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USDA LTAR Common Experiment measurement: Discharge from artificial subsurface drains

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Abstract

Subsurface drain discharge, sometimes simply referred to as drainage, is a process by which water is removed from a soil profile or area (ASABE, 2015). On agricultural lands with intermittent high-water tables due to precipitation or melting snow, water is removed using artificial (generally referred to as tile) drains or ditches to allow timely field operations and protect growing crops from being waterlogged. This discussion is limited to artificial subsurface (tile) drain discharge. In agricultural regions where crop production requires artificial subsurface drainage, drain discharge can represent a substantial portion of the annual water budget. Thus, measuring this water flow is important in understanding the water use of crops and potential impacts on downstream water movement. The measurement of subsurface drain discharge, together with a measurement of sediment and water pollutants, provides an assessment of the losses of these constituents from agriculture to the environment. Tracking them over time quantifies the beneficial effects of improved agricultural practices.

Guidelines

Site considerations

Agricultural plots or fields with artificial subsurface drains are typically flat or have little slope. In some cases, subsurface drain discharge is measurable using a weir and depth gauge at the tile outlet, where it empties into a drainage ditch. Because of slope limitations, an access pit must often be dug at the edge of the plot or field down to the drain line (Lawlor et al., 2008). Hydrologic isolation of study plots, or groups of plots, needs consideration. If subsurface water flow into a site from the surrounding area is concerning, install a perforated drain around the site perimeter. Keep drainage water from this perimeter drain separate from the plot collection system and route it downstream. Accomplish further isolation of plots within a site by installing a plastic-lined curtain between each group of plots or between plots to reduce lateral flow between plots (Kaspar et al., 2012). Such curtains need installation depths below the drain lines. For additional recommendations, refer to the section titled *"Placement and site maintenance"* in the *USDA LTAR Common Experiment measurement: Best practices for collection, handling, and analyses of water quantity measurements* (Baffaut et al., 2024).

Materials

- Discharge can be measured in a few ways, depending on the site access and outlet elevations, the potential for submergence, and the availability of electricity.
- Discharge can be routed into a tipping bucket with a counter that registers tips of a known volume.
- Use weirs or flumes with the measurement of water depth (known as "stage") recorded by floats, ultrasonic sensors, bubblers, or pressure transducers (Brakensiek, 1979; U.S. Dept. of Interior, 2001; USDA NRCS, 2022; Walkowiak, 2008).
- While this document is being written, radar sensors for stage measurement are being tested.
- Discharge can also be pumped from a sump through a mechanical or electromagnetic flowmeter with a built-in recorder or connected to a data logger.
- Sometimes area–velocity sensors using Doppler principles are used for backup measurement in submerged conditions; however, velocities less than 15 cm/s can result in inaccurate readings.

Data collection

1 **Measurement**

- Subsurface drain discharge can increase rapidly in response to precipitation events, so the stage is recorded at short time intervals (seconds to hours).
- Most often, discharge measurement devices are connected to an electronic data logger, which records stage in the device as well as additional parameters of interest, e.g., temperature.
- Construct a simple measurement system with a tipping bucket connected to a simple tip recorder with clock-recording capabilities.
- See https://transformingdrainage.org/videos/monitoring-tile-drain-flow for a video review of various techniques for measuring subsurface drain discharge.

2 **Site maintenance**

- Maintain equipment in a pit or field enclosure such that flooding is avoided during large events and rodents are excluded.
- Summer maintenance includes weed control.
- Depending on local conditions, take preventive measures in autumn to avoid freeze damage to equipment and lines.
- It is good practice to visit a site after a large precipitation event to check for damage and download data.

Data processing and quality control

3 Download data from datalogging equipment at an interval compatible with the importance of the project and the consequences of missing data.

4 Calibrate and check field equipment for accuracy regularly, e.g., from weekly to bi-annually, depending on the site visit interval and the propensity for issues with the equipment and site. Keep detailed notes of instrument calibration for subsequent data correcting.

5 Check stage data for missing values or potentially erroneous readings by visually inspecting time series plots of stage and discharge.

6 Calculate the subsurface discharge (the flow volume over a given unit of time) by inserting the stage measurements into a rating equation for the particular weir or flume in use.

7 Express discharge in units of volume per time, m^3 s^{-1}.

8 Refer to the section "*Quality control*" in the *USDA LTAR Common Experiment measurement: Best practices for collection, handling, and analyses of water quantity measurements* (Baffaut et al., 2024) for additional recommendations.

Data file formats and metadata

9 Keep data in a .txt, .csv, spreadsheet, or database format. Good practice necessitates maintaining backups physically in a remote location and/or in the cloud.

- Suggested metadata to record, depending on the situation, include: tile diameter, tile slope, drainage area, tile spacing, weir/flume size, stilling pipe size, equipment manufacturers and model numbers, and soil characteristics.

Recommendations for data collection

10 Table 1. Summary of recommendations for measuring subsurface tile drain discharge.

A	B	C	D
Attribute	Preferred	Minimum	Comments
Spatial scale	Field and plots	Field and plots	
Frequency	Year round at 1 to 10 minute intervals	Year round at 30 minute intervals	The frequency of measurement depends on the study purpose and the size of the drainage area
Covariate metrics	Precipitation, air or water temperature, irrigation, water table depth	Precipitation, irrigation	These covariates are useful for data quality control and analysis purposes
	Chemical variables		If chemical export is of interest

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