Caution Advisory for Application of *Guidelines for Sizing Irrigation Systems for Nutrient Management* dated March 2010 by Eric Swenson, P.E.:

These guidelines describe approaches and design guidance for the installation of distributed lagoon (manure) water distribution piping to effectively deliver controlled amounts of nutrients to various fields within a medium to large farming operation associated with the operation of a dairy.

These guidelines have been developed based upon my personal experience as a design professional working in this field since approximately 1998 including two years as a technical advisor for the University of California (UC) Agricultural Extension from April 2003 through April 2005. Each dairy site typically requires a customized approach to create the optimal design to best perform the intended service for a reasonable construction cost and long term operating expense.

Certified Crop Advisors, Agronomists, and irrigation system design professionals should all be utilized to create a final system design. The Guidelines contained in the attached document can be utilized to assist in guiding a final system design.

It is my desire that these guidelines will assist in the creation of better systems for the use of lagoon water as a nutrient source for crop production.

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GENERAL: In sizing irrigation systems for nutrient management four things are very important:

- Providing an adequate supply of irrigation water to provide a high distribution uniformity (uniform irrigation).
- Providing primary solids separation of manure water prior to irrigated application.
- Maintaining adequate velocity in pipelines containing manure water and manure water mixed with irrigation water.
- Adequately mixing manure water with irrigation water prior to field application.

ADEQUATE WATER SUPPLY: Fresh water supplies from surface water or groundwater (well water) need to be made available to provide a uniform irrigation. Excessively long irrigation sets over irrigate and provide excessive nutrients to the upper end of a field. Fresh irrigation water supplies are needed in the winter as well as the summer when double or triple cropping is used with manure water addition. In some cases additional water supplies will have to be developed to achieve these goals.
**PRIMARY SOLIDS SEPARATION:** Primary solids separation is the process of removing solids greater than 0.045 inches in size. This is usually accomplished through the use of settling basins or sloped screen separators. Removal of these oversize solids helps to reduce plugging in distribution piping and drop out (settling of solids) at the top of fields.

**SIZING OF MANURE WATER TRANSFER/DISTRIBUTION PIPING:** A high degree of success has been experienced using PVC pipe for the distribution of lagoon water. High density polyethylene would also make an excellent distribution pipe, but is not easily modified or repaired by staff currently employed at most dairies. Many sites have significant quantities of concrete distribution piping that can require significant maintenance effort to keep operational with minimal leakage. Pipelines conveying manure water should be sized to maintain a velocity range between 2.5 to 5.0 feet per second (fps). Sizing pipelines in this velocity range can be completed as follows:

1. Select typical nitrogen application rates that you anticipate using. Summer application rates on corn are typically in the 50 pounds of available nitrogen per acre per irrigation range. Winter applications of nitrogen can range up to 130 pounds per acre per irrigation.
2. Measure typical manure water nitrogen concentrations. You will need to calculate ammonia nitrogen available and organic nitrogen content. You or your crop advisor will need to decide what percentage of your organic nitrogen you anticipate being available for the current crop cycle (50% is a default value sometimes used for this value for pipe sizing purposes). For estimating purposes:
   \[
   \text{total nitrogen available} = \text{ammonia nitrogen} + \text{available organic nitrogen}
   \]
3. Estimate the range of rates that you typically irrigate your fields. This will include both summer and winter irrigation rates. To do this take the total time required to irrigate a field and divide it by the total hours required for the irrigation:
   \[
   \text{Irrigation rate} = \frac{\text{Irrigated Acres}}{\text{Total Irrigation Time}}
   \]
4. Calculate manurewater flowrates required for typical summer and winter irrigations. To do this, take the typical total nitrogen available that was calculated in step 2 and the estimated irrigation rate from step 3 for summer. Take these two values and go to Table 1 attached. Enter the table with these two values and write down the value that is in the table. This value represents the flowrate of lagoon water to apply 10 pounds per acre of available nitrogen. Multiply this flowrate by 5 to get a typical summer irrigation manure water flowrate for a 50 pound per acre application. Repeat this process for a typical winter irrigation with a maximum application of 130 pounds per acre. Multiply the value in table 1 by 13 to get the flowrate for 130 pounds per acre.
5. **Size your manure water transfer pipe** by selecting a pipe size that maintains a velocity ($V$) between 2.5 and 5.0 feet per second. Take the two flowrates from step 4 and size a pipe from table 2 that maintains the correct velocity range. Many times an exact fit is not possible and the size closest to the range is used. Pipelines successfully carrying manure in the field have not been found smaller than 4 inches in size and any pipeline smaller than 8 inches in size should be selected with great care due to high risk of pluggage.

Pumped pipeline systems should utilize combination air/vacuum vents and pressure reliefs that are sized and located as would be required on a clean water irrigation pipe. Good success has been found using two individual automatic vents with each having 2/3rds of the required total venting capacity. With 2 vents, failure due to plugging of one vent will not lead to complete absence of any automatic venting of the pipeline. Caution should be exercised when sizing pumps and piping to transfer very thick slurries found at the bottom of many storage lagoons. The density and viscosity of these slurries is significantly higher than for water.

**MANURE WATER/FRESH WATER MIXING:** It is desirable to fully mix lagoon and fresh water prior to application to the crop. This can be done in a number of fashions. One simple approach that has been employed is to discharge the lagoon water into an open standpipe at the beginning of an irrigation system, prior to the first irrigation outlet in the field. Another approach that has been used successfully is to construct round, pressure rated, steel, mixing chambers with automatic air vents where lagoon and fresh water mix prior to field application. Simple pipe tees where the lagoon water is introduced at 90 degrees to the main irrigation flow have also been used effectively.

**DILUTION OF LAGOON WATER PRIOR TO LAND APPLICATION:**

Dilution of lagoon water with fresh water does several positive things:
• Allows better distribution uniformity of nutrients over the field.
• Decreases the maximum salt loading on the crop.
• Allows reasonable velocities (2-5 ft./sec.) in irrigation distribution piping.

Dilution ratios of up to 10 parts fresh water to 1 part lagoon water have been noted in the field to achieve agronomic application rates of material. Summer dilution ratios can be in the 5 to 10 parts fresh water to 1 part lagoon water where winter dilutions are often 2 to 3 parts fresh water to 1 part lagoon water. Winter dilution rates are often lower due to the lack of availability of fresh water and the desire to dilute the lagoon water somewhat to reduce nutrient loading, improve nutrient distribution uniformity to the crop, and reduce crop exposure to high salt concentrations.

Some older lagoon water application systems only have one location for mixing lagoon water with fresh water. For land application areas in excess of approximately 300 acres for a single dairy, that have multiple sources of fresh water, it may be difficult to uniformly apply lagoon water during the peak irrigation season. One approach to increasing the flexibility of lagoon water application is to distribute lagoon water through a dedicated distribution system to multiple fresh water mixing points around a farm. This allows lagoon water to be applied at a distant field while still applying fresh water only at a field close to the lagoon water source.

It is very important to install an effective method of backflow prevention between fresh water sources and lagoon water mixing locations. If a well should shut down or a surface water canal should suffer a failure without backflow prevention, the potential for pumped or gravity transferred lagoon water to flow down a well or into a surface water conveyance facility may exist.

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1 See The Surface Water Irrigation Manual by Dr. Charles Burt published by Waterman Industries, Inc.
Calculation Sheet for Sizing Manure Water Transfer/Distribution Piping:

Step 1: Select typical nitrogen application rates in pounds/acre per irrigation:
Typical rates used are 50 and 130 pounds/ acres

- 50 pounds/ac 1.0a
- 130 pounds/ac 1.0b

Divide Value in (1.0a) above by 10 and enter here: 5 1.1a
Divide value in (1.0b) above by 10 and enter here: 13 1.1b

Step 2: Measure typical manure water nitrogen concentration:
Enter value for Total Kendal Nitrogen (ppm) ppm 2.0
Enter value for ammonia nitrogen (ppm) ppm 2.1
Subtract (2.1) from (2.0) to yield organic nitrogen (ppm) ppm 2.2
Estimate total available nitrogen by adding 2.1 to 2.2 divided by 2:

\[ \text{Total available} = \frac{\text{ammonia nitrogen (2.1)} + \text{organic nitrogen (2.2)}}{2} \] ppm 2.3

Step 3: Estimate Range of Irrigation Rates:

Winter:
- Slowest Irrigating Field (Divide Acres/Time in Hours) Acres/Hr 3.1
- Fastest Irrigating Field (Divide Acres/Time in Hours) Acres/Hr 3.2

Summer:
- Slowest Irrigating Field (Divide Acres/Time in Hours) Acres/Hr 3.3
- Fastest Irrigating Field (Divide Acres/Time in Hours) Acres/Hr 3.4
Step 4: Calculate Manure Water Flowrates:

Winter:

Maximum Flowrate:
Use value from (3.2) and (2.3) to enter Table 1 & Enter GPM Value Here: \[ \text{GPM} \]

Enter Value from Step 1.1b Above

\[ 13 \]

Multiply (4.1) by (4.2) and enter value here:

\[ \text{GPM} \]

Minimum Flowrate:
Use value from (3.1) and (2.3) to enter Table 1 & Enter GPM Value Here:

\[ \text{GPM} \]

Enter Value from Step 1.1a Above

\[ 5 \]

Multiply (4.5) by (4.5) and enter value here:

\[ \text{GPM} \]

Summer:

Maximum Flowrate:
Use value from (3.4) and (2.3) to enter Table 1 & Enter GPM Value Here:

\[ \text{GPM} \]

Enter Value from Step 1.1a Above

\[ 5 \]

Multiply (4.7) by (4.8) and enter value here:

\[ \text{GPM} \]

Minimum Flowrate:
Use value from (3.3) and (2.3) to enter Table 1 & Enter GPM Value Here:

\[ \text{GPM} \]

Enter Value from Step 1.1a Above

\[ 5 \]

Multiply (4.10) by (4.11) and enter value here:

\[ \text{GPM} \]
Step 5: Size Your Manure Water Transfer Pipe:

Winter Flows:

Maximum: Pick the smallest pipe size in Table 2 where V=5.0 FPS and the value in this column is greater than (4.3).

Enter Pipe Size= _________ Inches 5.1

Minimum: Pick the largest pipe size in Table 2 where V=2.5 FPS and the value in this column is less than (4.4).

Enter Pipe Size= _________ Inches 5.2
Note: Enter 4 if (4.4) is less than 110 GPM

Summer Flows:

Maximum: Pick the smallest pipe size in Table 2 where V=5.0 FPS and the value in this column is greater than (4.8).

Enter Pipe Size= _________ Inches 5.3

Minimum: Pick the largest pipe size in Table 2 where V=2.5 FPS and the value in this column is less than (4.12).

Enter Pipe Size= _________ Inches 5.4
Note: Enter 4 if (4.4) is less than 110 GPM

Step 5b: Select the smaller of the values from (5.3) and (5.4) and enter here: _________ Inches 5.5

Step 5c: Select the smaller of the values from (5.1) and (5.2) and enter here: _________ Inches 5.6

Step 5d: If (5.5) and (5.6) are the same size, this is your final pipe size, stop here.
If (5.5) and (5.6) are not the same, enter the larger of these two values here: _________ Inches 5.7

Find the pipe size one size larger than (5.7) in Table 2 and enter here: _________ Inches 5.8
This is your final pipe size selection.
Target gpm calculator

**Location**
- field 1

**Acres**
- 28.0

**expected run time (hour)**
- 11.2

**Target N/A**
- 100

**enter lab data**

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**enter lab data**

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**Target GPM**
- 2,853

**Flowrate to Set at Lagoon Discharge**

**Actual GPM**
- 1100

**actual hours**
- 11.2

**N/acre**
- 39

**min/acre**
- 24

*calculator for quick checks of application rates*

This will not function if you enter Acres per Hour above.
### Table 1

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