

April 23, 2007

Chair Dr. Karl Longley and Members
Central Valley Regional Water Quality Control Board
Sacramento Main Office
11020 Sun Center Drive #200
Rancho Cordova, CA 95670-6114

Sent via electronic mail to plowry@waterboards.ca.gov

**Re: Review of Tentative California Regional Water Quality Control Board –
Central Valley Region Waste Discharge Requirements General Order for
Existing Milk Cow Dairies**

Dear Regional Board Staff and Members of the Board:

We are writing on behalf of Baykeeper, the Sierra Club, the California Sportfishing Protection Alliance, and the Waterkeeper Alliance to provide comments on the Tentative Waste Discharge Requirements General Order for Existing Milk Cow Dairies (hereinafter “the Order”). We thank you for this opportunity to provide comments on the General Order; staff’s hard work to date on this issue is appreciated.

Outstanding Questions

1. Will there be a vehicle for regulating new dairies (facilities coming on line after October 17, 2005) by this or a similar Order? If not, approximately how many dairies will be exempt from these environmental regulations? What are the environmental risks posed by these potential dairies, individually and collectively?
2. What is the cutoff date for older dairies to be covered under this Order? Will there be a vehicle for regulating dairies older than this date by this or a similar Order? If not, approximately how many dairies will be exempt from these environmental regulations? What are the environmental risks posed by these older dairies, individually and collectively?
3. Are there dairies that did not complete a Report of Waste Discharge (which would preclude them from coverage under this Order) that would otherwise be covered by this Order? If so, approximately how many dairies will be exempt from these

environmental regulations? What are the environmental risks posed by these dairies, individually and collectively?

4. When will the Board decide the size of dairies to which this Order will apply? Will larger or smaller dairies be covered by a similar Order? If not, approximately how many dairies will be exempt from these environmental regulations? What are the environmental risks posed by these other facilities, individually and collectively?

Legal Analysis

Below is a brief discussion of the legal requirements supporting regulation of Central Valley dairies via a National Pollutant Discharge Elimination System (“NPDES”) permit. Please note that a more thorough legal analysis is contained in the letters submitted on our behalf by Lawyers for Clean Water on June 12, 2006 and January 16, 2007. We hereby incorporate these letters, which are attached, by reference

Federal and state law require that discharges from Central Valley dairies be regulated via an NPDES permit. The Clean Water Act prohibits discharges of pollutants to waters of the United States from point sources unless authorized by a permit issued pursuant to federal NPDES regulations. 33 U.S.C. § 1311; 40 C.F.R. § 122.41(b)(1). NPDES permits may be issued by the Environmental Protection Agency (“EPA”) or, as is the case in California, by a State to which EPA has delegated permitting authority. 33 U.S.C. § 1342(b)(1)(A), (c)(3). Delegated States, however, must regulate all discharges via permits that are at least as or more stringent than those required by NPDES permitting regulations. 40 C.F.R. § 123.25(a). Federal regulations specifically define CAFOs as point sources subject to NPDES permitting requirements. 40 C.F.R. § 122.23(a). (“Concentrated animal feeding operations are point sources subject to the NPDES permit program.”); *see also Revised National Pollution Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines for Concentrated Animal Feeding Operations in Response to Waterkeeper Decision*, United States Environmental Protection Agency, 71 Fed. Reg. 37744, 37784 (June 30, 2006) (“Concentrated animal feeding operations, as defined in paragraph (b) of this section, are point sources.”). To ensure consistency with federal NPDES regulations, therefore, any permit issued to CAFOs must be an NPDES permit with provisions as least as stringent as those specified in the applicable federal regulations.

Despite claims to the contrary in the fact sheet, the United States Court of Appeals for the Second Circuit did not “vacate[] the requirement for all CAFOs to either apply for an NPDES permit or demonstrate they have no potential to discharge.” Information Sheet at 22. While the *Waterkeeper* Court articulated that there are limits on EPA’s authority to require NPDES permits, its decision does not affect this Regional Board’s ability to issue an NPDES permit for Central Valley CAFOs. In fact, the *Waterkeeper* decision limited EPA’s ability in only one respect – the Court held that EPA could not require a facility to seek permit coverage merely because it has a “potential” to discharge. *Waterkeeper, Inc.*

v. EPA, 399 F.3d 486, 505 (2nd Cir. 2005). The court suggested, however, that EPA could issue permits where “necessary to effectively regulate water pollution from Large CAFOs, given that Large CAFOs are important contributors to water pollution and that they have, historically at least, improperly tried to circumvent the permitting process.” *Id.* at 506 n. 22. Thus, the *Waterkeeper* decision leaves open the possibility that a general permit is appropriate when necessary to control actual sources of water pollution.

Furthermore, the Second Circuit affirmed an NPDES permit requirement for CAFOs that have “actual” discharges. *Id.* at 505. EPA responded to the remand on this issue by adjusting its permitting regulations to require NPDES permits for CAFOs that have had discharges in the past or those that propose to discharge in the future. *See* 71 Fed. Reg. 37748-49; *see also* 40 C.F.R. § 122.21(a)(1). The existence of “proposed discharges” may reasonably be inferred from evidence of past discharges where the CAFO operator has not made the necessary repairs, modifications, or corrections to assure that repeat discharges are unlikely to occur. *See, e.g., Carr v. Alta Verde Industries*, 931 F.2d 1055 (5th Cir 1991). The administrative record suggests widespread discharges from dairy CAFOs in the Central Valley, and is sufficient to compel the Regional Board to require these facilities to apply for an NPDES permit. Rather than issuing individual or general NPDES permits to cover dairies with previous discharges, the Regional Board should make the proposed WDR an NPDES permit.

The evidence before the Regional Board, justifies a general NPDES permit approach to effectively control water pollution from milk cow dairies in the Central Valley. Findings 21-24 of the Tentative WDR summarize the substantial impact dairy operations have on water quality.¹ Finding 24 concludes:

“[t]he waste management systems at these existing dairies are commonly not capable of preventing adverse impacts on waters of the state either because of their outdated design or need for maintenance or both. Historic operation of these dairies has presumptively resulted in an adverse effect on the quality of waters of the state.”

In response to the documented impacts that milk cow dairies have on the waters of California, the Regional Board has correctly taken steps to resolve the problem. Inexplicably however, the Regional Board proposes to take this action without meeting its obligations under federal law. In 1999, the Santa Ana Regional Board, faced with similar evidence and under similar circumstances, issued a General NPDES permit for discharges from dairies and related facilities. It correctly concluded that EPA regulations set forth at 40 C.F.R. section 122.23(b) warrant regulation of most, if not all, dairies as CAFOs through the NPDES permit program. By not following the Santa Ana Region’s lead, the Central Valley Regional Board creates an inappropriate race to the bottom where dairies looking to escape Clean Water Act regulation may relocate to the Region, thereby increasing pollution in our watershed.

¹ Tentative WDR, Findings 21-24.

General Comments

1. *The Order should prohibit and otherwise discourage the over-application of manure and process wastewater.*

Over-application of manure and process wastewater nutrients is of utmost concern. Throughout the Order the operator is required to submit land application area identification information, but the Regional Board must check each dairy operation's land application areas against the land application areas submitted by other dairies and importers of manure and process wastewater to prevent double-counting, as has occurred in other states. The Regional Board should also check with other Regional Boards, should manure and process wastewater be exported across regional boundaries.

2. *The Order should recommend treatment technologies.*

Treatment technologies such as aerobic digestion, anaerobic digestion, composting, constructed wetlands, and nitrification-denitrification, in addition to storage covers and solid separation, are treatment methods that can significantly improve nutrient management and protect water quality. (Robbins, 2005). While the Regional Board may chose not to prescribe specific manure and process wastewater treatment technologies, failure to mention proven treatment technologies other than anaerobic digestion is remiss and suggests endorsement of that particular technology. A brief introduction to a variety of technologies in the Order is recommended.

3. *The Order should require monitoring of tile drain effluent.*

Tile drains in land application areas provide direct conduits for contaminants such as phosphorus, nitrogen, and pathogens from liquefied manure and process wastewater to waters of the State (Geohring et al., 1998; Scott et al., 1998; Hoorman et al., 2004; Geohring et al., 2005). Studies have shown that the surface application of liquid manure to land with tile drains leads to rapid increases of NO₃-N in the drainage effluent, approaching concentrations similar to that of the liquid manure (Geohring et al., 2005). It is well established that excessive levels of nitrogen and phosphorus in surface waters accelerate eutrophication and excess nitrogen in drinking water is a human and animal health hazard. However, immediate incorporation of liquefied manure resulted in the absence of increased concentrations of NO₃-N in drainage effluent (Geohring et al., 2005). The Order omits a discussion of the relationship between the presence of tile drains, liquefied manure application, and increased pollutant concentrations in drainage effluent. To adequately protect water quality, the drainage effluent from tile drains must be monitored and land application methods altered as necessary to better protect water quality.

4. *The Order should encourage incorporation of liquefied manure and process wastewater.*

As noted above, incorporation of liquefied manure and process wastewater can significantly improve the quality of effluent discharges from tile drains, as well as reduce the risk of contaminating any stormwater and therefore waterbodies of the State. Incorporation also prevents evaporation of ammonia; estimates suggest that as much as 35 percent of a farm's ammonia emissions occur during land application (Geohring et al., 2005). The Order lacks any discussion of incorporating manure and process wastewater during land application, instead relying on infiltration within 72 hours. Relying on infiltration alone is not protective of water quality, and methods of incorporation should be discussed and encouraged.

5. *The Order should prohibit the application of manure and process wastewater to cracked soils.*

Cracked or desiccated soils may provide a direct route for manure or process wastewater and their associated pollutants to reach surface or ground water via tile drains and infiltration. The Order must prohibit the application of manure or process wastewater to soils that are cracked or desiccated in order to protect water quality.

6. *The Order should prohibit application of manure and process wastewater to saturated or frozen land.*

It is well known that applying manure or process wastewater to land that is saturated or frozen will result in unnecessary runoff and degrade surface water quality. The Order is remiss in not prohibiting the application of manure and process wastewater to frozen ground (Land Application Specifications C.9, pg. 16). This prohibition should be incorporated into the Order and Prohibition A.11 (pg. 10) should include a prohibition of land application under saturated or frozen soil conditions.

7. *The Order should require an erosion and sediment control plan for land disturbing activities.*

Suspended solids, resulting from erosion, are one of the leading causes of impairment to U.S. waterbodies. Additionally, suspended solids can increase the concentrations of other pollutants by providing a binding site for pathogens and other contaminants, especially metals. The Order neglects to discuss or require erosion control for land disturbing activities such as construction. An erosion and sediment control plan should be required for any enlargement or new construction of waste storage facilities, animal housing structures, monitoring wells, or any other activity that disturbs vegetation and the soil surface (General Specifications B.8, pg. 13).

8. *The Order should require an emergency plan.*

An emergency plan—including local, state, and federal agency phone numbers—should be required as part of the operations and maintenance plan associated with storage facilities (General Specifications B.8.a.v, pg. 13). The emergency information and contact list should include: the office and cell/home phone number for owner/operator; office and cell/home phone number for facility manager; phone number for local law enforcement and state law enforcement; phone number for the closest fire department; office and cell phone numbers for primary and secondary CAFO officials; office and cell phone number(s) for state and regional/district water resource protection official(s); office and cell phone number(s) for any downstream drinking water suppliers; office and cell phone number for extension agent; office and cell phone number for soil and water conservation district agent; instructions for any containment measures for waste spills, fertilizer and pesticide spills, and potentially explosive situations; several copies of maps of the entire facility; and a posted copy of the emergency situation policy for all employees and visitors.

9. *The Order should require adequate freeboard for storage structures.*

Adequate freeboard is essential for both structural integrity and to prevent possible overtopping. Less than one foot of freeboard for below-ground storage structures and two feet of freeboard for above-ground structures should not be permitted (General Specifications B.10, pg. 13). Should freeboard of less than this depth occur the operator should be required to choose from a list of actions that will rectify the situation in the most environmentally sound manner possible, in conjunction with the farm's nutrient management plan.

10. *The Order should require the separation of roof drainage from manure or process wastewater.*

At every opportunity possible, clean water should be kept clean, including precipitation and roof drainage. All roofed structures should be guttered, with the roof drainage directed away from any animal production areas. Roof drainage should never be allowed to flow into corrals, where it will come in contact with manure or process wastewater (General Specifications B.15, pg. 14).

11. *The Order should better define “sludge” and “biosolids.”*

The terms *sludge* and *biosolids* are confusing as first used in Provisions E.6 (pg. 18), since many dairies and other livestock facilities generate material(s) that are referred to as sludge or biosolids during manure and process wastewater storage and treatment. These terms should either be defined as municipal or industrial sludge and municipal or industrial biosolids or removed from the Order.

Monitoring and Reporting Comments

1. *The Order must require nutrient monitoring for groundwater to protect public health.*

Nutrient contamination of groundwater, especially nitrogen is a significant concern. Increased levels of nitrogen in drinking water and agricultural supplies can cause the potentially fatal disease methemoglobinemia in human infants and spontaneous abortions, illness, and death in cattle. The Order only requires groundwater monitoring for minerals and only annually for two years after groundwater monitoring wells are installed (Monitoring Requirements A, Table 2 – Nutrient Monitoring, pg. MRP-3). This is not protective of groundwater resources, public health, or agricultural productivity. Instead, groundwater monitoring should occur at least once per year for five years after wells are installed and should include monitoring for nitrogen and phosphorus.

2. *The Order must require bacterial monitoring to protect public health.*

Bacteria are identified as the leading cause of water quality impairments in rivers and streams in the United States. Agricultural runoff contains bacteria, viruses, protozoa, and parasites from fecal contamination from livestock and wildlife. Pathogens in water also affect human health; upper respiratory and gastrointestinal illness, eye and ear infections, and skin rashes of various degrees of severity are examples of human health problems associated with runoff. Additionally, pathogen-laden runoff can contaminate shellfish beds, resulting in the closure of commercial and recreational shellfishing, and food crops. To adequately protect water quality and human health, tailwater discharges (Monitoring Requirements A, Table 1 – Discharge Monitoring, pg. MRP-6), stormwater discharges, and tile drainage systems (Monitoring Requirements A, Table 7 – Groundwater Monitoring, pg. MRP-7) should all be monitored for total and fecal coliform, indicators of fecal contamination.

3. *The Order should require monitoring upon specific operational changes.*

Successful nutrient management plans and farm management plans are contingent upon monitoring results. All monitoring results should directly feed back into nutrient management plans to better manage a facility's nutrient loads and to be protective of water quality. Additionally, any changes in manure and process wastewater collection, storage, or treatment processes; cropping alterations such as changes in species, rotation schedule, density, etc.; or changes in feed content should trigger monitoring, including reinitiating monitoring requirements that may have expired. All monitoring should be representative of the discharge or land application area to be monitored.

4. *The Order should require visual inspections in anticipation of rain events.*

An operator is required to visually inspect stormwater containment structures for discharge, freeboard, berm integrity, cracking, slumping, erosion, excess vegetation, animal burrows, and seepage during and after a *significant storm event* (Monitoring

Requirements A, Table 3 - Inspections, pg. MRP-2). The term *significant storm event* is defined as a “storm event that results in continuous runoff of stormwater for a minimum of one hour, or intermittent runoff for a minimum of three hours in a 12-hour period.” (Monitoring Requirements, pg. MRP-2 fn. 1). Since stormwater runoff volumes can differ across a farm depending on micro-climates, soil types, slope, and degree and type of vegetation, it may be difficult for an operator to estimate the volume of runoff across the entire facility, requiring a sophisticated monitoring system. Instead, the operator should be required to conduct visual inspections when rain is predicted by the National Weather Service or when precipitation is observed.

5. *The Order should require visual inspections for all applications.*

An operator is required to visually inspect the land application area daily when process wastewater is being applied (Monitoring Requirements A, Table 3 - Inspections, pg. MRP-2). To be protective of water quality, this requirement should be expanded to whenever manure, tail water, irrigation water, or other land applications occur.

6. *The Order should require nutrient monitoring before and after storage.*

Storage and treatment of manure and process wastewater can significantly change the nutrient concentrations and forms in these substances. In order to prevent any miscalculations of nutrient content resulting in over-application, nutrient monitoring should occur both before storage and treatment and after to determine the effectiveness of the treatment method and any losses to air via evaporation, as well as accurately characterize the nutrient contents and forms of these substances before they are land applied (Monitoring Requirements A, Table 2 – Nutrient Monitoring, pg. MRP-3).

7. *The Order should require a mass balance analysis of nutrient loadings.*

As stated above, excess levels of nutrients in surface water negatively affect water quality. The Order proposes an annual sum of manure applied to land application areas and exported offsite (Monitoring Requirements A, Table 2 – Nutrient Monitoring, pg. MRP-3). This requirement should be expanded to include process wastewater as well as sum the total nitrogen and phosphorus loads land applied and exported offsite as part of an overall nutrient balance.

8. *The Order should require more representative soil monitoring.*

Soil does not act as a bottomless sink for nutrients, as once believed. Excess levels of soil nutrients leach, contaminating water resources. The Order requires soil testing of each land application area every five years for total phosphorus (Monitoring Requirements A, Table 2 – Nutrient Monitoring, pg. MRP-4). This frequency is insufficient to protect water resources. Instead, the Order should require soil testing every three years for each land application area for total phosphorus. Testing locations should be representative of the land application area. Additionally, the nitrate-nitrogen spring and fall pre-plant soil tests should be required, rather than only recommended.

9. *The Order should require equipment calibration and calibration record keeping.*

Calibration of land application and monitoring equipment is a vital component of responsible nutrient management. A study of farmers' estimates of manure application rates found that 50 percent of the surveyed livestock producers and growers would have applied twice the desired application rate if they relied solely on visual estimates (Mancl and Slates, 2003). The tendency to underestimate manure application and therefore over-apply nutrients reinforces the need to calibrate land application equipment. All equipment should be calibrated according to the manufactures' instructions and records of this calibration should be recorded and kept for five years (Record-Keeping Requirements B, pg. MRP-9).

10. *The Order should require retention of monitoring records.*

All results of manure, process wastewater, irrigation water, soil, plant tissue, discharges, surface water, stormwater, subsurface water, and groundwater monitoring should be retained for five years, whether the monitoring is required by the Order or is additional monitoring (Record-Keeping Requirements B.6, pg. MRP-10).

11. *The Order must require complete monitoring of any and all un-permitted discharges.*

Any instance of a discharge that is not in compliance with this Order should be tested for nitrogen, phosphorus, and total and fecal coliform (Reporting Requirements C. 5, pg. MRP-11).

12. *The Regional Board must approve sampling plans.*

To best characterize the quality of water from domestic and agricultural supply wells, samples should be taken from an outdoor spigot or other access point prior to treatment or water softening (Groundwater Monitoring, Table 4 – Groundwater Monitoring, pg. MRP-7). Only cold water samples should be collected. A detailed sampling plan should be approved by the Regional Board prior to monitoring.

Attachment A Comments: Monitoring and Reporting Program Additional Groundwater Monitoring, Monitoring Well Installation and Sampling Plan, and Monitoring Well Installation Completion Report for Existing Milk Cow Dairies

1. *The Order should require installation of additional groundwater monitoring wells when pathogen levels are exceeded.*

As noted before, the presence pathogens in domestic and agricultural supply wells are a serious threat to human health. In addition to nitrate levels exceeding 10 mg/L in domestic wells, pathogen levels exceeding applicable domestic drinking water standards

should also trigger the need to install groundwater monitoring wells (Additional Groundwater Monitoring A, pg. MRP-18).

2. *The Order must ensure that monitoring wells are timely installed.*

While prioritizing dairies for groundwater monitoring wells is commendable, the current ranking system is inadequate because it fails to include a discrete range or percentage of scores that will require dairies to install groundwater monitoring wells during the various phases (Additional Groundwater Monitoring A, Table 5 – Groundwater Monitoring Factors for Ranking Priority, pg. MRP-18). With approximately 1,600 dairies eligible for coverage under this Order and proposed well installation phasing of only 100 to 200 dairies per year (Additional Groundwater Monitoring A, pg. MRP-17) it may take eight to 16 years to implement groundwater monitoring across the region. Discrete ranges or percentages of risk scores are required in order to ensure monitoring wells are installed in a timely manner and groundwater resources are being adequately protected.

3. *The Order must require pathogen monitoring of groundwater.*

Manure contains pathogens that livestock shed as they defecate. Pathogen contamination of groundwater is a significant health concern, especially if domestic water wells are affected. The groundwater monitoring program fails to adequately protect public health as it does not require testing for pathogens (Additional Groundwater Monitoring A, Table 6 – Additional Groundwater Monitoring, pg. MRP-20). Groundwater samples should be monitored for total and fecal coliform on a semi-annual basis.

Attachment B Comments: Waste Management Plan for the Production Area for Existing Milk Cow Dairies

1. *The Order should consistently use the term “process wastewater.”*

This attachment and other attachments use both *wastewater* and *process wastewater*, where in previous parts of the Order only process wastewater was used. To maintain consistency and prevent any confusion, only the term process wastewater should be used throughout the Order.

2. *The Order should require more detailed site maps.*

The site map should include the location of any steep slopes; highly erodible land; soil types; and crop rotation schedule, noting any legumes (Facility Description I.F.2.a, pg. B-2).

3. *The Order should require more information in the engineering reports.*

In addition to the storage capacity information required, the engineering report should also include the age(s) of waste storage or treatment structure(s), whether the waste

storage or treatment structure(s) are engineered systems or not and the name and contact information for the professional engineer who stamped any of the structures, and whether the waste storage or treatment structure(s) are lined and with what (Engineering Report II, pg. B-3).

4. *The Order must require adequate liners and leachate removal systems for ponds and treatment lagoons.*

Pond liners are an integral part of storage pond and treatment lagoon design to prevent pollutants from seeping and contaminating water resources. Pollutants of concern from seepage include nutrients, salts, pathogens, hormones, antibiotics, and other pharmaceuticals. Groundwater, drinking water wells, and surface water are at risk from contamination and possible ecosystem damage, not to mention public health concerns. The Regional Board is strongly urged to require all storage ponds and treatment lagoons to have an adequate liner and leachate removal and treatment system (Engineering Report II.B.2, pg. B-4).

Attachment C Comments: Contents of a Nutrient Management Plan and Technical Standards for Nutrient Management for Existing Milk Cow Dairies

1. *The Order should require NMPs to contain more detailed information.*

The nutrient management plan should include: the name and contact information (including address and phone number) for the person who created the NMP; the date that the NMP was drafted; the name, title, and contact information of the person who approved the final NMP; the date of NMP implementation; anticipated dates of completion/implementation for any planned managerial or structural BMPs; the date for the next review of the NMP; and the name(s), title(s), and contact information for anyone who inspects the facility, the date(s) of inspection(s), and the cause(s) for inspection.

2. *The Order should require disclosure of crop rotation schedules.*

The crop rotation schedule should also be included in the Crops Grown section (Land Application Area Information I.B.4, pg. C-3), noting any legumes.

3. *The Order should prohibit the application of manure to saturated soils.*

Nutrients, in both solid and liquid forms, applied to saturated soils pose a greater risk of contaminating water than nutrients applied to soils that are not saturated. While the Order prohibits the application of (process) wastewater under saturated conditions, it is remiss in not also prohibiting the application of manure to saturated soils (Nutrient Application Timing C.2, pg. C-12). To protect water quality, manure applications under saturated conditions must also be prohibited.

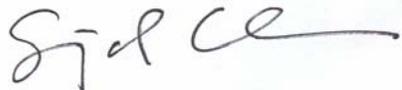
Conclusion

Baykeeper, the Waterkeeper Alliance, Sierra Club, and the California Sportsfishing Protection Alliance urge the Regional Board to issue an NPDES General Permit for Central Valley cow dairies. The significant water quality impacts from dairy discharges of nutrients and pathogens require the Regional Board to regulate this pollution source under federal law. By failing to issue a General Permit, the Board fails to adequately protect the Central Valley watershed.

In addition, we believe that the current Order and related plans, specifically the monitoring, waste management and nutrient management plans, are sorely lacking in critical information and requirements which are necessary to adequately regulate dairy pollution and protect our surface and groundwaters. We respectfully request the Regional Board make changes to the Order and Attachments based on our comments and concerns herein.

Thank you again for this opportunity to provide comments. If you should have any questions, please feel free to contact Sejal Choksi at Baykeeper.

Sincerely,



Sejal Choksi
Baykeeper

Dale Stocking
Sierra Club, Mother Lode Chapter

Bill Jennings
California Sportsfishing Protection Alliance

Jeffrey Odefey
Waterkeeper Alliance

Attachments:

- A. Comments on Tentative Waste Discharge Requirements General Order for Existing Milk Cow Dairies, submitted by Lawyers for Clean Water on January 16, 2007.
- B. Comments on Draft of Waste Discharge Requirements for Dairy CAFOs, submitted by Lawyers for Clean Water on June 12, 2006.

- C. Geohring, L.D., P.E. Wright, T.S. Steenhuis. 1998. Preferential Flow of Liquid Manure to Subsurface Drains. Drainage in the 21st Century: Food Production and the Environment. Proceedings of the Seventh International Drainage Symposium. Orlando, Florida.
- D. Geohring, L.D., S. Lee, P.E. Wright, T.S. Steenhuis, and M.F. Walter. 2005. Drainage Water Quality Response to Liquid Manure Application. American Society of Agricultural Engineers. ASAE Paper 05-2065. St. Joseph, Michigan.
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- H. Scott, C.A., L.D. Geohring, M.F. Walter. 1998. Water quality impacts of tile drains in shallow, sloping, structured soils as affected by manure application. Applied Engineering in Agriculture. 14(6): 599-603.