Appendix

Water Quality Monitoring

Eight Profile Farms

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Editor's Note:

As stated in Chapter One, monitoring water quality is difficult under the best of circumstances. Monitoring an individual farm and specific site for changes that may or may not be due to changes in the farming practices is even more complex. Upstream and off-farm variables can affect surface and groundwater quality at the monitored site. Isolating a practice and its impact pose unique problems for scientists. Also the actions of the farmers or ranchers who continue to go about their daily management routines, sometimes affect the integrity of the monitoring site, as happened on more than one occasion with the following farms. All scientists agree that it takes several years of data collection under a variety of conditions to draw clear conclusions. The following observations are based on relatively short-term, sometimes limited data collection. However, the experience and personal observations of the farmers and ranchers all indicate improved conservation and water quality protection efforts on their farms.

Steve Burr, Saline County
KBS Monitoring Project

KBS' Don Huggins explains the automated samplers at a farm tour on the Burr farm.

Prior to the implementation of the Kansas Biological Monitoring Survey (KBS) monitoring plan for the Burr farm, much of the conversion from crop to perennial grass was near completion. (See Burr profile.) Despite the lack of "pre-conversion" water quality data, KBS decided to monitor the management intensive grazing (MIG) practice for several reasons.

First, the prospect of monitoring freshly converted land (rather than the conversion process itself) was unique among the CWFP farms. Second, the local topography was inviting from a monitoring perspective. Points where runoff entered and exited the managed MIG paddocks were easily identified, and installing sampling equipment was relatively straightforward. Additionally, the premise that the perennial forage and grass waterways could filter nutrients and pesticides from the runoff was a good water quality hypothesis to test.

The monitoring program at the Burr farm consisted primarily of paired automatic runoff samplers. The samplers were placed to collect runoff as it entered a westerly MIG paddock and as it exited an easterly MIG paddock into a small tributary of Mulberry Creek. Between the two samplers, water flowed through the two paddocks, which served as a continuous grass waterway until the runoff exited to the creek.

Results of the monitoring program are varied, as would be expected due to local environmental and climatic variables. Five runoff events were collected by the sampler located where water enters the property, and six events were collected as it exits the property.

Observed trends in some nutrient and herbicide concentrations were indicative of the role of the perennial grass in filtering the water as it flowed over the MIG paddocks. Concentrations of nitrogen compounds, organic phosphorous and atrazine were higher as runoff entered the property.

Total phosphorous and phosphate concentrations were higher where water exited the paddocks to the creek. However, this was expected due to the placement of the sampling unit in an area with exposed soil that could more easily transport phosphorous compounds in runoff. Further complicating the findings was the cattle access around the bottom sampler, which resulted in the accumulation of fecal material in the drainage area that was easily transported into the collection sump. This possibly resulted in the elevated nutrient concentrations and made drawing conclusions difficult.

Dan and Mary Howell, Marshall County
KBS Monitoring Project

The Howell farm was included in the Kansas Biological Survey monitoring program for several reasons. As part of their whole farm planning, the Howells were quite interested in finding out what levels of nutrients and herbicides were present in runoff and groundwater associated with their conversion from crops to grazing, especially the land parcels nearest the stream. The local site conditions were conducive to the establishment of a monitoring program, and the presence of the perennial Corndodger Creek along the converted management intensive grazing (MIG) paddocks made a more comprehensive monitoring program feasible. (See Howell profile.)

The Kansas Biological Survey set up a monitoring program that included the collection of runoff, groundwater, and surface water from Corndodger Creek. The local watershed contributing to the runoff onto the Howell farm was one of the larger watersheds among the monitored farms. Runoff was collected at the very bottom of this drainage area as it flowed down a former grass waterway before emptying directly into Corndodger Creek.

Groundwater was collected at depths of one, four and eight feet at three locations in a MIG paddock. The first spot was in the middle of a paddock, the second at the interface of the paddock and the riparian woodland and the third was set in the riparian zone near the creek. Surface water was collected at three locations on Corndodger Creek: upstream of the Howells, near the MIG paddock and downstream from the Howells. Additionally, the creek was surveyed for habitat diversity and aquatic invertebrate species that might serve as indicators of the stream's overall health.

The analyses of runoff, groundwater and surface water from the Howell monitoring program were indeed telling. Six runoff events were collected over the three-year period from 1998 to 2000. Total nitrogen concentrations decreased with each subsequent runoff event. Total phosphorous values also decreased, but more along a seasonal gradient. Nitrates and ammonia showed more variability. The results of the groundwater analyses showed the most variability in ammonia and phosphate concentrations where the MIG paddock met the riparian zone. Levels of ammonia were highest when groundwater was sampled in June and July, perhaps as a result of field applications within the watershed. The analyses from Corndodger Creek appear to indicate seasonal differences in water quality for both nitrogen and phosphorous compounds and herbicides. Concentrations of all three groups were highest in the late spring and early summer, while early spring and fall values were typically lower.

Alan Hubbard, Pottawatomie County
KBS Monitoring Program

The attraction of the Hubbard farm to the Kansas Biological Survey was the variety of watering systems Alan incorporated into his management intensive grazing (MIG) system. (See Hubbard profile.) As Alan Hubbard indicated that runoff events were few and far between in his area, sampling runoff wasn't going to be easy. Since the rocky nature of Potawattomie County prevented the hand augured installation of groundwater samplers, groundwater sampling of his native grass-based management intensive grazing system was not feasible.

KBS collected surface water from three watering ponds on the Hubbard farm. The ponds were of different size, and each was located in a different MIG paddock. From 1998-2000 each of the ponds was sampled sixteen times for nutrients, herbicides and coliform bacteria.

Results of the Hubbard monitoring program show differences based on the pond, the timing of the cattle using the ponds, rainfall and the season. The largest of the three ponds consistently had higher nitrate, ammonia and phosphate concentrations but it should be noted that much of the drainage area of this pond consisted of cultivated land to the east of the pasture areas. Atrazine and metolachlor concentrations were higher in the large pond after runoff events thus confirming that much of the runoff was from cultivated crop land adjacent to the grazing areas.

The water quality of the two smaller ponds displayed much less seasonal variations in values, as the cattle were fenced out of those ponds. As expected, coliform bacteria levels were highest after cattle accessed to the ponds but bacterial densities in pond water diminished quickly once the cattle were excluded from the pond areas.

Alan Hubbard limited access to ponds in his pastures with fencing, but also provided water via a well and gravity supply line to watering tanks throughout 30 some paddocks. He noted that where the cattle have a choice they prefer the clean tank water to ponds or streams.

Tim Kunard, Franklin County
KBS Monitoring Project

Groundwater samplers were placed at one foot and two foot depths on the Kunard site.

The Kunard farm presented a good opportunity to monitor a parcel of land just undergoing the conversion from row crop to grazing land. (See Kunard profile.) When the monitoring program was set up, wheat was still being grown on the land that eventually was converted to a management intensive grazing system (MIG) system. A single runoff sampler was installed to collect water from an intermittent creek that runs the length of the property. A cluster of three groundwater samplers (a one-foot and two four-foot depths) was installed in a fallow area near the runoff sample which was located just downstream from the parcel under conversion to the MIG system.

The monitoring program at the Kunards was the most challenging program established by KBS. The combination of human error, equipment malfunctions and dry conditions resulted in the collection of only three runoff events throughout all of 1998 and 1999 and no runoff samples were collected in 2000. While three events were not enough to examine for water quality trends, seasonal differences in water quality are apparent.

Total nitrogen and atrazine levels were higher in spring samples than in the fall sample set. Total phosphorous levels dropped with each subsequent sampling event. Organic phosphorous and nitrogen, most often associated with organic waste, were variable independent of the season.

Groundwater was collected twice each year for a total of six sample periods. Total nitrogen levels appear to drop over time, perhaps due to the elimination of fertilizer applications. Nitrate, total phosphorous and phosphate levels in the groundwater were very similar among the differing sample periods.

Bruce Spare, Saline County
KBS Monitoring Project

For many farmers attending the farm tours, like the one at the Spare site above, this was their first opportunity to hear about the water quality monitoring process and equipment.

On the Spare farm, the conversion of highly erodable cropland to perennial forages presented a good opportunity for the Kansas Biological Surveys to examine the impact of these changes on water quality. (See profile page 55.) The monitoring program established at the Spare farm consisted of both runoff and groundwater collections. A runoff sampler was placed in a management intensive grazing (MIG) paddock very near the channel of an intermittent stream but it was later moved uphill after determining that the creek was overflowing into the sump of the sampler.

Three clusters of groundwater samplers were installed to collect water from three distinct drainages occurring within the MIG area on the farm. Six runoff events were collected from 1997 to 2000, though three sample sets seem to have been influenced by the overflowing intermittent stream. Remaining water quality data indicated seasonal differences in total nitrogen, ammonia and nitrate. Overall, total phosphorous concentrations in the field runoff decreased somewhat and this seemed likely due to the establishment of perennial forage cover.

Groundwater data was surprisingly consistent over time for two of the three sampling sites. Higher and more variable concentrations of total nitrogen, nitrate, total phosphorous and phosphate were detected on a hillside near a watering point. Cattle may have affected water quality at this sampling site more than the other two.

The depth at which the groundwater was sampled also affected nutrient concentrations. Total nitrogen, nitrate, ammonia, total phosphorous and phosphate concentrations were higher in shallow groundwater (one and four feet sampling depths) than at the eight foot sampling depth. Herbicide values in groundwater were consistently very low at all three sampling locations.

Jim Townsend, Julia and Richard Townsend, Dickinson County, KBS Monitoring Project

The choice to include the Townsend farm in the Kansas Biological Survey monitoring project was an easy one to make. The local topography and established grass waterways allowed for runoff and groundwater collection at numerous points along the drainage ways many of which converged to drain into a wetland area located along a intermittent stream course. The conversion of some acreage from cropland to perennial forage permitted the collection of "background" data. The presence of a natural wetland also allowed KBS to monitor the role of a wetland in altering on-farm water quality. These factors, combined with the Townsends' enthusiasm and desire to learn more about agricultural nonpoint source pollution, led KBS to establish an extensive monitoring effort on the Townsend farm. (See Townsend profile.)

The monitoring program at the Townsends' farm consisted of sampling runoff, groundwater, and surface water from the intermittent stream that runs through the natural wetland. Runoff samplers were positioned to collect water flowing off a cultivated field that was converted to pasture into a grass waterway and at a downstream site where water flowed from the waterway into the wetland. Clusters of groundwater samplers were placed along the edge of the grass waterway and in the wetland. Grab samples were collected nine times at three spots in the stream. Additionally, the stream draining into and out of the wetland was surveyed for habitat diversity and aquatic invertebrates.

Analyses of the wetland runoff samples over time revealed consistent levels of total nitrogen, total phosphorous, nitrate and phosphate. These data suggest that the wetland can help in stabilizing and in some cases enhance water quality in an agriculturally-dominated watershed. Runoff water quality from the converted field varied more on a seasonal basis, with values for total nitrogen, total phosphorous, nitrate and phosphate being highest in the late spring and declined as the season progressed. Values for these nutrients were higher in runoff collected from the field than from samples collected from the wetland.

Differences in groundwater chemistry were a function of sampling depth, sampling location, and sampling date. Concentrations of phosphorous compounds, total nitrogen and herbicides decreased with depth. Nitrogen compounds appeared to decrease as the conversion from cropland to perennial forages progressed. Levels of phosphorous compounds in groundwater varied seasonally but no trend was noted over the length of the project.

Nutrient concentrations in the stream samples were temporally and spatially consistent except for several spikes. These spikes were probably the result of several rather intense rainfall events. This consistency of stream values again points out the role of wetlands in stabilizing local water chemistry.

Herb Bartel, Marion County
KBS Monitoring Project

KBS collected water, invertebrate, and wetland vegetation samples from or near three pits Herb deepened along a drainage gully to make a sort of artificial wetland. Herb also filled the gullies with organic matter, which trapped sediment and slowed the water. KBS findings indicate that these artificial wetland pools act as filters, decreasing nutrient concentrations along the gully.

The unique nature of the cropping system established by the Bartels immediately made the farm a natural candidate for a monitoring program. A tour of the farm and conversations with the Bartels confirmed that the farm would be the first to have a monitoring program tailored to the specific site conditions and goals the Bartels had identified for their farm. (See Bartel profile.)

The crop rotation practices and local topography allowed for installation of paired upslope/down slope runoff samplers and three clusters of groundwater samplers. Runoff was sampled as it entered and exited the parcel of cropland under study. Groundwater samplers were placed along the overland flow route through the same parcel to collect groundwater at various depths as it moved through the same parcel.

In addition, water, invertebrate and wetland vegetation samples were collected from or near three artificial wetland pools formed along a drainage channel (i.e. classic gully). While the combination of management practices employed by the Bartels makes interpreting results of the monitoring program difficult, several observations are noteworthy.

The wetland complex developed by Herb Bartel functioned to regulate water chemistry. Total phosphorous, total nitrogen, nitrate and phosphate concentrations all appear to decrease as water filters through the successive wetlands that were spaced along the channel.

Runoff water quality from the managed field to the north of the wetland area remained consistent until composted dairy bedding was applied near the samplers to reduce local erosion. Increased concentrations of both nitrogen and phosphorous were the trade-off for managing for this local erosion and water quality.

Groundwater samples were similarly influenced by the addition of the compost. Concentrations of total phosphorous in groundwater at the affected sampling sites (upper and lower) increased at the shallowest sampling depth. However, before the compost application, there was an apparent trend with both ammonia and total phosphorous concentrations decreasing as groundwater flowed through the managed land.

One specific runoff event was of particular interest. A rain storm occurring several days after Herb applied ammonia fertilizer to a recently acquired parcel of land resulted in very high nutrient runoff concentrations. Concentrations of ammonia and atrazine were ten times higher in samples taken from the newly acquired land when compared to the project's land managed through the Bartel's crop rotation. This clearly indicates that the timing of such applications is an important component of any crop management practice.

Rod Peters, Marion County KBS Monitoring Project

The Peters farm was included in the Kansas Biological Survey monitoring efforts due to the unique nature of the project and the enthusiasm of Rod Peters. This project was the lone cropping system that subscribed to no-till practices. (See Peters profile.) Rod had already been involved with no-till for several years before his involvement with the Clean Water Farms Project, therefore the collection of background data on the pre-conversion wasn't possible. However, KBS thought it important to include different types of land management practices in the overall monitoring project.

The monitoring program established at the Peters' farm included the installation of a single runoff sampler and a cluster of adjacent groundwater samplers. The runoff sampler was installed to collect water flowing through a bermless waterway and exiting the farm. Groundwater samplers were placed adjacent to the runoff sampler to assess the water quality of groundwater moving into the nearby stream channel. As the bermless waterway wasn't extended until after the establishment of the monitoring project, KBS hoped to measure the relative effectiveness of the waterway in reducing nutrient and herbicide concentrations in surface runoff from the no-till fields.

Runoff and groundwater samplers were placed at the bottom of a waterway on the Peters' site to assess water quality flowing through the waterway, and groundwater moving to the nearby stream.

Results from the runoff sampling suggested that the concentrations of nutrients and herbicides moving through the waterway remained fairly consistent throughout the study period. The single exception was a set of high concentrations that were associated with a rather large runoff-producing storm. Herbicide concentrations in runoff were higher when compared to other monitored farms, but that was expected due to the nature of no-till practices.

Unfortunately, only one runoff event occurred after the extension of the bermless waterway was completed and examination of the effectiveness of the waterway based on one set of values is highly speculative. However, concentrations of nitrogen compounds, phosphorous compounds and herbicides in groundwater sampled by the waterway after the extension was completed are all lower than pre-extension samples.