

Conservation Planning integrating site assessment and hydrologic modeling at the Mississippi State University Dairy Unit, Sessums, MS

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ABSTRACT

Reducing non-point source pollution associated with agricultural production is a high priority for policy makers and researchers. The test case of a 10-acre dairy farm headquarters was used to compare hydrologic modeling outcomes using HSPF to evaluate before- and after-installation effects of Best Management Practices (BMPs). The test site is a part of the Mississippi Agricultural and Forestry Experiment Station Dairy Unit, an 880-acre facility consisting of a dairy production facility, pasture, row crop and riparian forest in northeast Mississippi. The MAFES Dairy Unit is adjacent to Catalpa Creek in the Tibbee Creek watershed. Catalpa Creek was evaluated to determine its' condition before research into BMP implementation began, so that baseline data can be compared to conditions following future improvements. After an extensive site assessment of the production headquarters, opportunities for improving runoff were explored, and included the design of a vegetated swale that would slow runoff from the dairy production site and act as a buffer in the event of an overflow from adjacent treatment lagoons. HSPF was used to evaluate the effectiveness of this and other BMPs that were placed in the landscape. Future work and research will evaluate the entire site and include cost/benefit analyses of BMPs that are identified as potentially beneficial to water quality, control of water quantity, and increase wildlife habitat. The Conservation Planning process will be improved through the use of these tools, which allow multiple scenarios to be tested for their efficacy before final decisions are made as to land management practice.

Keywords: Agriculture, Hydrology, Management and Planning, Surface Water, Water Quality

Background

The Mississippi Agricultural and Forestry Experiment Station (MAFES) Dairy Unit is an 880-acre dairy production and research site. The site was chosen for research into conservation planning and design. The first stage of research included a hydrologic assessment of the headquarters and dairy production facility. Conservation practices selected for modeling were determined through consultation with Mississippi State University Department of Animal Sciences faculty, Dairy Unit staff, and MAFES administration. The primary concern was potential overflow of the treatment lagoon system. Also of research interest are agricultural impacts to Catalpa Creek, an impaired waterbody running through the southern portion of the site.

Methods

The Latis© framework (Wilkerson et al. 2006) was employed to investigate the effectiveness of conservation practices and their associated costs and benefits. Hydrologic assessment included calculation of sub-basin areas for the dairy production headquarters in ArcView™ and modeling of existing site runoff using BASINS/HSPF (Bicknell et al. 2001). A consultation with Dairy Unit staff and faculty members was conducted to determine their concerns regarding site hydrology. Their comments were used to help in determining site design needs and criteria. Prior to the selection or design of Best Management Practices (BMPs) for the property, an inventory and analysis of existing conditions was necessary to better understand the needs on the property. The

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Murdock, et al

site visits included a windshield survey of the entire 880-acre agricultural operations, a guided tour of the Dairy Unit facility that included demonstrations of the day-to-day operations, and two visual stream assessments of two reaches (Reach A and Reach B) of Catalpa Creek which runs through the southern portion of the property. The results of the site visits were used to identify potential problem areas throughout the farm, especially the areas directly affecting Catalpa Creek. Conservation practice design for the headquarters area included water harvesting, the placement of a vegetated swale adjacent to onsite treatment lagoons, and the conversion of a grass-dominated area on the site to woodland. The site was then modeled in HSPF taking the conservation practices into account. The design storm used for modeling occurred on November 1-17, 1993. A determination of costs associated with BMP installation and maintenance was performed using BUBBA (Wilkerson et al. 2006), a BMP selection spreadsheet that is an integral part of Latis.

Three observers from the Department of Landscape Architecture at Mississippi State University performed a visual assessment study of Catalpa Creek to determine the overall condition of the creek based on the USDA Stream Visual Assessment Protocol (USDA 1998). This document outlines specific criteria for assessing a stream, creek, or river and includes a scale for grading the overall condition of the water body. The assessment of the middle two-thirds (Reach A) of the property reach was conducted on June 14, 2006, and the assessment of the upper one-third (Reach B) of the property reach was conducted on June 22, 2006. The two reaches accounted for approximately the upper two-thirds of the creek present on the property. The lower third of the property reach was not assessed using the stream assessment protocol.

Results and Discussion

Consultation with Dairy Unit Faculty and Staff

The tour of the Dairy Unit headquarters identified several areas that could lead to potential environmental hazards on the property. The major concern of the researchers and the Dairy Unit manager was the undersized waste treatment lagoons. The lagoons pose a serious environmental threat

because a potential overflow would pollute Catalpa Creek, potentially causing a fish kill in the creek as well as the catfish ponds downstream that uses water from the creek for its operations. The employees expressed the need for excess capacity in the lagoons or a buffer between the lagoons and the adjacent stream which flows directly into Catalpa Creek.

The guided tour of the Dairy Unit headquarters allowed the researchers to understand the every-day operations of the dairy as well as the common problems encountered by the employees. The major concern of the dairy manager was the waste treatment lagoons. The two-lagoon system was not properly sized to meet the needs of the dairy operation and is highly likely to overflow causing a major environmental hazard. If an emergency overflow occurs, the effluent will enter the adjacent stream and flow directly into Catalpa Creek. This could cause a fish kill in the creek or in the catfish farm downstream that uses water from the creek for its operation. This was the main concern of the researchers and led to the selection of the Dairy Unit headquarters as the site for this study.

Stream Assessment

Following a visual assessment of Catalpa Creek, the three observers evaluated the creek separately using the grading scale in the protocol. The conclusion of all three observers was that the reach of Catalpa Creek on dairy unit property was in poor condition. The observations included heavy hydrologic alteration and channelization of the reach, erosion of the creek bed, evidence of clear-cutting was present in the riparian zone of the creek banks, resulting in reduced cover for fish species and aquatic insects. There were, however, various types of in-stream fish cover, limited barriers to fish movement, and numerous types of aquatic insect habitats. A variety of Group I, II, and III macro-invertebrates were observed throughout the dairy unit reach, which shows the varying conditions of the creek. Group I invertebrates, which are very intolerant of pollutants included Riffle beetles, Gilled snails, and a Dobsonfly (Hellgrammite). The presence of Group I invertebrates indicates that while the physical conditions of much of the reach has been altered, water quality has not displaced them from portions of the

stream, which is encouraging for long-term management. Approximately one-fifth of the reach has not experienced significant streamcourse alteration. The group II invertebrates, which are moderately tolerant of pollutants, were crayfish, damselfly larvae, damselflies, dragon fly larvae, dragon flies, mussels and clams. Finally, the group III invertebrates, which are very tolerant of pollutants, observed were leeches and snails. Other invertebrate species could possibly be found in the creek using benthic organism retrieval equipment.

Root systems appeared to partially stabilize the banks within the reach, but signs of erosion are present. No concrete swales or riprap was present within the reach. Stream fish cover, aquatic insect habitat, and macro invertebrate species were present. The creek bed was striated for significant portions of the reach, which suggests that the creek channel is continually eroding. The conclusion of the researchers was that if steps are not taken to restore the forest buffers of Catalpa Creek, the health of the creek will deteriorate and more problems will arise. The results of the visual stream assessment identified problem areas within the creek itself and throughout the MAFES property that will eventually be addressed with the selection, design, and potential implementation of stream buffers on the property.

The portions of the farm that were modeled were not immediately adjacent to Catalpa Creek. However, the tributary adjacent to the modeled portion of the site affects Catalpa Creek, and is therefore a part of the overall effort to address the conservation of the creek. Future work will include modeling of conservation practices on the entire 880-acre site.

Hydrologic Modeling

The conservation practices modeled yielded a 72% reduction in flow as modeled in HSPF (Fig. 1).

The costs associated with implementation were:

- \$22,000 for installation of bioretention area at the base of the treatment lagoon levee.
- \$350.00 in annual maintenance cost of streamside buffer
- \$2,400 for installation of two 500-gallon rainwater storage tanks

These measures will be included in a Comprehensive

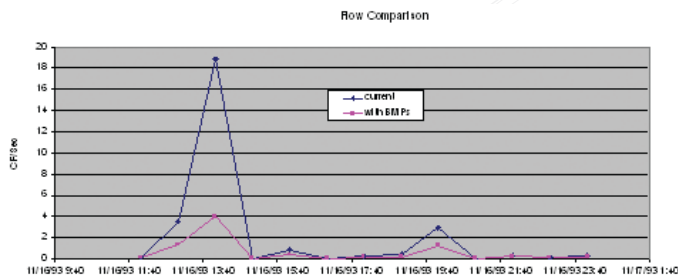


Figure 1. Model results for FLOW in Latis© (BASINS/HSPF)

Conservation Plan (CCP) being developed for the entire site. Future modeling and planning will address agricultural runoff associated with the 880-acre site, a determination of potential costs and benefits of installation of streamside buffers, development of the graphical user interface for agricultural end-users, and field verification of modeling results for all installed conservation practices. End-user needs assessments are underway to aid in the development of the graphical user interface.

An agricultural extension of Latis, FarmLatis, has the potential to aid end-users (resource agency personnel, farmers) in the development of Comprehensive Conservation Plans by allowing for multiple scenarios and outcomes during the initial planning stages.

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