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Edge-of-field

water quality in two Wisconsin watersheds

Results of long-term water quality studies

How does land use and agricultural management affect water quality? This relationship was evaluated in a long-term study recently completed by UW Discovery Farms, a farmer-led research collaborative. The study was conducted within two watersheds in western Wisconsin and directly measured soil, water and nutrient losses from farm fields, a small city and natural areas. Results of this study allow us to compare different land uses, but also provide insight into how well different agricultural management practices can lead to water quality improvements. Ultimately, the results provide valuable information to farmers about practical ways they can protect water quality. Learn about the research, key findings as well as farmer perspectives inside.

FALL 2018

Edge-of-field

water quality in two Wisconsin watersheds

Soybeans in the Dry Run watershed.

INTRODUCTION

Wisconsin is rich in water and agricultural resources, which form an intimate and complex relationship. This relationship is perhaps most complex at the interface between the two, where agricultural practices may – or may not – directly affect water quality. Wisconsin's farmers are well aware that agricultural runoff can wash valuable soil and nutrients into lakes and streams, negatively impacting water quality.

Efforts to curb agricultural runoff have led to the increasing use of several practical farming practices, including conservation tillage, no-till, cover crops and grassed waterways. But how well do these and other practices actually reduce nutrient and soil runoff, and how much does their effectiveness depend on local soils and topography?

UW Discovery Farms, a farmer-led research collaborative, recently completed a 7-year study to evaluate how land use and agricultural management affect water quality. We performed research on multiple farms under varying management systems in two western Wisconsin watersheds. Soil and nutrient runoff was measured via monitoring at the edges of fields – the physical, complex interfaces between agricultural lands and surface waters.

Monitoring edge-of-field (EOF) water quality on a watershed scale can inform farmers and communities about the relationships between different land uses, land management and local stream water quality. The results compiled here demonstrate how different practices may influence losses and runoff. **These findings have compelled participating farmers to reconsider how they manage their land, with several farmers trying out new practices for the first time or improving their current management practices.** As one participating farmer puts it: "Monitoring gave us hard evidence, like it or not." That valuable evidence is the best tool for informing practical management strategies for protecting water quality. The evidence we uncovered could help you keep soil and nutrients on your own fields and out of your local streams.

Contents

PROJECT BACKGROUND

Sites were selected by UW Discovery Farms in two Wisconsin watersheds: Dry Run in northwestern Wisconsin (sites DR1 through DR3) and Jersey Valley in the Driftless Area (sites JV1 through JV6). Within the two watersheds, we based our site selections (Figures 1 and 2) on monitoring feasibility, farmer interest and the ability to represent local farming systems and land uses.

Because our main goal was to better understand how agricultural land management decisions affect soil and nutrient runoff, we primarily focused on monitoring agricultural land. However, we were also interested in how the runoff from agricultural land broadly compares to runoff from other land uses. That's why we also set up EOF monitoring stations on three non-agricultural sites. These included a site within the City of Cashton, one at the edge of a grass field that had been in the Conservation Reserve Program (CRP) for 10-plus years and one in a wooded ravine.

We monitored the following items at each site: three forms of nitrogen (nitrate, ammonium and organic), two forms of phosphorus (particulate and dissolved and

Where we monitored:

The Dry Run watershed is an 18,000-acre watershed in northwestern Wisconsin. The eastern portion of the watershed has somewhat poorly-drained soils and poorly-defined drainage patterns, while the western portion has long slopes, well-drained soils and well-defined drainage patterns. These different soil types influence management options and decisions. In the past 20 years, this area has seen a transition from dairy farms to grain systems, with corn and soybeans now being the most common crops.

The Jersey Valley watershed is a 4,500-acre watershed in the Driftless Area in southwestern Wisconsin. This region is characterized by steep slopes, flash floods and trout streams. Corn for silage or grain and alfalfa are the most common crops, as the watershed is home to many dairy farms.

Figure 1. Locations of surface monitoring sampling stations in the Dry Run watershed

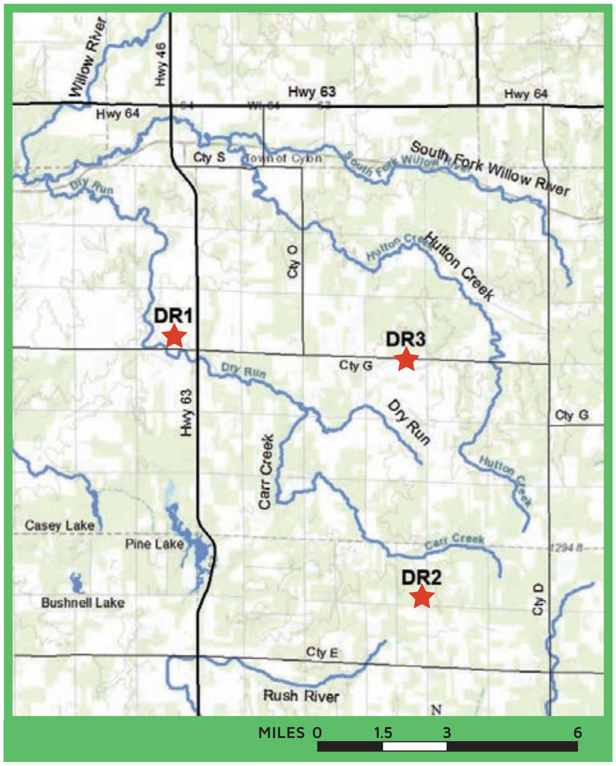
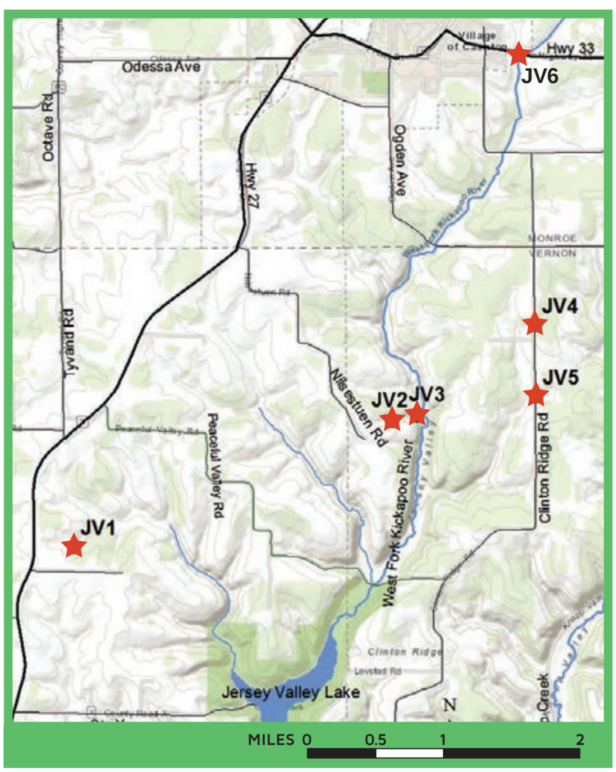


Figure 2. Locations of surface monitoring sampling stations in the Jersey Valley watershed



suspended sediment (reported as soil loss). Precipitation, soil moisture, soil temperature, humidity, air temperature and other weather parameters were also recorded continuously. Field management was recorded with information provided by participating farmers.

Management practices among agricultural sites

Discovery Farms purposefully selected EOF monitoring sites on agricultural land under varying management practices. Sites DR1, DR2, JV2, JV4 and JV5 are all managed as agricultural cropland or pasture. Refer to Table 1 for details about all agricultural and non-agricultural monitoring sites.

DR1 is a grain farm in the Dry Run watershed that incorporates turkey manure in the fall. Throughout the 7-year study, DR1 was planted with either corn or soybeans in parallel strips along the contour of hill slopes with a well-functioning waterway. A chisel plow and disc were used to incorporate manure and cornstalks after corn years in the rotation, and more than 30% residue consistently was left on the surface.

DR2 is a grain and dairy farm that was planted as corn, soybeans, alfalfa and oats using conservation tillage practices during the study. DR2's challenging soil hydrology make it difficult to compare to the other agricultural sites, but we still learned valuable lessons here (see management implications 3 and 4 on pages 10 and 11).

JV2 is a permanent pasture in the Jersey Valley watershed. Cattle are grazed on the fields from the end of June until September.

JV4 is a medium-sized, no-till dairy operation. Manure is surface applied, and the farm occasionally uses vertical tillage, which lightly incorporates the manure in addition to sizing residue.

JV5 is a dairy operation using injected manure and vertical tillage. The producer at JV5 spreads manure with an injection toolbar that uses deep sweeps to incorporate manure. These fields are finished with an implement to smooth the surface before planting. During the monitoring period, JV4 and JV5 were a mixture of alfalfa and corn in strips on the contour, and both had waterways.

Three non-agricultural sites were also included in the study. **DR3** is a field in grasses, enrolled in the Conservation Reserve Program, **JV3** is a steep wooded ravine and **JV6** is at the edge of the village of Cashton with a population of 1,100.

JV1 – runoff mixing

During several storms in 2016 and 2017 runoff from a dry lot near JV1 overtopped a berm meant to distinguish the monitoring area. This made it impossible to separate impacts from field management to impacts from the dry lot. Dry lot areas like this one are important to check when considering the most effective ways to reduce a farm's overall environmental impact.

In order to conduct edge-of-field monitoring, a clear monitoring basin must be defined. From the data and eyewitness accounts it became apparent during the monitoring period that a clearly defined monitoring basin could not be defined at JV1, which is why JV1 is not included in the ag site comparison.

Table 1. Descriptions of the study's edge-of-field monitoring sites.

	DRY RUN WATERSHED MONITORING SITES			JERSEY VALLEY WATERSHED MONITORING SITES					
	DR1	DR2	DR3	JV1	JV2	JV3	JV4	JV5	JV6
Description	Grain farm with a corn/ soybean rotation	Grain and dairy farm with corn, soybeans, alfalfa and oats	Grass CRP estab- lished 10+ years ago	Dairy farm with corn silage or grain and alfalfa rotation	Grazed pasture	A steep wooded ravine	Dairy farm with corn silage or grain and alfalfa rotation	Dairy farm with corn silage and alfalfa rotation	Rural village, population of 1,100
Category	Cropland	Cropland	CRP	Cropland	Pasture	Ravine	Cropland	Cropland	City
Primary Soil Type	Well-drained silt loam	Poorly drained silt loam	Well-drained silt loam	Moderately well-drained silt loam	Well-drained silt loam	Well-drained silt loam	Well-drained silt loam	Moderately well-drained silt loam	Well-drained silt loam
Average Slope	4%	5%	7%	5%	9%	12%	5%	6%	7%
Soil Test Phosphorus*	High	Optimum	Excessively High	Excessively High	Excessively High	Not applicable	Excessively High	Excessively High	Not applicable
Alfalfa in Rotation During Study	No	Yes	Not applicable	Yes	Yes	Not applicable	Yes	Yes	Not applicable
Tillage**	Conservation tillage	Conservation tillage	Not applicable	No-till	No-till	Not applicable	No-till	Conservation tillage	Not applicable
Manure Management (type, placement, season)	Solid turkey litter; incorporated spring or fall	Liquid dairy manure; incorporated spring and fall	Not applicable	Solid dairy manure; surface applied spring, fall and winter	Solid beef manure; surface applied summer and fall	Not applicable	Liquid dairy manure; surface applied spring or fall	Liquid dairy manure; incorporated spring or fall	Not applicable
Commercial Fertilizer Management	Incorporated	Surface	Not applicable	Surface	Surface	Not applicable	Surface	Surface	Not applicable

*Soil Test P levels are based on those defined in *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin* (UW-Extension Publication A2809) for loamy soils and dairy based rotations as follows: Low = 12-17 ppm, Optimum = 18-25 ppm, High = 26-35 ppm, Excessively High > 35 ppm.

**Tillage methods are defined as follows: No-till = one-pass direct plant method that only disturbs soil in the planter row; Conservation tillage = multiple pass method that lightly disturbs soil across a whole field with vertical tillage or moderately disturbs narrow bands of soil while leaving the remainder of the soil undisturbed with strip tillage.

Sampling station
for surface runoff monitoring

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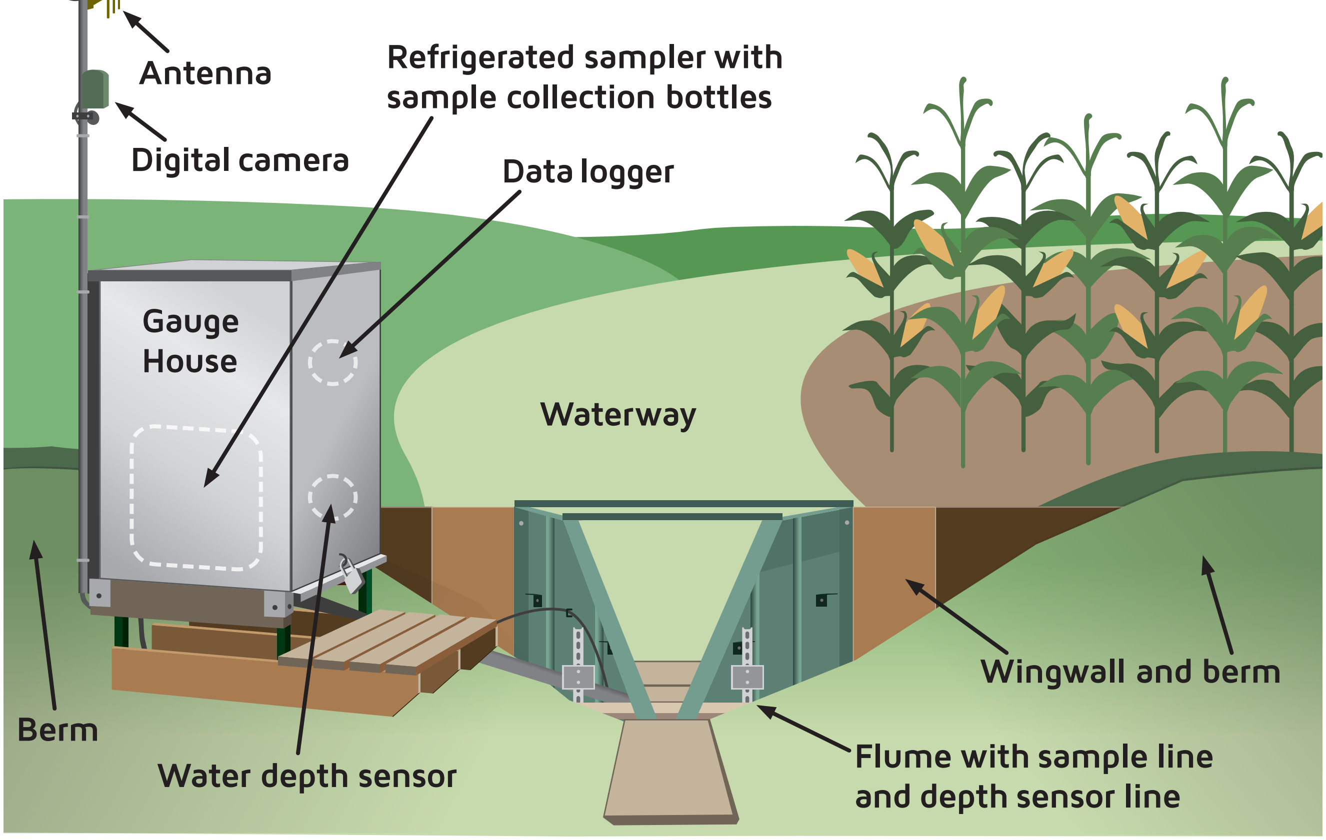
Runoff is channeled through the edge-of-field monitoring equipment before it continues to flow to the natural surface water system. The sampling station monitors runoff volume and collects and refrigerates water samples that are taken to a lab to measure nutrients and soil content.



Antenna: Two-way communication provides data collection and control of the monitoring equipment.

Digital camera: Captures site conditions and records depth readings to verify flow data.

Gauge house: Contains monitoring equipment.

Waterway: Flow path for water to reach the flume.

Flume: Runoff is directed through this control structure to determine flow rate.

Wingwall and berm: Plywood or sheet piling combined with earth to direct runoff into the flume.

Depth sensor and sampler line: Records water levels and transports water samples into the gauge house.

INSIDE THE GAUGE HOUSE:

Refrigerated sampler: Collects and stores water samples during runoff events until they are retrieved.

Sample collection bottles: Contain water samples to be analyzed.

Data logger: Computer system that operates monitoring equipment and collects and stores data.

Water depth sensor: Senses pressure to determine water depth in the flume. Flow rate is then calculated from the water depth and flume rating equations.

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What is edge-of-field monitoring?

Edge-of-field monitoring consists of a monitoring station with a flume that is usually placed at the end of a waterway on a monitored farm field. All water within a determined area will flow through the flume when runoff occurs. At that point, samples are automatically collected to be analyzed for sediment, nitrogen and phosphorus. In addition, the total water flow is measured. All of this can be used to identify the amount of nutrient and sediment loss from the monitored area.

FOUR CLEAR MANAGEMENT IMPLICATIONS

After 7 years of continuous monitoring of the agricultural EOF sites, we can draw several strong conclusions that have implications for the management decisions you make on your land.

1. Tillage practices and landscape conditions influence soil loss

Edge-of-field monitoring typically showed lower soil losses during runoff events at pasture and no-till sites (JV2 and JV4) than at conservation tillage sites (DR1 and JV5) (Table 2). At JV2 and JV4, a combination of year-round soil cover, little soil disturbance and conservation practices like contour strips and grassed waterways protected these fields from high soil losses even during extreme rainfall. Soil losses at JV2 and JV4 were also very consistent from year to year.

Table 2. Soil loss (lb/ac) at four edge-of-field sites

WATER YEAR*	DR1	JV2	JV4	JV5
2011	181	4	7	132
2012	180	22	136	142
2013	893	33	61	102
2014	1,142	170	246	3,822
2015	821	8	12	33
2016	28	243	187	2,690
2017	146	360	45	570

*A water year is October 1 through September 30.

Meanwhile, annual soil losses at the conservation tillage sites (DR1 and JV5) varied significantly, from a low of 28 lb/ac at DR1 in 2016 to a high of 3,822 lb/ac at JV5 in 2014. This year-to-year variability in soil loss is critical for determining impacts of agricultural management practices. In 3 of the 7 years, soil losses at DR1 and JV5 were similar to the pasture and no-till sites (JV2 and JV4). However, there were large differences in soil loss in the other 4 years of the study period.

Breaking it down further, 65% of the annual soil loss at DR1 occurred during June. In fact, nearly all of the soil loss in 2013 at DR1 occurred during one week in June. Several inches of rain fell over the course of one week and the crop was not developed enough to provide adequate soil protection. In addition, the field had been tilled the previous fall and again in the spring to incorporate turkey manure. A combination of saturated soils, little soil cover and recent disturbance led to higher soil losses.

In 2014, there were four rainfall events greater than 1.5 inches at DR1 early in the growing season, and a total of 14 inches of rainfall in that period. The farmer had planted soybeans in May after one vertical tillage pass, and then the soil remained saturated through most of the summer. Saturated soils with little cover and larger storms created the conditions for erosion. Using these results, the farmer is now working toward limiting tillage passes to those required for manure incorporation. He has also repaired a waterway. Both changes should lead to sustained lower soil losses.

ADVICE FROM A PARTICIPATING FARMER:

"Consider changing the way you manage bean ground. Before working with Discovery Farms, I had been either moldboard or chisel plowing fields planted to soybeans. After seeing the first two years of monitoring results, I began to no-till plant soybeans on steeper ground, and now I do it on most soybean fields. This change has had a big impact on reducing soil losses, which is something our results showed us we needed to adjust."

Residue (above) and cover crops help reduce erosion and soil loss. A white binder is shown to indicate size and scale of residue.

Tillage and bare soil coupled with poorly timed heavy precipitation led to significant soil losses at JV5 in 2014 and 2016. JV5 saw dramatically more soil loss those years than any other years. In 2014, most soil losses occurred in June. The farmer had incorporated manure on two of JV5's fields in April and used a vertical tillage pass in May to smooth out the field for corn planting. Runoff and soil loss followed soon after when in June 9.3 inches of rainfall (including three events greater than 1.5 inches) fell on the freshly tilled fields. In 2016 most of the soil loss occurred in late September after the farmer had harvested corn silage. With little cover left on the surface, consecutive storms greater than 2 inches, and monthly rainfall over 10 inches, the soil was vulnerable to erosion.

As the EOF monitoring shows, large and consecutive storms play a major role in soil loss. Farmers and farm advisors need to consider a network of conservation practices that can protect fields during weather that delivers intense rainfall or many consecutive days of precipitation on already saturated soil. **Keys for soil protection include maintaining cover on the soil with residue or cover crops, maintaining waterways and minimizing soil disturbance.** It is possible even in challenging landscapes to keep soil losses at bay. Identifying strategies to reduce soil losses is the first major step in protecting water quality while also protecting farmland.

ADVICE FROM PARTICIPATING FARMERS:

"For us, cover crops have been an economic and environmental win-win. We can open up a manure application window in the summer, take a rye crop for forage, and come back and directly plant corn into it."

"Cover crops can work at a couple of different parts of the rotation. We have had success with rye after alfalfa before corn and rye after corn silage before alfalfa."

"Gauge what is more important. We had an issue with slugs in no-till soybeans, so we went back to tillage before beans even though no-till had worked really well for years. But we were then seeing soil losses. Should we deal with a few issues with slugs once in a while or deal with soil loss? That is the decision-making process we had to go through. We decided that runoff is more of a concern than slugs because slugs only affect us once in a while. We don't like to lose the soil, so that was a big part of our decision. We are working toward a combination of practices tailored to each field."

"You just might get hooked on cover crops after experiencing less weed competition to start the year off, more green ground time, and the benefits of erosion control."

2. Once soil loss is controlled, pay close attention to factors like P accumulation at the surface.

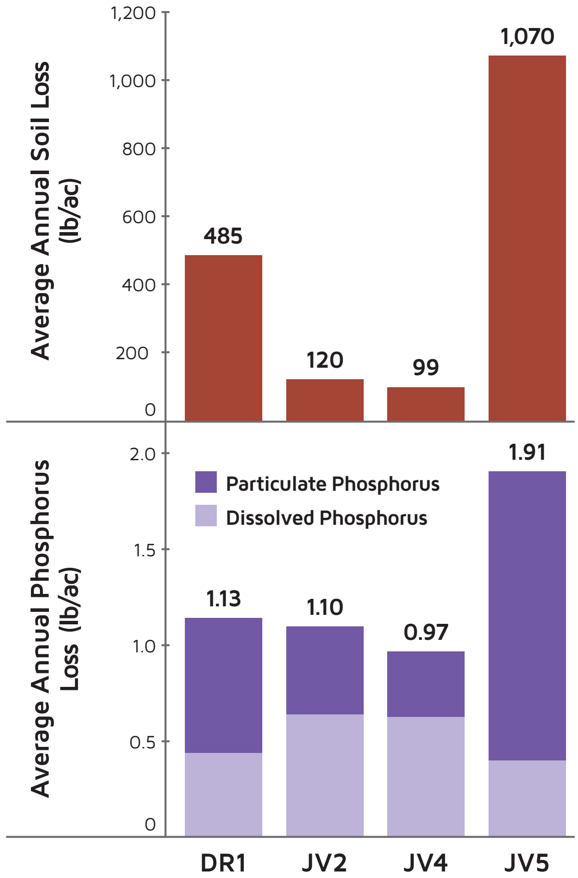
Soil loss and P losses are related, but P loss cannot be totally explained by transport with soil. Still, sometimes the best solution to managing P loss is to manage soil loss, as is the case in JV5, where particulate phosphorus loss (i.e., soil loss) is the main driver of phosphorus loss.

Once soil loss is at bay, it is important to keep in mind dissolved P loss. Dissolved P loss often is the dominant source of P loss in systems that do not incorporate manure or nutrients. That's because a high concentration of P can form on the soil surface in these systems. That accumulated P can be transported when runoff leaves the surface. There are indications that manure incorporation could decrease a field's potential risk for dissolved P loss as long as the practice doesn't disturb soil so much that it creates erosion and soil loss issues. Considering both dissolved and particulate P loss is critical when determining realistic expectations for P loss from different land uses and management systems.

No-till and pasture management are very effective at controlling soil loss, but the nature of these management styles applies phosphorus to the soil surface where it remains to be incorporated naturally – and slowly – through weather and soil biology.

Average annual soil losses were 4-10 times lower at the pasture and no-till sites (JV2 and JV4) than the conservation tillage sites, but average annual P loss between JV2, JV4 and the DR1 conservation tillage site were very similar. The proportion of dissolved P loss from the conservation tillage sites was lower than the no-till or pasture sites because the farmer delivered P from manure and/or fertilizer below the surface through incorporation.

Figure 3. Soil and P losses at four sites



WHAT IS TOTAL PHOSPHORUS?
Total Phosphorus is a combination of Dissolved Phosphorus (DP) and Particulate Phosphorus (PP). DP moves with water and PP moves with soil particles.

At JV2 and JV4, P losses were mainly in the dissolved form. Both farms surface applied manure without incorporation during spring, summer and fall. Dissolved P losses could be decreased at JV4 if the farmer were to incorporate manure and fertilizer under the surface, however any action that results in increased soil loss, like increased soil disturbance or less soil cover, would create its own set of particulate P loss – and soil loss – concerns. Similarly, DR1 could possibly decrease soil losses slightly by decreasing current tillage intensity, but total P losses may not decrease. Instead, the change may be in the proportion of dissolved to particulate P loss.

DID YOU KNOW?

Through our larger Discovery Farms dataset, we've seen that the two main reasons for dissolved P losses are P concentration at the surface and timing of manure application. Farmers in each watershed said they reconsidered nutrient timing and placement to reduce their risk of nutrient losses.

ADVICE FROM A PARTICIPATING FARMER:

"Most of our runoff comes from the spring melt, so we are definitely thinking twice about putting anything out there in late fall or on frozen ground because it needs a chance to work into the ground."

Considering that JV2 is in permanent pasture, it is unlikely that any management practice could reduce dissolved P loss short of pasture renovation to mix surface P deeper into the soil, which brings a risk of soil loss. It is important to note that of the agricultural sites, JV2 had the lowest amount of runoff, so total P loss was influenced by the site's high concentrations of P on the soil surface rather than the amount of water moving over the surface. **This reflects the risk of P buildup at the soil surface in pasture systems in general. This can be a challenge to resolve but is very important to recognize.** Taking soil samples of the top 1-2 inches provides a better understanding of what is happening near the surface and insight into whether P stratification is contributing to a higher risk of dissolved P loss.

The conservation tillage, permanent pasture and no-till sites all achieved average total P loss of one pound per acre, which is a good target for farms to work toward. **Keeping soil losses to a minimum, watching buildup of P at the surface and avoiding manure and fertilizer applications close to runoff events are the main components of achieving these low losses.**

Sampling soil in young corn planted through the previous year's residue.

3. Know when field management alone will not achieve nutrient loss goals.

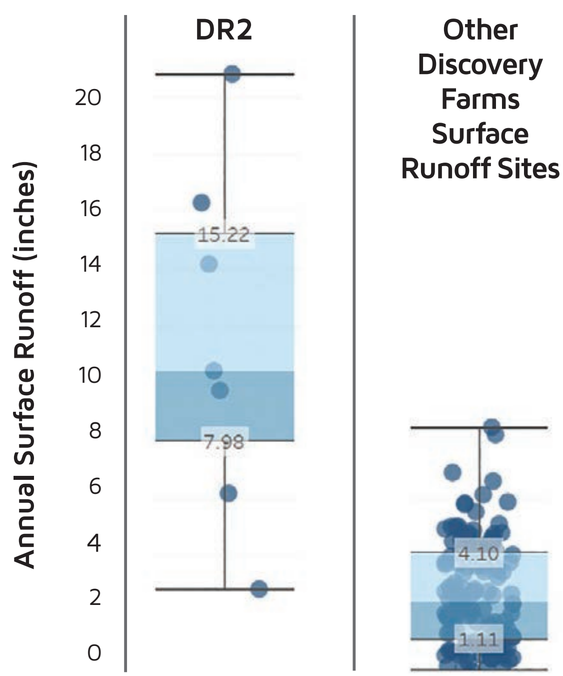
Sometimes, even the most prudent land management is not enough to reduce nutrient losses. Farmers are very aware that many factors – including weather, soil type and hydrology – are out of our control, and sometimes these factors can unite and wreak havoc. A clear example of this is at the monitoring site DR2, which experienced more runoff than has ever been recorded at any other Discovery Farms monitored site (Figure 4). This high level of runoff greatly impacted nutrient and soil losses as well as possible solutions for nutrient and soil loss reduction.

DR2 had lower concentrations of N and P compared to other Discovery Farms EOF sites. However, DR2 had higher total losses than other sites in part due to the unusually high runoff volume. This begs the question: what is causing so much runoff at this site?

DR2 has a seasonal high-perched water table, and soils in at least part of the field feature low permeability or low infiltration. This presents inherent challenges that influence management options.

The challenge with soils of low permeability and a seasonal perched water table high in the landscape is that a consistently saturated root zone inhibits crop growth and limits options for management practices. For example, alfalfa could not even survive in this field because of the saturated conditions. One way to decrease the amount of water in the soil profile is to use

Figure 4. Runoff at DR2 compared to other Discovery Farms sites



A high water table and low soil permeability resulted in much greater runoff recordings at DR2 compared with typical runoff at other Discovery Farms.

The color-shaded portion of each box plot represents the middle 50% of the data. Where the dark blue shading and light blue shading meet represents the median. The dots represent individual runoff events.

tillage. However, for soils that are usually saturated, adding tillage adds a risk of soil loss since runoff events are frequent. Without soil structure or cover, the soil is not well armed against erosion during the next runoff event. At DR2, when tillage was used to establish corn or alfalfa, soil losses ranged from 2,800-6,200 pounds per acre. **The combination of a water saturated root zone, little soil cover and soil disturbance created the conditions for substantial soil loss.**

Another way to decrease the amount of water in the soil profile could be to install tile drainage, depending on the depth of the confining soil layer that restricts water infiltration. Installing tile would reduce the amount of water moving over the soil surface, which would in turn reduce P and soil losses. In this scenario, however, nitrate may still move through tile lines. The farmer at DR2 would like to pursue less tillage and more cover crop use, but these goals will be very difficult to accomplish until the amount of water at the surface is controlled.

4. Risk of nutrient loss from application timing isn't limited to manure or winter.

The time between fertilizer or manure applications and a runoff event can be a significant driver of nutrient losses. A clear example of this effect occurred at DR2 in June 2013 and 2014. Figure 5 shows that most runoff events in the Dry Run watershed follow a linear pattern with total P loss and soil loss relating to each other. The two events that do not follow the trendline indicate that runoff was high in P without any soil loss. At DR2, the farmer applied N, P and K after first crop alfalfa shortly before two different runoff events. These two runoff events resulted in the most dissolved P loss of the project from a single event. When nutrients do not have time to bond with the soil, they are readily available to be moved by runoff water.

Farmers should assess both the risk and need of applying manure or fertilizers before they apply them. June is a month with a high runoff risk. When runoff risk is high, you must take extra caution when considering nutrient applications. In addition, you should make sure nutrients you apply are necessary for crop growth.

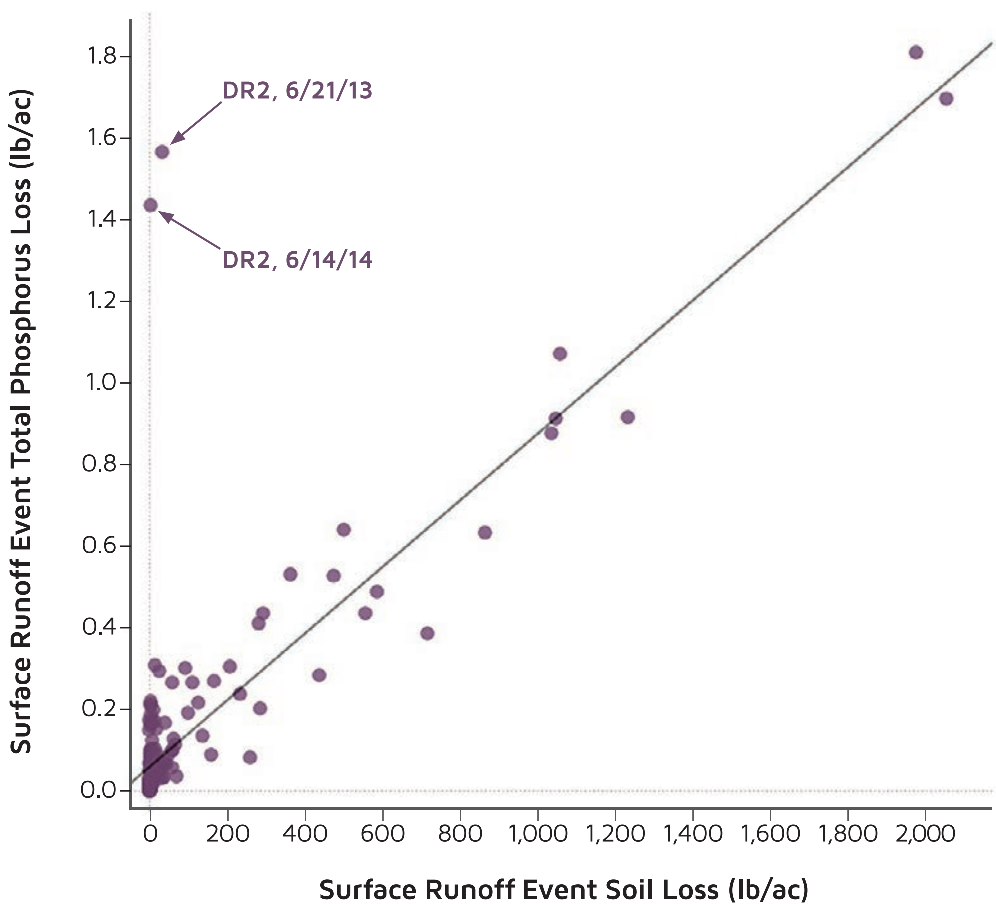
We recommend using the *Runoff Risk Advisory Forecast* at **www.manureadvisorysystem.wi.gov/app/runoffrisk** to avoid applying when runoff risk is high.

ADVICE FROM PARTICIPATING FARMERS:

"We have been putting half of the N on in early May and the other half on in that mid-June time frame. This is worth considering so that you don't have to take the risk of having N laying out there before the plant can really utilize it and while runoff and leaching are real possibilities."

"We have moved more N applications from pre-plant to side-dress to lower the risk of that valuable N leaving our fields."

Figure 5. All surface runoff events at DR1, DR2 and DR3 (239 measured)



A soil pit at DR2 during a summer field day highlighted challenges with infiltration for this farm's soils.

COMPARING AG RUNOFF TO NON-AG RUNOFF

Farmers can sometimes be put on the defensive in regard to runoff and its effects on water quality. But how does agricultural runoff compare to runoff from urban and wild environments? Do non-agricultural areas also offer opportunities for communities to improve sediment and nutrient loading into our streams?

As part of our watershed project, Discovery Farms placed monitoring stations in three non-agricultural locations to explore these questions. We selected one urban site and two non-agricultural rural sites – a CRP field and a wooded ravine. The following are some of the most interesting observations we made. Keep in mind that these observations only reflect single sites, and we therefore are not able to draw scientifically significant conclusions from them.

More urban runoff volume led to similar lb/ac soil and nutrient losses between the urban and ag sites.

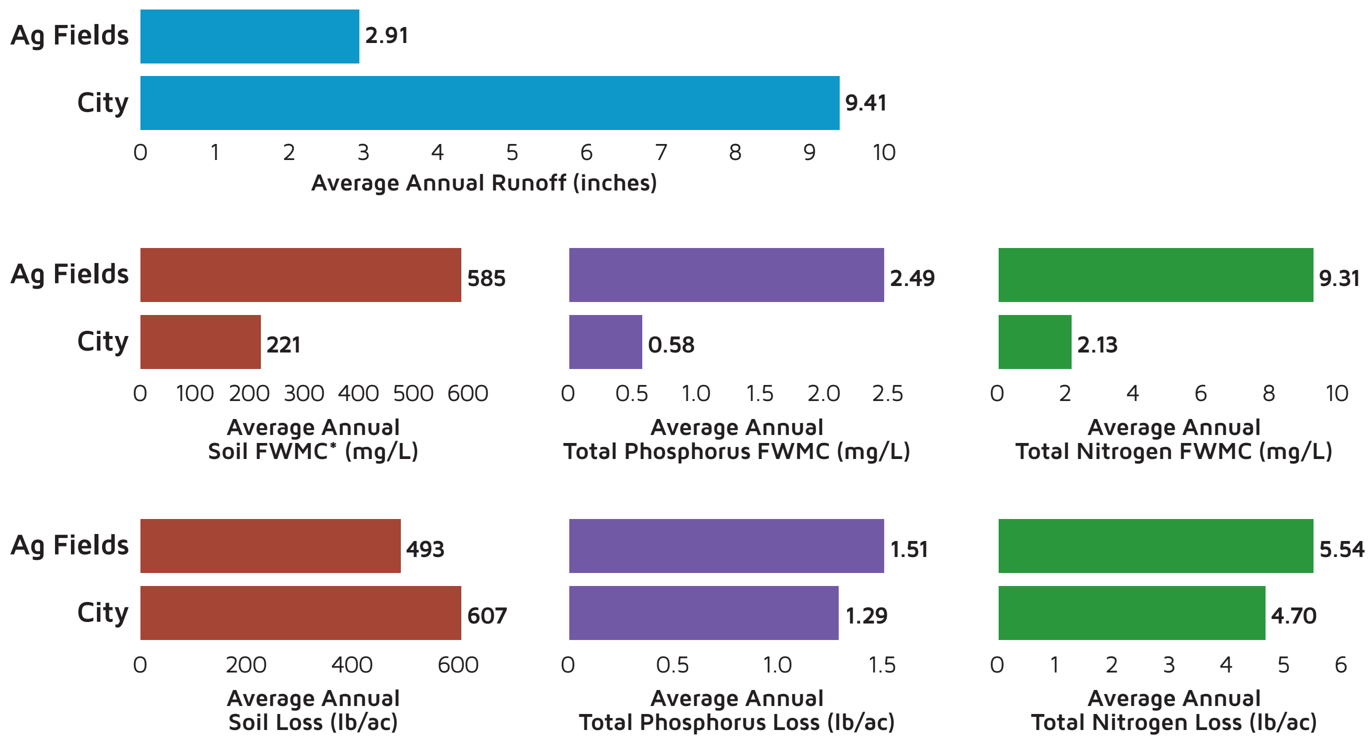
When we compare the urban site to the agricultural sites in the Jersey Valley watershed, understanding how yields are calculated becomes increasingly important. Yield, or loss in pounds per acre, is a function of concentration and total runoff. Concentration is the amount of nutrients in a sample and is measured in milligrams per liter.

The urban site's runoff volume was 2-3 times more than agricultural sites (Figure 6). This comes as no surprise considering the impervious nature of cities compared to the increased infiltration that occurs on agricultural land, especially during summer months.

However, runoff from the urban site had lower soil and nutrient concentrations than agricultural sites. With lower concentrations but higher average annual runoff, the city and agricultural sites had similar levels of losses.

High Runoff + Low Concentration can equal nutrient loss of Low Runoff + High Concentration

Figure 6. Agricultural and city site average measurements



*Flow weighted mean concentrations (FWMC) are concentrations that are adjusted for the variability in flow over a given period of time (e.g., monthly or annually). FWMCs allow for comparisons between sites with different flows or between years when a site has different flow volumes. FWMC is the total load divided by the total flow volume. It can be calculated on a monthly, annual, frozen/non-frozen or study-period basis.

Soil and P losses were lower on CRP land due to less runoff

At the CRP site (DR3), low runoff and low/mid nutrient concentrations resulted in low annual nutrient losses. The CRP site experienced less runoff compared to other Discovery Farms EOF sites. In addition, N and soil concentrations were lower than at other surface sites, thus N and soil yields were lower.

Unlike N and soil concentrations in runoff, P concentrations from CRP were similar to agricultural sites. Coupling similar P concentrations with lower runoff volumes means the CRP field produced lower P yields than the agricultural sites. This demonstrates how dependent dissolved P losses are on runoff volume. But it is important to note that there were measurable P losses at the CRP site, suggesting that a goal of zero P loss for any system is likely impossible.

The CRP site (DR3) had lower runoff and lower nutrient loss than non-CRP ag sites.

The wooded ravine was mostly a sink

Another watershed feature we monitored was a gully area (JV3), a steep, wooded ravine that received its runoff from JV2. We wondered whether this part of the landscape is a source of nutrients, meaning that it produces more than it absorbs, or a sink of nutrients, meaning that it absorbs more than it produces.

We determined whether JV3 was a source or sink by calculating the difference in the nutrients, runoff and soil loss between nearby JV2 and JV3. More total P, dissolved P, total N and runoff entered the top of the gully than left the bottom during 6 of 7 years. However, there was always more nitrate at the bottom of the gully than what was measured at the top. This particular gully area is usually a form of water quality protection for the stream below.

The only time during the 7 years of monitoring that the gully was a major source of runoff, soil loss, particulate and dissolved P and total N was in July 2017 during a large storm. During the July 2017 storm, 22,000 pounds of soil washed out of the gully, which equates to 75% of the soil loss measured at JV3 during the entire 7-year study period.

Discovering a successful pathway to water quality improvements

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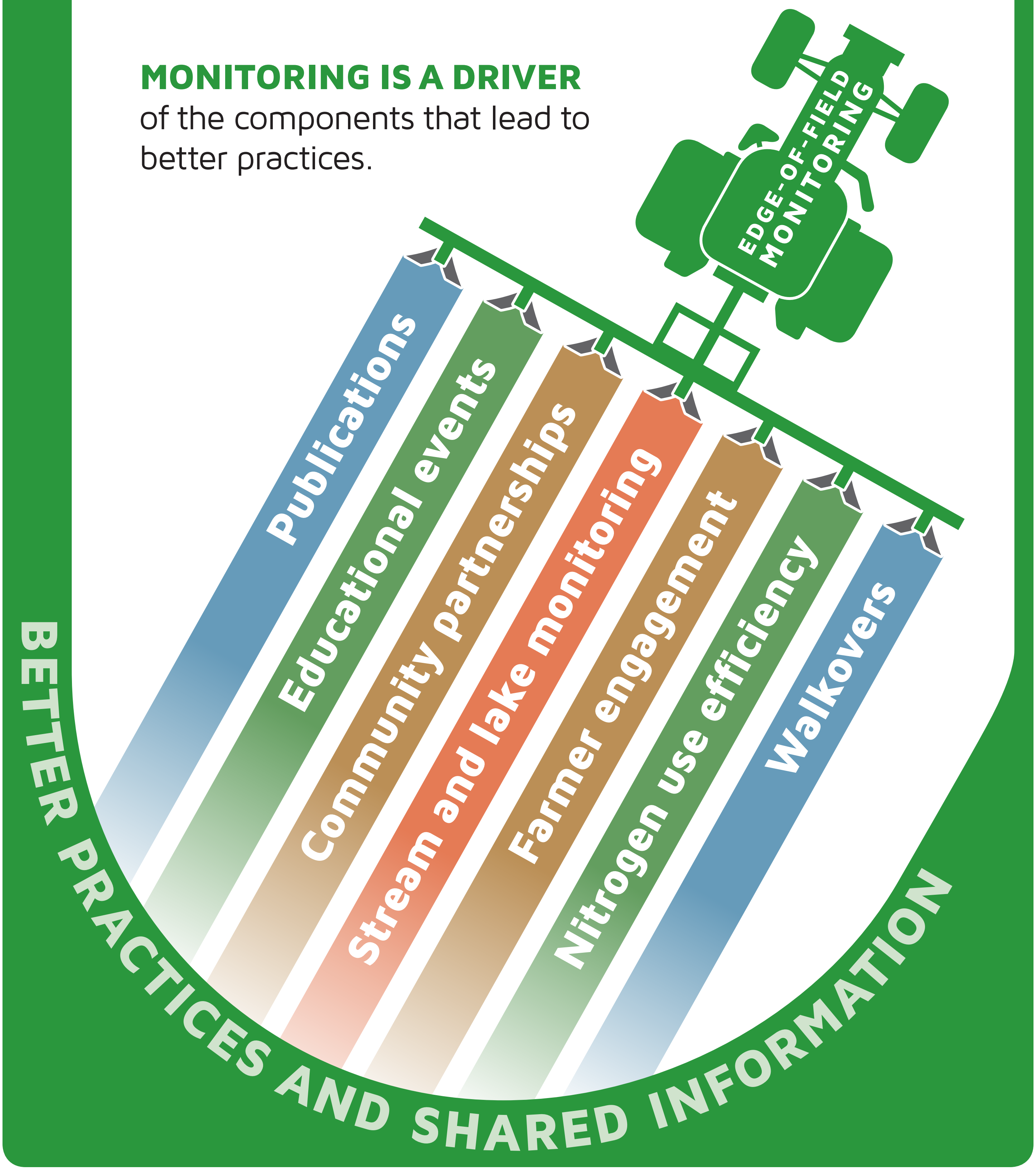
MONITORING IS A DRIVER of the components that lead to better practices.



Jersey Valley field day (above) where attendees took a look at a field interseeded with cover crops. Farmers share ideas (right) during a monitoring site tour.

BUILDING ON WATER QUALITY MONITORING

Water quality monitoring acted as the foundation for other projects in the Dry Run and Jersey Valley watersheds. Edge-of-field monitoring is expensive and can't be done on every farm, so to increase the number of opportunities to participate and learn, UW Discovery Farms conducted a series of related but different projects that all had their own role in farmer collaboration and education.

Sixty farmers across the two watersheds received whole farm walkovers that visually assess erosion and erosion potential. For more information on walkover results, read the complementary publication titled *Field walkover guide: A practical on-farm conservation tool*.

Farmers in both watersheds also participated in the Nitrogen Use Efficiency Project. This project offered farmers and consultants tools to form a roadmap supporting more effective nitrogen application strategies. Visit **www.uwdiscoveryfarms.org/on-farm-projects/nitrogen-use-efficiency** for additional details on this project.

The Jersey Valley and Dry Run watershed projects were the most comprehensive and multi-dimensional performed to date by UW Discovery Farms. Beyond the aforementioned additional projects, other activities in the watershed included annual farmer meetings and field days, nutrient management planning and cover crop opportunities.

An edge-of-field runoff monitoring station in the Dry Run watershed.

Participating farms make this research possible

Thank you to the many Jersey Valley and Dry Run watershed farmers and landowners who participated in this research. These watershed projects provided valuable lessons learned to add to the robust Discovery Farms dataset. Farmer leadership is a pillar of the Discovery Farms foundation. Throughout the course of these several year studies, we were witness to farmers stepping up as leaders in a collaborative community to support conservation beyond edge-of-field monitoring. We commend this and know that protecting water resources is a group effort. Small steps lead to big steps, and having access to on-farm research results can paint a clearer picture of agricultural impact on water quality.

Edge-of-field

water quality in two Wisconsin watersheds

DISCOVERY FARMS WISCONSIN

www.uwdiscoveryfarms.org

Results of long-term water quality studies

Authors: Amber Radatz, Callie Herron, Tim Radatz, Matt Ruark, Kevan Klingberg and Todd Prill

This publication is available in pdf format at uwdiscoveryfarms.org and available from the UW Discovery Farms office, PO Box 429, Pigeon Falls, WI 54760, 715-983-5668

Thank you to the many reviewers who contributed to this publication.

For over a decade, UW Discovery Farms has worked with Wisconsin farmers to identify the water quality impacts of different farming systems around the state. The program, which is part of UW–Extension, is under the direction of a farmer-led steering committee and takes a real-world approach to finding the most economical solutions to agriculture's environmental challenges. If you are interested in learning more about UW Discovery Farms, visit www.uwdiscoveryfarms.org, email erica.olson@ces.uwex.edu or call 715.983.5668.

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