Bois d'Arc Lake WPP Chapter 6: Strategies for Watershed Protection Plan Implementation

Texas Water Resources Institute
make every drop count

TEXAS A&M AGRILIFE

NORTH TEXAS MUNICIPAL WATER DISTRICT

Chapter 6: Strategies for Watershed Protection Plan Implementation

Introduction

Chapters 4 and 5 illustrate the diverse sources of bacteria and nutrient loading in the Bois d'Arc Lake watershed. No single source of *E. coli* in the watershed is the primary cause of current levels in the watershed. According to the GIS analysis, cattle, sheep, OSSFs and deer have the highest potential to contribute *E. coli* to the waterbodies and their tributaries; however, all potential sources in the watershed contribute at some level. Due to the diverse potential sources, a range of management strategies are recommended to address all potential sources of *E. coli* in the watershed. Recommended management strategies were developed based on stakeholder feedback and management recommendation effectiveness in reducing bacteria loading.

Estimated potential load reductions from each management measure are presented with each recommended action discussed in this chapter. Each loading estimate presented is based on a predicted worst-case scenario loading. As a result, these estimates do not accurately predict real loadings that are occurring or expected load reductions that may be realized in-stream. Actual reductions are dependent on several factors that may trigger the need for adaptive implementation. Potential annual load reductions from management measures are discussed through this chapter and indicate that reducing bacteria loads entering the waterbodies in the watershed to levels that support primary contact recreation use is feasible.

Priority implementation areas for each recommended management strategy were identified based on spatial analysis and stakeholder feedback. While management measures can be implemented throughout the watershed, priority locations were selected based on areas where management strategies could be most effective in removing or reducing potential loading.

Stakeholder input was crucial throughout the decision-making process for these suggested management strategies. Management measures suggested in this chapter are voluntary and will rely on stakeholder adoption for successful implementation. Therefore, receiving stakeholder input on willingness to adopt these practices is important throughout this process. All management measures were discussed with and approved by stakeholders to ensure community support and successful implementation.

Management Measure 1 – Developing and Implementing Water Quality Management Plans or Conservation Plans

Potential bacteria loadings in the Bois d'Arc Lake watershed from cattle and other livestock are relatively high compared to other evaluated sources. Livestock waste is mostly deposited in upland areas and transported to water bodies during runoff events. Therefore, much of the *E. coli* bacteria in livestock waste dies before reaching a water body. However, livestock may spend significant amounts of time in and around water bodies, thus resulting in more direct impacts on water quality.

Livestock distribution is highly dependent upon availability and distribution of water, food and shelter. This allows livestock to be managed easily compared to non-domesticated species. The time livestock spend in and around riparian areas can be reduced by providing supplemental water, feed, shade and forage around a property. As a result, it can effectively reduce the potential of *E. coli* concentrations from runoff entering nearby water bodies.

A variety of BMPs are available to achieve goals of improving forage quality, diversifying water resource locations and better distributing livestock across a property. Practices commonly implemented to effectively improve forage and water quality are listed in Table 1. However, the actual appropriate practices will vary by operation and should be determined through technical assistance from NRCS, TSSWCB, and local soil and water conservation districts (SWCDs) as appropriate. In the last three years over 70 Conservation Plans have been developed in Fannin County. Through implementation of this watershed plan we hope to increase the adoption of Conservation Plans (CPs) and Water Quality Management Plans (WQMPs) to 100 total plans over the next 10 years. Load reductions achieved from this measure will vary depending on where and what conservation measures are implemented in various plans. Establishing additional acreage under management practices and additional conservation plans in this watershed is the primary goal of this management measure.

Table 1. Available pasture and rangeland practices to improve water quality

Practice	NRCS Code	Focus Area or Benefit
Brush Management	314	Livestock, water quality, water quantity, wildlife
Fencing	382	Livestock, water quality
Filter Strips	393	Livestock, water quality, wildlife
Grade Stabilization Structures	410	Water quality
Grazing Land Mechanical Treatment	548	Livestock, water quantity, wildlife
Heavy Use Area Protection	562	Livestock, water quantity, water quality
Pond	378	Livestock, water quantity, water quality, wildlife
Prescribed Burning	338	Livestock, water quality, wildlife
Prescribed Grazing	528	Livestock, water quality, wildlife
Range/Pasture Planting	550/512	Livestock, water quality, wildlife
Stream Crossing	578	Livestock, water quality
Water Well	642	Livestock, water quality, wildlife
Watering Facility	614	Livestock, water quantity

Natural Resources Conservation Service, NRCS

The implementation of CPs and WQMPs is beneficial, regardless of location in the watershed. Although those management measures mainly address and calculate bacteria sources from cattle, the use of CPs and WQMPs can reduce fecal loading from all types of livestock. Research has proven that recommended management measures also reduce nutrient and sediment loading from properties where they are implemented. The overall effectiveness of CPs and WQMPs can be greater on properties with riparian habitat. Therefore, all properties with riparian areas are considered a priority. Meanwhile, properties without riparian habitat are also encouraged to participate in implementation activities. Priority areas will include subwatersheds 1 and 2. Table 2 summarizes management recommendations for cattle and other livestock in the watershed.

Table 2. Management measure 1: Cattle and other livestock

Pollutant Source: Cattle and Other Livestock			
Problem: Livestock derived fecal loading into water bodies			
Objectives: • Work with landowners to develop property-specific CPs and WQMPs to protect water quality • Provide technical and financial assistance to producers • Reduce fecal loading from livestock in riparian areas			
Location: Subwatersheds 1 and 2, with priority given in rural areas near waterbodies			
Critical Areas: Properties with creek and tributary access, especially those using them as a livestock watering source			
Goal: Develop up to 100 plans (Conservation and/or WQMPs) focused on minimizing the time spent by livestock in the riparian corridor and better use of available grazing resources across the property.			
Description: CPs and WQMPs will be developed to address direct and indirect fecal deposition from cattle and other livestock. BMPs to reduce time spent in the creek or riparian corridor, improve grazing distribution, and grass quality, and decrease runoff will be recommended. Likely practices include prescribed grazing, cross-fencing, pasture planting, water wells, and watering facilities. Education program delivery will support and promote implementation adoption.			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
Producers, NRCS, TSSWCB, SWCDs	Develop, implement, and provide financial assistance for livestock CPs and WQMPs @ $15,000 per plan for 100 plans	2022-2032	$1,500,000
AgriLife Extension, SWCD, NTMWD	Deliver education and outreach programs and workshops to landowners	2022, 2025, 2029	N/A
Estimated Load Reduction			
Prescribed management will reduce loadings associated with livestock by reducing runoff from pastures and rangeland as well as reducing direct deposition by livestock. Implementation of 100 WQMPs and CPs is estimated to reduce annual loads from livestock by 1.53×10^{12} cfu *E. coli* per year in the Bois d'Arc Lake watershed.			
Effectiveness	High: Decreasing the time that livestock spend in riparian areas and reducing runoff through effectively managing vegetative cover will directly reduce NPS contributions of bacteria and other pollutants to creeks.		
Certainty	Moderate: Landowners acknowledge the importance of good land stewardship practices and management plan objectives; however, financial incentives are often needed to promote the WQMP and CP implementation.		
Commitment	Moderate: Landowners are willing to implement stewardship practices shown to improve productivity; however, costs are often prohibitive and financial incentives are needed to increase implementation rates.		
Needs	High: Financial costs are a major barrier to promote implementation. Education and outreach are needed to demonstrate benefits of plan development and implementation to producers.		

Management Measure 2 – Promote Technical and Operational Assistance to Landowners for Feral Hog Control

Potential *E. coli* and nutrient loading from feral hogs across the watershed represents a considerable potential influence on instream water quality. While other sources of *E. coli* are potentially larger in volume, feral hogs' preference for dense habitat, available food resources, and water enhance the potential affects that they have on instream water quality. Behaviors including rooting and wallowing further affect water quality by degrading ground cover, increasing soil/ sediment disturbances, and decreasing bank stability. Each of these effects increases erosion and causes enhanced pollutant (*E. coli*, nutrients, and sediment) transport to water bodies during runoff events. Wallowing in the edges of water bodies also affects water quality between runoff events.

Physically removing hogs from the watershed is the best strategy for reducing their impact on water quality. A variety of methods exist to accomplish this goal, and other tactics can also improve the success of removal efforts. In the watershed, trapping animals is the most effective means for removing large numbers of hogs. With proper planning and diligence, trapping can successfully remove large numbers of hogs at once, whereas shooting or catching with dogs typically results in fewer individuals being removed before they move to another part of the watershed. Hunting hogs is already common across the watershed and should certainly continue.

Excluding feral hogs from supplemental feed is also an effective management tool. Feral hogs are opportunistic feeders and are known to access supplemental feeding stations such as wildlife feeders. Erecting exclusionary fences around deer feeders has been shown to reduce the ability of feral hogs to access these food sources (Rattan et al. 2010). Additionally, exclusion from easily accessible food sources can enhance trapping success nearby.

Education resource delivery also improves feral hog removal effectiveness. Landowner participation and education is crucial to the management of feral hogs within the watershed. The Texas A&M AgriLife Extension Service has developed a variety of educational resources that are available at: http://feralhogs.tamu.edu. They include information on feral hog biology, trapping techniques and types, wildlife feeder exclusion techniques, trap designs, research studies, and more. Additionally, they deliver focused feral hog education programs that include hands-on trapping technology and technique demonstrations.

Trapping hogs may provide a potential source of income, or at least a means to recuperate some costs associated with repairing feral hog damage and trapping efforts. The State of Texas allows live feral hogs to be transported to approved feral hog holding facilities where they can be sold to the holding facility. Purchase prices vary by facility and are market driven. There is a facility in nearby Delta County. Hogs transferred to state-approved holding facilities are then processed for slaughter or moved to approved hunting facilities. It is recommended that trapped hogs be taken to a slaughter facility, rather than a hunting facility, where the risk of re-introduction into the watershed is a concern. An online mapping tool and listing of approved facilities is available at: https://tahc.maps.arcgis.com/apps/webappviewer/index.html?id=6406b01b5b284f2398c31179288698 08. Other informational resources such as regulations regarding feral hog movement and holding restrictions are also available at this website. Each of these needs, priority management areas, and expected *E. coli* loading reductions are discussed further in Table 3.

Table 3. Management measure 2: Feral hogs

<table>
<tr><th colspan="4">Pollutant Source: Feral Hogs</th></tr>
<tr><td colspan="4">Problem: Direct and indirect fecal loading, riparian habitat destruction, soil damage from rooting</td></tr>
<tr><td colspan="4">Objectives:
Reduce fecal contaminant loading from feral hogs
Reduce hog population
Reduce food supply for hogs
Provide education and outreach to stakeholders</td></tr>
<tr><td colspan="4">Location: Entire watershed, with highest priority in subwatersheds 1 and 2</td></tr>
<tr><td colspan="4">Critical Areas: Riparian areas and travel corridors from cover to feeding areas</td></tr>
<tr><td colspan="4">Goal: Manage the feral hog population through available means to reduce the total number of hogs in the watershed by 15% (1,565) and maintain them at this level</td></tr>
<tr><td colspan="4">Description: Voluntarily implement efforts to reduce feral hog populations throughout the watershed by reducing food supplies, removing hogs, and educating landowners on hog removal techniques.</td></tr>
<tr><th colspan="4">Implementation Strategy</th></tr>
<tr><th>Participants</th><th>Recommendations</th><th>Period</th><th>Capital Costs</th></tr>
<tr><td>Landowners, Land Managers, and Lessees</td><td>Voluntarily construct fencing around deer feeders to prevent feral hog use
Voluntarily identify travel corridors and employ trapping and hunting in these areas to reduce hog numbers
Voluntarily shoot hogs on sight; ensure that lessees shoot hogs on sight</td><td>2022-2032</td><td>$200/feeder</td></tr>
<tr><td>NTMWD, AgriLife Extension</td><td>Deliver Feral Hog Education workshops</td><td>2023, 2026, 2030</td><td>$7,500 each</td></tr>
<tr><th colspan="4">Estimated Load Reduction</th></tr>
<tr><td colspan="4">Removing and maintaining feral hog populations directly reduces fecal loading potential to water bodies in the watershed. Reducing the population by 15% in the Bois d’Arc Lake watershed is estimated to reduce potential annual loads by 5.44×10^{13} cfu E. coli annually (Appendix *).</td></tr>
<tr><td>Effectiveness</td><td colspan="3">Moderate: Reduction in feral hog population will result in a direct decrease in bacteria and nutrient loading to the streams; however, removing enough hogs to decrease their overall population will be difficult.</td></tr>
<tr><td>Certainty</td><td colspan="3">Low: Feral hogs are transient and adapt well to their environment. They move freely due to food and habitat availability, and hunting/trapping pressure. Removing 15% of the</td></tr>
</table>

	population each year will be difficult and is highly dependent upon the diligence of watershed landowners.
Commitment	Moderate: Landowners are actively battling feral hog populations and will continue to do so as long as resources remain available. Hogs adversely affect their livelihood.
Needs	Moderate: Funds are needed to provide education and outreach to further inform landowners about feral hog management options, adverse economic impacts.

Management Measure 3 – Identify, Inspect, and Repair or Replace Failing On-Site Sewage Systems

OSSFs are used to treat wastewater in areas of the watershed where centralized wastewater treatment facilities are not available. Conventional systems use a septic tank and gravity-fed drain field that separates solids from wastewater prior to distribution of the water into soil where actual treatment takes place. In Bois d'Arc Lake watershed, approximately 49.8% of the watershed's soils are considered very limited and 41.8% are somewhat limited. This indicates that conventional septic tank systems are not suitable for the proper treatment of household wastewater.

In these areas, advanced treatment systems, most commonly aerobic treatment units, are suitable alternative options for wastewater treatment. While advanced treatment systems are highly effective, the operation and maintenance needs for these systems are rigorous compared to conventional septic systems. Limited awareness and lack of maintenance can lead to system failures. Failing or non-existent OSSFs can provide significant bacteria and nutrient loading into the watershed. The exact number of failing systems is unknown, however, it is estimated as many as 440 systems may be malfunctioning across the watershed. A number of reasons contribute to OSSF failure, including improper system design or selection, improper maintenance and lack of education and financial resources.

To address these needs, efforts are required to focus on expanding and providing education and workshops to homeowners (Table 4). Additionally, maintenance providers, installers and inspectors should be secured to assist homeowners to repair or replace OSSF systems if issues arise. While OSSFs should be replaced as needed across the entire watershed, priority will be placed on subwatershed 2. Additionally, priority will be placed on OSSFs within 150 yds of perennial water bodies.

Table 4. Management measure 3: OSSFs

Pollutant Source: Failing OSSFs			
Problem: Pollutant loading from failing or nonexistent OSSFs			
Objectives: • Identify and inspect failing OSSFs in the watershed • Secure funding to promote OSSF repairs/replacements in low income areas • Repair or replace OSSFs as funding allows			
Location: Entire watershed, increased priority in subwatershed 2 and near water bodies			
Critical Areas: OSSFs situated on soils that are not suitable for OSSF drain fields and within 150 yards of a perennial waterway			
Goal: Identify, inspect, and repair or replace (as appropriate) 30 failing OSSFs in the watershed located within very limited soils, or within 150 yards of a waterway			
Description: OSSF failures will be addressed by working to identify and inspect failing OSSFs within critical areas. Failing systems will be repaired or replaced as appropriate to bring them into compliance with local requirements			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
County or cities	Administer OSSF repair/replacement program to address deficient systems identified during inspections	2022-2032	$10,000/yr
County or cities	Identify and inspect failing OSSFs within priority areas; increased priority for OSSFs near water body	2022-2032	$750/inspection
Homeowners	Repair/replace OSSFs as funding allows	2022-2032	~$7,500/system
Estimated Load Reduction			
As planned, repair or replacement of 30 failing OSSFs in the Bois d'Arc Lake watershed would result in a potential load reduction of 6.94×10^{15} cfu *E.coli*/yr (See Appendix *).			
Effectiveness	High: Replacement or repair of failing OSSFs will yield direct *E. coli* reductions to the waterways and near waterway areas of the watershed.		
Certainty	Low: Funding available to identify, inspect, and repair or replace OSSFs is limited; thus, the actual level of implementation attainable is uncertain.		
Commitment	Moderate: Depending on funding sources available and stakeholder buy-in on allowing outside assistance, this is a strategy that could potentially have the greatest effect on human health and should be a top priority.		
Needs	High: Funding to identify, inspect and repair/replace OSSFs is limited. Costs to administer a program, identify, inspect, and repair/replace OSSFs are considerable. Many homeowners with failing OSSFs may not realize that their OSSF is failing, so		

	delivering educational resources to them is critical. Some homeowners may know that they need a new OSSF but may not have funds available to acquire one.

Management Measure 4 – Reduce the Amount of Pet Waste Mixing into Water Bodies

Dog waste was identified as one of the largest potential bacteria sources in the watershed. Given the association between dogs and human activity, addressing the waste and bacteria loads generated by dogs is relatively simple compared to other sources. Properly disposing of pet waste into a trash can is a simple and effective way of reducing *E. coli* loads in the watershed.

Adoption of this practice across the watershed, however, is likely not very probable and will require effort to encourage pet owners to implement it. First, expanded education and outreach efforts to educate and encourage pet owners to pick up pet waste are needed. Second, pet owners can be encouraged to pick up pet waste when pet waste bags and disposal bins are easier to access in public areas. The priority areas for this management measure are urbanized and public areas located in subwatershed 3. Table 5 summarizes management measures for pet waste.

Table 5. Management measure 4: Pet waste management

Pollutant Source: Dogs			
Problem: Improperly disposed dog waste is left on the surface and washes into streams during rainfall or irrigation runoff			
Objectives: • Educate residents on disposal of pet waste • Install and maintain pet waste stations in public areas			
Location: Entire watershed, with highest priority in subwatershed 3			
Critical Areas: Urban areas, homes with dogs near waterways			
Goal: To reduce the amount of dog waste in the watershed that may wash into water bodies during runoff events by providing educational and physical resources to increase stakeholder awareness of the water quality and potential health issues caused by excessive dog waste			
Description: Expand distribution of educational messaging regarding the need to properly dispose of pet waste in the watershed. Specifically target homeowners and the general public. Stock and maintain existing dog waste stations in parks and other public areas to facilitate increased collection and proper disposal of dog waste.			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
Cities	Install at least 5 pet waste stations in area parks and other potentially high dog concentration areas	2022-2032	$500/station
Cities, counties, AgriLife Extension, NTMWD	Develop and provide educational resources to residents	2022-2032	N/A
Estimated Load Reduction			
Load reductions resulting from this management measure are reliant on changes in people's behavior, and therefore uncertain. Assuming 20% of targeted individuals respond by properly disposing of pet waste, an annual load reduction 2.83×10^{13} cfu *E. coli*/yr.			
Effectiveness	High: Collecting and properly disposing of dog waste is a sure way to prevent *E. coli* and nutrients from entering local waterways. This will directly reduce the quantity of *E. coli* in the watershed.		
Certainty	Low: Some dog owners already collect and properly dispose of dog waste. Those who do not may be a difficult audience to reach or convince that dog waste should be collected and discarded properly despite their respective reasons for not doing so.		
Commitment	Low: There are relatively few parks in the watershed. Adding signage or waste stations is not a high priority.		
Needs	Moderate: Pet waste stations are relatively inexpensive. Additional work required to maintain stations should be minimal.		

Management Measure 5 – Implement and Expand Urban and Impervious Surface Stormwater Runoff Management

One of the sources of *E. coli* and nutrients entering into water bodies is stormwater generated in urban areas. Compared to other sources, the chances of bacteria loading from urban impervious surface is currently relatively low, based on percent total land cover (Table 6). The main objective of this management measure is to organize general stormwater management education and outreach programs and educate residents about stormwater BMPs. The entities involved are AgriLife Extension, cities, property owners, and contractors. The second objective is to work with local municipalities to identify and install demonstration BMPs that manage stormwater runoff as appropriate and as funding permits. BMPs that are commonly known are rain gardens, rain barrels/cisterns, green roofs, permeable pavements, bio retention, swales, and detention ponds. These BMPs are adopted based on the precipitation amount, pattern, and local preferences. The third objective is to monitor the effectiveness of BMPs and suggest new techniques to manage stormwater. Therefore, multiple processes can be introduced to identify the most effective one.

Table 6. Management measure 5: Urban stormwater runoff

Pollutant Source: Urban Stormwater Runoff			
Problem: Fecal bacteria and nutrient loading from stormwater runoff in developed and urbanized			
Objectives: • Organize general stormwater management education and outreach program • Educate residents about stormwater BMPs • Monitor the effectiveness of BMPs and suggest new techniques to manage stormwater			
Critical Areas: Urban areas of the watershed, with priority in subwatershed 3			
Goal: Reduce *E. coli* loading associated with urban stormwater runoff through implementation of stormwater BMPs as appropriate and to increase residents' awareness of stormwater pollution and management			
Description: Potential locations and types of stormwater runoff management BMP demonstration projects will be identified in coordination with cities, public works, and property owners			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
Cities, Property Owners, Contractors	Identify and install stormwater BMPs as funding becomes available	2022-2032	$4,000-$45,000/acre (estimate)
AgriLife Extension, NTMWD	Deliver education and outreach to landowners	2023-2028	N/A
Estimated Load Reduction			
Installation of stormwater BMPs that reduce runoff or treat bacteria will result in direct reductions in bacteria loadings in the watershed. Potential load reductions were not calculated because the location, type, and size of projects installed will dictate the potential load reductions; however, they have not been identified yet.			
Effectiveness	Moderate to High: The effectiveness of BMPs at reducing bacterial and nutrient loadings is dependent on the design, site selection and maintenance of the BMP.		
Certainty	Moderate: Installation of BMPs requires sustained commitment from city officials or property owners.		
Commitment	Moderate to Low: Urban stormwater management is not a high priority for local municipalities; financial or other incentives will be needed to encourage and secure long-term commitment.		
Needs	High: It is unlikely stormwater BMPs will be installed without financial assistance.		

Management Measure 6 – Identify Potential Wastewater Conveyance System Failure and Prioritize System Repairs or Replacement

Wastewater conveyance system failure causes inflow and infiltration (I&I) issues that may result in system overloads. A broken sewer line is a common source for inflow and infiltration issues. Within the watershed, inflow and infiltration were identified as the largest issues that centralized systems must deal with regardless of system size. I&I can have a diluting effect that sometimes decreases treatment efficiency and can increase utility pumping and treatment cost. Currently, efforts are underway within all centralized systems to identify and address these issues. Sewer inspection cameras can be utilized to find conveyance systems failures. Furthermore, education and outreach are needed to reduce excessive inflows from opened cleanouts.

The main goal of this management measure is to work with entities operating WWTFs to continue and expand inspection efforts and identify problematic areas within their WWTFs. Once identified, entities will work to repair or replace problematic infrastructure to reduce inflow and infiltration issues and minimize WWTF overload occurrences. Table 7 summarizes management measures for centralized wastewater systems.

Table 7. Management Measure 6: Centralized Wastewater

Pollutant Source: Centralized Wastewater			
Problem: Inflow and Infiltration issues caused by wastewater conveyance system failures			
Objectives: • Expand system inspections by working with WWTF to identify problem areas • Increase rate of WWTF conveyance system repairs			
Location: WWTF service areas			
Critical Areas: All WWTFs			
Goal: Work with WWTF entities to identify problematic areas within their WWTFs. Once problem is identified, work to replace or repair problematic infrastructure. Reduce E. coli loading associated with sewer system failures that occur during high rain events and unauthorized discharge.			
Description: Smoke tests, camera inspections etc. can be used to identify connections where I&I problems exist. Prioritize system repairs or replacements based on system impacts (largest impact areas addressed first). Deliver education and outreach to residents.			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
WWTF Operating Entities	Perform WWTF conveyance system testing to ID inflow and infiltration problem areas; prioritize problem areas for repair/replacement	2022-2032	$3,000-$10,000/site
WWTF Operating Entities	As funds allow, repair or replace WWTF conveyance infrastructure	2022-2032	$100 - $150/ft Total cost TBD
WWTF Operating Entities	Provide educational resources regarding inflow and infiltration (uncapped cleanouts; faulty sewer lines) and effect of malfunctions with utility bill inserts	2022-2032	N/A
Estimated Load Reduction			
Load reductions from inspections and subsequent repairs or replacements of wastewater conveyance infrastructure and education delivery cannot be accurately estimated. Not all inflow infiltration to WWTF conveyance systems results in WWTF overloading. Instead, the number of inflow and infiltration locations repaired and the reduced number of WWTF overloads will signify progress made in reducing pollutant loading in the watershed.			
Effectiveness	High: Reducing the number and volume of inflow and infiltration issues will directly reduce *E. coli* loading to receiving waters. Moderate: Education delivered via utility bill inserts will reach some folks but not all. The number of people changing their behavior cannot be quantified.		
Certainty	Moderate: Each entity operating a WWTF in the watershed already performs inflow and infiltration inspections and makes repairs as needed and as funding allows.		

	High: Utility bill inserts are common and information on inflow and infiltration can easily be included.
Commitment	Moderate: Each entity operating a WWTF will continue to perform inspections and repairs within their respective collection systems.
Needs	High: Financial assistance needs are great. Operating budgets for entities are small and already strained, making financial assistance to inspect and repair conveyance system a must.

Management Measure 7 – Reduce Illicit and Illegal Dumping

Stakeholders indicate that illicit dumping, particularly of animal carcasses, can be problematic. These issues typically occur at or near bridge crossings where individuals may dispose of deer, hogs or small livestock carcasses in addition to other trash. The scope of the problem is not entirely known or quantified but anticipated to be a relatively minor contributor to bacteria loadings in the watershed compared to other sources. However, development and delivery of educational and outreach materials to local residents on proper disposal of carcasses and other trash could help reduce illicit dumping and associated potential bacteria loadings. Table 8 summarizes management measures for illicit dumping.

Table 8. Management measure 7: Illicit and illegal dumping

Pollutant Source: Illicit and Illegal Dumping			
Problem: Illicit and illegal dumping of trash and animal carcasses in and along waterways			
Objectives: • Promote and expand education and outreach efforts in the watershed			
Critical Areas: Entire watershed with focus at bridge crossing and public access areas			
Goal: Increase awareness of proper disposal techniques and reduce illicit dumping of waste and animal carcasses in water bodies throughout the watershed.			
Description: Education and outreach materials will be developed and delivered to residents throughout the watershed on the proper disposal of carcasses and waste materials.			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
AgriLife Extension, Counties, NTMWD	Develop and deliver educational and outreach materials to residents	2022-2032	N/A
Estimated Load Reduction			
Load reductions are likely minimal from this management measure and were not qualified.			
Effectiveness	Low: Preventing illicit dumping, especially animal carcasses, is likely to reduce bacteria loads by some amount, although this loading is likely limited to areas with public access.		
Certainty	Moderate: Anticipating changes in resident behavior due to education and outreach is difficult at best. Reaching residents that illegally dump is likely difficult.		
Commitment	Moderate: Many stakeholders indicate illicit dumping occurs; however, enforcement is difficult in rural areas. The issue is not a high priority and commitment of limited resources will likely remain low.		
Needs	Moderate: Some financial resources will be required to develop educational materials. Information could be incorporated into ongoing watershed related educational and outreach efforts.		

Table 9. Bois d'Arc Lake watershed management measures, participants, goals, and estimated costs

Management Measure	Participants	Unit Cost	Implementation Goals (years after implementation begins)					Total Cost
			1 2	3 4	5 6	7 8	9 10	
Livestock								
Develop 100 WQMPs/conservation plans	TSSWCB, SWCDs, NRCS	$15,000 per plan	20	20	20	20	20	$1,500,000
Education events and outreach	AgriLife Extension, SWCDs, NTMWD	N/A	Approximately once every 3 years					N/A
Feral Hogs								
Install feral hog enclosures	Landowners	$200 per feeder	As many as possible					Varies
Feral hog removal	Landowners	Varies	15% reduction or 1,565 hogs/yr					Varies
Feral hog removal workshop	AgriLife Extension, NTMWD	$7,500 each	3					$22,500
OSSFs								
Develop OSSF repair/replacement education program	Counties	N/A	1					N/A
Identify and inspect 30 failing OSSFs	Homeowner, county DR or contractor	$7,500 per system	6	6	6	6	6	$225,000
Pet Waste								
Install and maintain 5 pet waste stations	Cities	$500 per station	1	1	1	1	1	$2,500
Develop and deliver educational and outreach materials	Cities, AgriLife Extension, NTMWD	N/A	1	1	1	1	1	N/A
Urban Stormwater								
Identify and install potential stormwater BMP projects	Cities, property owners, contractors	$4,000 to $45,000/acre treated	As many as possible					Varies
Centralized Wastewater								
WWTF conveyance system testing to ID inflow and infiltration problem areas	WWTF operating entities	$3,000-$10,000/site	As many as possible					Varies
Repair or replace WWTF conveyance infrastructure	WWTF operating entities	N/A	As many as possible					Varies
Illicit Dumping								
Develop educational and outreach materials	Counties, AgriLife Extension, NTMWD	N/A	Develop and deliver annually					TBD

Table 10. Total estimated loading reduction

Management Measure	Expected *E. coli* Load Reduction (from previous section)
Agricultural Management Measures	
Water Quality Management Plans (TSSWCB/Local SWCDs)	$1.53x10^{12}$ cfu/year
Conservation Plans (NRCS)	
Livestock Management Education and Outreach	
Feral Hog Management	
Feral Hog Removal	$5.44x10^{13}$ cfu/year
Supplemental Feeding Exclosures	
Feral Hog Education and Outreach Programming	
OSSF Management	
OSSF Repair and Replacement	$6.94x10^{15}$ cfu/year
OSSF Owner Education and Outreach	
OSSF Installer and Service Provider Education and Outreach	
Dog Management	
Dispose of Dog Waste into trash receptacles	$2.83x10^{13}$ cfu/year
Total Reduction	$7.02x10^{15}$ cfu/year

Expected Loading Reductions

Implementation of the management measures in the WPP will reduce *E. coli* loads across the watershed. Many of the management measures will provide direct *E. coli* load reductions. Other management measures, such as education and outreach programs, will result in reductions but are not easily quantified. The bulk of expected load reductions come from management measures recommended for livestock, pet waste, OSSFs and feral hogs (Table 10). Improvements in urban stormwater and illicit dumping can also be expected to contribute to improved water quality