How to Apply a Target Rate of Lagoon Nitrogen Using a Flow Meter and Throttling Valve

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This publication explains how to use a flow meter and throttling valve to control the amount of liquid manure (also called dairy pond water or lagoon water) injected into the fresh water source when irrigating a field in order to deliver a predetermined amount of nitrogen.

1. Decide what rate of nitrogen (N) you need to apply, in pounds per acre. Information on deciding on the amount a nitrogen needed by a crop is contained in other publications (See "Determining a Target Rate of Lagoon Nitrogen for an Individual Application").

> *Example:*
> *In this example you have already decided to apply 50 lbs of available N/acre*

2. Determine the concentration of nitrogen in the lagoon water that you will be using for this application. There are two main forms of nitrogen in liquid manure, ammonium and organic. The ammonium nitrogen is immediately available to plants. Organic nitrogen will become available as soil microbes break it down. If you base your application only on the concentration of the ammonium form of nitrogen, you will likely over-apply nitrogen because the organic form that is added is ignored. Basing your application on the total of both forms may result in yield loss because the organic form nitrogen may not be broken down to plant-available forms quickly enough for the crop to be able to use it. Usually you will want to count all of the ammonium nitrogen and a portion of the organic nitrogen as crop available.

   Total Kjeldahl Nitrogen (TKN) is a laboratory analytical procedure that determines the concentration of the combined ammonium and organic forms of nitrogen . Subtract the lab value for the concentration of ammonium nitrogen from the TKN to obtain the concentration of organic nitrogen.

> *Example:*
> Lab results:
> *TKN (Total Kjeldahl N) is 633 mg/L**
> *Ammonium N is 300 mg/L.*
> **mg/L (milligrams per liter) and ppm (parts per million) are the same*
>
> *TKN minus ammonium N = organic N*
> *633 TKN – 300 ammonium N = 333 mg/L organic N*
>
> *If we assume that 30% of the organic form nitrogen will become available over the next few weeks (this rate will vary) , multiply the organic N by that percentage expressed as a decimal:*

333 mg/L organic N x .3 = 100 mg/L organic N

*Add the rapidly available organic N concentration to the ammonium-N concentration and use the value as the available N concentration.**

300 mg/L ammonium N + 100 mg/L organic N = 400 mg/L available N

**Regulations require that all the nitrogen applied to a field be reported making it important to record the total N applied in addition to these N calculations used for fertilizing the crop at this specific irrigation.*

3. Estimate how many minutes per acre or hours per acre it will take to irrigate this field?

Example:
Based on experience, it will take 15 hours to irrigate this 30 acres, or 30 minutes per acre.

4. Determine the flow rate needed to obtain the desired pounds per acre of lagoon nitrogen based on the pond concentration and expected irrigation run time using the appropriate table for your situation.

Gallons per minute to achieve a target application rate

50 lbs N/acre

lbs/Kgal	lbs/ac-in	mg/L or ppm	irrigation hours/acre			irrigation minutes/acre			
			1½	1¼	1	50	40	30	20
1.7	45	200	333	399	499	599	749	999	1498
2.5	68	300	222	266	333	399	499	666	999
3.3	91	400	166	200	250	300	374	499	749
4.2	113	500	133	160	200	240	300	399	599
5.0	136	600	111	133	166	200	250	333	499
5.8	159	700	95	114	143	171	214	285	428
6.7	181	800	83	100	125	150	187	250	374
7.5	204	900	74	89	111	133	166	222	333

Table 1. Complete sets of tables are available at manure.ucdavis.edu.

Example: Using the 50 lbs N/acre table, if the pond concentration is 400 mg/L and it takes 30 minutes to irrigate one acre, a flow rate of 500 gpm will apply 50 lbs of N per acre. Five hundred gpm should work as long as pipeline diameter is not larger than 10 inches and the lagoon water is not excessively thick. See section B for more information on determining safe lower limits on flow rates.

CAUTION: Do not throttle back the pump more than it is safe for the pump or so much that the velocity of the water in the pipeline is not fast enough to keep solids from settling and plugging the pipe. Confirm that the flow rate is adequate to avoid plugging problems by using Table 2 in Section B below to look up the minimum safe operating gpm for your pipeline diameter that will maintain enough velocity in the pipe to keep solids in suspension. If the proposed gpm for the irrigation is less than the safe operating gpm for the pump, skip to the Alternative Procedure described on page 6

5. Write the target gpm and supporting information on the irrigation field record sheet.

Irrigation Record Sheet

Name of Facility: *My Dairy*

Date: *7/1/2011*

Source lagoon: *main lagoon*

Record weather conditions for day before, day(s) of and day after irrigation

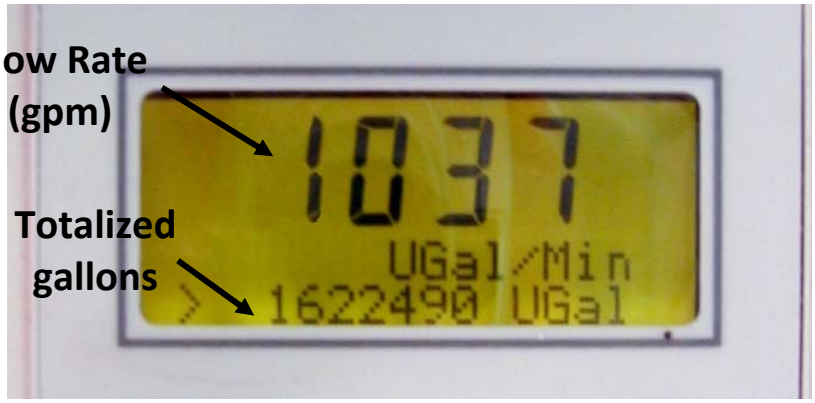
date					
weather					

s = sunny
o = overcast
c = cloudy
lr = light rain
sr = steady rain
hr = heavy rain
w = windy

expected concentrations	total N	NH_4-N	Org-N	% avail	Avail N
	633	*300*	*333*	*30%*	*400*

Location	acres	Irrigation number	Target lbs N per acre	Expected total run time	Lagoon only hours or %	Target gpm	Location Start Date/Time	Location End Date/Time	Meter Start (total gallons)	Meter End (total gallons)	Average gpm	Fresh Water Source(s)	irrigator initials & notes
Home Place	*30*	*1*	*50*	*15 hrs*	*100%*	*500*							

6. Adjust the flow with the throttling valve or pump controller until the meter displays the target flow rate. In most instances the flow rate displayed will fluctuate somewhat so don't worry if you cannot achieve an exact match with your target rate. A valve specifically designed for throttling will be easier to regulate. Depending on the meter, it may be possible to adjust the readout to display an averaged flow rate.



A flow meter readout will display both the flow rate (gpm) and the totalized flow (hundred or thousand gallons). The flow rate is like the speedometer, it tells how fast the water is being appliedd The totalizer is like the odometer, it tells how many gallons have passed through the meter. Ask your supplier how to access these readings if they are not already displayed.

Irrigators should be instructed to not throttle the pump below the pre-determined minimum gpm, which should be posted near the throttling valve. The minimum should be increased to prevent pipeline plugging and the supervisor notified if the lagoon water is thicker than expected, or if the

pump becomes noisy. Excessive noise when the pump is throttled is an indication that damage may be occurring.

7. During the irrigation, record the date, and starting and ending flow meter totalizer values for each field, along with the weather conditions the day before, day of, and day after the irrigation. It is a good practice to also record the start and end date and time for each field or area and the average actual flow rate (gpm), especially if it is different than the desired target gpm. This information is used as a backup method to confirm application rates in case the totalizer reading was not transcribed correctly or is illegible.

Irrigation Record Sheet

Name of Facility: *My Dairy*

Date: *7/1/2011*

Source lagoon: *main lagoon*

Record weather conditions for day before, day(s) of and day after irrigation

date	*6/30/10*	*7/1/10*	*7/2/10*		
weather	*s*	*s*	*s*		
expected concentrations	total N *633*	NH_4-N *300*	Org-N *333*	% avail *30%*	Avail N *400*

s = sunny
o = overcast
c = cloudy
lr = light rain
sr = steady rain
hr = heavy rain
w = windy

Location	acres	Irrigation number	Target lbs N per acre	Expected total run time	Lagoon only hours or %	Target gpm	Location Start Date/Time	Location End Date/Time	Meter Start (total gallons)	Meter End (total gallons)	Average gpm	Fresh Water Source(s)	irrigator initials & notes
Home Place	*30*	*1*	*50*	*15 hrs*	*100%*	*500*	*7/1/10 4:20 am*	*7/1/10 7:20 pm*	*131000*	*135500*	*525*	*Canal*	

8. Once the irrigation is complete, calculate the amount of nitrogen actually applied to see how close the application was to the target amount.

You may prefer to use a worksheet or an Excel spreadsheet to record data and calculate results. Both of these are available at manure.ucdavis.edu.

a. How many gallons were applied to the field, as thousand gallons:
Be sure to take into account the totalizer multiplier factor. Most meters are set to display totalized gallons as either thousand gallons or hundred gallons.

(Ending totalized gallons – beginning totalized gallons) x factor = gallons applied

Example:
The beginning totalizer reading was 131000 and the ending reading was 135500. The reading is in hundred gallons.

135500 – 131000 = 4500 hundred gallons.

4500 hundred gallons x 100 = 450,000 gallons

We need this amount expressed as thousand gallons

450,000 gallons ÷ 1000 = 450 thousand gallons

b. How many pounds of nitrogen were in that volume

You will need to know the concentration of the liquid manure that you applied. Agitation, freshwater additions and position of the sludge layer with respect to the pump intake can all greatly affect the variability of the material being applied.

Calculate the pounds applied using this equation:

mg/L* nitrogen x thousand gallons x .008345 = pounds nitrogen applied

*mg/L (milligrams per liter) is the same as ppm (parts per million)

Example:
TKN (total Kjeldahl nitrogen) is 633 mg/L
ammonium nitrogen is 300 mg/L.
organic nitrogen is 333 mg/L (TKN includes both ammonium and organic nitrogen so subtract the ammonium from the TKN to get the concentration of organic N).

Total nitrogen
633 mg/L TKN x 450 thousand gallons X .008345 = 2377 lbs TKN

Ammonium nitrogen300 mg/L ammonium N x 450 thousand gallons X .008345 = 1126 lbs ammonium N

Organic nitrogen
333 mg/L organic N x 450 thousand gallons X .008345 = 1250 lbs organic N

c. How much nitrogen was applied to each acre

pounds nitrogen applied ÷ number of acres = pounds nitrogen applied per acre

Example:

2377 lbs TKN ÷ 30 acres = 79 lbs Total nitrogen/acre
1126 lbs ammonium N ÷ 30 acres = 37 lbs/acre ammonium N
1250 lbs organic N / 30 acres = 42 lbs/acre organic N (of which only 30% was assumed to be available to the plants in the next few weeks)
Available nitrogen per acre applied =(.3 x 42)lbs organic N + 37 lbs ammonium N = 12 + 37 = 50 lbs available N per acre

The amount of organic nitrogen that will become available to this crop depends on many factors, including the amount that remains in a crust, how rapidly the particles break down, the temperature

and the time remaining until harvest. For this example, it was assumed that 30% would become available within the next few weeks after application.

9. If the application was significantly above or below the target, the nitrogen amount in subsequent irrigations may need to be adjusted.

Section B:

Alternative procedure to use when the target GPM is less than the safe operating GPM of the pump or when the flow rate would be low enough to present a risk of plugging the pipeline

If the gpm needed to apply the target application is lower than the lagoon pump can be safely throttled back or the flow rate would be less than the pipeline could deliver without plugging, one way to apply a target rate is to only run the lagoon pump during the last portion of each check or set. First determine the lowest safe operating gpm, considering the pump and the size of the pipeline, and then determine how long to run the pump on each set.

A. Determine a minimum safe pump output flow rate based either on pipe diameter (use Table 2) or pump characteristics from the manufacturer, whichever is lower. Use table 2 below to determine a minimum flow rate for a particular pump.

Minimum gpm to maintain velocity in pipe to prevent solids from settling

feet per second	manure pipeline diameter (inches)												
	2	4	6	8	10	12	15	16	18	20	24	30	36
2	20	78	176	313	489	705	1101	1253	1585	1957	2819	4404	6342
2.3	23	90	203	360	563	810	1266	1441	1823	2251	3241	5065	7293
3	29	117	264	470	734	1057	1652	1879	2378	2936	4228	6606	9513
4	39	157	352	626	979	1409	2202	2505	3171	3915	5637	8808	12,684
5	49	196	440	783	1223	1762	2753	3132	3964	4893	7047	11,010	15,855

Table 2. Use this table to determine the minimum gpm that will maintain a high enough velocity to prevent solids from settling out and plugging the pipeline. NRCS recommends a minimum of 2-5 ft/sec for 4-10% suspended solids. Use the higher or lower velocity depending on your solids level, the slope and roughness of the pipeline, and how difficult it would be to clean out your pipeline should plugging occur.

Example:
The pipeline is 10 inches in diameter but there is good solids separation and the pipeline is short, smooth, and easy to clean out if necessary. Using Table 2, a gpm of 500 should maintain a velocity of between 2 and 2.3 feet per second. In this example, 500 gpm minimum pump flow should be sufficient under normal circumstances to prevent plugging and protect the pump. When pumping thicker material, a higher minimum would be used.

B. Use the "Pounds of Nitrogen per Hour" table (Table 3) to look up how much nitrogen your pump is putting out based on the pump gpm and the concentration you determined in step 2.

Pounds of Nitrogen per Hour

concentration of N in lagoon: lbs per thsnd gal	lbs/ac-in	mg/L or ppm	gallons per minute (GPM) 250	500	750	1000	1250	1500	1750	2000
1.7	45	**200**	25	50	75	100	125	150	175	200
2.5	68	**300**	38	75	113	150	188	225	263	300
3.3	91	**400**	50	100	150	200	250	300	350	401
4.2	113	**500**	63	125	188	250	313	376	438	501
5.0	136	**600**	75	150	225	300	376	451	526	601
5.8	159	**700**	88	175	263	350	438	526	613	701
6.7	181	**800**	100	200	300	401	501	601	701	801
7.5	204	**900**	113	225	338	451	563	676	789	901

Table 3. Complete tables are available at manure.ucdavis.edu.

Example:
The pump minimum gpm is 500 gpm. In this example, the concentration of available N is 800 mg/L concentration, twice the concentration used in the first example, and the pump will apply 200 lbs of N per hour.

C. Calculate how many pounds of nitrogen you want to apply to each set or check. Then calculate or look up how long to run the lagoon pump on each check in Table 4, "Run time for lagoon pump to achieve a target application rate," based on the pounds of nitrogen per hour the pump is putting out. The pump should run for the calculated time during the last part of the irrigation so that the nutrients are applied uniformly along the length of the field.

Run time for lagoon pump to achieve a target nitrogen application

total lbs N needed	pond output in lbs of N per hour 100	200	300	400	500	600
250	2 h 30 m	1 h 15 m	0 h 50 m	0 h 38 m	0 h 30 m	0 h 25 m
500	5 h 0 m	2 h 30 m	1 h 40 m	1 h 15 m	1 h 0 m	0 h 50 m
750	7 h 30 m	3 h 45 m	2 h 30 m	1 h 53 m	1 h 30 m	1 h 15 m
1250	12 h 30 m	6 h 15 m	4 h 10 m	3 h 8 m	2 h 30 m	2 h 5 m
1500	15 h 0 m	7 h 30 m	5 h 0 m	3 h 45 m	3 h 0 m	2 h 30 m
1750	17 h 30 m	8 h 45 m	5 h 50 m	4 h 23 m	3 h 30 m	2 h 55 m

Table 4. Complete tables are available at manure.ucdavis.edu.

Example: Each check is 5 acres. 50 lbs N/acre x 5 acres = 250 lbs of nitrogen should be applied to each check. If the pump is putting out 200 lbs of N per hour, you will want to run the lagoon pump during the last 1 hr 15 minutes of the irrigation for that check.
250 lbs N / 200 lb N per hour = 1.25 hours or 1 hour and 15 minutes. Or look it up using Table 4.

D. Write the target pump run time on the irrigator sheet along with the target flow rate and the assumptions used to determine the run time. This additional information will be useful if the irrigation does not take the time expected or the pond concentration is noticeably different than anticipated.

Irrigation Record Sheet

Name of Facility: *My Dairy*
Date: *7/1/2011*
Source lagoon: *main lagoon*

Record weather conditions for day before, day(s) of and day after irrigation

date	6/30/10	7/1/10	7/2/10		
weather	s	s	s		
expected concentrations	total N 1200	NH_4-N 629	Org-N 571	% avail 30%	Avail N 800

s = sunny
o = overcast
c = cloudy
lr = light rain
sr = steady rain
hr = heavy rain
w = windy

Location	acres	Irrigation number	Target lbs N per acre	Expected total run time	Lagoon only hours or %	Target gpm	Location Start Date/Time	Location End Date/Time	Meter Start (total gallons)	Meter End (total gallons)	Average gpm	Fresh Water Source(s)	irrigator initials & notes
Home Place	*30*	*1*	*50*	*15 hrs*	*1 hr 15 min/ck*	*500*							

E. The lagoon pump will be run during only the last portion of each set or check. Decide when the irrigation set on that area will end, and then subtract from that time the length of time that you determined that the pump needs to run. Also subtract enough time to compensate for the travel time of the blended water from the mixing point to the field outlet.

Example:
It will take 2 ½ hours to irrigate a 5 acre check. The lagoon pump needs to run 1 hr 15 minutes.
It takes 20 minutes for the blended water to travel from the mixing point to the check.
The irrigation will start at 3 pm.

3 pm plus 2 hrs 30 minutes total run time per check = 5:30 pm finish time
5:30 pm minus 1 hr 15 minutes run time for the pump = 4:15 pm. This is the time the lagoon water should begin entering the field. But because it takes 20 minutes from the mixing point to the field, the pump needs to be turned on 20 minutes earlier at 3:55 pm and turned off 1 hour 15 minutes later, at 5:10 pm so that the line will be clear as the irrigation begins on the next check.

The on and off times have to be calculated for each check.

F. Adjust the throttling valve on the lagoon pump until the flow meter reads the target flow rate, which in this case would be the minimum operating gpm, as described in step 6.

G. Record data and calculate application rates according to the instructions in steps 7 – 9. .

Other methods to reduce application rates

Applying the lagoon water only during the last part of an irrigation set or check is only one option for reducing the amount of lagoon water nitrogen applied during a single application. Other options include:

- Maintaining a more dilute pond
- Making changes to pumps and pipelines to accommodate lower application rates
- Increasing the speed of the irrigation
- Changing cropping patterns and nitrogen budget to accommodate larger applications

For more information see the publication “Designing Dairy Liquid Manure Transfer Systems”