

Constructed wetlands for dairies

Component aids dairy wastewater treatment system

By Joanne Littlefield



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Researchers examine soil and water quality in the wetlands.

NOTE

UA College of Agriculture and Life Sciences (CALS) researchers from Agriculture and Biosystems Engineering, the Office of Arid Lands Studies, Animal Sciences, and Soil, Water and Environmental Sciences, as well as the Natural Resources Conservation Service (NRCS), and USDA, all collaborated on this project.

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Keeping cows clean and healthy requires continual pen and lane flushing in dairies, using thousands of gallons of water daily. The wastewater that is the end result has a high organic content which can be difficult to filter for reuse. Dairy operators, recognizing the need to recycle this water, have turned to University of Arizona College of Agriculture and Life Sciences (CALS) research for answers.

In the mid-1990s Rovey Dairy in Glendale, Arizona (northwest of Phoenix) began meeting with CALS faculty to determine the suitability of the site for experiments focused on plants and pond lining systems that would result in the cleanest water. Dairy owner Paul Rovey says he decided to participate in the project because it would benefit not only his operation, but the university and the dairy industry in Arizona as well.

"We liked the idea of having some new avenues for dealing with wastewater in a different, maybe a proactive kind of a way," Rovey says. "It's truly a dairy constructed project, and we've proven that if the dairy industry in Arizona decides dairies need to use this kind of system, a dairy can build a constructed wetlands on their own with the information that's available."

Conventional on-site treatment for manure has included scraping the pens and stockpiling the manure for fertilizing adjacent crops. In contrast, a flush system uses dairy wash water to remove manure from the dairy cow feeding lanes. This method saves labor, but increases the quantity and nutrient loading of

wastewater, which requires an improved wastewater treatment system for dairies with flush systems.

The Natural Resources Conservation Service (NRCS) and CALS have been working on guidelines for dairy operators and other confined animal feeding operations to meet Clean Water Act standards and Arizona Department of Environmental Quality inspection criteria. Beginning in 1996 an integrated dairy wastewater treatment system, which includes wetlands, was constructed at the Rovey Dairy adjacent to the milking parlor and feeding pens to meet these more stringent clean water regulations.

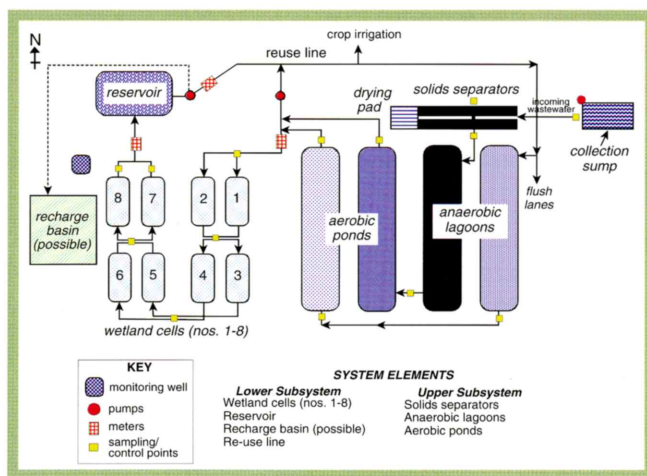
The two-phase project includes research equipment for conducting experiments on the treatment system. Phase one was completed in 2000; phase two's redesign and re-engineering were undertaken in response to phase one research results, and system modifications were completed in 2001.

THE TREATMENT SYSTEM

Over the last few years, municipalities across the nation have been developing wetlands systems of some kind to treat wastewater for reuse. The system being investigated for dairies is intended to be less complex and therefore less expensive for dairy operations to install and maintain.

The dairy wetlands component at Rovey Dairy includes a series of treatment cells or ponds to filter and remove contaminants from the water so that it can be recycled and conserved. The system, while man-made, is designed to mimic a natural setting, allowing plants to do the work of complicated pumps and filters. These treatment cells (*see chart, right*) include solids separators, anaerobic lagoons, and aerobic ponds.

The goal of the entire treatment system, including the wetlands, is to enable the dairy to decrease new water consumption. Thus the research team is examining ways to treat dairy wastewater so that the dairy can use it either as blended irrigation water for flushing back into the barn flush lanes, or as the water applied to composting the dairy manure solids. Martin Karpiscak, an associate research scientist with the CALS Office of Arid Land Studies and Bob Freitas,



Wastewater Treatment System at the Rovey Dairy

an associate in Cooperative Extension in the Department of Agricultural and Biosystems Engineering are the principal investigators on a collaborative project that includes researchers from the UA Department of Animal Sciences; the Department of Soil, Water and Environmental Science; and Cooperative Extension, Maricopa County.

According to Freitas, the arrangement of the ponds and lagoons is critical. The team has tried different configurations of the system, and found during the first phase of the project that insufficient oxygen was available for transforming nitrogen from the ammonium form to plant-available nitrate form, which the wetlands plants can use more readily.

One of the most significant findings indicates the importance of lining the ponds. Freitas says a compacted clay liner offers a considerable degree of sealing capacity. "For protection for groundwater we suggest that, at the very least, a clay liner be used that meets NRCS standards," he says. "Our research shows that over time the spaces clog between soil particles. As a biofilm is formed, the leakage rate declines."

WATER QUALITY, PLANTS AND INSECT CONTROL

Along with structural concerns, the research team needed to develop ways to keep the water clean. Karpiscak says the scientists checked the water for contaminants, including 1) pathogen levels, such as *Cryptosporidium* and *Listeria*; 2) indicator organisms such as total and fecal coliform; and 3) various forms of nitrogen such as nitrates and nitrites. They investigated the suitability of different plant species for the wetlands, taking plant measurements and samples to see how quickly the plants were growing.

"We also looked at things such as electro-conductivity to determine water salinity, at water temperature and at dissolved oxygen content," Karpiscak says. "One of our graduate students collected data on water quality of the wetlands cells, and wrote a master's thesis on the nitrogen content in the soil profile as well as in the plant material."

Unfortunately, mosquito breeding can be a problem with open bodies of water such as wetlands. Karpiscak says *Bacillus thuringiensis* var. *israeliensis* (Bti.) is typically used to control mosquito larvae in clear water. "The problem is that dairy water is not clear water. Neither Bti. nor *Bacillus sphaericus* worked very effectively for any period of time because of the high organic content," he notes. Research showed that the application of a larvicide (mineral oil) to seal the water surface so that the mosquito larvae could not breed worked the best in this situation.

The project is now moving into its second phase, according to Freitas. "Based upon our initial results, a new design of increased path length, multiple aerobic and anaerobic cycling, and an improved gravel based wetlands cell system shows promise in more effective water treatment," he says. The gravel-based system will also limit mosquito breeding. As the researchers fine-tune their recommendations, new guidelines will be developed and made available to dairy operators throughout the arid regions of the country.

Major funding for this project was provided by the Arizona Department of Water Resources, the Arizona Department of Environmental Quality, and the U.S. Bureau of Reclamation. ☐

WHAT IS A CONSTRUCTED WETLAND?

In brief, a constructed wetland is a water treatment facility. Duplicating the processes occurring in natural wetlands, constructed wetlands are complex, integrated systems in which water plants, animals, microorganisms and the environment—sun, soil, air—interact to improve water quality.

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