Exhibit (limitations of non-standard flow measurement methods)

Limitations of Non-standard Flow Measurement Methods

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Introduction

In the past, several flow measurement methods have been proposed (and/or used) by the dairy industry that do not conform to the standard flow measurement methods (hydraulic structures and velocity sensing meters) that the department has proposed in the rule. These alternate approaches represent non-standard flow measurement methods, including the use of level gauges in lagoons and equipment hours recorders on pumping systems. The department contends that these methods are unsuitable for flow measurement at dairy facilities for the reasons explained below.

Lagoon Level Gauge Flow Measurement

Under certain circumstances, a lagoon level gauge can be used to estimate the rate of discharge (flow) from an impoundment. By locating a level gauge that has a vertical scale in a manner such that it spans from the minimum to the maximum liquid elevation in a lagoon, the level of liquid in the lagoon can be readily determined. If the liquid depth is measured in the lagoon prior to pumping wastewater to irrigation and then again at the end of the pumping cycle, the volume discharged can be calculated when the dimensions of the lagoon are known. If the duration of the pump cycle is timed, the pumping rate can be determined according to the following formula:

$$Q = \frac{V}{T}$$

Where:

Q = *Quantity*
V = *Volume (pumped out of lagoon)*
T = *Pumping duration (time)*

For example, if the liquid level in a rectangular lagoon that is 100 ft by 50 ft is lowered 3 ft over a 10 hour pumping period, the flow rate of the pump(s) can be estimated as follows:

$$1{,}500 cuft/hr = \frac{100 ft \times 50 ft \times 3 ft}{10 hrs}$$

Figure 1. shows a diagrammatic representation of the volume removed in 10 hours.

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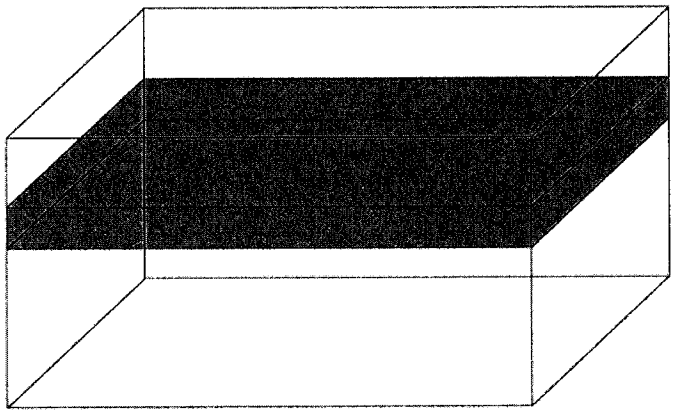

Figure 1.

However, this approach cannot be used as a practical method for measuring discharge volumes at dairy facilities for the following reasons:

1. Accurately calculating the volume pumped from a lagoon can be difficult. The simple rectangular lagoon in the previous example does not exist in the real world. Typically, domestic wastewater lagoons are prismoidal in shape (see figure 2).

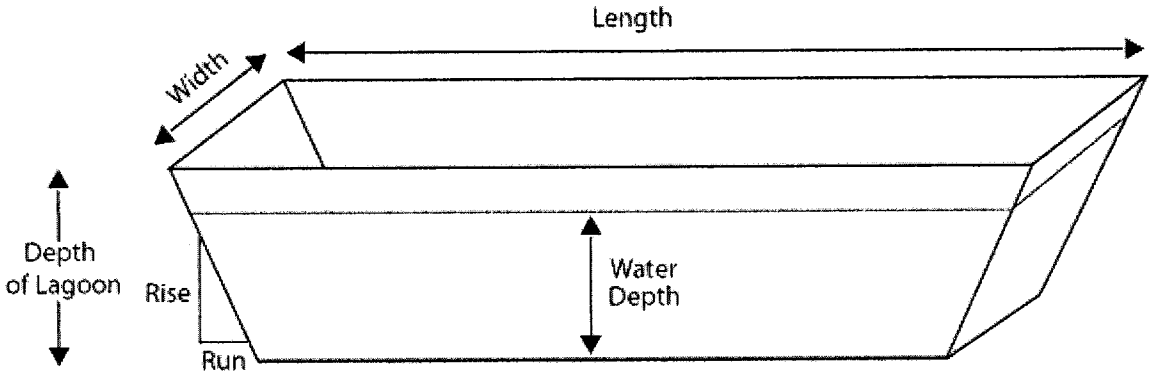

Figure 2.

A fairly accurate assessment of the volume of the contents of this type of lagoon can be derived from the prismoidal equation:

$$V = (d/6) \times (A_t + A_b + 4\,A_m)$$

Where:

V = *Volume of liquid in lagoon*

d = *depth of liquid in lagoon*

A_t = Surface area at top of water (L×W)

A_b = *(L-2×ES×d) (W-2×SS×d)*

A_m = *(L-ES × d) (w-SS × d)*

And;

L = length at water line
W = width at water line
ES = the slope of the end (horizontal run ÷ vertical run)
SS = the slope of the side (horizontal run ÷ vertical run)

However, dairy lagoons often have varying shapes and non-standard construction. This makes calculation of the volume from a measured drop on a level gauge difficult, at best.

2. Inflow that enters the lagoon during the pumping period is not accounted for. The liquid level drop that is observed during pumping is reduced by inflow entering the lagoon at the same time. There is no good way to account for this inflow and it introduces a significant negative error (i.e. the discharge is underrepresented).

3. If settled solids occupy a portion of the volume removed during pumping, a negative error in the calculation of the volume is introduced (see figure 3).

Insert picture of sludge mound
Figure 3.

4. This approach does not account for liquid gained by precipitation or lost through evaporation. Although the errors introduced by precipitation and evaporation are generally limited on any given day, over the course of a year they are significant.

5. Unlike totalizing meters and data loggers, no record, outside of the record created by the permittee, exists to verify the flow measurements.

Pump Equipment Hours Recorder Flow Estimation

Pump equipment hours recorders can be used to estimate the total volume transferred in pumped systems where the pumping rate has been accurately established. By summing the length of time that a pumping system operates and multiplying the time against the pumping rate, the discharge rate can be estimated. The formula for this is as follows:

$$V = R \times T$$

Where:

V = *Total volume discharged*
R = *Pumping rate*
T = *Pumping duration (time)*

However, there are a number of limitations to this approach. Mainly; the pumping rate is rarely fixed, especially in dairy irrigation systems. Irrigation pumps that discharge from dairy lagoons operate under conditions of varying dynamic head. The changing factors that contribute to changes in the dynamic head include:

- Changes to the distance that the discharge is being pumped,
- Differences in the static lift to various discharge locations,
- Changes created by the operation of a single pump vs. multiple pumps,
- Changes in the level in the lagoon (affects net positive suction head of the pump),
- Other hydraulic inputs to the system, such as from a irrigation well, and;
- The degree of plugging in the sprinkler heads.

The changing dynamic head in the pumping system results in changes to the pumping rate that are not easily identified or taken into account. It is unreasonable to expect that NMED or the permittee could account for all of the changing factors that could affect the pumping rate in these circumstances, and therefore; this method of flow estimation is unsuitable for permit compliance monitoring.