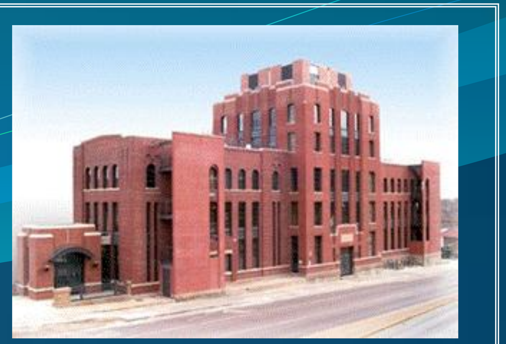

Scale dependence in the efficiency of grassed waterways within an agricultural watershed

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Introduction

It is estimated that 90% of U.S. cropland is losing fertile soil above the sustainable rate. In Iowa, one-half of the fertile topsoil has been lost during the last century of farming. In addition, 60% of Iowa soils are over-fertilized which drastically lowers water quality. In response to soil degradation and decreasing water quality, Best Management Practices (BMPs) have been widely adopted by Iowan agricultural producers to increase retention of runoff volume, as well as reduce sediment delivery and Non-Point Source (NPS) pollution. Common BMPs in the croplands of southeast Iowa are Grassed WaterWays (GWW's) which have been found to effectively reduce runoff/sediment conveyance and gully formation by slowing water flow and increasing infiltration rates.

Construction of the GWW's in eastern Iowa

Objective and Hypothesis

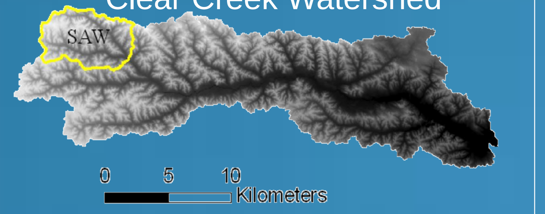
This research investigates the scale-dependent, storm-event based efficiency of GWW's within an agricultural Iowa watershed. The efficiency of the GWW's was examined by utilizing the physically based, distributed parameter Water Erosion Prediction Project (WEPP) model, which was calibrated for single storm events. It is hypothesized that GWW's provide localized erosion protection, thus the impact of implementing GWW's is likely to decrease with catchment size.

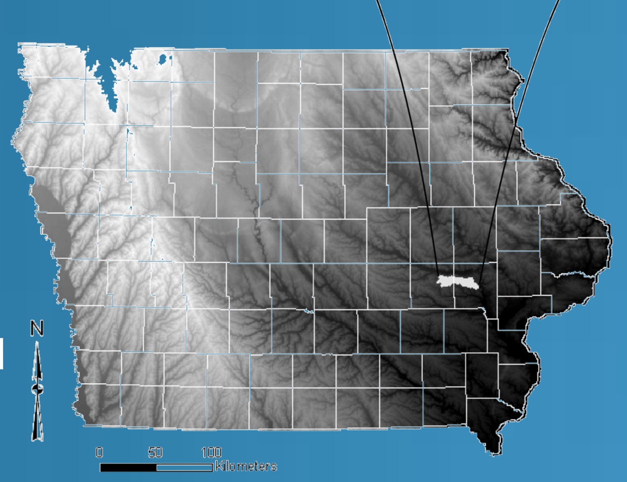
Site Description

This study focuses in the headwaters of the Clear Creek Watershed (CCW) within the 26 km^2 South Amana catchment (SAC), located in eastern Iowa, with the following characteristics:

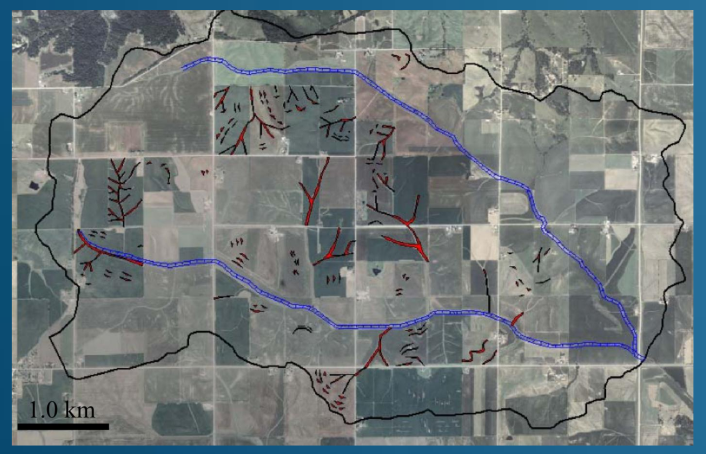
- Average gradient of 4%
- Soil texture is silty clay loam
- Average annual precipitation of ~ 900 mm/yr
- Corn and soybean cover ~ 80% of the watershed

Clear Creek Watershed





The SAC within the CCW in Iowa



The SAC and the GWW's indicated by the red, dendrite shape features

GWW characteristics in the SAC

- Bromegrass (*Bromus wildenowii*)
- Uncut grass cover
- Parabolic shape
- Average width = 11.5 m
- Average length = 250 m for drainage areas < 30 acres
- Average slope = 2%

Methodology

The efficiency of GWW's to reduce NPS pollution was examined for single events at various spatial scales. Potential factors affecting the efficiency of a GWW include:

- GWW dimensions (e.g., length)
- Gradient of the contributing hillslopes
- Magnitude of the events (e.g., peak runoff rate Q_{peak})
- Prevailing soil conditions
- Condition of the grass cover (i.e., cut or unmanaged)

I. Field Measurements

Field measurements from May to November 2007 and from June to October 2008 were performed to support the calibration/validation of WEPP:

- A *dual-tipping bucket rain gauge*, located near the center of the SAC, provided real-time precipitation measurements through a cellular modem.
- Continuous stage measurements at 15-minute intervals were collected with a *Global Water WL16 pressure transducer* at the SAC outlet.
- Flow velocity measurements were performed at the SAC outlet using an *Acoustic Doppler Velocimeter (Flowtracker)* by *Sontek* to produce a stage-discharge rating curve.
- An automated *Sigma 900 MAX Portable Sampler* by *Hach* was deployed at the SAC outlet to collect suspended sediment samples.

II. Model Calibration/Validation

- The WEPP model was employed to generate event-based runoff and soil erosion rates in the SAC for evaluating GWW's for 8 storm events (4 events for calibration and 4 events for validation).
- Model calibration was performed by adjusting individual key parameters within their expected physical ranges until the modeled runoff and sediment yield (SY) at the SAC outlet approached the measured values during the event.
- Runoff was primarily controlled by the hydraulic conductivity, while upland erosion and SY by interrill and rill erodibility, critical hydraulic shear stress and Manning's coefficient.

Event	Date	Rainfall	Runoff	Water Discharge	Susp. Sed. Load
---	---	(mm)	(mm)	(m^3)	(ton)
1*	6/22/07	74	55	1,421,000	2600
2a	8/19/07	24	2	50,800	10
4	7/7/08	51	5	136,000	100
5*	7/12/08	13	2	56,200	40
6a*	7/17/08	43	16	416,500	550
6b	7/19/08	30	16	422,800	1450
6c*	7/21/08	19	13	330,500	1050
8	9/12/08	62	30	790,600	2200

* Calibrated events

III. Model Simulations

Model simulations consisted of two components:

(1) Assessment of the effect that GWW length has on reducing runoff and SYs at the **hillslope scale**, by altering the GWW length between 100 m - 600 m and planting corn the remaining length. Results were compared with the modeling study performed by Hjelmfelt & Wang (1999) (H&W) who evaluated GWW length for a field in Goodwater Creek, Missouri.

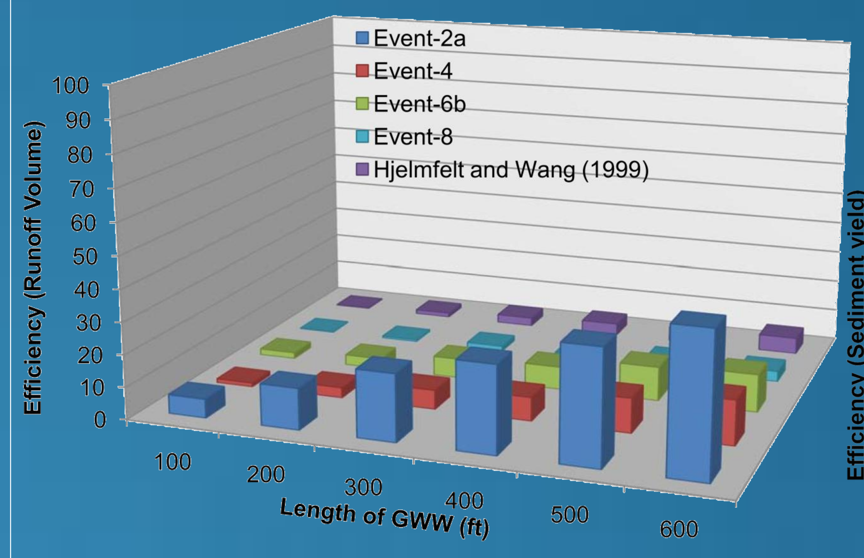
(2) Assessment of the effect that **various spatial scales** within the SAC (i.e., hillslope, plot, sub-catchment) may have on the efficiency of GWW's for a **fixed** GWW length obtained from (1).

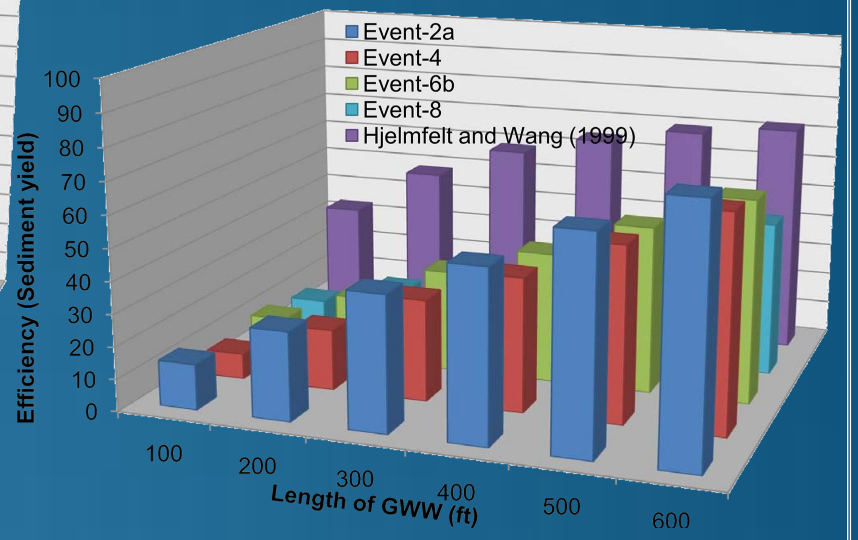
Spatial scale	Drainage area (km^2)
Hillslope	0.27
Plot	1.33
Sub-catchment	14.2

Results

(1) Hillslope Scale

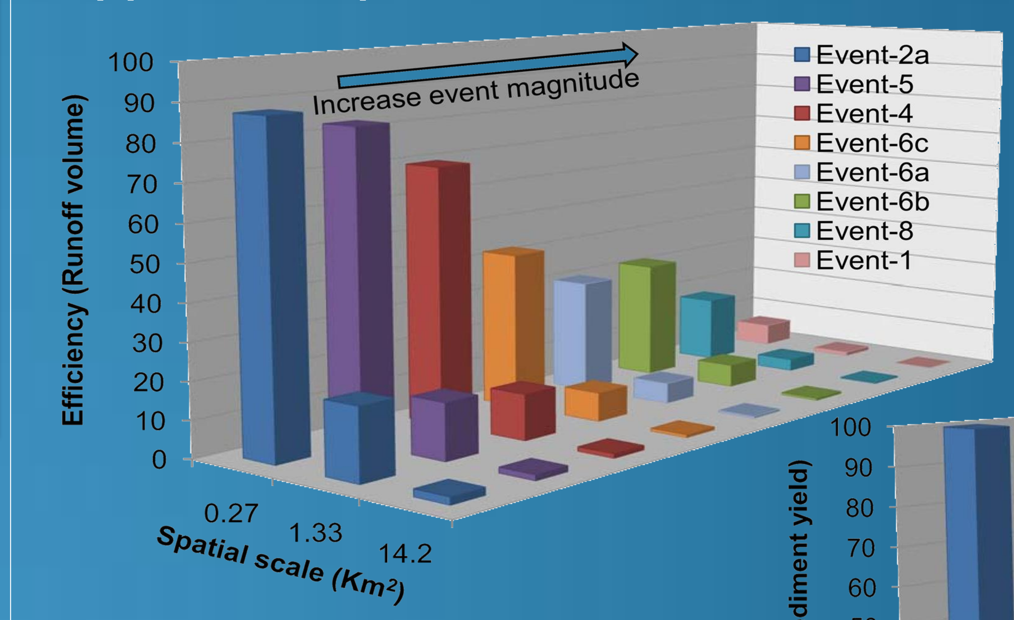
- ✓ Reductions in runoff volume and sediment yield from the contributing hills increased as the length of the GWW increased.
- ✓ Reduction in runoff volume and SY increased about 20 and 2 times, respectively, in the H&W study, while in the present study the reduction was 9 and 6 times, respectively.
- ✓ Differences between the results on the two studies are attributed to:
  - (i) The recorded differences in the peak runoff discharges (Q_{peak}) between the two study sites and the variability amongst their values.
  - (ii) Performance of existing transport capacity formulas when nearly saturated conditions exist (H&W study) vs. well drained soils (SAC).



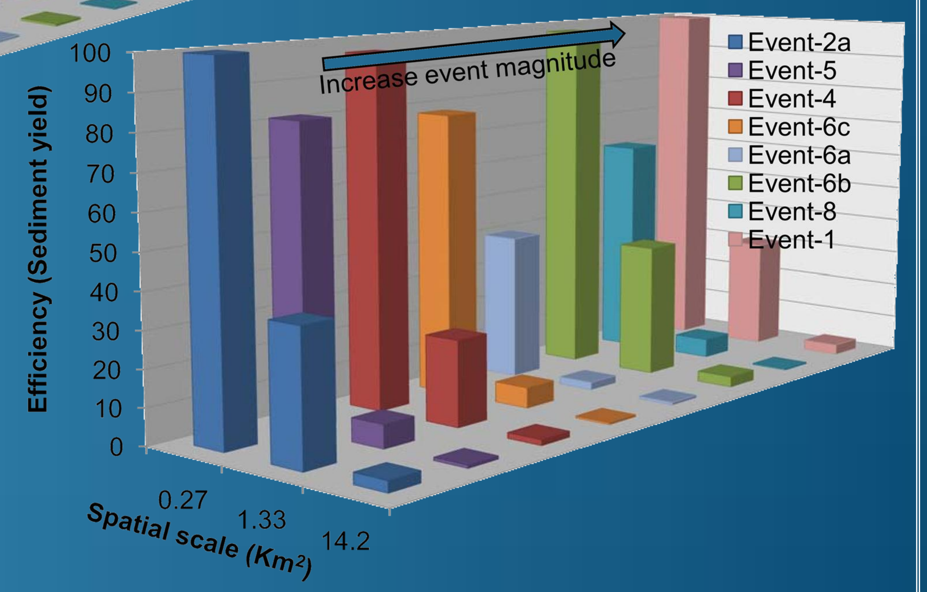


Runoff (left) and SY (right) reduction as a function of the GWW length for the H&W (1999) and the present study

(2) Various spatial scales



Efficiency of GWW's at different spatial scales for runoff (left) and SY (bottom) reduction



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