Integrating Constructed Wetlands, Water Supply Reservoirs, and Subirrigation Into a High Yield Potential Corn and Soybean Production System[1]

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ABRTRACT

Three constructed wetlands have been designed, constructed, and linked with water supply reservoirs for corn and soybean production systems using subirrigation. The overall purpose is to demonstrate how construction and management of wetlands coupled with subirrigation can be economically profitable for farmers, thus stimulating the adoption of wetlands and reducing adverse impacts of agricultural runoff in the Ohio portion of the Maumee River Basin. These wetlands have been constructed on prior-converted cropland (soils are dominantly silty clay and clay) to receive drainage from adjacent cropland, resulting potentially in zero-discharge from those fields directly to streams, except during extreme precipitation events. Agricultural runoff and subsurface drainage recharge the wetland seasonally, and the reservoir serves as a supplemental water supply source for subirrigating corn and soybean. At each site (Defiance, Fulton and Van Wert counties, Ohio), subirrigation systems were designed and retrofitted on existing subsurface drained cropland. A conventional subsurface drained comparison is also located at each site. Two sites are managed by agricultural organizations and one site is managed by a private farmer (Fulton County). Non-replicated yield data, averaged over four varieties of both corn and soybean, for 1996 (first year of study) from the Fulton County site indicated a yield increases for both corn and soybean of approximately 50% for subirrigated versus conventionally drained cropland. As-built drawings are currently being prepared, and a comprehensive monitoring system is being designed to collect a large variety of data useful for hydrologists, biologists, wetland ecologists, modelers and decision support system designers, engineers, and natural resources conservationists. The presentation will summarize the project, with particular emphasis on the design and system specifics, the cropping and water management systems, and the monitoring system that will be installed in 1997 and 1998.

Keywords. Subsurface drainage, subirrigation, water supply, reservoir, constructed wetlands, corn, soybean, yield, economics

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INTRODUCTION

PURPOSE

The overall purpose is to demonstrate how construction and management of wetlands coupled with subirrigation can be economically profitable for farmers, thus stimulating the adoption of wetlands and reducing adverse impacts of agricultural runoff in the Maumee River Basin. The Maumee Valley RC&D (MVRCD) is located in northwest Ohio at the confines of the Michigan and Indiana state borders. The MVRCD drainage area lies entirely within the Maumee River Basin.

Constructed wetlands have been liked with water supply reservoirs for corn and soybean production using subirrigation. Wetlands have been constructed on prior-converted cropland to receive drainage from adjacent cropland, resulting in potential zero-discharge from those fields directly to streams, except during extreme precipitation events. Agricultural runoff and subsurface drainage will recharge the constructed wetland seasonally. The reservoir serves as a supplemental water supply source for subirrigating corn and soybean crops in adjacent fields. Subirrigation research conducted in Michigan and Ohio suggests a strong potential for northwestern Ohio, but often water supply is a limiting factor. The demonstration project was built on the need to enhance and properly utilize wetlands near agricultural land use areas where the success of subirrigation has a high potential. The general hypothesis is that these integrated systems can be economical. A large variety of relatively simple, but valuable data can be obtained that could have great utility for hydrologists, biologists, wetland ecologists, modelers and decision support system designers, engineers, and natural resources conservationists.

SITES

Three demonstration sites were evaluated on which the Wetland - water supply Reservoir - SubIrrigation System (hereafter stated as WRSIS) was developed. Each site lies in the Maumee River Basin. 1) Defiance Agricultural Research Association (DARA), 2) Shininger Farm (SHININGER), and 3) Marsh Foundation (MARSH) (see Figure 1). All primary facilities have been installed at all three sites. Crop production inputs and yields will be obtained at all sites. All sites will be instrumented for selected water, sediment and agricultural chemical data collection. However, the priority order will be DARA, MARSH, and SHININGER. Finalization of the as-constructed documentation (i.e., illustrations, specifications) is in progress.

Figure 1.

OBJECTIVES

The general objective is to demonstrate how the WRSIS can work in a farm setting. Specific objectives are:

1. Develop one to five WRSIS sites, replacing 7% of the prior converted cropland with constructed wetland at each site;
2. Construct a water balance for each site;
3. Demonstrate that runoff and subsurface drainage discharges from each site will be reduced by 85%;
4. Demonstrate that sediment, nitrate and phosphorus loading at each site will each be reduced by 75%;
5. Demonstrate that crop yields at each site will exceed county averages by 30%
6. Survey the development and retention of wetland vegetation and wildlife habitat;
7. Conduct a simple economic analysis of production inputs and outputs, and demonstrate that the WRSIS is an economically viable option for farmers;
8. Develop an operation and management guide; and
9. Teach 50 farmers how the WRSIS might have potential for their land.

EXPERIMENTAL APPROACH

The conceptual system is illustrated in Figure 2. Preliminary site measurements include selected soil physical properties (i.e., saturated hydraulic conductivity for subirrigation design parameters, and soil survey), and determination and location of topographic and landscape features, drainage features and structures, etc. Water flow rate (mass or volume per unit time) and volume (total mass or volume) from subsurface drainage, runoff, and pumping, entering and leaving the: constructed wetland, the water supply reservoir, and the cropped subirrigated and subsurface drained areas. Sediment concentration the cropped subirrigated and subsurface drained areas. Sediment concentration (mass per unit volume), and sediment deposition (depth and estimated mass) in the constructed wetland and water supply reservoir, and the pump sumps. A conceptualization of the system water balance is given in Figure 3.

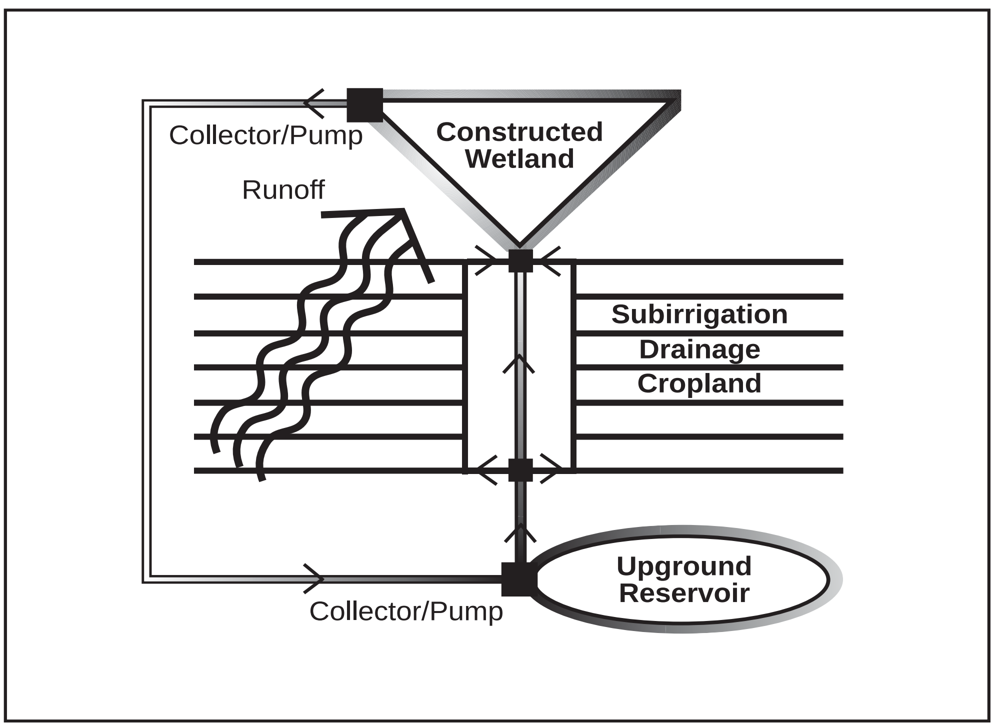

Figure 2. Integrated system conceptualization

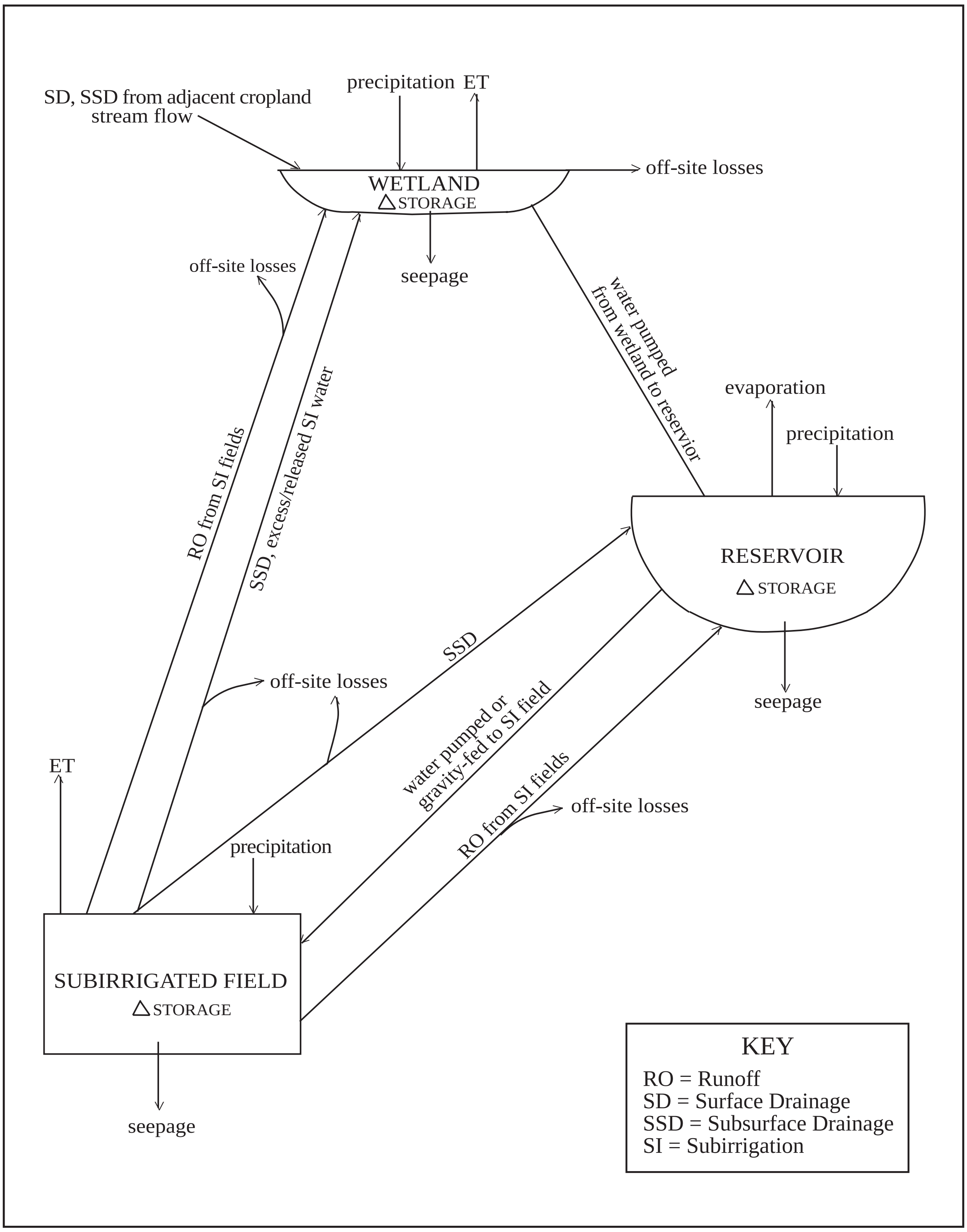

Figure 3. System water balance

Selected nitrogen and phosphorus compounds, and selected pesticide concentration (mass per unit volume), and nutrient loading rates (mass per unit area) and amounts (total mass) applied/discharge to/from the system. Seasonal development and sustainment of wetland vegetation, surrounding wildlife habitat and observed indicators of wildlife use will be inventoried, recorded, and progressive changes analyzed.

Corn and soybean grain yields (mass per unit area, and total mass) from the cropped subirrigated and subsurface drained comparison areas. Capital investments, design consultations, and rates, amounts and costs for seed, fertilizer, fuel, labor, electricity, operation and management, consulting, etc.

Daily maximum and minimum temperature, daily precipitation (and breakpoint rainfall if available), wind speed, solar radiation, and pan evaporation are desired. All climatic data to be obtained from local weather stations (airports, NOAA reporting station, Water Pollution Control centers, etc.), where possible. Small weather stations may be established at each site.

The monitoring and instrumentation plans are under development, the specific sampling locations are being selected, as-constructed illustrations and documentation are being completed, and the research protocol is under development.

PROJECT MANAGEMENT

The project is a cooperative team effort between the Maumee Valley RC&D (MVRC&D), USDA-Natural Resources Conservation Service (NRCS), USDA-Agricultural Research Service (ARS) Soil Drainage Research Unit, The Ohio State University (OSU), Michigan State University (MSU), Heidelberg College (HC), Soil and Water Conservation Districts (SWCD), farm cooperators and county commissioners, Ohio and Michigan Land Improvement Contractors (O&MLICA), Drainage Products Industry (ADS, Hancor, Haviland, Baughman), with recent collaboration with ODNR Division of Wildlife (SW), USF&WS, USACOE, and other local and state agencies and organization (some to be identified at later date).

The Project Coordinator with the MVRC&D provides overall management, and coordinates all activities and specific tasks with the Project Team and sponsors. Drs. Brown, Fausey, and R. Cooper serve as the Technical Committee. The Project Manager has overall responsibility for the management and operation of all sites. The daily management and operation at each site is: DARA Site - B. Czartoski, B. Clevenger, B. Rohrs; Shininger Farm Site - Fred and William Shininger; and Marsh Foundation Site - T. Krill, and selected farmer members of Farm Focus. Selected project personnel and graduate students are also actively involved.

All site evaluation and design work was performed by the Project Team, primarily: MVRC&D, MSU, USDA-NRCS, SWCD, USDA-ARS, and OSU. All WRSIS construction and installation was accomplished through competitive bid process, with Project Team responsible for some tasks. All cooperators and team members submit all data and information necessary for the economic analysis to the Project Manager at the MVRC&D. The Project Manager and selected project personnel maintain the records, and provide data and information to the person(s) conducting the economic analysis.

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