

CONTROL OF DAIRY LAGOON WATER APPLICATIONS IN ALFALFA

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ABSTRACT

For most effective use of dairy lagoon water on alfalfa, it is necessary to apply the lagoon water at known rates. To do this, it is necessary to know both the volume of water applied and the concentration of nutrients in that water. The concentration of ammonium form nitrogen may be assessed rapidly and accurately by using a colorimetric ammonium quick test, and the volume is most easily and accurately measured using a flow meter installed on the lagoon water outlet pipe. Other methods of measuring flow include measuring pond drop, pump output times time, or by using a hand-held flow meter.

Key Words: alfalfa, flow measurement, manure, nitrogen, lagoon water, dairy waste

CROP NUTRIENT CONTENT OF DAIRY LAGOON WATER

Nitrogen in Lagoon Water

Nitrogen in lagoon water is present in mostly two forms, ammonium and organic nitrogen. The ammonium form is identical to that found in commercial ammonia-form fertilizers and is available for the plant to use as soon as it is applied. The nitrogen in the organic form is bound up in organic matter such as bacterial bodies or plant particles. It needs further decomposition before it is available to the crop. Because the particle size of this organically bound nitrogen is small, it is likely that it is broken down fairly quickly, however, as of yet there has been little research on the behavior of this material in the soil. Depending largely on the amount of solids in the lagoon water, the amount of organic nitrogen can range from almost none to very large amounts-several times the amount of ammonium-form nitrogen. There is very little or no nitrate form nitrogen in lagoon water. The ammonium and organic nitrogen types in lagoon water will eventually be converted to the nitrate form after they are applied to the soil, provided they are not taken up or lost in other ways.

The concentration of ammonium in a lagoon will often vary throughout the season. The amount of variation depends greatly on how the lagoon and flush system are managed. To properly manage nutrient application from ponds that fluctuate in concentration, it is necessary to estimate the nitrogen concentration at the start of each irrigation where lagoon water is to be applied. A quick test for ammonium has been developed for use in the field. This colorimetric test, carefully performed, will give a sufficiently accurate determination of the ammonium content of lagoon water in less than 5 minutes. If a less accurate method is used to estimate the lagoon water nitrogen concentration during lagoon water application, samples should be taken during

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the irrigation and the concentration confirmed later so that application rates can be adjusted accordingly in subsequent applications.

When sampling straight lagoon water, the sample needs to be drawn from the same area in the pond as the water applied to the field because the water in the pond is usually not uniform with respect to solids, and sometimes even the nutrients dissolved in the liquid portion are not uniform. In one of the study lagoons this past season, a sample drawn from the flush was nearly 100 ppm lower in ammonium than a sample pumped from the bottom of the same lagoon because fresh water had been added near the surface a few days earlier. If a lagoon is not well mixed, it may be necessary to sample several times over the course of an irrigation to determine the proper application rate adjustments.

Other Plant Nutrients

Alfalfa is a heavy user of potassium and lagoon water is often comparatively high in this nutrient. The concentration of potassium may be several times the concentration of ammonia nitrogen. Phosphorus concentrations are variable and may or may not be adequate to meet the requirements of the crop if the lagoon water is applied at rates based on nitrogen alone.

Managing Solids on Alfalfa

Lagoon water that has gone through a settling basin or is drawn from the upper portion of the lagoon will have fewer solids than that which contains the sludge from the bottom of the pond. If deposition of solids onto alfalfa is a concern, consider installing a settling basin, applying lagoon water that has been diluted by fresh water later in the summer, or using only lagoon water that has been drawn from the upper level of the lagoon. It will also be easier to estimate the amount of available nitrogen being applied because, in general, lagoon water that is relatively low in particulate matter will also be low in organic nitrogen content.

OPTIONS FOR MEASURING LAGOON WATER APPLICATIONS

In order to determine the amount of lagoon water nitrogen being applied to a field, both the amount of water being applied and the concentration of nutrients in the water must be known. A sample should be drawn from the same water as is being measured. If the combined flow of the lagoon and fresh water is being measured, then the diluted lagoon water should be sampled. If the volume or flow of undiluted lagoon water is being measured, then a sample of the undiluted pond water needs to be taken. If a method of measuring the volume of undiluted pond water applied is used, it is not necessary to know the flow of fresh water except as it influences irrigation run time.

There are several methods of measuring the amount of lagoon water applied. Some methods will allow a predetermined target amount of nitrogen to be applied while others are best suited to calculation after the fact of what was applied. The soil nutrient holding capacity and nutrient needs of the crop are important considerations in choosing a method.

Flow Meter on Lagoon Water Outlet

The easiest method of regulating the amount of nitrogen being applied is to install an in-line flow meter on the lagoon water outlet pipe. With this system, a quick test or other estimate of lagoon water nitrogen is made, and a target flow rate is read from a chart based on N concentration (ppm), the desired application rate (lbs N/A), and the time the irrigation is expected to take (minutes or hours per acre). A valve is adjusted until the flow meter display reads the target flow rate (gpm).

After the irrigation is completed, the total gallons applied is recorded from the meter totalizer, the nitrogen concentration is confirmed (if necessary), and run times are adjusted to calculate the exact amount that actually went on in that irrigation. Based on these values, the target nitrogen rates are adjusted in subsequent irrigations.

With this system it is possible to achieve very accurate application rates, even when applying relatively small amounts of lagoon water. This is an advantage when applying lagoon water to alfalfa or other salt-sensitive crops where it may be important to not apply too much in any one irrigation.

Flow Meter Selection

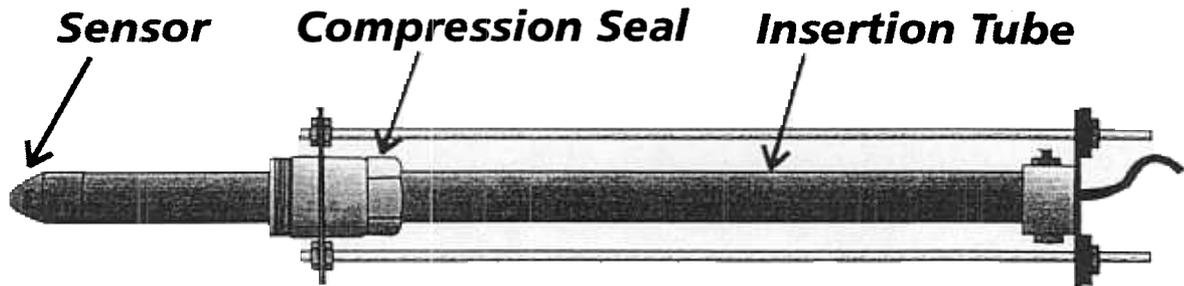
Most flow meters actually measure velocity of the water. The speed of the water is multiplied by the cross sectional area of the pipe to determine flow. Many flow meters will convert velocity into flow themselves but some read out only in velocity and the conversion from velocity to flow must be made manually.

There are many types of flow meters available but only a few are appropriate for use in dairy lagoon water because of the presence of debris and solids which clog or foul the mechanisms.

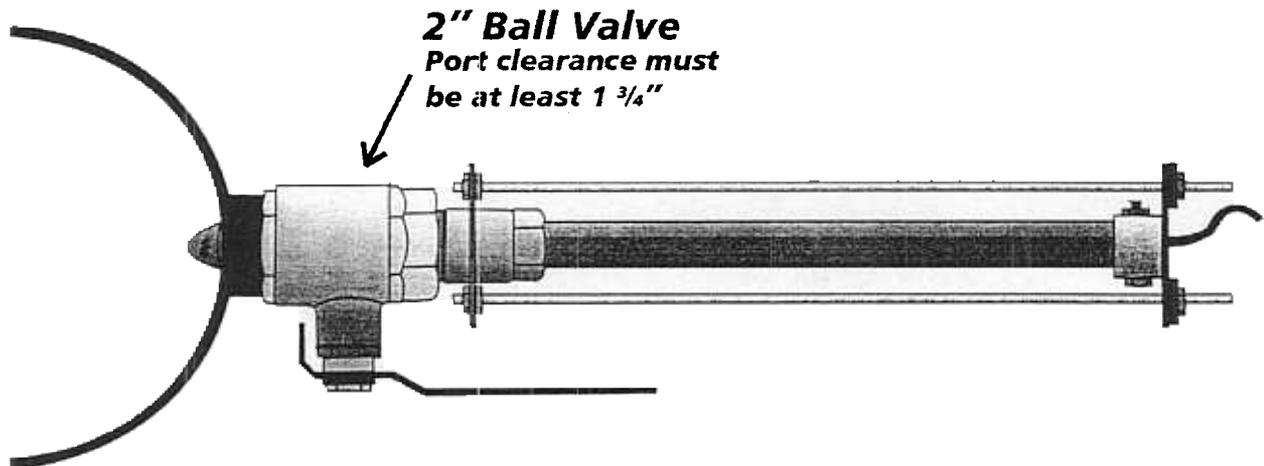
For our demonstrations, we selected a Marsh McBirney model 282 flow meter. The sensor on this meter is inserted into the lagoon water flow, usually through a 2" nipple and valve mounted on the outflow pipe of the lagoon. This flow meter has several advantages over other types of meters.

- It is highly resistant to fouling. The sensor tip protrudes only $\frac{3}{4}$ of an inch into the pipe. The wedge shaped sensor tip provides minimal surface area for debris to accumulate.
- The sensor design and electronic signal strength is sufficient to give accurate readings in water with relatively high solids content.
- The sensor and mount can be quickly and easily taken out and cleaned, stored, or used in another location.
- The same sensor can be used on any size pipe larger than eight inches diameter.
- Once the sensor is installed, it is not necessary to have more than occasional access to it, and the flow display can be mounted at some distance from the sensor.
- The display reads out in gallons per minute and also gives the total number of gallons.
- The meter uses 120 v power but there is also a 12 v model that can run off a deep cycle battery for use in locations where commercial power is not available.

Although best performance is obtained when placed the optimal distance away from elbows or valves, the ability to characterize the velocity in the pipe by profiling the flow affords some limited flexibility under less than optimal conditions.



Marsh McBirney model 282 sensor and housing. The long insertion tube is used during profiling to insert the meter all the way to the far wall. Once profiling is complete, the tube and threaded placement rods may be replaced by shorter ones for a more compact installation during normal operation.



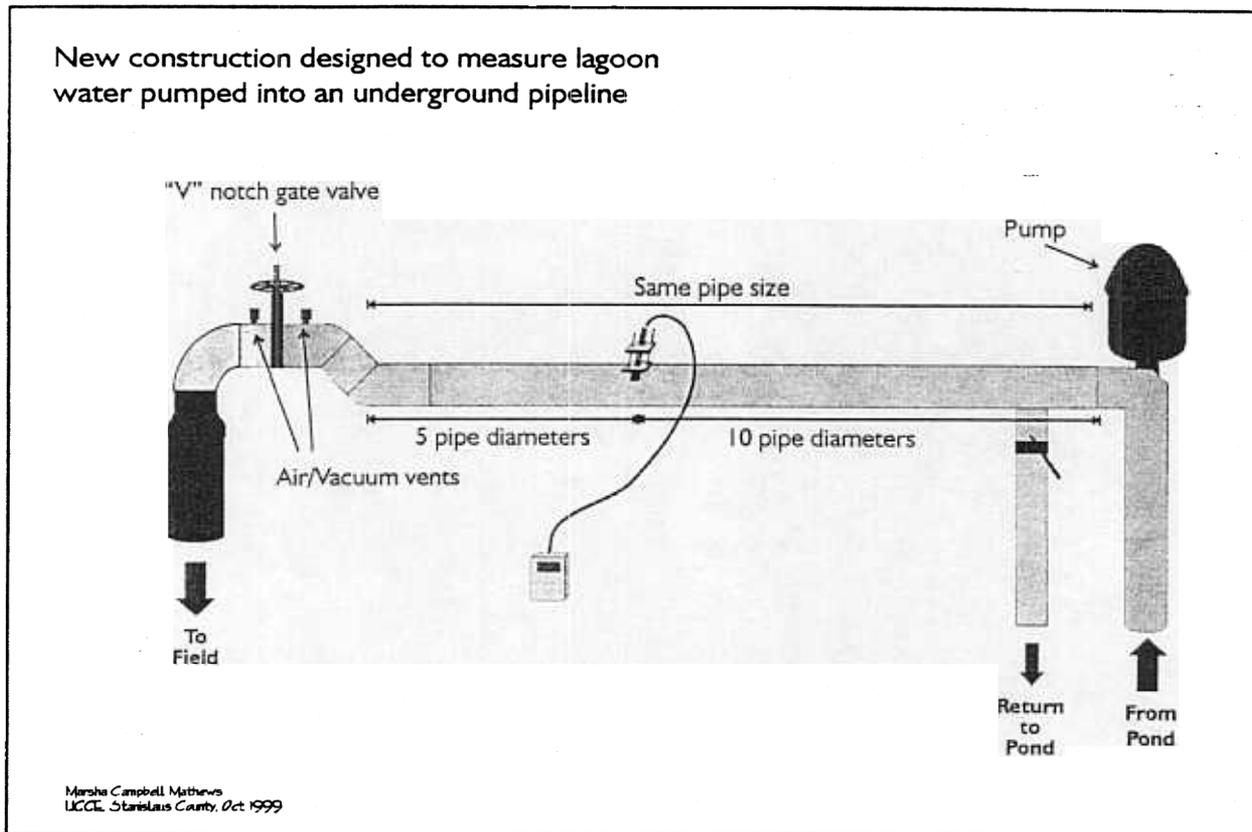
Marsh McBirney model 282 meter sensor shown as mounted in a lagoon water pipeline through a 2 inch ball valve. The sensor protrudes into the pipeline only 3/4 of an inch. Exact placement of the sensor is critical to proper performance of the meter.

This meter has been performing very acceptably in our 1999 trials in two locations. This meter was designed mainly for use in sewage treatment plants and current list price is about \$3500. The manufacturer is planning to come out this winter with a model designed specifically for lagoon water irrigation that should cost between \$2500 and \$3000.

The placement of the flow meter is critical to obtaining accurate flow readings. For a flow meter to perform properly it must see:

- a full pipe at all times. This is ensured by raising the pipeline downstream of the sensor at least one pipe diameter above the section of pipe where the sensor is installed.
- a uniform water velocity across the cross section of the pipe where the sensor is located. The sensor must be located at least 10 pipe diameters downstream and 5 pipe diameters upstream of elbows, tees, y's or changes in pipe size. An even greater distance away from active valves is necessary.

An example of flow meter placement is given in the following diagram, which shows how a meter might be placed on new construction. A meter can often be installed in existing plumbing, although in some cases modifications may be necessary.



OTHER METHODS OF MEASURING LAGOON WATER APPLICATION

Pond Drop

The concept behind the pond drop method is to determine the surface area of the pond in acres, then multiply the pond surface acreage by the number of inches of vertical drop as the pond is used to irrigate a known number of acres. Multiplying the area of the pond (in acres) by the drop (in inches) gives the acre-inches of pond water that went out during irrigation. Acre inches multiplied by the pounds of nutrient per acre inch gives the total pounds of nitrogen applied. The pounds of nitrogen applied per acre is determined by dividing the total applied by the number of acres irrigated.

While the pond drop method may appear to be simple and straightforward, in practice obtaining accurate pond drop readings is often challenging for many reasons, such as odd shapes and non uniform side slopes, the presence of irregular areas of built up solids, other inflows to the pond, and the difficulty of establishing and using a measuring pole. If fresh water was being introduced into the pond at the same time as the pond was being drawn down, using pond drop as a method of estimating nutrient application is virtually impossible. Irrigations that begin and/or

end during the middle of the night can be problematic because it is difficult to read a measuring pole in the dark even if a competent person is available to record the measurements, and the pond level may change by morning. For all these reasons, the pond drop method is sometimes unreliable. Various devices are available to electronically measure water levels, however, a flow meter is probably a better investment.

The pond drop method is best used to determine how much pond water has been applied and is also useful to check the accuracy of other methods of determining application. It can be difficult to use this method to achieve a target application rate because of the amount of acreage that must be irrigated before the rate of drop can be established and adjusted.

Pump Output

With this method, the output of the pump (gpm) is estimated and the time the pump was run is recorded. Once the concentration of nitrogen in the lagoon water is known, a lookup table or simple calculation gives the total pounds of N applied. The total pounds of nitrogen applied divided by the number of acres gives the pounds of N applied per acre. This method has limited accuracy because several factors will cause pump output to vary, including the level of water in the pond and the amount of solids being pumped. To calculate pounds of nitrogen per 1000 gallons, multiply ppm (or mg/L) nitrogen times .008345, or use a look up chart.

Flow of Irrigation Water Using a Hand Held Flow Meter

A spot check of the combined fresh and lagoon water flow can be made using a hand-held electromagnetic velocity meter attached to a pole inserted down a standpipe or vent accessing an underground pipeline. The concentration of ammonium in the water coming out of the valve is determined, then the lagoon water flow is adjusted until a desired target concentration is achieved based on concentration, flow rate, estimated run time, and number of acres irrigated.

This method makes the assumption that the flow from the district and the pond are uniform throughout an irrigation. This often is not the case due to fluctuations in the amount of water delivered by the district and because water delivery to different parts of the field may vary due to changes in pipeline characteristics such as slope and diameter. In our experience over the past two seasons, it has been necessary to obtain a new measure of the flow each irrigation in order to determine the correct amount of lagoon water to apply. Where there is a considerable lag between the time a change is made on output from the lagoon water outlet until the time the results of the change can be seen in the field, it can take a long time to adjust the lagoon water output to achieve a target application rate. This method can be very helpful in determining application rates when it is not feasible to make permanent changes to the system.

Summary of Application Measurement Methods

Method	Accuracy	Ease of setup	Ease of regular use	Cost
Pond Drop	Varies	Easy (with computer or chart)	Easy	Low
Installed Flow Meter	High	Difficult	Very Easy	High
Hand Held Flow Meter	Varies	Moderate	Moderate	High
GPM x time	Low	Easy	Easy	Low