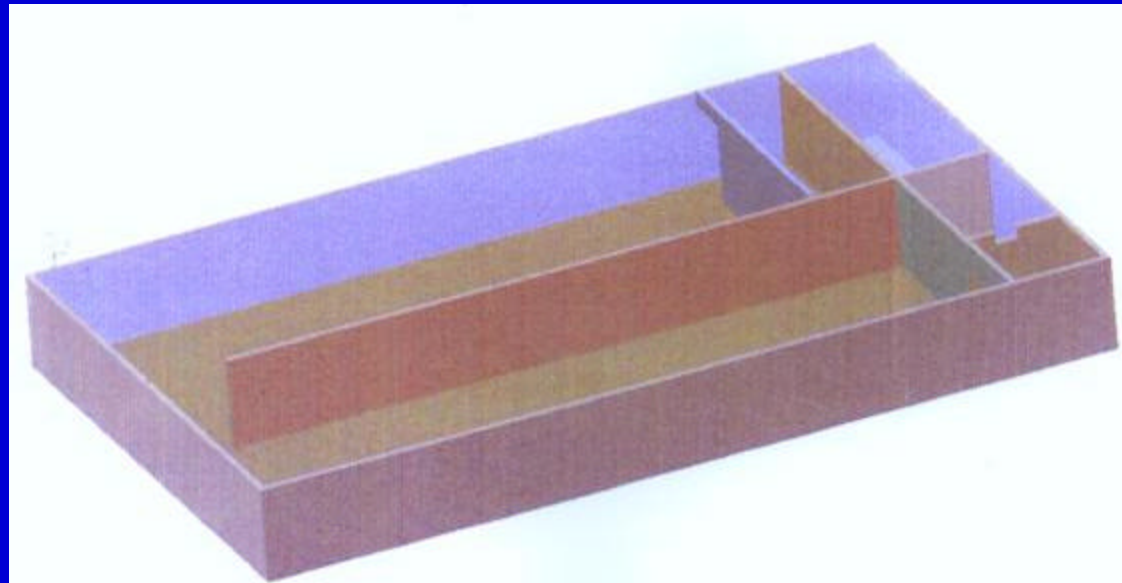
Plug Flow Disadvantages

- ◆ Total solids need to be close to 12%
- ◆ Short Circuiting



Plug flow

- ◆ **Vertical**
With Conical Bottom
Sand Laden Dairy Manure
- ◆ **U shaped**



Tops: Hard or Soft?

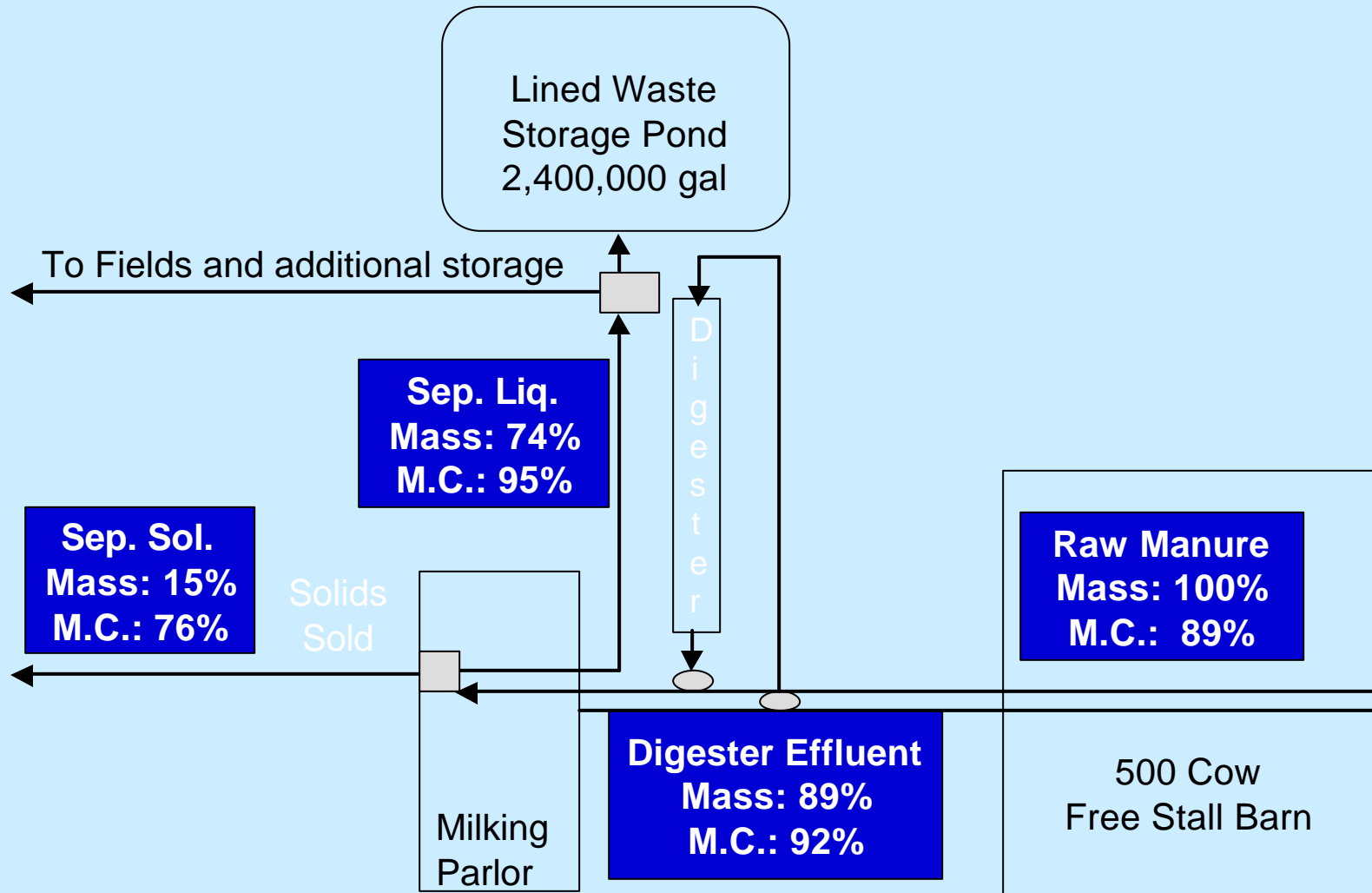
- ◆ **Soft**

 - Less cost, more storage, accessible**
 - Vandals, collapsable, life**

- ◆ **Hard**

 - Long life, Insulated, Pressurized**
 - Cost, inaccessible, sealing**

Farm A Anaerobic Digestion

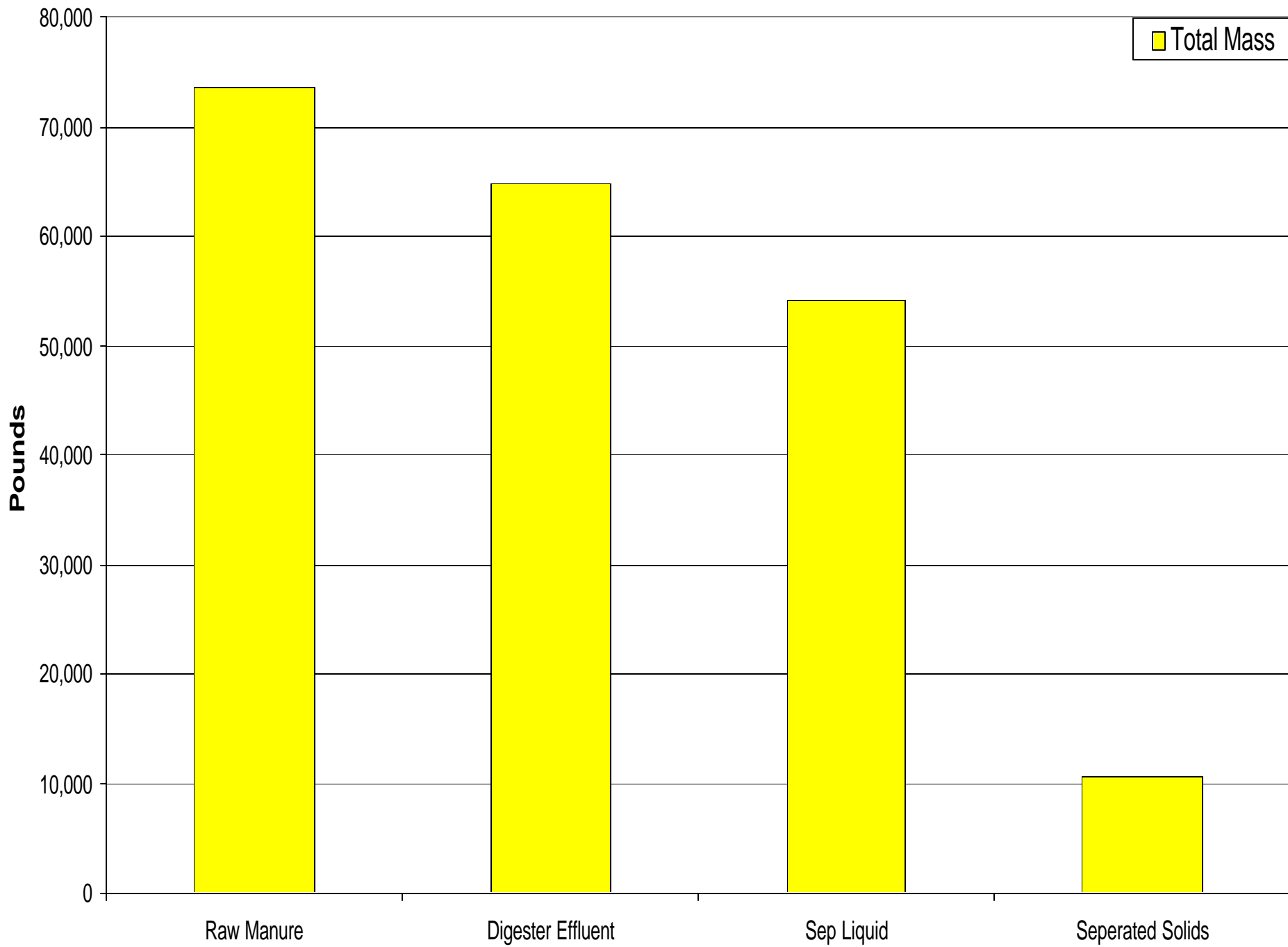


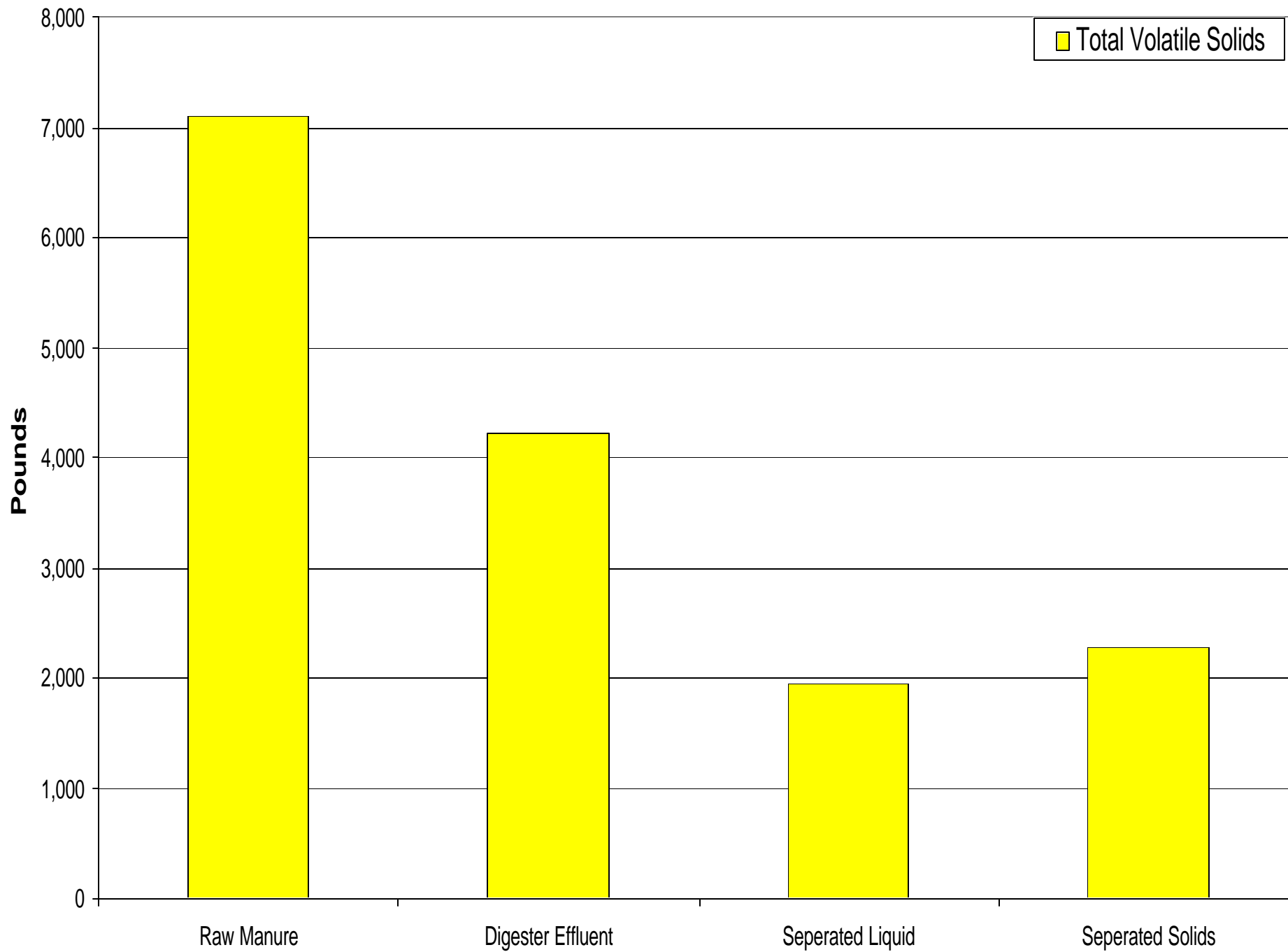




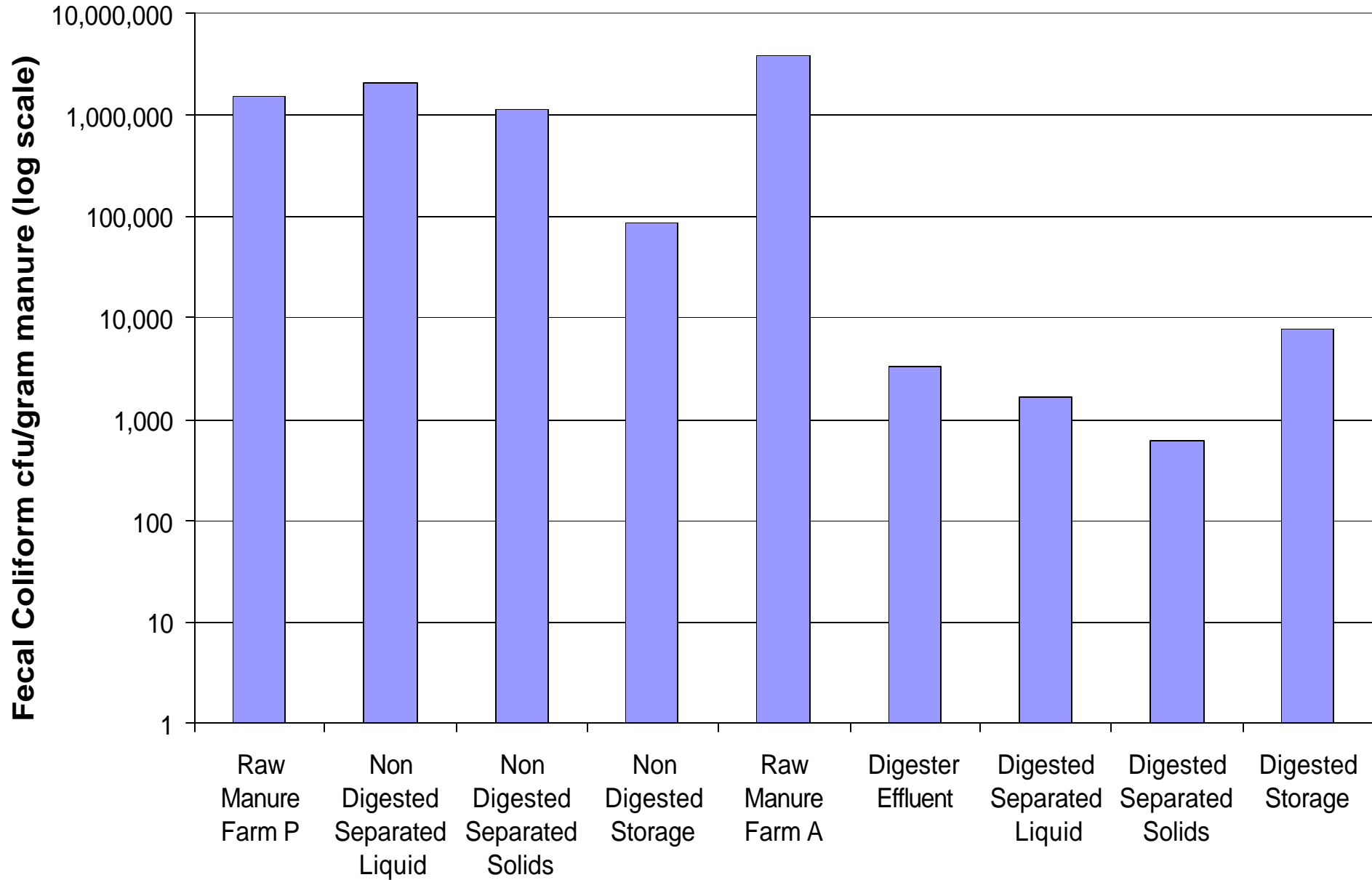






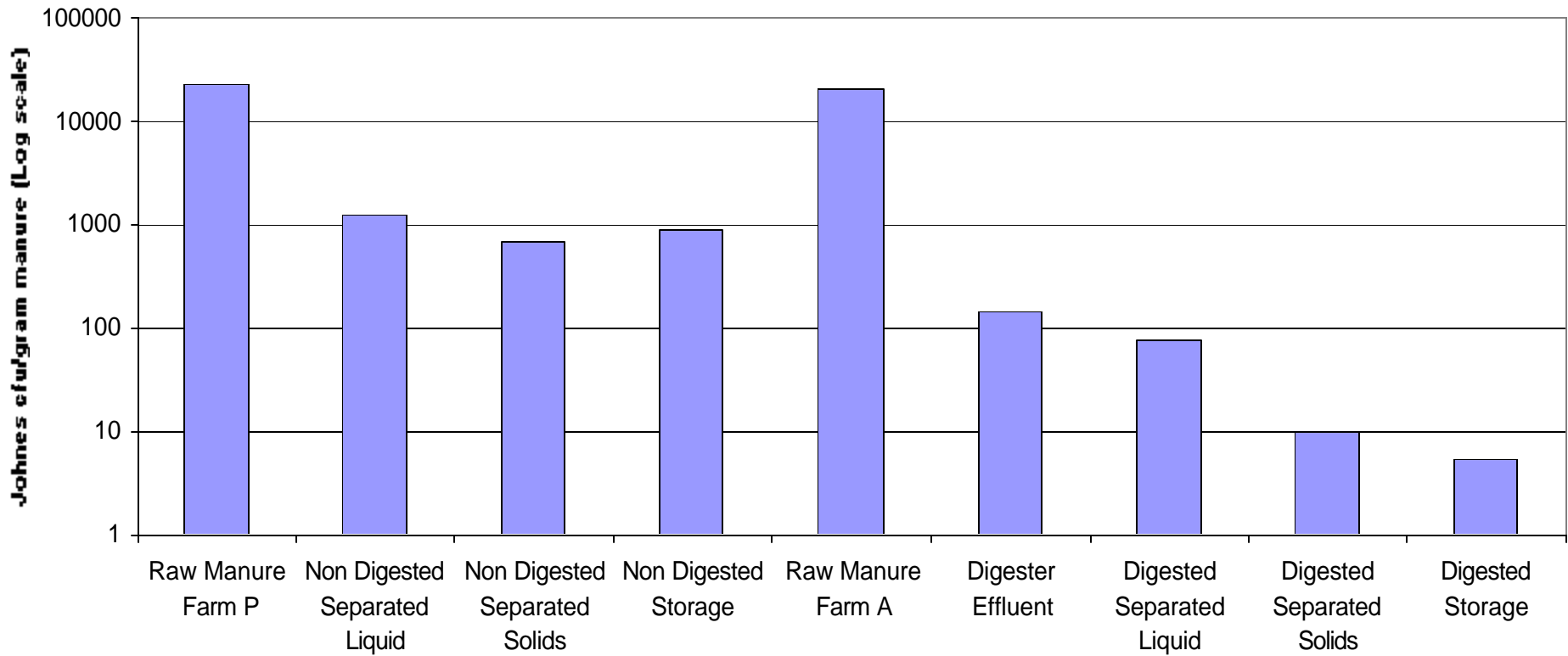


Fecal Coliform data for digested and non-digested dairy manure



Johnes

Johnes content in separated digested manure vs separated non-digested manure



Component	\$
Digester - manure pump (20 Hp) - engineering design - concrete digester (incl. floating insulation, gas containing cover, 2 hot water heating circuits) <i>subtotal</i>	 9,000 20,000 160,000 189,000
Energy conversion - engine generator (used) & switching equipment - rebuild the engine - rebuild the generator - plumbing, electric, and mechanical systems - run cable to utility hook-up - electrical engineer consultant <i>subtotal</i>	 15,000 2,000 9,000 9,000 8,000 18,000 61,000
Solids separation - effluent pump (7.5 Hp) & variable speed drive - separation equipment - building for separator equipment <i>subtotal</i>	 3,000 25,000 25,000 53,000
Liquid waste storage lagoon - lagoon (excavation, fence, pipe, outlet structure) - plastic liner <i>subtotal</i>	 18,000 42,000 60,000
TOTAL	363,000

Contact Information

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MANURE DOESN'T SMELL
IT STINKS
MAR 9

PUT IT IN
YOUR OWN
BACKYARD



Digesters Influence Barn Design

No Sand

No Flushing





Limited Water Use is Paramount

Dairy Development International, LLC

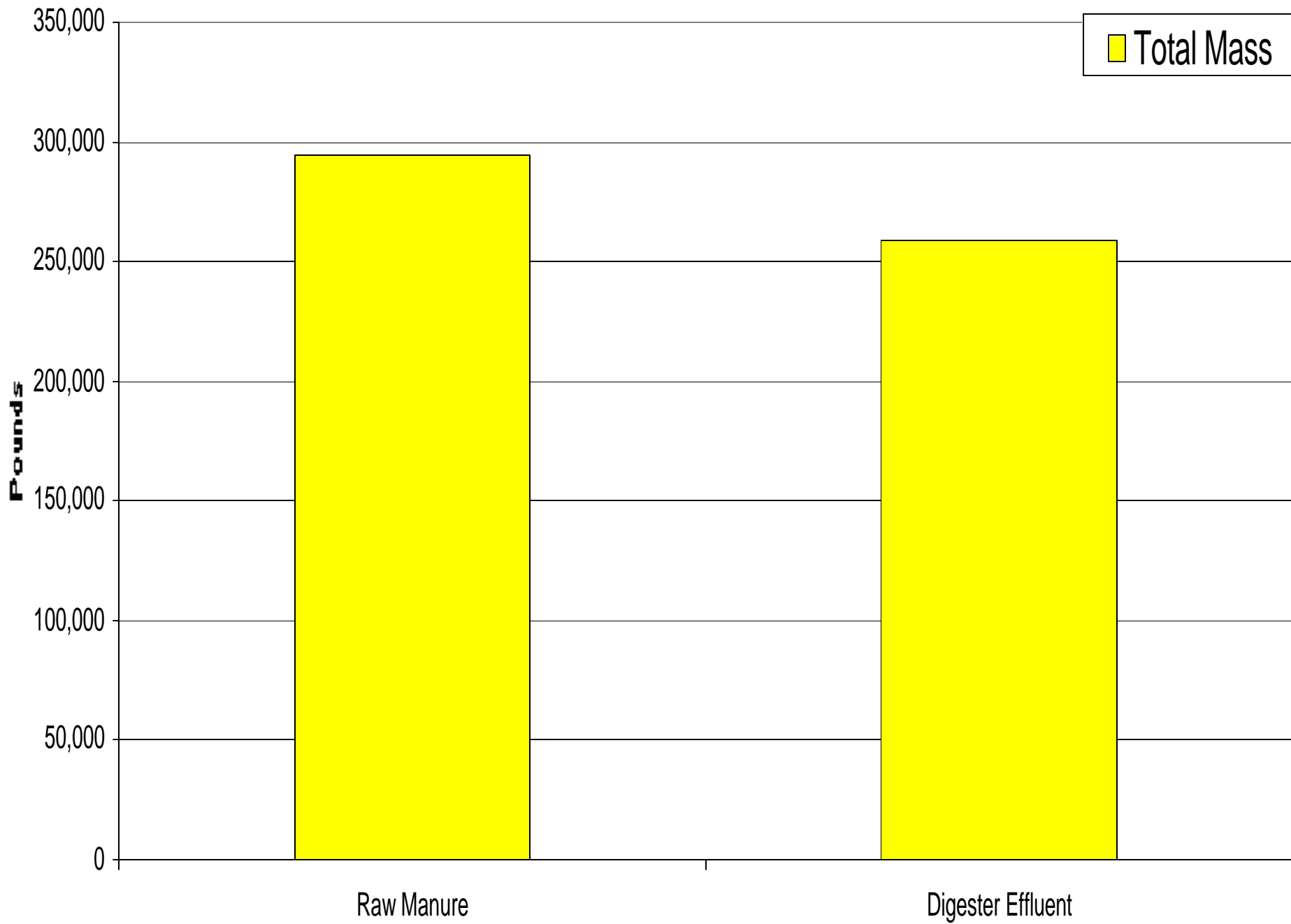


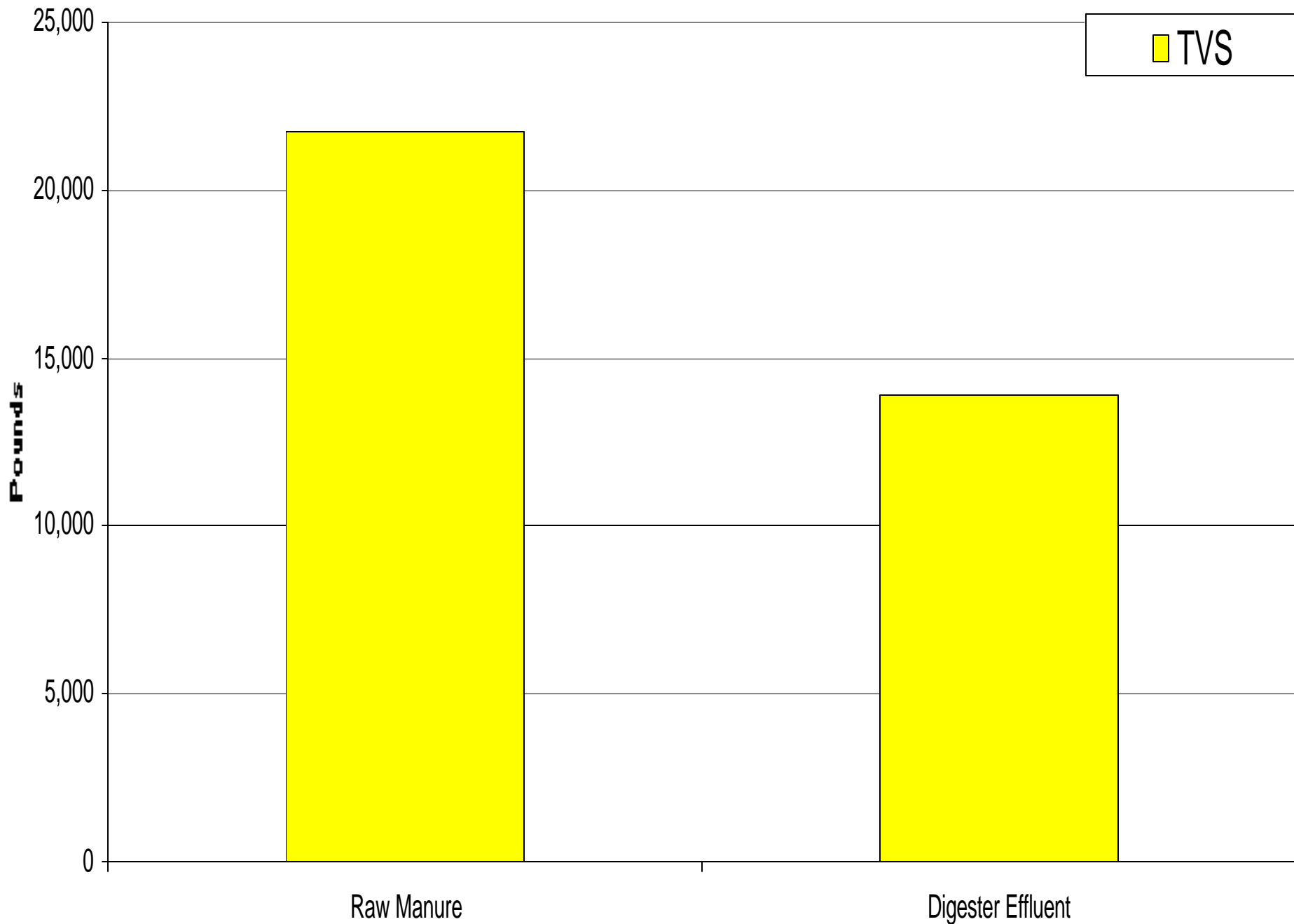
Lawrence R. Jones, Ph.D.
General/Farm Manager

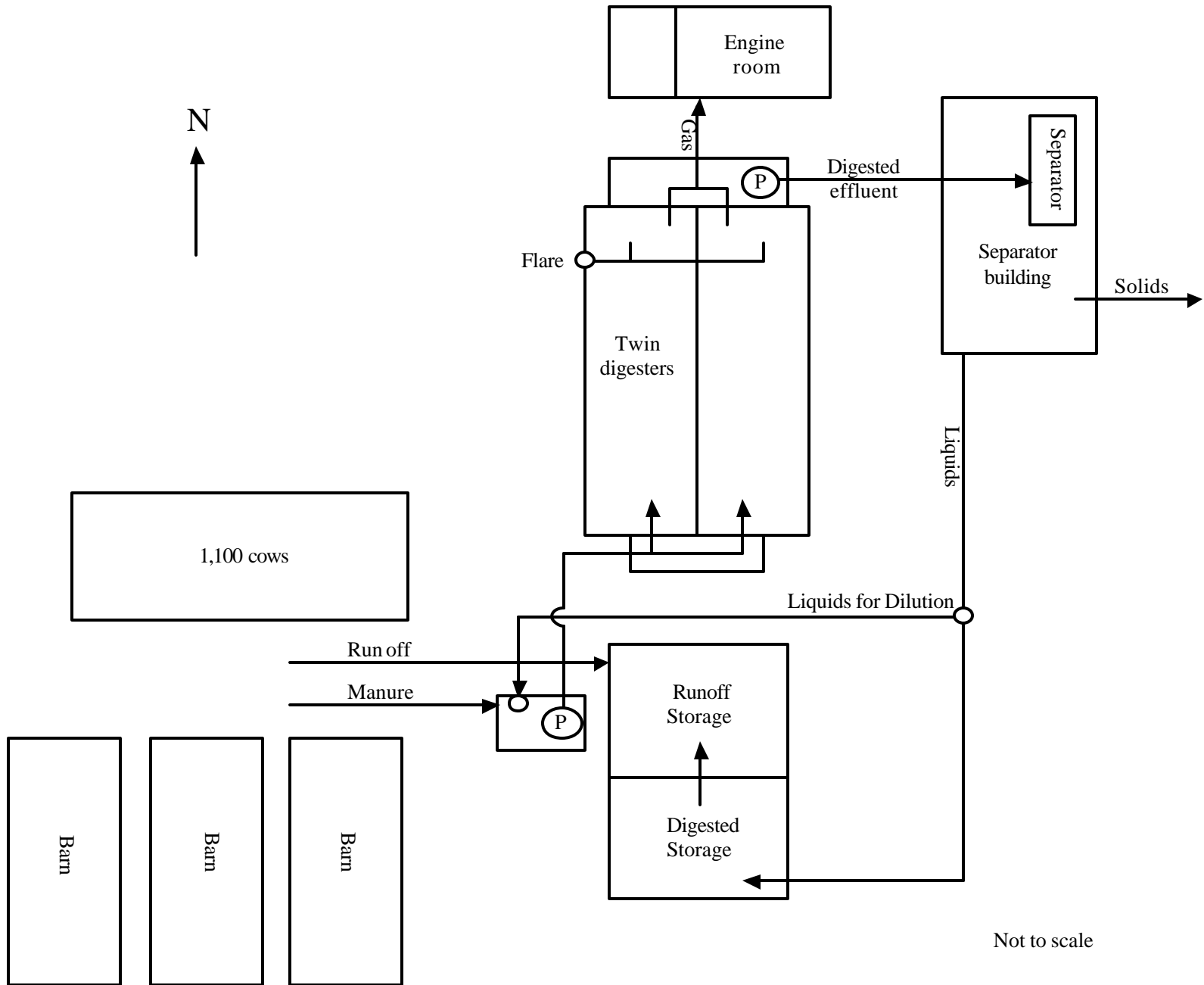
Dairy Development International

- ◆ Low electric price
- ◆ Odor control needed
- ◆ Natural gas vs. bio gas microturbines
- ◆ Heated floor
- ◆ Excess liquids
- ◆ Heating system
- ◆ Temperature control
 - Groundwater
 - Thermometers off
 - Vapor lock
- ◆ Micro turbines for natural gas
- ◆ foam

	Items	Costs/Benefits
Capital Costs	Digester	\$350,000
	Electrical and Heating Systems	
	- Microturbines	\$185,000
	- Boiler and Piping	\$50,000
	Subtotal	\$235,000
	Solids and Liquids Separation	
	- Separator	\$46,613
	- Separator Building	\$42,387
	Subtotal	\$89,000
	Liquid Storage	\$315,000
	Others	\$43,800
	Total Capital Cost	\$1,032,800
	Total Annual Capital Cost	\$71,895
Annual Operating Costs	Maintenance, Repairs, Insurance	\$29,619
	Spreading	\$58,000
	Management	\$6,370
	Total Annual Operating Cost	\$93,989
Annual Benefits Including	Electric Savings	\$42,400
	Heat Savings	\$6,000
	Odor Control	\$15,000
	Solids	\$12,000
	Nutrients	\$45,000
	Total Annual Benefits	\$120,400
Annual Cost Per Cow (\$/cow/year)		\$53.51







Not to scale

Noblehurst Digester Top Being Installed

24' X 4' Precast H.C. Planks

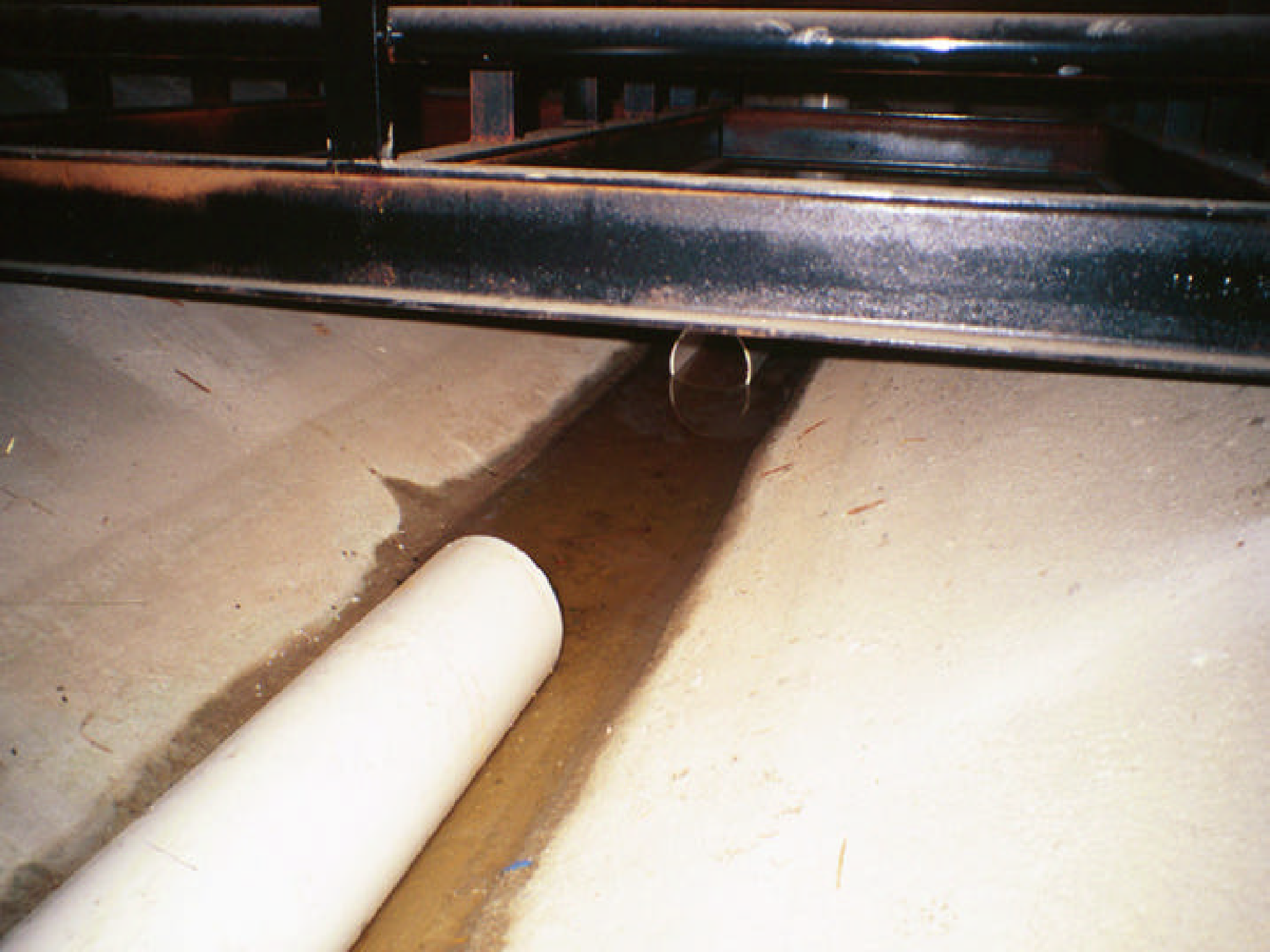


Later topped with 4" of structural concrete



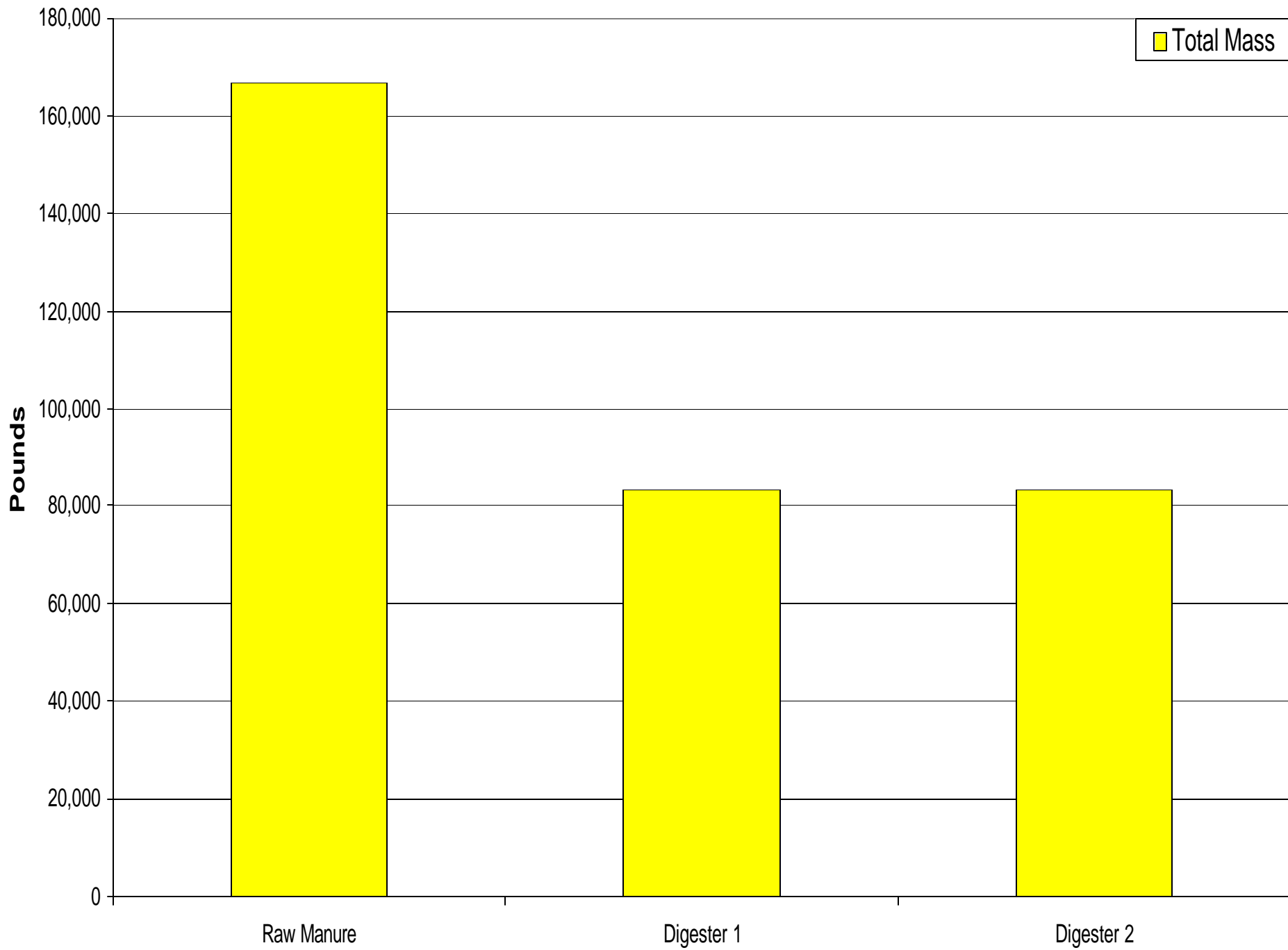
Note heat exchanger and grit-pit.



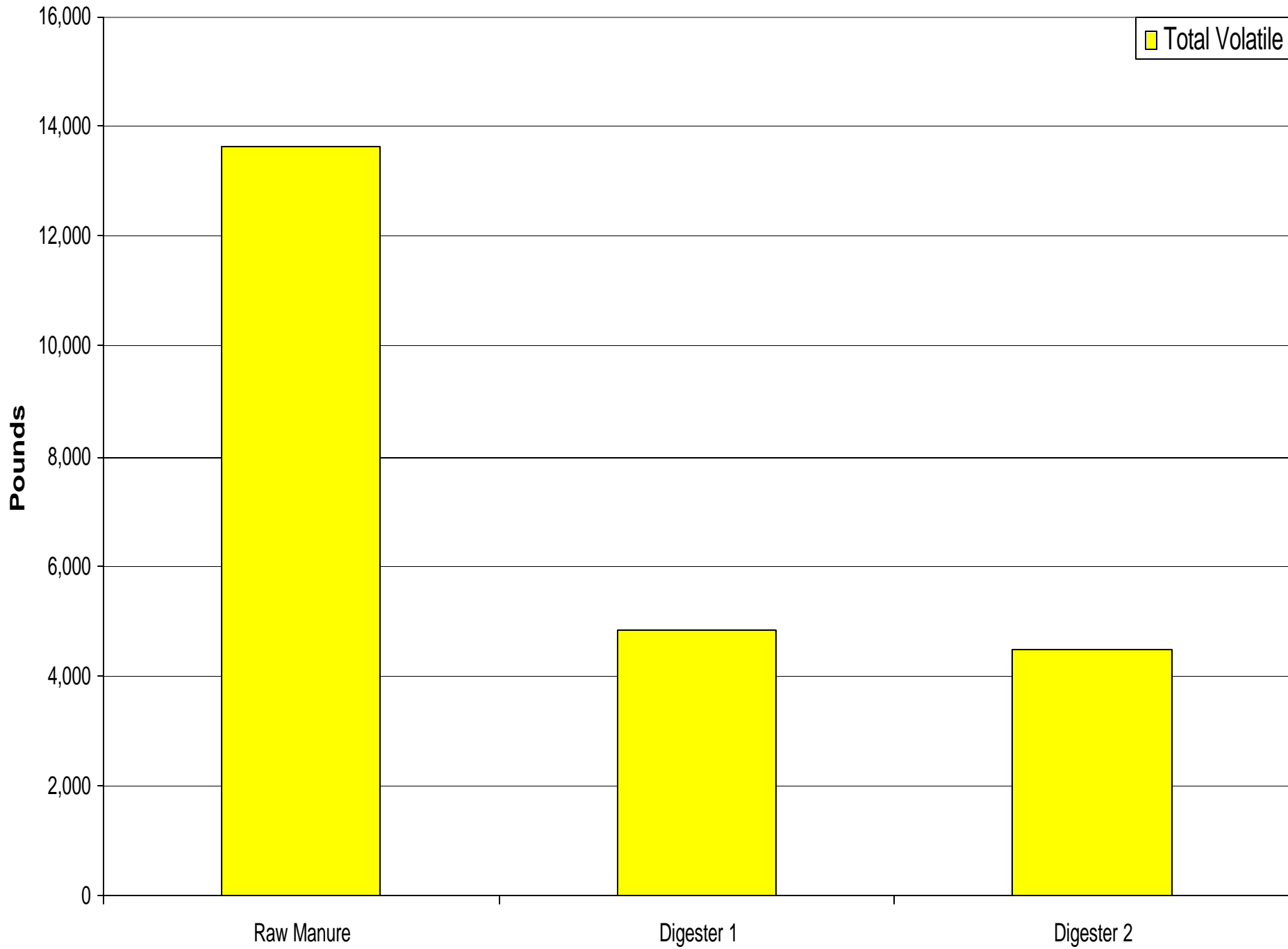


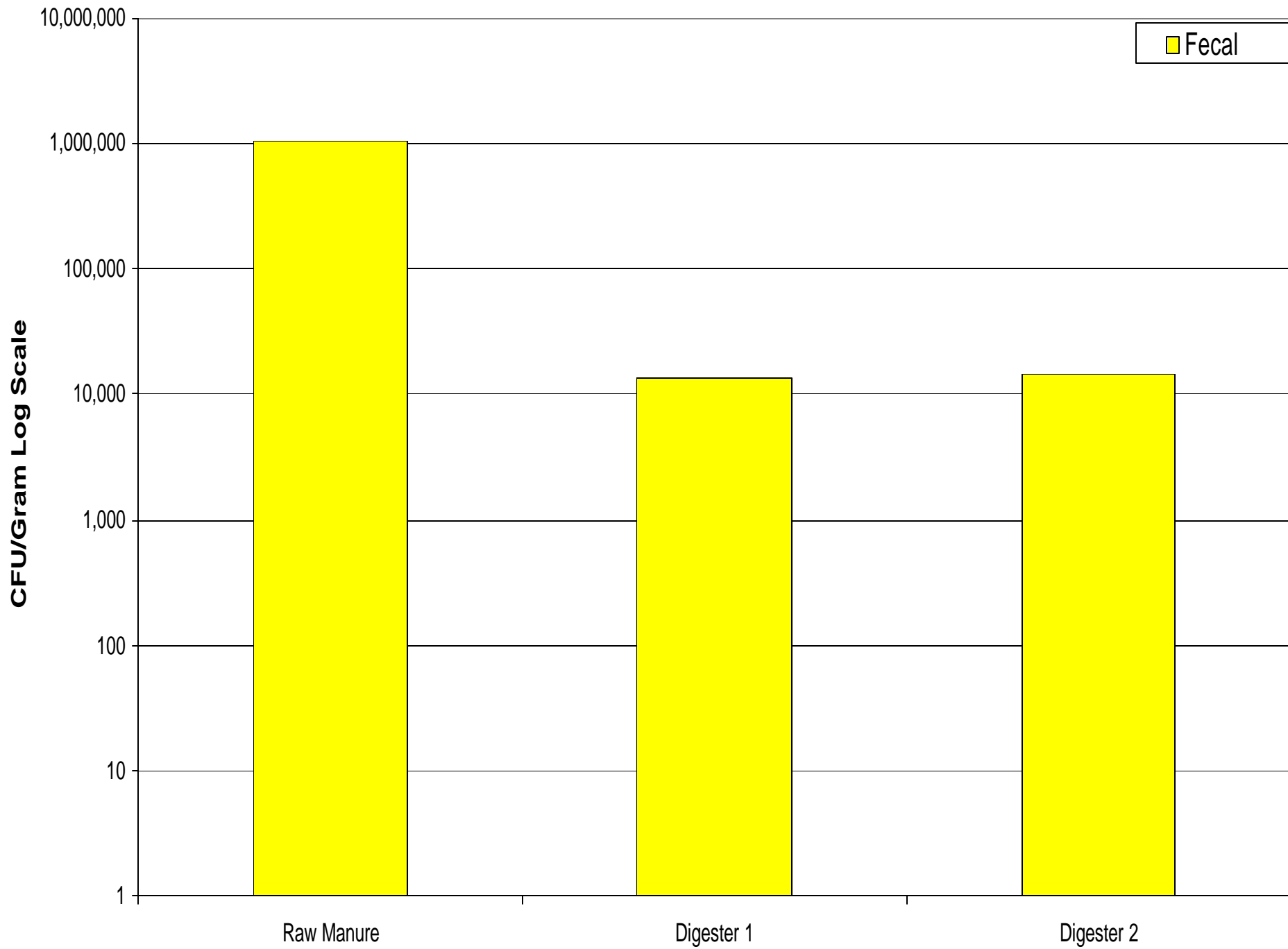






	Items	Cost/Benefit	
	Digester	*	
Capital Costs	- Digester Construction and Materials	\$250,000	
	- Cover for digester	\$60,000	
	- Engine Generator Set	\$310,000	
	- Engine Generator	\$241,000	
	- Switching Equipment	\$18,000	
	- Engine Building	\$43,500	
	Subtotal	\$302,500	
	- Manure Storage	\$60,000	
	Solids and Liquids Separation		
	- Separator	\$26,000	
	- Separator Building	\$35,000	
Subtotal	\$61,000		
	Others (flare, pumps)	\$14,200	
	Total Capital Cost	\$747,700	
	Total Capital Cost per cow	\$680	
	Total Annual Capital Cost	\$68,522	
Annual Operating Costs	Maintenance, Repairs, Labor, Fuel, Insurance, etc.	\$37,675	
	Manure Spreading Cost (@0.005/gallon)	\$51,000	
	Electricity Savings and Sales (projected)	-\$60,000	
Annual Benefits	Heating Fuel Savings (projected)	-\$6,000	
	Compost sale (projected sales @ net \$2/cubic yard)	-\$11,680	
	Odor Control (@\$9/cow/year)	-\$9,900	
	Total Annual Benefits	-\$77,680	
	Annual Net Cost Per Cow (\$/cow/year)	\$50 **	
Note: * - The operating costs (maintenance and repairs) and revenues are projected numbers as of November 1, 2003. An updated analysis will be provided with real data once the system is operated for one year.			
** - Manure management without digester and solids separator would cost \$50/cow.			





Digester Reductions (%)

Characteristic	AA	DDI	Nobles
Fecal Coliform	99.9	99.3	98.7
Johnes	99.3	98.7	

Digester Reductions (%)

Characteristic	AA	DDI	Nobles
Total Solids	27.5	23.5	24.5
Volatile Solids	32.3	23.5	31.7
Volatile Acids	85.7	56.3	85
COD	30.5	8.1	22.5

Digester Reductions (%)

Characteristic	AA	DDI	Nobles
NH3	-37	-28	-27
Ortho-P	-16.7	-14.4	-44

Conclusions:

- ◆ **Alternative Systems depend on farm situation**
- ◆ **Maximize By-Product Use**
Maximize Profits
- ◆ **Integrate with other enterprises**
- ◆ **More Research is Needed**