Milk House Wastewater
Irrigation System Design

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Design Objectives
- Daily application of wastewater to minimize storage requirements
- Utilize nutrients

Irrigation
- Spray wastewater on cropland or pasture throughout the year
- Infiltration area size based on agronomic rates

- Installed on slopes up to 15%
- Sized on crop nutrient removal
- Requires 150 to 800 square feet per cow

Schematic of Systems

Design Steps
- Septic Tanks sizing
- Sizing of irrigation area
- Determining # of zones and irrigation heads
- Pump sizing
Septic Tanks
- Maximum of 3-day Hydraulic Retention Time (HRT), bulk tank size or 1000 gallons
- Removes some solids and fats
- Longer HRT may create odor problems

Farm Example #1
- 60 cow dairy
- 5 gallons per cow per day
- 300 gpd
- 3-day HRT = 900 gallons
- Bulk tank = 800 gallons
- Minimum size is 1000 gallons
- Choose maximum ~ 1000 gallon tank

Pump tank
- Pump tank is in addition to septic tank volume.
- Maximum of 1-day HRT or 500 gal.
- For our example use 500 gallons.

Application Area Selection
- Cropland with slopes less than ~3%??
- Pasture or well vegetated areas with slopes up to 15%
- Avoid spraying into the trees (e.g. along fence lines)
- Avoid application to alfalfa

Wastewater Characteristics

<table>
<thead>
<tr>
<th>TABLE 1. Milk house wastewater characteristics*</th>
<th>Virgin Tank mg/l (lb/1000 gal)</th>
<th>Second Tank mg/l (lb/1000 gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>125</td>
<td>75</td>
</tr>
<tr>
<td>TSS</td>
<td>95</td>
<td>40</td>
</tr>
<tr>
<td>Total Oils and Grease</td>
<td>175</td>
<td>110</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>65 (3.54)</td>
<td>55 (1.40)</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>55 (0.40)</td>
<td></td>
</tr>
</tbody>
</table>

*Average values based on 3 gal per cow per day from established dairy farm in the University of Minnesota.

~0.8 lb P per cow per year
~1 lb Total N per cow per year

Sizing for N or P?
- For areas with runoff potential (erosion) size based on P removal otherwise use N removal or utilization
- Approximately 1 lb of total N produced per cow per year
- Estimate 40% availability or about 0.4 lbs N per cow per year
Crop Requirements
- UMN Publication BU-06240
- Table 4 in Design Guide
- Think “crop rotation” and “nutrient removal” base on N or P

Area based on N
\[ A_N = \frac{0.4 \, \text{lbs} \, N \, \text{cow-yr} \times 43,560 \, \text{ft}^2 \, \text{acres} \times \# \, \text{cows}}{F_N} = \frac{17,000 \times \# \, \text{cows}}{F_N} \]

- \( A_N \) = Acres required based on N requirements
- \( F_N \) = Annual fertilizer utilization in lbs/acre

Case Farm #1 based on N
- Cropland in Summer (7 months)
  - Corn (150 bu/acre) and soybean rotation (45 bu/acre)
  - 150 bu/acre x 0.8 lbs/bu = 120 lbs/acre
  - 45 bu/acre x 3.5 = 157 lbs/acre
  - Average of 138 lbs/acre
- Pasture in winter (5 months)
  - 3.5 tons per acre estimated yield
  - 27 lbs/ton of N removed or 95 lbs per acre

Calculation
- If all cropland
  \[ A_N = \frac{17,000 \times \# \, \text{cows}}{F_N} = \frac{17,000 \times 60}{138} = 7400 \, \text{ft}^2 \]
- If all pasture
  \[ A_N = \frac{17,000 \times \# \, \text{cows}}{F_N} = \frac{17,000 \times 60}{95} = 10,900 \, \text{ft}^2 \]

Irrigation Zones
- Minimum of two application zones
  - Winter versus summer
  - Drying before crop harvest
  - Drying before grazing

Impact Heads
- Used in summer only
- 150’ diameter spray
- Option of part circle
- ½ inch orifice

Impact Heads
- Full Circle
- Part Circle

Brass ball valves in bottom of manhole
Wobbler Heads
- Winter or Summer application
- 50’ diameter circular spray pattern
- 9/32” orifice

Zone Sizing
- Fraction of annual wastewater application applied so area must be reduced accordingly to meet crop uptake
- So if applying to cropland 7 months of the year the cropland area would be 7/12 of the total cropland area calculated with annual application

Case Farm #1
- Summer
  - Cropland 7,400 ft² x 7/12 = 4400 ft²
- Winter
  - Pasture 10,900 ft² x 5/12 = 4500 ft²

Effective Area Calculation
\[ EAA = [(N_L - 1) \times S_L + D] \times [(N_W - 1) \times S_W + D] \]
- \( EAA \) = Effective Application Area
- \( N_L \) = Number of heads along length
- \( N_W \) = Number of heads along width
- \( D \) = Diameter of spray pattern
- \( S_L \) = Spacing along length
- \( S_W \) = Spacing along width

Use maximum spacing of 70% of diameter

Case Farm #1 Winter Layout
- 4500 ft² minimum
- Wobbler heads @ 55 ft diameter
- Trial and Error with Calculations
  - Spacing of 30 feet
  - 1 Head = 2400 ft²
  - 1 row of 2 heads =

\[ EAA = [(30 - 1) \times 30 + 55] \times [(30 - 1) \times 30 + 55] = 4675 \text{ ft}^2 \]

Note: Why is this different than Table 5?
Because...

37 foot spacing

30 foot spacing

Case Farm #1 Summer

- 4400 ft² required
- Impact head @ 135 ft diameter
- Table 5 in Design Guide
- Trial and Error with EAA Calculations
  - 1 Head = 14,300 ft² (full circle)
  - 1 Head = 7,150 ft² (half circle)
- Caution: Do not use EAA equation with one head

Pump Sizing

- Pump sized according to system flow rate and pressure
- Pump located in pump tank sized for a minimum of one day of wastewater flow
- High Head Effluent Pump

Pump Sizing: Flow rate

- Flow rate (gpm) is a function of the number of heads in any zone and the system pressure

<table>
<thead>
<tr>
<th>psi</th>
<th>gpm 25</th>
<th>gpm 30</th>
<th>gpm 35</th>
<th>gpm 40</th>
<th>gpm 45</th>
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</thead>
<tbody>
<tr>
<td>psi</td>
<td>33.8</td>
<td>37</td>
<td>40.1</td>
<td>42.9</td>
<td>45.6</td>
</tr>
<tr>
<td>dia (ft h)</td>
<td>120</td>
<td>134</td>
<td>142</td>
<td>150</td>
<td>154</td>
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System flow rate is sum of all flows per head in a single irrigation zone . . .

Pump Sizing: Pressure

- Function of
  - Flow rate
  - Pipe Diameter
- Use Table 3 in Design Guide

Pressure: Pipe Friction

Friction loss in pipe

Pressure to spray effluent

Elevation
### Pressure: Irrigation Heads
- Pressure (psi) is required to get effluent to spray from heads.
- Function of type of head and flow rate

#### Typical Impact Head Characteristics

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System pressure is constant in system **NOT** additive with # of heads.

### Case Farm #1 Winter Pressure
- Assume:
  - Wobbler head 15 psi and 8.8 gpm
  - 2 heads is flow of ~18 gpm
  - Set at 6 ft

- Elevation
  - 20 ft (14 + 6)
- Friction
  - 300 ft of 2 inch pipe at 18 gpm = 2.2 ft
- Irrigation Head requirement
  - 15 psi or 34.5 ft (conversion factor of 2.3)
- Total pressure = 20 + 2.2 + 34.5 = 57 ft

Manufacture specs found in Table 6.

### Summer Pressure
- Assume:
  - Impact head 30 psi and 34 gpm
  - 1 head is flow of ~37 gpm
  - Set at 6 ft
- Elevation
  - 20 ft (14 + 6)
- Friction
  - 300 ft of 2 inch pipe at 37 gpm = 8 ft
- Irrigation head requirement
  - 30 psi or 69 ft (conversion factor of 2.3)
- Total pressure = 20 + 8 + 69 = 97 ft

Manufacture specs found in Table 6.

### Pump Summary
- Winter
  - Flow rate = 18 gpm
  - Total Pressure = 57 ft
- Summer
  - Flow rate = 37 gpm
  - Total Pressure = 97 ft

### Pump Curve Charts

![Pump Curve Chart](chart.png)

### Control Valves
- Installed in insulated manholes
- Ball valves
  - Brass have been successful
  - Some plastic are being tried
- Convenient locations for access throughout the year
Controlling the Zones

- Zone 1
- Zone 2

Manhole with control valves at convenient location

Valve Box Rodent Protection

Home sweet Home!!

Gravel around manhole

Installation

- Same as with Bark Beds
  - Drainback of all pipes (1% finished slope)
  - Good pipe connections
- Valve box installed with rock perimeter to prevent rodents

Other Design Considerations

- Potential for odor concerns during application time
  - Timer on irrigation pump
  - Floats combined with 24 hour timer so application can is done at a consistent time each day