

West Fork Des Moines River (WFDMR) Total Maximum Daily Load (TMDL) Implementation Project Level III Inventory Final Report

Objective

The Minnesota Pollution Control Agency (MPCA) has identified fifteen stream reaches in the WFDMR watershed that are impaired due to fecal coliform and were listed on the Impaired Waters Lists in 2002, 2004, and 2006. The TMDL Report for the WFDMR watershed was completed in 2008. A TMDL report calculates the maximum amount of pollutant that a water body can receive while still achieving water quality standards. It also conducts a source assessment of the impairments and allocates the load to different point and nonpoint sources. The TMDL Report states that the primary contributing sources to fecal coliform bacteria are livestock on overgrazed riparian pasture, surface-applied manure on cropland, feedlots lacking adequate runoff controls, and inadequate septic systems. The TMDL Implementation Plan was completed in 2009 to identify potential strategies to address impairments. The TMDL Implementation Plan states that a Level III Feedlot Inventory will be completed for every feedlot in the watershed within the first five years of the project. At the time the TMDL Implementation Plan was completed, there were 740 feedlots in the watershed. Because this Implementation Project was a four-year endeavor, 80% of the feedlots were inspected during the grant period. This was 44 sites in Cottonwood County, 142 sites in Nobles County, 190 sites in Jackson County, and 216 sites in Murray County for a total of 592 sites. The inventory is instrumental in order to gauge the need for funds to address the feedlots and ultimately decrease the bacteria concentrations in the streams and rivers. The inventory will provide an understanding of the need for feedlot fixes and opportunities for future grant applications.

Methods

A Master List was compiled prior to the start of the feedlot inspections. Each Master List contained registered feedlots in the watershed that could be inspected in order to meet the 80% goal. These lists did not contain every registered feedlot in the watershed and placed an emphasis on inspecting open feedlots. The Watershed Coordinator and County Feedlot Officer (CFO) were responsible for compiling the list in each county.

The Watershed Coordinator visited with the CFO to schedule feedlot inspections approximately two weeks prior to conducting the inspections. During this visit, the inspection date was scheduled and the inspection sites were selected. Depending on the feedlot sizes, types, and locations, four to ten inspections were scheduled for a single day. The CFO printed out the Water Quality Feedlot Detail Report from the MPCA's Delta database to gather information about the feedlots. Letters were drafted to send to each producer, notifying them of the date and time of their inspection. The TMDL project brochure was also included with the letter and both were mailed to the feedlot producers. Some CFOs preferred not to schedule a time for the individual inspections to offer more flexibility during the day of the inspections. Sites were viewed from county Geographic Information System (GIS) programs to gather information about the layout of the sites and a map of the feedlot was printed. Some CFOs preferred to also drive by the sites prior to the inspection. A four-week rotation was established with the counties to ensure CFOs were not overwhelmed with the increased work load. Feedlot inspections began in the townships in the northwestern part of each county. Every feedlot in that township was inspected before moving to the next township. This process ensured that all feedlots were systematically inspected without bias.

After feedlot inspections were scheduled, the Watershed Coordinator completed a copy of the Customizable Feedlot Inspection Form from the MPCA website. Two copies of the inspection form were printed; one for the CFO and one for the Watershed Coordinator.

On the day of the scheduled inspections, the Watershed Coordinator again met with the CFO at their office. They drove to the inspection sites together in a county vehicle. While on site, information was gathered from the producer regarding the general livestock practices on the site. Livestock numbers, times of year the lots are in use, cement pads, gutters, cleaning frequency, and snow removal were all noted. Information was gathered regarding water flow, including clean water entering the feedlots, runoff direction, buffer, contributing water, slope, and end of treatment. The map was used to identify and make note of these flow patterns.

After the inspection day, the Watershed Coordinator used the information collected on site to run the Minnesota Feedlot Annualized Runoff Model (MinnFARM). MinnFARM is a program that predicts annual pollutant loading for Chemical Oxygen Demand (COD), Phosphorus, Nitrogen, Biological Oxygen Demand (BOD₅), and fecal coliforms from feedlots in Minnesota. The model also predicts if the feedlot is in compliance with MPCA's water quality standards and assigns a prioritization index of feedlot pollution. Indexes range from 0 to 100, with higher numbers being a higher prioritization.

The Watershed Coordinator used various GIS programs to take any further measurements needed to run the MinnFARM. MinnFARMS were only run for open feedlots. The CFOs were consulted if there were any further questions about the site. Oftentimes sites were inspected and either had no livestock present or had much fewer livestock than the registration stated. If this occurred, the MinnFARM was run for what the site was currently registered for, as this is what the site is capable of holding. If a site was determined non-compliant, multiple scenarios were run on MinnFARM to determine what could be done to the site to bring it into compliance.

Once the MinnFARM was run, the Watershed Coordinator again met with the CFO to discuss the sites and the MinnFARM results. At this meeting, concerns about each site and possible improvements that could be made were discussed. If a CFO did not agree with the MinnFARM outcome, possible scenarios that could affect the outcome were discussed. If the CFO still did not agree with the MinnFARM outcome for a site, they could use their Best Professional Judgement and overrule the MinnFARM outcome. A follow up letter was sent to the producer and noted compliance status, concerns at the site, and possible solutions. This was done as soon as possible to ensure the landowner was notified of their compliance status in a timely fashion. A copy of the MinnFARM was also provided to the CFO to include in the county file.

All paperwork used for the inspections was kept and stored in binders in the Watershed Coordinator's office. MinnFARM compliance and ranking was added to the Master Spreadsheet for the county and notes from the inspection and feasible fixes were also noted on the Master Spreadsheet. Following the TMDL Implementation Project, CFOs will be provided with this information to aid them in improving open feedlot runoff.

Results

Throughout the four year project a total of 596 feedlot inspections were completed. Figure 1 shows the location of the registered feedlots within the WFDNR watershed, which feedlots were inspected, and which feedlots were not inspected. Many registered feedlots were not included on the master feedlot lists; these sites are also shown in Figure 1. Overall, 80.5% of the registered feedlots in the watershed

were inspected for the feedlot inventory. Table 1 shows how many inspections were completed in each county. The majority of the inspections took place in Murray and Jackson Counties, while the fewest inspections were in Nobles and Cottonwood Counties.

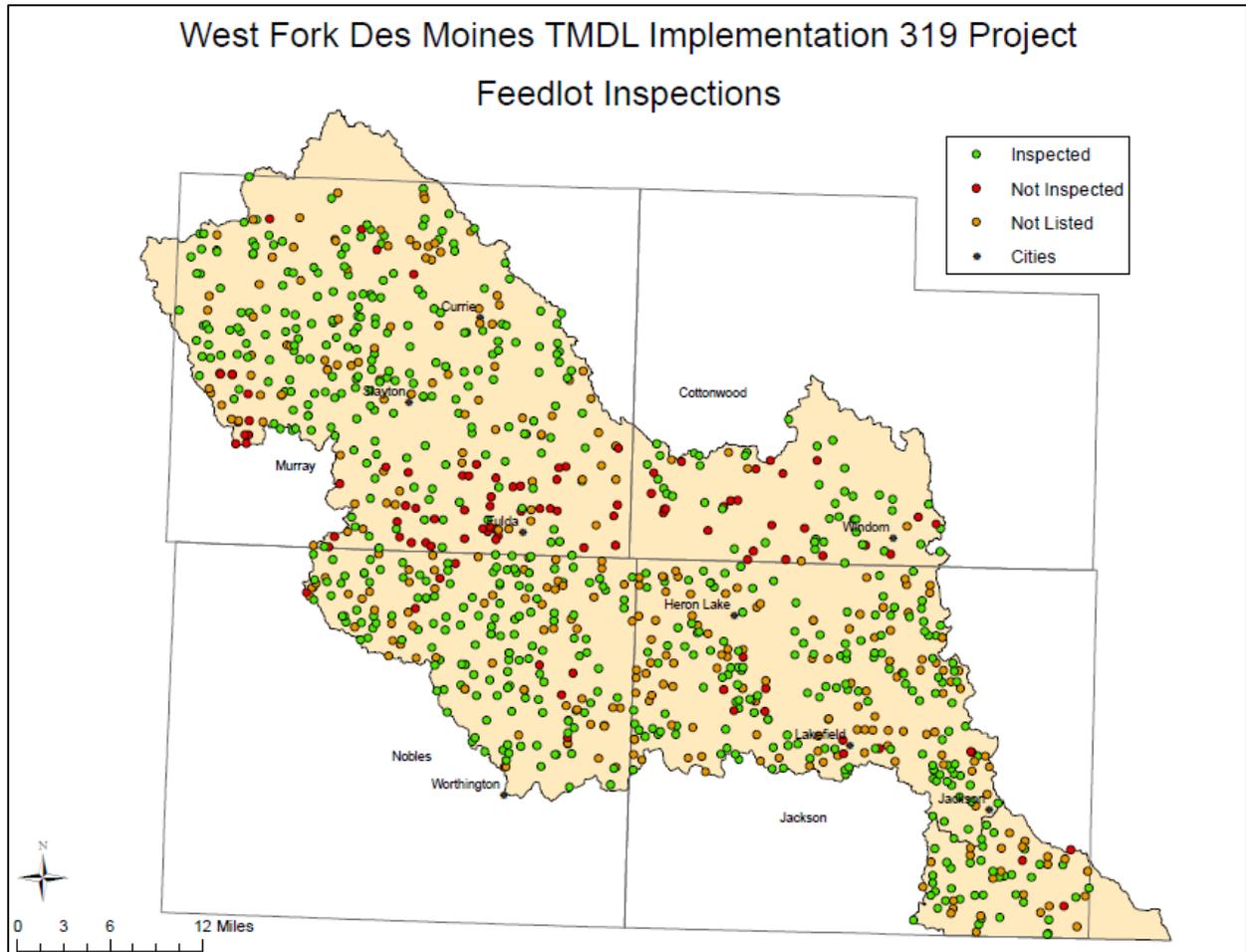


Figure 1: Registered feedlots in the West Fork Des Moines River Watershed according to MPCA for the West Fork Des Moines River TMDL Implementation 319 Project

Table 1: Number and types of feedlots inspected by county for the West Fork Des Moines River TMDL Implementation 319 Project

Type of feedlot	County				Total	Percent
	Cottonwood	Jackson	Murray	Nobles		
Open feedlot	32	100	137	56	325	54%
Deactivated	0	17	14	46	77	13%
No open feedlots	5	22	22	8	57	10%
Zero discharge	6	49	46	29	130	22%
Under 10 animal units	0	2	2	3	7	1%
Total	43	190	221	142	596	100%

The feedlots that were inspected were classified as one of five types: open feedlots, deactivated, zero discharge, no feedlots, and under ten animal units. Table 1 also shows how many of each type of feedlot was inspected in each county and the overall percentage of feedlot types. Figure 2 shows the different types of feedlots inspected in the watershed and how common they were. Open feedlots were the most common type of feedlot visited and sites registered for under 10 animal units were the least common.

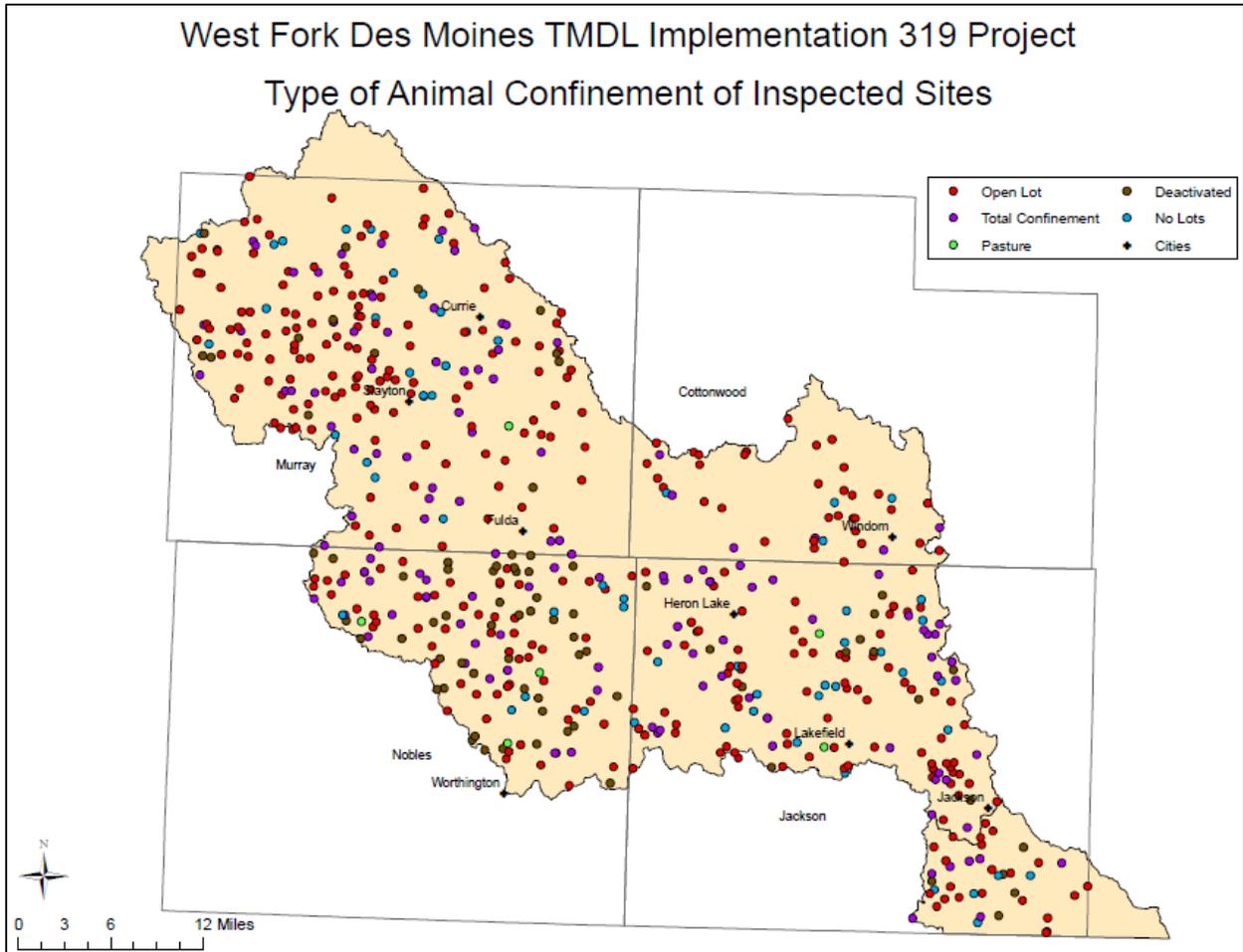


Figure 2: Types of feedlots inspected for the West Fork Des Moines River TMDL Implementation 319 Project

MinnFARM was used to determine compliance for open feedlots and assign a priority index. Table 2 shows the priority index as well as the percent of compliant and non-compliant sites inspected in each county and for the entire inventory. Both Nobles and Murray Counties had more than 50% non-compliant feedlots. Cottonwood and Jackson Counties had lower percentages of non-compliant feedlots. Figure 3 illustrates the layout of compliant and non-compliant feedlots throughout the watershed. Overall, the majority of the open feedlots inventoried were non-compliant and were spread evenly throughout the watershed.

Table 2: Open feedlot compliance status based on MinnFARM results and average indexes by county for the West Fork Des Moines River TMDL Implementation 319 Project

	County				Total
	Cottonwood	Jackson	Murray	Nobles	
Number compliant	18	53	36	27	134
Number non-compliant	14	47	101	29	191
Percent compliant	56%	53%	26%	48%	41%
Percent non-compliant	44%	47%	74%	52%	59%
Average index	12.0	8.8	15.2	11.8	12.3

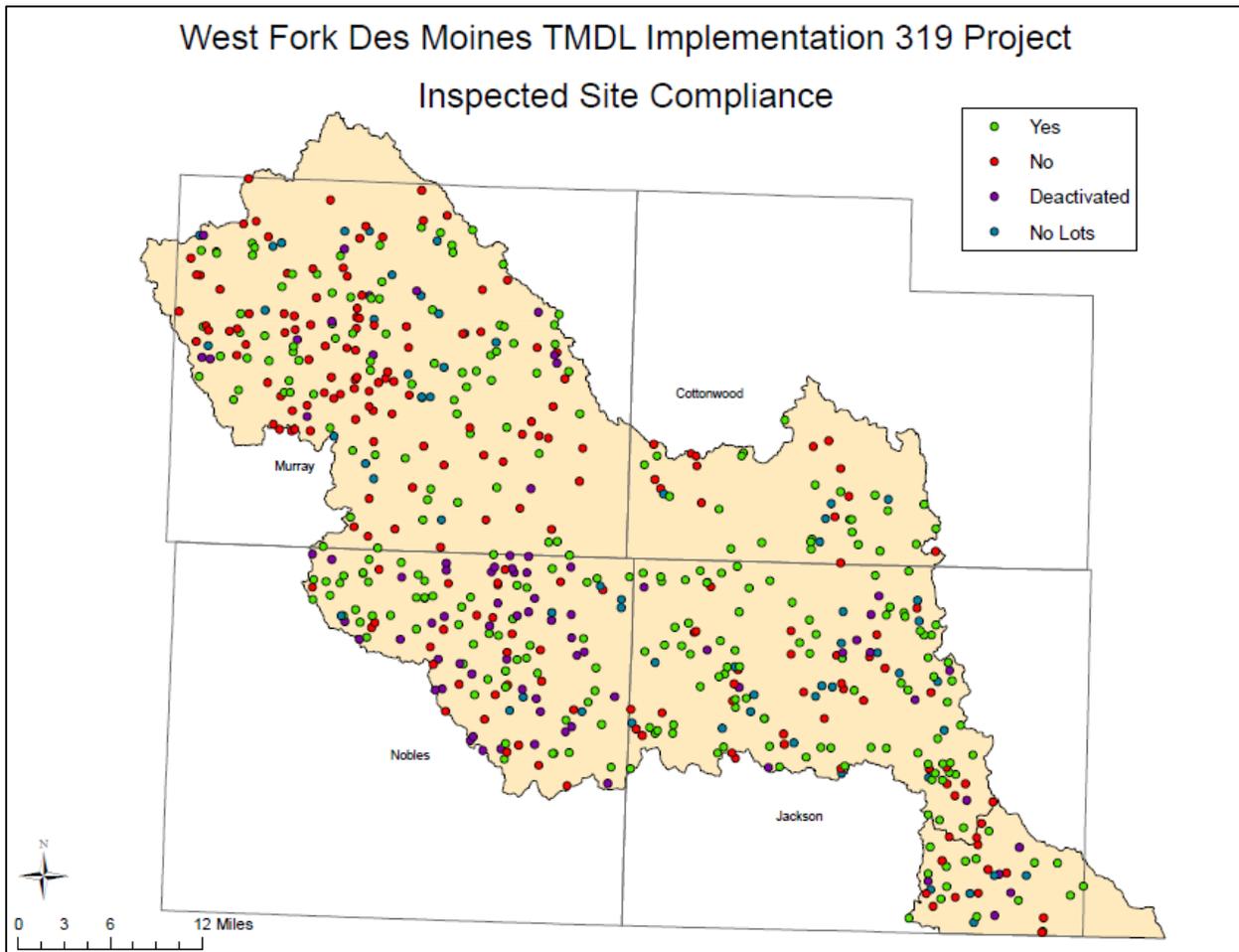


Figure 3: Compliance of feedlots inspected for the West Fork Des Moines River TMDL Implementation 319 Project

Figure 4 illustrates the range of indexes that were calculated for both compliant and non-compliant open feedlots. Table 2 also shows the average MinnFARM index per county and the average index overall for the inventory. Indexes calculated for this inventory ranged from 0-100. Fifty percent of the MinnFARM indexes fell below 8. Murray County had the highest average index and Jackson County had the lowest average index. The overall average MinnFARM index for the inventory was 12.3. According to

Figure 5, there are multiple high priority and low priority sites in each county throughout the watershed. Each county has several high priority sites that need to be addressed.

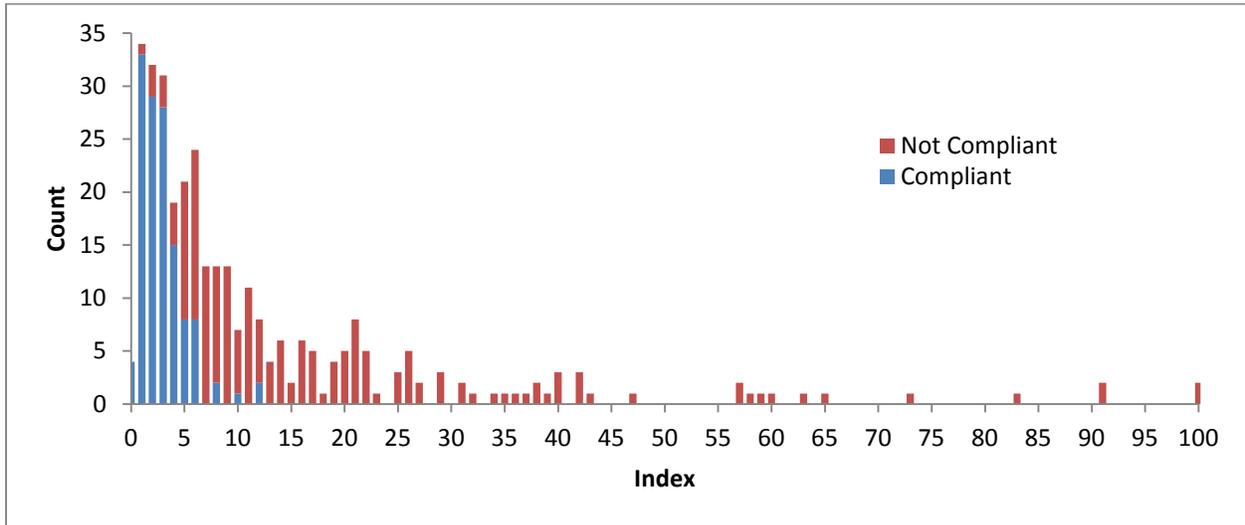


Figure 4: Range of MinnFARM indexes and how often they occurred as results for the West Fork Des Moines River TMDL Implementation 319 Project

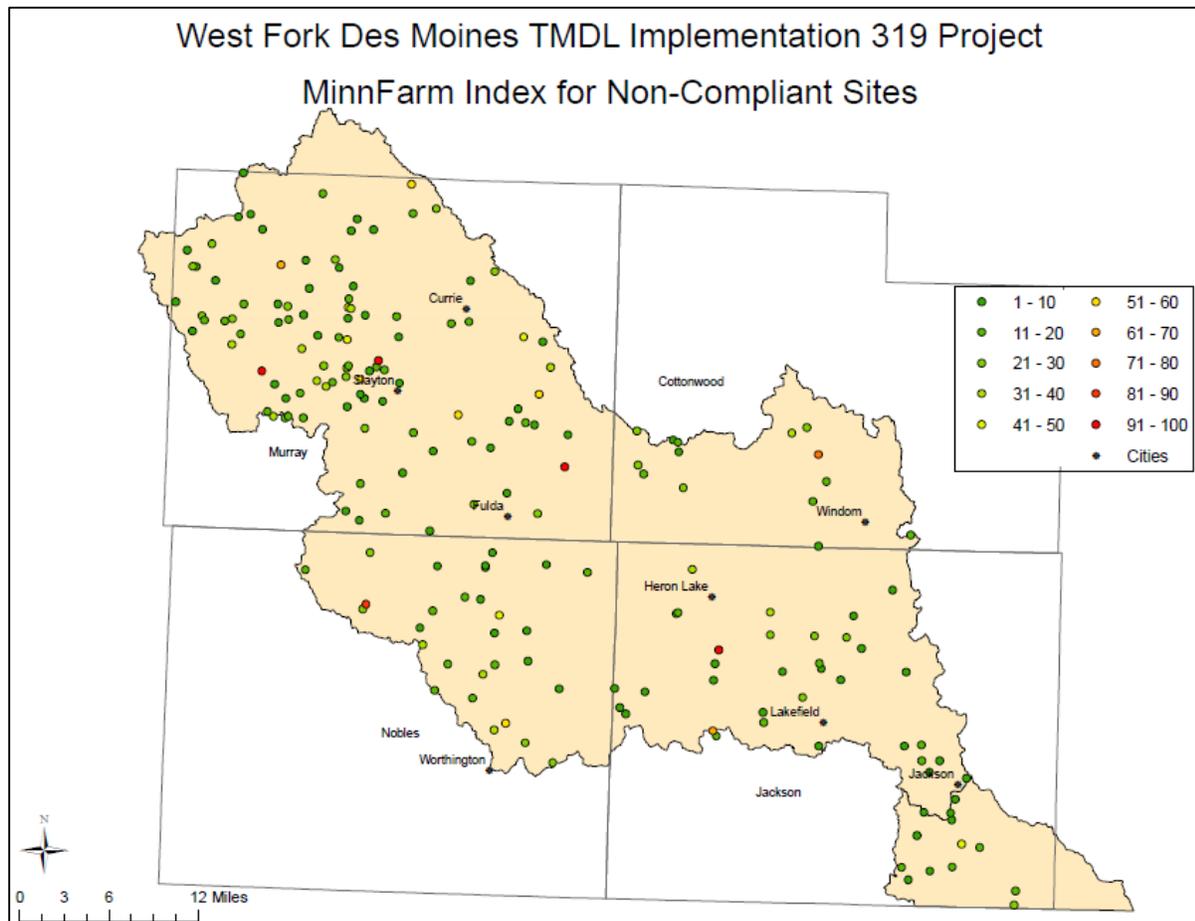


Figure 5: MinnFARM indexes for non-compliant feedlots inspected for the West Fork Des Moines River TMDL Implementation 319 Project

Proximity to surface water is a concern for open feedlots. For the purposes of this inventory, surface water is defined as rivers, lakes, streams, wetlands, tile intakes, and other bodies of water. Figure 6 shows the compliance status of open feedlots inspected within 1,000 feet of surface water. There were non-compliant sites within 1,000 feet of surface water in each county. Many of them are also located on impaired waters. There are impaired water segments in each county throughout the watershed. As illustrated in Figure 7, Murray County has the highest number of non-compliant open feedlots within 1,000 feet of surface water with an index over 20; Cottonwood County has the fewest.

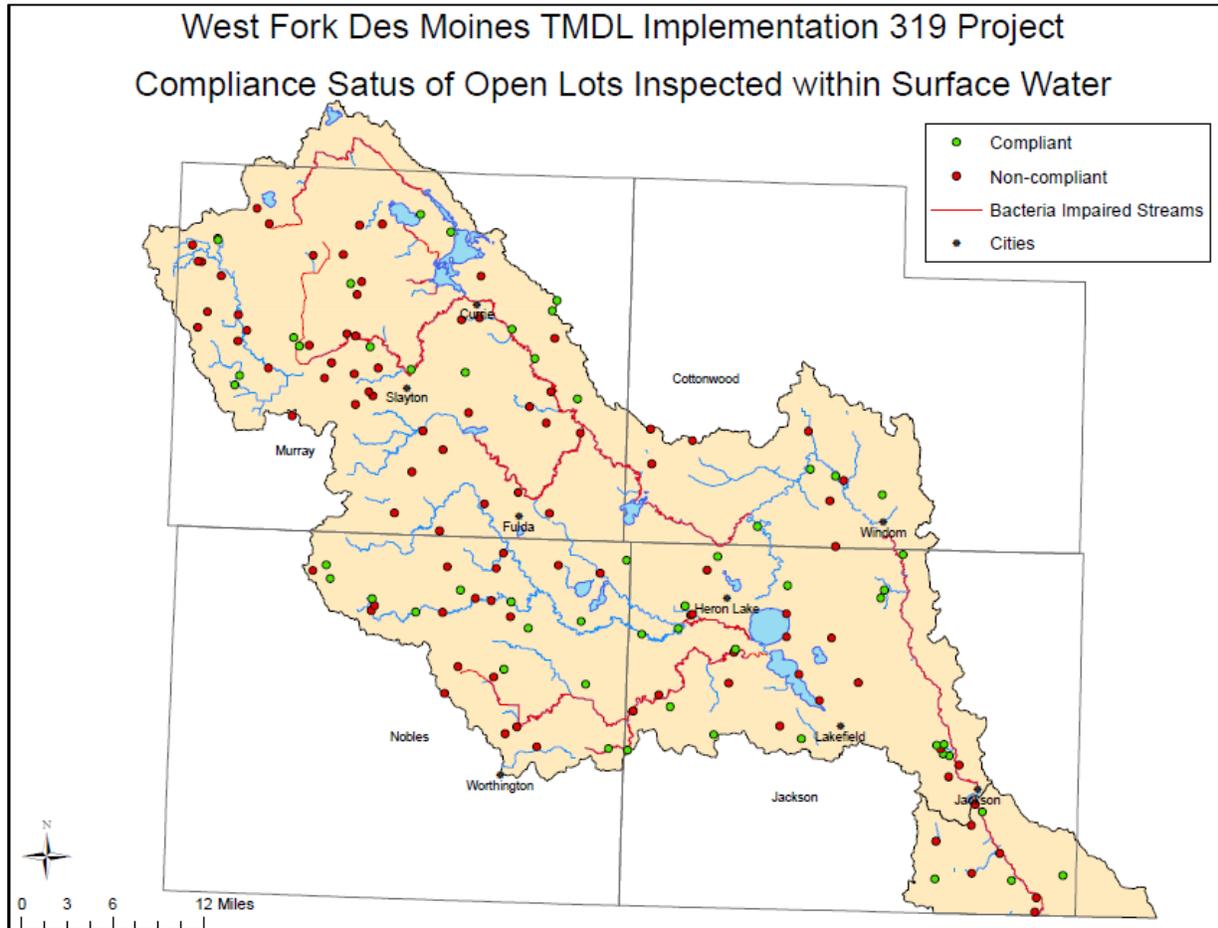


Figure 6: Compliance status of open feedlots inspected within 1,000 feet of surface water for the West Fork Des Moines River TMDL Implementation 319 Project

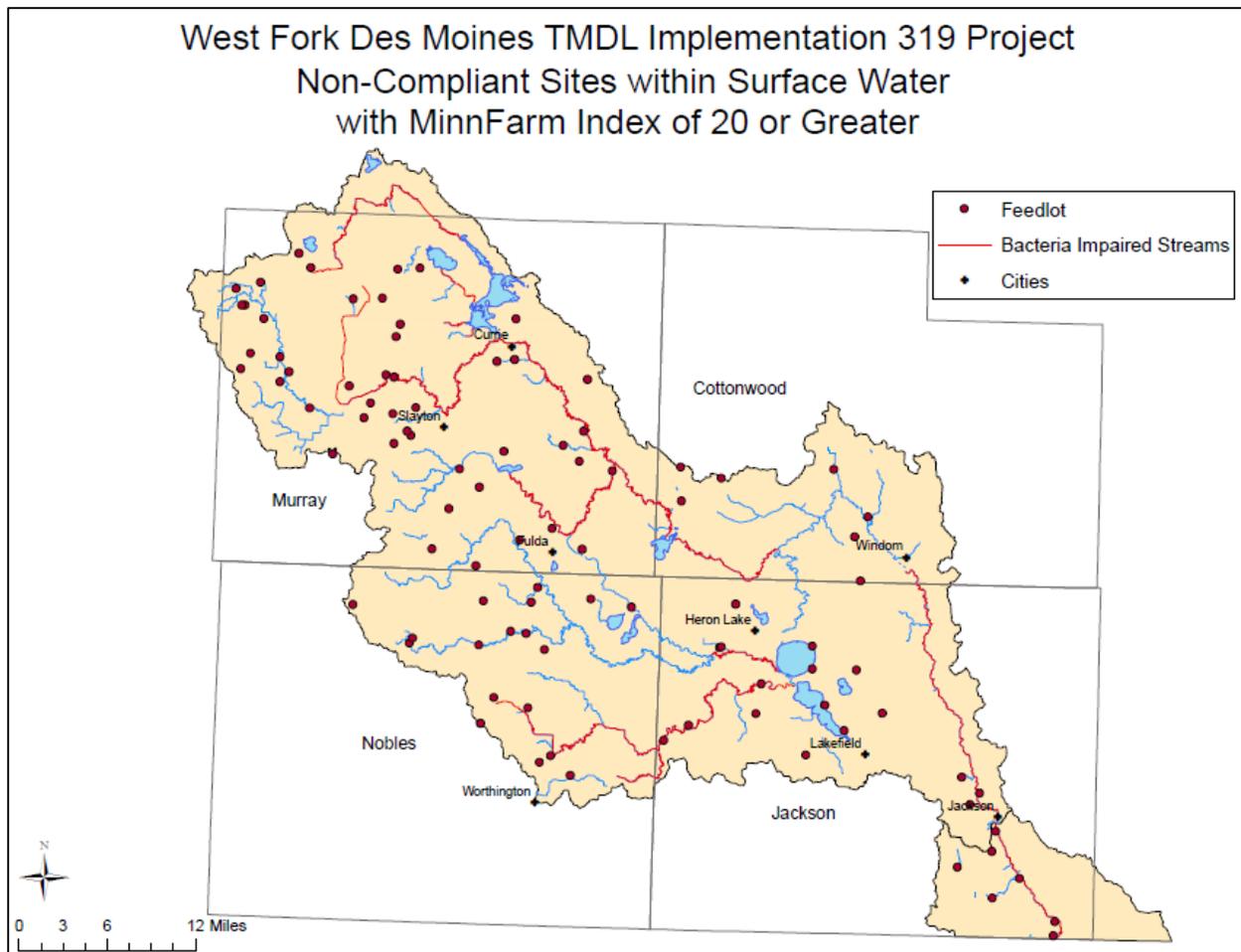


Figure 7: Non-compliant open feedlots with a MinnFARM index 20 or greater located within 1,000 feet of surface water inspected for the West Fork Des Moines River TMDL Implementation 319 Project

Discussion

Types of Feedlots

The goal of completing 592 inspections was surpassed. Cottonwood County fell short of one inspection due to a counting error. Jackson and Nobles Counties both met the inspection quotas, and Murray County exceeded the inspection quota. The southeast corner of Murray County did not have as many inspections as the rest of the county. This occurred because the inspection goal had been met by the time this area of the county was being inspected. Cottonwood County appears to have little variety in the type of feedlots present. This is due to the low number of feedlots inspected in Cottonwood County compared to the rest of the watershed. The different types of feedlots are spread evenly throughout the rest of the watershed.

The goal of this project was to inspect open feedlots, so they were specifically targeted and were the most abundant type of feedlot inspected. Although there were many open feedlots inspected, many of them contained no active feedlots. Many sites remain registered even though they have not had livestock on them for several years. This is done to increase the property value for future resale, or in the hopes that family members will utilize the site for livestock in the future.

The second most abundant type of feedlot inspected was zero discharge sites. These sites were total confinement hog, cattle, and poultry barns. These types of facilities are increasing in popularity and expanding in size in southwest Minnesota for ease of livestock management and manure production. The manure produced at these sites is stored for an extended period of time either as liquid manure in lagoons or as solid manure in stockpiles. Manure is then land applied in large quantities in the spring before planting and the fall after harvest. Although zero discharge sites are not a concern for producing open feedlot runoff, they still have the potential to pollute surface waters due to poor manure management. Lagoons need to be correctly sized to ensure they are capable of holding all manure generated between pump outs. Runoff from poorly placed manure stockpiles and from land application is also a concern.

Following zero discharge sites, deactivated sites were the next most common sites inspected. These are sites that were registered at the time the project began, but have since deactivated. As fewer people farm in Southwest Minnesota, it is becoming more common for smaller feedlots or outdated facilities to go unused and eventually deactivate. Nobles County had the highest number of deactivated feedlots. When the Nobles County Master List was created, many deactivated feedlots were unknowingly added. Nobles County has had a history of problems working with the Delta database, which could have contributed to the large number of deactivated feedlots that were added to the list.

Sites that were empty and had no remaining holding areas for livestock, but were still registered with the county were classified as “no open feedlots”. MinnFARMS were not run for these sites because there were no livestock holding areas to measure or use for calculations. Some of these empty sites will deactivate in the near future, but some will remain registered to increase property value. Sites that were strictly used for pasturing livestock were also classified as “no open feedlots”. Technically these sites do not need to be registered; the county cannot regulate pastureland. Jackson and Murray Counties had the highest numbers of no open feedlot sites. Areas in these counties are hilly and a large amount of cattle are grazed on them.

Sites with under 10 animal units were the least common type of feedlot. If a feedlot has less than 10 animal units it does not need to be registered and CFOs cannot regulate them. Some producers do not realize this so they continue to maintain a feedlot registration. Other sites that fall in this category were registered for more livestock when the project began, but more recently dropped to under 10 animal units. Most sites with under 10 animal units had pasture-like conditions for livestock so a MinnFARM was not run.

Feedlot Compliance

MinnFARM results revealed that the majority of open lots inspected for the inventory were not compliant. Murray County has the highest percentage of non-compliant sites. This could be due to the large number of sites inspected in Murray County and suggests that the most feedlot work needs to be done in Murray County. However, each county has high index feedlots and high priority sites to target for implementing feedlot fixes.

Over half of the MinnFARM indexes for compliant and non-compliant open feedlots fall below 10. However, there are still many feedlots indexes that exceed 10. Although non-compliant open feedlots are a concern for affecting surface water quality, a site with an index under 10 is of small concern for polluting surface waters. Indexes from 10-20 are of moderate concern and any index over 20 should be addressed. Open feedlots that have an index over 20 are contributing large amounts of bacteria and E.coli and should be the highest priority for reducing open lot runoff.

Non-compliant feedlots located within 1,000 feet of surface water are also a pollution concern. Figures 6 and 7 are great tools to use to target E.coli loading on specific stream stretches. It is not surprising that impaired waters have several non-compliant feedlots located on them. Non-compliant feedlots that are located on impaired waters are clearly identified and can be easily targeted for feedlot improvements. Non-compliant open feedlots within 1,000 feet of surface water with an index over 20 are a major concern. These are feedlots that are contributing a significant amount of E.coli to surface waters and need to be addressed.

Obstacles

Staff turnover caused complications with this project. There were four total CFO turnovers that occurred in Cottonwood and Jackson counties. During this time feedlot inspections ceased until another employee was hired and trained for the position. This shortened the time frame available to complete the project, especially in Jackson County.

Staff turnover was an issue with the Watershed Coordinator position as well. The project started with Lauren Michelsen who served as Watershed Coordinator from January 2012–March 2012. Kiel Tschumperlin then served as Watershed Coordinator from August 2012–June 2014 and Amanda Schultz served as Watershed Coordinator from June 2014–August 2015. This may have caused inconsistencies with how the inspections were conducted and how the MinnFARMS were run, as components can be subjective. Time spent searching for and training a new Watershed Coordinator reduced the amount of time that could be spent working with CFOs to do inspections, further reducing the project timeline.

Oftentimes the producer was not able to attend the scheduled inspection. Talking to the producer to get an understanding of how the operation is managed is very helpful when running a MinnFARM. If the producer is not present, some details need to be inferred and may be incorrect, resulting in an inaccurate MinnFARM representation. Some producers were able to be reached by telephone following the inspections to discuss their site, but this was often difficult to accomplish.

There are many sites within the WFDNR that are registered but have not housed livestock for several years. These sites proved to be difficult to assess; they often looked compliant because there were no signs of livestock or runoff, yet the MinnFARM showed pollution potential. Inferences were often made in these instances, which may have led to incorrect MinnFARM results. Empty sites were typically passed as compliant by the CFO, even if the MinnFARM listed the site as not compliant. These sites should be monitored and if they are to be restocked, they should be reassessed.

The master lists of registered feedlots that were compiled were inconsistent between the four counties. Master lists did not contain information for every registered feedlot. Instead, they contained just over the required 80% of feedlots that needed to be inspected in the watershed. This was not communicated to all Watershed Coordinators and was discovered after the inventory had been completed. This caused difficulties when a feedlot needed to be skipped, because there were few other remaining feedlots. Some counties eliminated total confinement sites from the master list while others did not. Some feedlots were also added to the list that were located outside of the WFDNR watershed.

There were two livestock disease outbreaks that made completing inspections difficult. Porcine Epidemic Diarrhea Virus (PEDV) and Highly Pathogenic Avian Influenza (HPAI) were both prevalent during the time of this project and limited which sites could be visited for inspections. Extreme caution was taken when inspecting sites with swine or poultry. There were also time restrictions on how often these types of sites could be visited. It was advised not to visit sites with domestic poultry to limit the

spread of HPAI. This put further time restrictions on how often inspections could be completed and narrowed down the pool of sites that could be inspected.

Unexpected Outcomes

There were many projects completed during the WFDNR TMDL Implementation Project as a result of the inventory. The most notable success was the execution of several small-scale feedlot fixes. These improvements were simple fixes that did not necessarily bring the site into total compliance, but greatly reduced the amount of runoff from the property. These fixes included moving fences to allow seeding of a larger buffer area, adding gutters to reduce clean water from entering the lots, constructing berms to divert clean water, and dirt work to improve buffer areas.

Results from an inspection in Murray County were also used to successfully secure a Clean Water Fund grant through the Board of Water and Soil Resources (BWSR). These funds were used to construct a manure pit for a dairy operation and eliminate runoff entering Beaver Creek.

The inspections were also a great way to distribute information to producers and answer any questions they may have face-to-face. There were often gaps in knowledge regarding animal units, manure record requirements, application setbacks, and how to calculate nutrient availability to crops. Many conversations were also had regarding best management practices and options for site improvements.

During the feedlot inspections, registration errors with the county and the Delta database were found and corrected. Incorrect owners, spellings, and addresses were all found and corrected. Duplicate registrations and deactivated lots that had not been marked as such were adjusted. Proximity to public waters and site characteristic information was also verified and updated in Delta.

Conclusion

The WFDNR Watershed is plagued with waters impaired with high E.coli levels. Runoff from feedlots is a major contributor to E.coli in surface waters. The Level III Feedlot Inventory completed for this project shows that non-compliant feedlots are located throughout the entire watershed. Every county in the watershed has high-polluting feedlots that need to be addressed in order to control the E.coli levels in surface waters. The trend continues that the large feedlots expand while small or outdated feedlots have high rates of attrition. A new age of technology and a new generation of conservation-minded farmers are also encouraging sound management practices.

Feedlot Improvements

Open feedlots that are non-compliant with high indexes should be targeted for implementing feedlot fixes. Reducing open feedlot runoff from these sites will be the most beneficial in reducing E.coli levels in impaired streams. Although the highest index sites should be addressed, it is not feasible to start with the highest MinnFARM index sites and work down the list to implement improvements. Landowner willingness and financial ability are major factors when considering a feedlot fix project. Importance should be placed on the landowners who are willing to work with county staff and the MinnFARM indicates a pollution potential.

Most non-compliant feedlots with an index over 20 will require complex and costly improvements to make the site compliant. Building a roof structure to house livestock is a simple way to reduce runoff. Large manure basins can also be constructed to capture all feedlot runoff. Moving the feedlot to a less sensitive area with flat slopes and a large buffer area is another option. Large scale feedlot

improvements should be designed by an engineer. These types of improvements could cost hundreds of thousands of dollars.

Non-compliant open feedlots with indexes under 20 can make smaller improvements to make the site compliant. Smaller feedlot fixes include adding gutters to barn roofs or open tile intakes upstream of feedlots. This eliminates clean water from entering feedlots, reducing the volume of runoff from open lots. Moving fences to decrease lot sizes will also reduce runoff volume and increase buffer area. Buffers can be enhanced with resizing, re-sloping, and reseeded to allow better quality treatment area and more infiltration. Small runoff settling areas are also beneficial for allowing solids to settle out of runoff. Smaller scale feedlot improvements such as these will cost a few thousand dollars. MinnFARM is a good tool to use for these types of sites to determine practices that will reduce open lot runoff.

Starting with feedlot improvements in the headwaters and working downstream is an efficient way to improve water quality in the WFDNR. Using the result maps, non-compliant feedlots in the headwaters of bacteria impaired streams can be easily identified and targeted to reduce E.coli loading. Headwaters of individual impaired reaches throughout the watershed are priority for implementing feedlot fixes. The headwaters of the WFDNR in Murray County are also a high priority for implementing fixes. Murray County also has the highest percentage of non-compliant feedlots and sites with the highest indexes. This makes Murray County an especially critical area to implement feedlot fixes in order to improve water quality in the WFDNR. Non-compliant feedlots located on stretches that are not impaired also need to be addressed. Improving these sites will ensure that these stretches do not become impaired in the future. To help implement feedlot fixes, CFOs should work with producers to encourage improvement projects and identify producers who are willing to make enhancements. County Soil and Water Conservation District (SWCD) staff should be actively pursuing funding for feedlot fixes. CFOs and SWCD staff need to work together to implement improvement projects on feedlots.

Inventory

Through this inventory, 80.5% of the feedlots within the watershed have been assessed. However, one fifth of the registered feedlots still remain to be evaluated. In order to fully understand feedlot pollution potential in the watershed, the remaining feedlots should be included in the Level III Feedlot Inventory. CFOs should continue to work with the Watershed Coordinator to complete the inventory. Having a complete inventory will be very beneficial to reduce open feedlot runoff. When considering remaining feedlots to inspect, the MPCA database should be consulted to ensure that all currently registered feedlots are listed and that the feedlots actually lie within the watershed boundary. An emphasis should also be placed on inspecting open feedlots.

Manure Application & Records

Manure nutrient and application records are valuable resources to ensure manure is being land applied responsibly to reduce runoff. Feedlots registered for over 100 animal units are required to keep manure application records. Those registered for over 300 animal units are required to keep additional soil records and Manure Management Plans (MMP). Generally, large producers are aware of these records and maintain them. However, many do not actually utilize these records or understand how to use them for proper manure management.

Smaller feedlot producers who raise livestock on the side tend to keep poor records due to lack of time and information. They are often unaware of the sensitive areas in their fields and therefore apply manure in these areas. They do not keep track of previous applications and have a higher likelihood of over applying.

During feedlot inspections, CFOs collect the required records from producers but do not actually analyze them. If records are not supplied, the feedlot producer is given notice that they are “non-compliant”, however they are not pursued to ensure they begin to keep the necessary records. No one is holding producers accountable to ensure they are maintaining the appropriate records and their manure is not being land-applied carelessly. CFOs already have a large workload and do not have enough time to keep track of producer’s records for them. It would be beneficial if the counties had an employee that worked in tandem with the CFOs to focus specifically on MMPs and manure records. This would place higher importance on proper manure management, further reducing E.coli runoff. Crop consultants are also a resource that livestock producers have confidence in and can be used as a third party to inform producers on proper manure management.

Informational mailings are another means to distribute information to all feedlot producers. During the feedlot inventory, producers in the WFDNR watershed were sent a packet of information regarding proper manure records, handling, and application. There were many questions and confusion from producers surrounding the packets that were mailed. Although mailings are a means to distribute information to producers, it is not guaranteed that everyone will look at the material, utilize, or even understand it. To make mass mailings more beneficial in the future, providing less information more often is a better option.

Sites in Shoreland

Generally, deactivating unused feedlots is discouraged by CFOs. Registered feedlots provide funding for the county and makes reopening a feedlot in the future easier. However, deactivating feedlots that are in shoreland should be encouraged to ensure that future feedlots would not operate and produce runoff in critical areas. Currently, state legislature does allow for deactivated feedlots to reopen in sensitive areas with ease. However, some local zoning ordinances are stricter than state legislature and could prevent these feedlots from reopening. Unused feedlots located in shoreland should be encouraged to deactivate, depending on the individual county zoning ordinances.

Grazing Livestock

According to the 2008 TMDL Report, overgrazed riparian areas also contribute to bacteria loading in the WFDNR. Currently, little is done to regulate grazing as CFOs cannot regulate pastureland. SWCD staff could work with producers who graze livestock and encourage them to keep livestock out of surface waters. An additional inventory of pastureland and grazed riparian areas in the watershed would be beneficial for SWCD staff working to improve grazing practices.

Other Concerns

E.coli is just one of many concerns facing water quality in the WFDNR. Erosion and sedimentation continues to be a problem. Landowners are concerned about land loss as stream banks slough away, further increasing water turbidity. Nutrient loading continues to be an issue. Both commercial fertilizers and manure runoff contribute to high amounts of nutrients in surface water. Encouraging proper application rates, practices, and timing will decrease runoff from row crops and reduce nutrient loading. Reducing feedlot runoff will also improve water quality. Flooding is another difficulty facing the watershed. Wetland restorations and water retention areas should be constructed for flood storage. Implementing in-field systems such as cover crops, grassed waterways, or filter strips also enhances the landscape’s ability to hold water and filter nutrients. These other areas of concern should also be explored for opportunities to address E.coli.