# CHARACTERIZE PHYSICAL AND CHEMICAL PROPERTIES OF MANURE AND RELATED EMISSIONS IN CALIFORNIA DAIRY SYSTEMS TO IMPROVE GHG EMISSION ESTIMATES

## I. OBJECTIVE

This study seeks to better understand the characteristics, handling, and emissions of manure generated by California dairy systems using a combination of modeling, field sampling, and emissions measurements. Currently there is a lack of data describing California's dairy manure quantity, composition, and management, which all can significantly affect emissions. Improved measurements and modeling will result in more accurate emissions analysis that can better inform policy processes.

## II. BACKGROUND

Manure contains significant amounts of carbon and nitrogen, both of which can result in emissions of greenhouse gases (GHGs) and other pollutants. According to the current California GHG emission inventory, which uses national defaults or global emission factors, manure management contributes roughly 1/3 of statewide $N_2O$ emissions (~4-5 $MMTCO_2e$) and about a quarter of statewide $CH_4$ emissions (~10 $MMTCO_2e$). Despite its importance, there has been little research on $N_2O$ and $CH_4$ emissions from manure management, particularly with respect to California systems. Fortunately some of the biochemistry pathways for manure emitting greenhouse gases are reasonably well understood. For example, when manure is stored in liquid form (particularly in large lagoons on dairies), the resultant low-oxygen conditions allow anaerobic, methanogenic bacteria to grow and digest the volatile solid portion of manure carbon compounds, thus emitting methane. As for nitrogen, when manure is land applied, bacterial nitrification-denitrification processes occur and release oxides of nitrogen including $N_2O$. California livestock is modeled to excrete hundreds of kilotons of nitrogen (N) annually in the form of manure, an amount equivalent to more than half of the annual chemical nitrogen fertilizer sales in the state based on the fertilizer tonnage data. Roughly half of the livestock manure nitrogen is produced from dairy farms (dairy cows and heifers). Further study of the ultimate fate of dairy manure nitrogen and volatile carbon and field measurements to characterize manure in representative dairy farms (including manure collection and storage facilities - bedding, gutters, lagoons, etc.), are needed to better understand manure-related emissions and to refine emission factors associated with various manure management practices.

The results of this project will be used to develop California-specific model inputs to refine GHG and other pollutant emission estimates to improve the emissions accounting of manure management practices in California. It will also help quantify the methane impacts from the current industry trend of increasing animal concentrations per farm.

## III. SCOPE OF WORK

- Literature review of dairy manure emissions and management systems found in California.

- Sample manure at multiple representative dairies to follow nutrient flow throughout the various stages of manure management for corral and free stall animal systems. Sampling should include at least one thoroughly mixed lagoon. To the extent possible, emissions measurements for pollutants other than greenhouse gases should be included in the sampling protocol, such as oxides of nitrogen, ammonia, etc.
- Use collected data to develop estimates of $CH_4$ emissions from all lagoons in California and compare the differences in estimated $CH_4$ and $N_2O$ emissions between modeling results using the current national and international default parameters and using California-specific data.
- Monitor copper inputs due to potential impact on lagoon bacteria.

## IV. DELIVERABLES

- Quarterly progress reports and conference calls;
- Draft final report;
- Peer-reviewed publication(s), as appropriate;
- Final report and research seminar in Sacramento;
- All data and analyses generated through the course of this project;
- Additional deliverables to be determined in consultation with ARB staff.

## V. TIMELINE AND BUDGET

It is anticipated this project will be completed in 42 months from the start date. This allows 36 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. The estimated budget for this project is $400,000.