Drainage Water Recycling
Managing Water for Tomorrow’s Agriculture

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Crops need water. Not too much, Not too little.
Midwestern farmers know how to manage excess water.
We have an impressive drainage infrastructure for getting rid of excess water
And drainage is increasing.
Drainage installation field day at Davis Purdue Ag Center, 2017
But sometimes too much water is followed by too little.

In 2015,

Too much (June)            Then too little (July)
Two problems with our current water management

Sometimes too much,  
→ Flooding, Nutrient loss

Sometimes too little,  
→ Crop water stress
Problems related to too much water: Nitrate and phosphorus losses

Leads to poor water quality
Problems related to too little water: Crop water stress
Problems related to too little water: Crop water stress

Loss paid by Crop Insurance in Indiana, 1991-2015 (25 years)

Flooding/Excess Moisture: $930 million
Drought: $1.6 billion
How will this situation change in the future?
Two problems with our current water management
Both getting worse as **extreme weather increases**.

Spring: More runoff and nutrient loss

Summer: More drought and crop yield loss
In periods with too much water already, we expect more in the future.

More water quality problems

More flooding
In periods with too little water already, we expect drier conditions in the future.

More crop loss

More need for irrigation using potentially scarce water supplies
Solution: More storage of drained water in the landscape

Advancing drainage water storage through
- Controlled drainage (drainage water management)
- Saturated buffers
- Drainage water recycling
Drainage water recycling

Storing drained water in a pond

and irrigating it back onto crops later in the season
This is an old idea, being revived to meet tomorrow’s water management challenges
Two problems

Drainage water recycling addresses both.

Sometimes too much. Sometimes too little.
Drainage water recycling stores drained water in a pond and irrigates it back onto crops later in the season. But there is a major challenge. Storing water is expensive!
Research question: How much water storage do you need?
We developed the Drainage Water Recycling Evaluation Tool (DWRET) to answer that question.

http://drainage.agriculture.purdue.edu
Calculates the benefits of various sizes of water storage

User inputs a range of storage volumes.

Example: 0 to 100 acre-feet
Input: Daily drain flow

If measured, that is great.
Input: Daily drain flow

Select your location, to use estimated (modeled) drain flow

To begin, click on a location to select a grid cell that will be used in calculations. Make sure to confirm the selection.
Input: Storage, Soil, Irrigation characteristics

### Drainage Flow into the Water Storage

- **Drained Area**: 160 acres
- **Include Surface Runoff**

For drain flow, there are two options:

- Upload .csv file with daily values of date, precipitation, drainflow, surface runoff, evaporation, and crop ET

### Water Storage Size and Initial Depth

- **Avg. Water Storage Depth**: 10 acre-feet

### Irrigation

- **Irrigation Area**: 80 acres
- **Irrigation Depth Applied at One Time**: 1 inch
- **Maximum Soil Moisture Content**: 10 inches
Output

Average annual **captured flow** across storage sizes.

Proportional to the nitrate and phosphorus loss reductions of the system.

Average annual **irrigation supply** across storage sizes.

5 inches
Output – Monthly across all years for one size

Average monthly **inflow** (drain flow + surface runoff if selected)

Average monthly **water depth in storage reservoir**
Output – Monthly across all years for one size

Average monthly **captured flow** for one size

Average monthly **irrigation supply** for one size
Output – Monthly for one year

Average monthly **captured flow** for one year

Average monthly **irrigation supply** for one year
Behind the scenes:
How are these values calculated?
Behind the scenes: Tracking water storage and use

1. Pond Water Balance
2. Soil Water Balance

Root Zone Volume $V_{\text{max}}$ – total water storage capacity
Precipitation $P$
Evaporation $E$
Irrigation $I$
Seepage $SP$
Evapotranspiration $ET$
Runoff $RO$
Deep percolation $dp$
Upflux $UF$

Water balance in a Drainage Water Recycling system

Given: daily drain flow (plus surface runoff if desired).

The tool tracks

1. Soil-crop water use and irrigation needs

2. Storage water level and volume
1. Storage Reservoir Water Balance

+ Drain flow (D)
+ Precipitation (P)
- Evaporation (E)
- Seepage (SP)
- Irrigation (I)

Daily Water Volume =
\[ D + P - E - I - SP \]
2. Soil Water Balance

- Precipitation (P)
- Irrigation (I)
- Runoff
- Evaporation/Transpiration (ET)

Depletion \((D_p) = \ D_{p,i-1} - (P - RO) - I + ET\)
Irrigation – The connection

- Calculate crop water demand
- Identify total available water (TAW)
- When demand exceeds readily available water (RAW), water use is limited.

\[
\text{TAW} = (K_{cb} + K_e) \cdot ET_o = ET_c
\]

\[
(K_sK_{cb} + K_e) \cdot ET_o = ET_{c,adj}
\]
3. Water balance in the reservoir

- As water flows into the storage reservoir:

  1. It is captured if available storage > inflow

  2. It overflows downstream if available storage < inflow
Example: Davis Purdue Agriculture Center in Indiana

Field Data
(2006-2016, daily)
• Drain flow
• On-site climate
• Water Quality
  • Nitrate-N

Data from Saadat, Bowling, Frankenberger
Various Sizes of Storage Reservoir

- 2% of field area
- 4% of field area
- 6% of field area
- 8% of field area
- 10% of field area

Avg. Depth: 10 feet

Drainage water recycling in MI

6% - 5 acres

2% = 1.6 acres
Results: Nitrogen Load Captured (kg/ha)

- **Orig. Load**
- **Storage Reservoir % of Irrigated Field**
  - 2%
  - 4%
  - 6%
  - 8%
  - 10%

- **Nitrogen Load, and Captured Load (kg/ha)**: 12 kg/ha
Results: Annual Percent Nitrogen Reduction

Nitrogen Load % Reduction vs. Storage Reservoir % of Irrigated Field

- Avg: 45% reduction
Results: Annual Applied Irrigation (mm)

- **Annual Applied Irrigation (mm):** 0, 50, 100, 150, 200, 250, 300
- **Desired Storage Reservoir % of Irrigated Field:** 2%, 4%, 6%, 8%, 10%
- **Output from DWRET**

Graph showing the relationship between applied irrigation and storage reservoir % of irrigated field. The green line represents the output from DWRET, with a shaded area indicating the irrigation desired range.
Results: Irrigation Sufficiency

Applied Irrigation, % of desired

Storage Reservoir % of Irrigated Field
You can explore more: The Drainage Water Recycling Evaluation Tool (DWRET) will be available next week at http://drainage.agriculture.purdue.edu
Summary

- Drainage water recycling benefits include both increased crop yield and reduced nutrient losses downstream.
- Water storage reservoirs must be large, ranging from 2% to more than 10% of the field area. 6% provides many benefits.
- [http://drainage.agriculture.purdue.edu](http://drainage.agriculture.purdue.edu) provides a new tool to help estimate benefits for various sizes.
- Optimal size must balance benefits with costs, and depends on climate, topography, soils, and crops.

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