California Dairies:
Protecting Water Quality

A primer for consultants, local government agencies, and lending institutions

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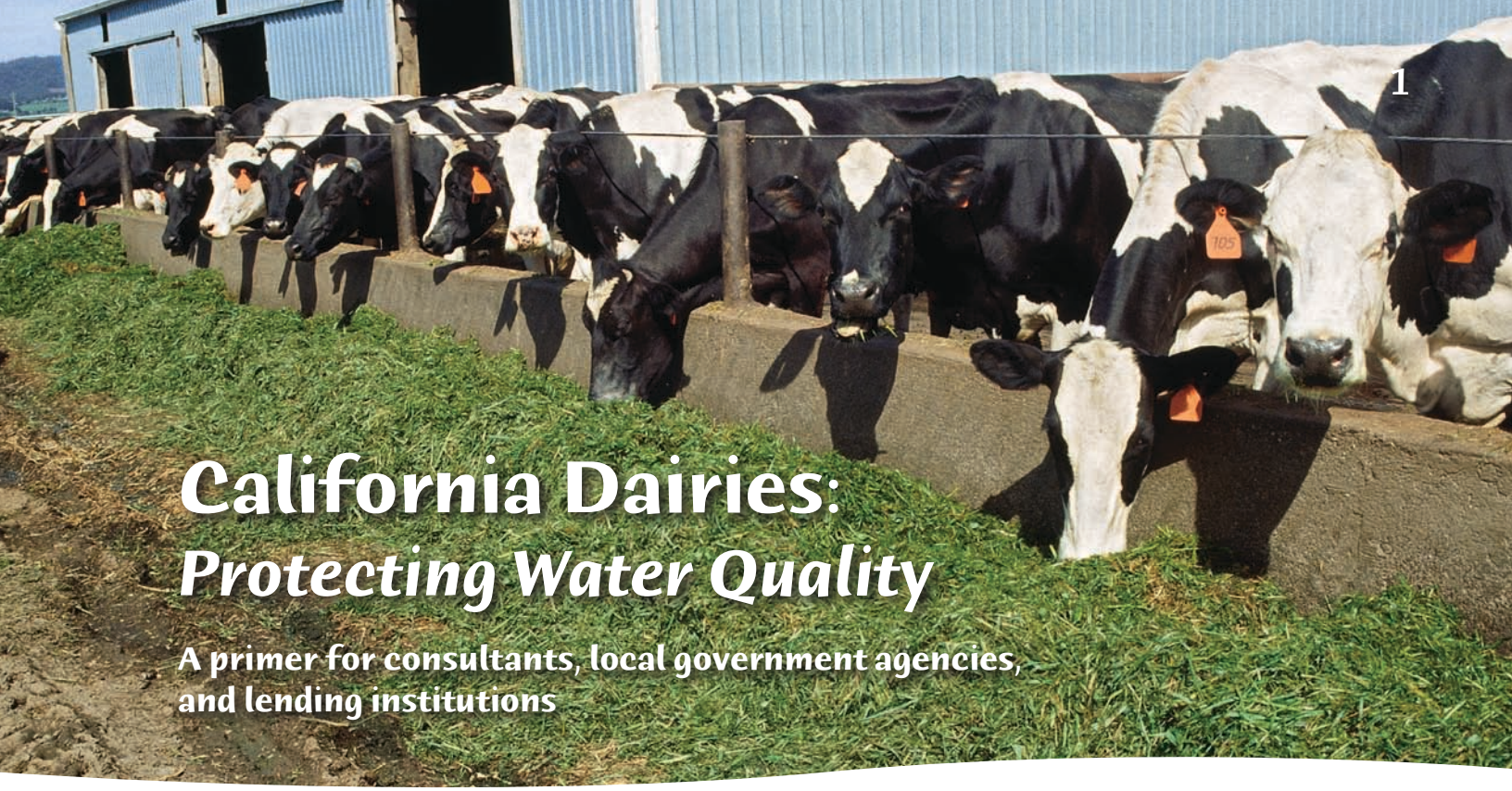
Contents



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Introduction

Milk is California's number one agricultural commodity, with a farmgate value in 2004 of more than five billion dollars. For many years dairy farming has provided a stable economic base for rural communities in the state. California's dairy farms produce milk of unsurpassed nutritional quality used to make award-winning cheeses, ice cream, yogurt, butter and many other products for both local and international markets.

In recent decades, many changes have taken place on the state's dairy farms. The number of dairies has decreased, while average herd size has increased. Dairy producers have made substantial upgrades to milking facilities and animal housing, improving sanitation and animal comfort. Change in the size and structure of dairy facilities is mainly a result of the increasing cost of labor, land, and water in California as well as the increased demand for affordable milk, cheese, and other products. Some dairy producers have developed niche markets for organic or other specialty products.

Dairy farming has in some ways enhanced the state's environmental quality — for example, by preserving open space and wildlife habitat. As dairy producers have worked to remain profitable and meet consumer demands, they also have been faced with increasing scrutiny by state and local environmental health and planning agencies and by environmental groups.

Increased stringency of regulations and public scrutiny have pushed dairies — especially those expanding or newly constructed — to invest in improved

This guide summarizes the practical approaches and technologies that have been implemented by progressive dairy producers to protect surface and groundwater quality.

Each dairy is different and operates under a different set of constraints; practices must be tailored to each situation.

manure management systems. Research by University of California scientists and others has increased the understanding of environmental impacts associated with dairies and has led to development of improved technologies. Wide-scale adoption of farming practices that protect the environment depends on awareness and support of businesses such as lending institutions, consulting engineers, and crop management companies, as well as regulatory agencies.

This guide summarizes the practical approaches and technologies that have been implemented by progressive dairy producers to protect surface and groundwater quality. Because each dairy is different, and practices must be tailored to each situation, the management practices described here should be viewed as illustrations of the potential for improvement and not as recommendations for all dairies.

California's Dairies and the Environment: *The Promise and the Challenge*

Dairy farming as practiced in much of California provides environmental services to society. Most dairies in the state combine livestock and crop production on the same property, and this combination has certain environmental advantages compared to farming systems that have only crop production or only livestock. These environmental benefits are a result of:

- Production of deep-rooted, high nutrient-uptake forage species, which provide year-round protection of vulnerable soils.
- Recycling of manure nutrients and water to crops on the farm.
- Provision of wildlife habitat, open space, and view corridors. Pasture and hay crops provide critical bird, mammal, amphibian and reptile habitat in California.*

However some aspects of dairy farming in California increase the risks to water quality such as:

- The location of some dairies on well-drained porous soils, which can increase the potential for leaching of nutrients and salts to groundwater aquifers.
- Use of manure flush systems that generate a large volume of dilute nutrient liquid, which cannot economically be transported off-farm and must be distributed to crops via the often less-than-perfect flood irrigation systems.

- Uncertainty in the crop nutrient value of manure. This sometimes leads dairy producers to apply 'insurance' rates of commercial fertilizer to crops that have already received manure. This decreases the percent of applied nutrients that is recovered by crops and increases the risk of water quality impacts.
- Limited availability of flat land for manure application. Application to steeply sloping land carries the risk of runoff and contamination of surface waters.

*Putnam, D., M. Russelle, S. Orloff, J. Kuhn, L. Fitzhugh, L. Godfrey, A. Kiess, and R. Long. 2001. Alfalfa, Wildlife and the Environment. California Alfalfa and Forage Association, Novato, California.

Overcoming these limitations can be both costly and technically challenging. However, in recent years, solutions with less environmental impact have been developed and are being used by an increasing number of dairy producers. For example, the percent of dairy producers reporting use of mechanical screens and settling basins to remove coarse solids from manure flush water in Tulare, Fresno, and Madera Counties increased significantly from 1994 to 2003.* Several organizations have supported the development and promotion of these solutions, including the University of California, the USDA Natural Resources Conservation Service, and an industry-government partnership, the California Dairy Quality Assurance Program.

*Data drawn from Meyer, D.M., I. Garnett, and J.C. Guthrie. 1997. A survey of dairy manure management practices in California. Dairy Sci. 80:1841-1845, and from Dairy manure nutrient management survey results – September 2004, unpublished report available from the University of California Sustainable Research and Education Program, Davis, CA.

California Dairy Quality Assurance Program

The California Dairy Quality Assurance Program (CDQAP) helps the state's dairy producers understand and meet federal, state, regional, and local requirements for manure management and water quality protection. The CDQAP is a partnership of California dairy organizations, federal, state, and regional government agencies, and the University of California Cooperative Extension. It offers a voluntary certification program that assists producers to comply with federal, state, and local environmental regulations. Contact your UC Cooperative Extension dairy advisor or trade organization for a current list of courses and activities, or go to http://www.cdqa.org.

University of California Cooperative Extension

The University of California Cooperative Extension (UCCE) is the outreach arm of the land grant college system in the state. The UCCE is comprised of county advisors and campus-based specialists in agriculture, natural resources, youth, nutrition, family and consumer sciences. Through applied research, field testing and education, UCCE advisors and specialists work to develop environmentally sound farming methods. Contact information for UC county farm advisors specializing in dairy science and agronomy can be found at http://ucanr.org/ce.cfm.

Natural Resources Conservation Service

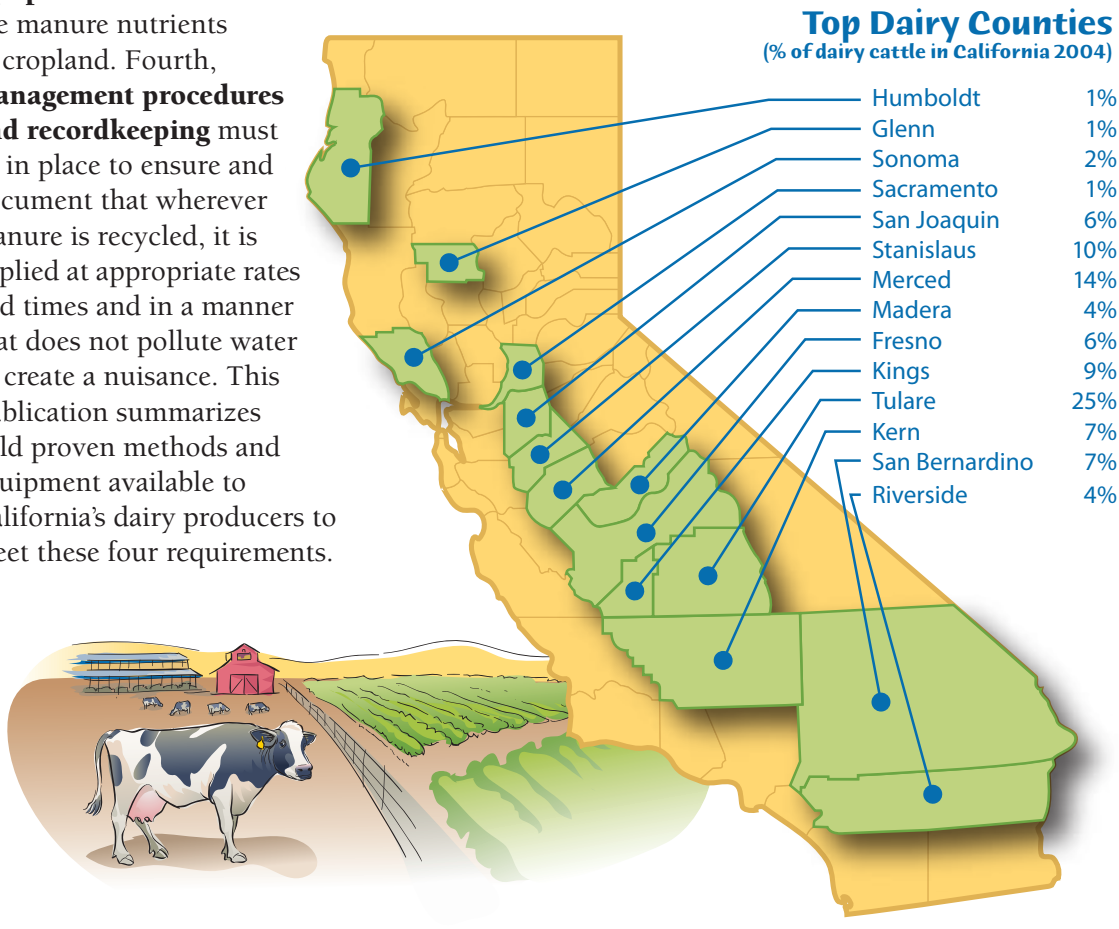
The mission of the USDA Natural Resources Conservation Service (NRCS) is to assist private landowners in conserving or protecting soil and water quality. NRCS defines "conservation" as wise use of natural resources - soil, water, air, plant, and animal - in order to sustain productivity of current and future generations. NRCS accomplishes this mission by working directly with local Resource Conservation Districts and Resource Conservation and Development Councils. Contact information for your local NRCS staff can be found at the NRCS website http://www.ca.nrcs.usda.gov/contact.

How Are Dairy Producers Responding to the Challenge?

There are four essential components that all dairies must develop if water quality is to be protected. First, there must be **sufficient cropland** to receive recycled wastewater and manure at rates matching the crop demand. Where the milk herd is too large for the land base, manure nutrients must be transported off farm; and in that case, there must be some assurance that the manure will be used in an environmentally sound manner at its final destination. Secondly, there must be **suitable storage** for manure during periods of rain and low crop nutrient demand so that nutrients, salts, and pathogens can be kept out of waterways. Third, there must be a **distribution infrastructure and equipment** to transfer the manure nutrients to cropland. Fourth, **management procedures and recordkeeping** must be in place to ensure and document that wherever manure is recycled, it is applied at appropriate rates and times and in a manner that does not pollute water or create a nuisance. This publication summarizes field proven methods and equipment available to California's dairy producers to meet these four requirements.

The process of upgrading an existing dairy facility to an 'ideal' dairy facility takes time. As progressive dairy producers have worked to improve their nutrient management practices, they have demonstrated a wide range of possible solutions to the challenges facing them.

The specific measures taken by a dairy producer to protect water quality will vary with topography, climate, and surrounding land use and availability. Most of California's 2000 (±) dairies operate in one of three basic ways: with irrigated cropland; with non-irrigated pastures and hayfields; and with little or no adjoining cropland.



Source: California Department of Food and Agriculture

A. Dairies with Irrigated Cropland

The majority of dairies in the state and nearly all of the 1500 dairies in the Central Valley fall into this category. In this style of dairy farming, the cattle are housed in freestall barns, open corrals, or some combination of the two. On acreage surrounding the dairy facility, irrigated forages — typically silage corn, sudangrass, alfalfa, and cool-season grasses — are produced nearly year-round. On many such dairies, the freestall barns and feed lanes in corrals are flushed with water, rather than scraped. (Freestall barns are open-sided structures with only a roof supported by poles. Cows are free to wander and occupy any open stall as opposed to a stanchion barn in which cows are confined to designated stalls.) Flushwater is then stored in earthen lagoons before application to the crops through the furrow or flood irrigation system. The proportion of manure nutrients collected in liquid form varies among dairies from ~10% to almost 100% of all manure excreted. Protection of both surface and groundwater quality is a high priority for Central Valley dairies. The practices listed here are aimed primarily at reducing the potential for groundwater degradation with nitrate and other salts. Some practices also lower the risk of runoff into surface waters.

The recordkeeping and analysis procedures must be expanded to cover the manure generation and recycling components of the dairy.

Management Measure A1. *Assess dairy farm nutrient balance and upgrade the manure recordkeeping system*

Modern dairy management systems are information intensive and require relatively sophisticated data collection and analysis systems. These recordkeeping and analysis procedures must be expanded to cover the manure generation and recycling components of the dairy. When planning upgrades or dairy expansion, producers must assess and record dairy herd size, manure nutrient generation levels, manure collection and storage efficiency, crop land availability, crop nutrient needs, and irrigation system performance. Dairy producers may benefit from conducting a **whole farm nutrient assessment** in which nutrient inputs in the form of feed and fertilizer are compared to nutrient exports in milk and any transfer of manure off-farm.

Management Measure A2.
Transfer manure nutrients off-farm

Insufficient crop acreage forces producers to apply manure at rates exceeding crop nutrient requirements. This increases the potential for leaching of salts and nitrates and for groundwater contamination. Where cropland area on the dairy is inadequate, producers should:

- Transport liquid and solid manure to neighboring farm fields that are not already receiving manure. This should be done under a written agreement.
- Sell solid manure after composting or transport raw manure to off-farm composting facility.

Management Measure A3.
Modernize the liquid manure distribution system

Some dairies have enough cropland to potentially receive all manure generated but have not installed an adequate system of pipes to carry the liquid manure to all crop fields. This leads to overapplication of nutrients on crop fields closest to the storage ponds. Modern engineered distribution systems include:

- Piping to additional crop fields
- Flow control valves or variable drive pumps that allow control of the rate of liquid manure applied to crops
- A system for uniform mixing of liquid manure with fresh irrigation water. Lack of such a system leads to non-uniform and excessive application of manure nutrients to some crop fields

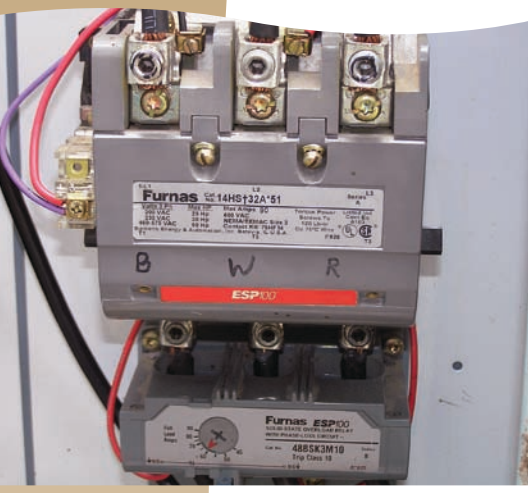
Liquid manure transfer pipeline with electromagnetic flow meter.

- Flow meters or other devices for measuring the quantity of liquid manure applied to crops
- Intensification of crop nutrient uptake by double or triple cropping (e.g., silage corn/sudangrass/cool-season small grain forage rotation). Some dairies may be able to increase manure applications to alfalfa, which typically receives little or no manure.

Management Measure A4.
Increase manure storage capacity and reduce waste volume

Inadequate liquid manure storage forces producers to apply manure water to fields at times of low crop nutrient uptake and during rainy periods, increasing the risk of runoff and leaching. Improved design and operation includes:

- Addition of liquid storage pond capacity sufficient to hold manure during periods when crop nutrient demand is low. This storage capacity is



Sprinkler pen timer control boxes or lockout boxes installed to restrict sprinkler use and conserve water.

in addition to the legally required freeboard — the upper part of a pond that must be kept empty.

- Employment of water conservation measures in the milking facility or sprinkler pens to reduce the volume of wastewater requiring storage. Water conservation practices focusing on parlor water, sprinkler pens, and runoff from concrete surfaces have the largest potential to reduce water use and storage needs.*
- Installation of settling basins and/or mechanical screens to reduce solids content of flush water. Solid particles can build up in storage lagoons, reducing capacity. Coarse solids removed from the flushwater before transfer to storage lagoons can be composted and recycled as bedding, and fine (settled) solids can be applied as a solid fertilizer to crop fields.
- Timely removal of buildup of manure solids in ponds to maximize lagoon storage capacity. Even with settling basins and screens, fine solids will accumulate in storage lagoons. This material must be checked and periodically removed by dredging or excavation.

Mechanical screen removes coarse solids from manure flush water.

What about anaerobic digestion?

A few dairies in California are using anaerobic digestion to generate electricity. The objective of anaerobic digestion (AD) is to degrade solid organic material in a no-oxygen environment and capture the methane gas generated by this process. The methane is then converted to electricity to offset energy costs at the dairy. AD in a controlled environment can be beneficial in reducing odor. AD may transfer a portion of nitrogen and phosphorus from the liquid effluent to the solid residue. However, AD does not markedly change the total quantity of the nutrients and salts that eventually must be either recycled to cropland or transferred off farm for other uses.

Management Measure A5. *Apply nutrients to crops at agronomic rates*

A principal cause of over-application of manure to crops is the variability in the nutrient value of manure. Knowledge of manure nutrient content allows producers to reduce use of commercial fertilizers without risking crop yields. Some dairies that have implemented improved nutrient management techniques have experienced increased costs but these increases can be offset by savings in commercial fertilizer expenses. The main practices being pioneered on dairies are:

- Frequent manure sampling and analysis of nutrient content. Manure nutrient content is highly variable, and "book values" are unreliable.

* D. Meyer, B. Reed, C. Batchelder, I. Zallo, P. L. Ristow, G. Higginbotham, M. Arana, T. Shultz, D. D. Mullinax, J. Merriam 2006. Water use and winter liquid storage needs at central valley dairy farms in California. Applied Engineering in Agriculture.Vol. 22(1): 121-126.

- Use of flow metering (or other accepted techniques for estimating liquid manure application rates) and control valves to apply pre-determined amounts of manure water during irrigations. For solid manure, accounting of the weight of manure applied.

Liquid manure flowmeter.

- Integration into farm production recordkeeping of manure nutrient content and quantities applied to each field.
- Use of soil and plant analysis as tools to back up manure nutrient application decisions and to evaluate the manure application program at the end of each season.

Management Measure A6. *Improve irrigation system efficiency and water distribution uniformity in surface gravity-based irrigation systems*

Poorly designed and operated irrigation systems are a major cause of nutrient leaching and runoff. In some regions of California, excessive irrigation is a leading cause of nitrate and salt leaching to groundwater. Most dairies in the Central Valley apply manure to crops by mixing manure water with fresh water and applying it during normal irrigation events. Non-uniform irrigation therefore directly leads to non-uniform manure nutrient applications. A well-established approach for addressing this is to conduct an **irrigation system evaluation** and make one or more improvements. For example:

- Re-level fields to create the proper field slope for irrigation.

"Torpedos" for smoothing furrows.

- Reduce field lengths (e.g., cutting long fields in half) — a practice that can improve irrigation uniformity.
- Compact soil in furrow bottoms, e.g., by pulling heavy weights ("torpedoes") through the field with a tractor. This can speed up the flow of water across the field and make the irrigation more uniform.
- Install a tailwater return system to prevent surface runoff during irrigations with manure water or rain events. Increased irrigation water flow rates can lead to improved water (and manure) distribution uniformity, however, higher flow rates will also usually increase the volume of tailwater generated, which if not captured and recycled may enter surface waters.
- Use irrigation scheduling methods promoted by the California Department of Water Resources. However, in some locations, the producer's flexibility to irrigate at the optimum time is constrained by the irrigation district water delivery schedules.

Tail water return pump.

B. Dairies with Non-irrigated Pasture and Hay Fields

Dairies in this category are common in the northern San Francisco Bay Area and along the north coast. Although some dairies in the region do irrigate, rolling terrain, irregularly shaped fields and limited summer water supply often make this difficult or impossible; and the higher winter and spring rainfall make it possible to produce hay, grain, and pasture without irrigation for part of the year. Dairies in this region generally operate with smaller herds than are typical in the Central Valley and Southern California. Mature cattle are generally housed in freestall barns, and young stock are raised on pasture. Producers often use a double waste pond collection system that allows separate management of solids and liquids. Manure is applied to the fields by pumping, by slurry truck, or in a few cases through "big gun" sprinklers.

The main water quality goal is to limit movement of nutrients and pathogens from manure to protect aquatic organisms, habitat, recreational waters, and shellfish harvesting.

The main water quality goal for this style of dairy is to limit movement of nutrients and pathogens from manure into surface water to protect aquatic organisms, habitat, recreational waters, and shellfish harvesting. Contamination of groundwater is a concern in some locations but typically is a lower risk than in the Central Valley due to the topography and hydrology.

Management Measure B1. *Limit manure runoff from animal confinement areas*

During the summer and fall months, cattle are kept in pasture or stall barns with exercise and outside feeding areas. Manure builds up in these areas, and they are devoid of significant vegetation. This requires that they be managed to protect surface water sources when the winter rains begin. Practices include:

- Scraping corral areas to remove manure before rains begin, reducing the nutrient source load and thereby decreasing the risk of manure runoff reaching surface water.

- Restricting the use of exercise lots during the winter or reducing size. This can decrease the risk of surface water pollution by reducing the source of potential contaminants.
- Seasonal seeding or mulching of exercise lots and outside feeding areas to improve soil stability and water infiltration.*
- Leveling or grading corrals and in some cases reseeding to eliminate rills and gullies and channelization of flow, thereby minimizing soil erosion.

Management Measure B2.
Prevent runoff from manured fields from entering surface waters

During the fall, it is common for producers in the northern Bay Area and coastal regions to spread manure on hay fields. The fate of the manure nutrients depends largely on the intensity of the first few rain events. If rains are light, manure nutrients are carried into the soil profile where they are available to support newly emerging plants. However, if initial rains are heavy, the risk of nutrients being washed into nearby waterways may be increased. Practices to limit this risk include:

- Enhancing stream bank vegetation to reduce surface runoff and increase deposition of sediment and nutrient loads before entering surface waters.
- Leaving buffer zones of sufficient size between manured areas and water courses. This increases transit time of overland flow and infiltration, reducing the risk of sediment or manure nutrients reaching surface water. The required buffer size depends on vegetation cover density, slope and soil characteristics.
- On steep land, controlling the amount and timing of liquid manure releases so that it does not flow into surface water.
- Incorporation or partial incorporation of manure on hay fields (vs. surface broadcast with no incorporation). By incorporating manure and manure nutrients into the soil, their availability for transport in surface runoff is reduced.

* Lennox, M. J., D. J. Lewis, J. Gustafson, K. Tate, and E. R. Atwill. In press. Water quality treatment for exercise lots and feeding areas: Seeding and mulching practice for California coastal dairies and ranches. Oakland: University of California Division of Agriculture and Natural Resources.

C. Dairies with Limited Cropland

Dairies with little or no adjoining cropland — common in the Chino Basin near Los Angeles and found in a few other places in California — must import most of their feed and transport most manure off farm for other uses. The cattle in these dairies are housed most of the time in dry-lot corrals. Liquid and dry wastes are managed separately on these farms. Liquid wastes account for a small portion of stored manure and may be applied to land near the dairy if there is a small acreage of sudangrass, oats and barley adjoining the dairy. These crops are grown in constant rotation in order to maximize the amount of nutrients that can be applied per year. Solid manure is trucked to more distant farms or to commercial composting facilities.

In the Chino Basin, urbanization has greatly decreased the amount of nearby land available for crop production and manure recycling. The low land-to-cow ratio makes dairy production environmentally and economically unsustainable. This model of dairy is becoming obsolete and will most likely disappear. There were once over 450 dairies in the Chino area. Today that number is 150 (Almeida, 2006). Of the dairies still standing in the area, between 70 and 80 percent have been sold or are in escrow, according to Nathan deBoom, formerly of the Milk Producers Council.*

*Almeida, Christina. 2006. Sprawl pushes dairy families to consider leaving California. Union-Tribune Publishing Co. ASSOCIATED PRESS. San Diego. February 25, 2006. http://www.signonsandiego.com/news/state/20060225-0941-ca-dairyflight.html

Management Measure C1. *Develop off-farm markets for solid manure*

Dairies do not own adequate crop land for the use of all the manure nutrients generated on the farm. This can increase the risk to ground and surface water contamination if the nutrients remain on the farm. Dairy producers can mitigate this risk by establishing reliable business relationships that allow the producer to:

- Use the manure on nearby specialty crop farms.
- Dispose of manure through commercial markets where it can be composted or treated in a digester before being used as a soil amendment by landscape contractors, bagged for home garden use, or made into fireplace logs or peat pots for commercial nurseries.

Management Measure C2. *Manage corrals so they do not become sources of pollution*

Dairies without cropland are often based on a dry-lot system of cow management. Dry-lots can accumulate large amounts of manure and can present a risk to ground and surface water if not managed properly. Improved techniques include:

- Scraping and removing manure from corrals three or four times per year, including immediately before the rainy season.
- Grooming corrals by grading and adding soil before the rainy season to ensure adequate corral slope and facilitate drainage.

Management Measure C3. *Minimize liquid waste volume requiring off-farm disposal*

Manure water produced during normal dairy operations is generally disposed of on-site for dairies with limited cropland. Practices have been developed by these dairy producers to reduce the risk that these nutrients can present under limited land conditions. These include:

- Water conservation: Water is conserved and reused whenever possible. For example, water used to cool the milk can be collected and reused to wash the cows.
- Triple cropping on the small areas of available cropland: Growing a continuous rotation of warm and cool season grasses allows multiple applications of manure nutrients during the year. Triple cropping allows more nutrients to be applied to smaller amount of land but it requires a higher level of crop management than with less intensive crop rotations.
- Manure water containment: No water that has come into contact with manure leaves the property as run off. It is collected and held in large ponds until it can be applied to the wastewater management land.

Water is reused whenever possible, for example water used to cool the milk can be collected and reused to wash the cows.

Summary

California dairies are operating in an unprecedented environment of regulatory oversight and public scrutiny. Producers are faced daily with the challenge of providing affordable dairy products while protecting the state's water and air quality. With the complexity and size of modern dairies, a more "engineered" approach must be taken than in the past when dairies were smaller and in most cases farther from large urban populations.

To address these new challenges, progressive dairy producers have in recent years made improvements in four critical areas:

1. suitable storage for manure
2. infrastructure for distributing manure nutrients to cropland
3. provision of sufficient cropland and specific crop nutrient and irrigation practices
4. management procedures and recordkeeping

While the main responsibility for this progress is rightly placed on the state's dairy farmers, it will greatly help the situation if political leaders, lending institutions, government agencies, and the urban public become more knowledgeable about the constraints facing dairy producers as well as the technologies available to them for protecting the state's natural resource base.

Additional Reading

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Authors

Patricia L. Ristow
Postgraduate Researcher
University of California, Davis

G. Stuart Pettygrove
Cooperative Extension Soils Specialist
University of California, Davis

Deanne M. Meyer
Cooperative Extension Livestock Waste Management Specialist
University of California, Davis

David Lewis
Watershed Management Advisor
University of California Cooperative Extension
Sonoma, Marin, and Mendocino Counties
Santa Rosa, California

Nyles Peterson
Dairy Advisor and County Director
University of California Cooperative Extension
San Bernardino, California

Janet C. Broome
Former Associate Director, University of California Sustainable Agriculture Research and Education Program
Area Plant Pathologist
University of California Cooperative Extension
Sacramento, Yolo and Solano Counties

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