La Nana Bayou Watershed Protection Plan
Draft Chapter 6 – Management Measures

Introduction

Since no single source of *E. coli* is the primary cause of water quality issues in La Nana Bayou, multiple strategies should be deployed to address pollution concerns. A diverse range of management measures selected by stakeholders will focus resources for the stakeholder's highest priorities in the watershed. Input from watershed residents 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 paramount. All management measures were discussed with and approved by the stakeholders to ensure community support and successful implementation.

Estimated potential load reductions for 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 that was discussed in chapter 4. As a result, these estimates do not 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 strategies. 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. The strategies outlined in this chapter, in no particular order, are:

- Management Measure 1: Mitigate Urban Stormwater Runoff Issues
- Management Measure 2: Promote the Development of Water Quality Management Plans or Conservation Plans
- Management Measure 3: Technical Assistance for Urban Waterfowl Management
- Management Measure 4: Promote BMPs for Managing Feral Hog Populations
- Management Measure 5: Promote Proper Disposal of Pet Waste in Urban Areas
- Management Measure 6: Identify, Inspect, and Remediate Failing On-Site Sewage Facilities
- Management measure 7: Reduce Illegal Dumping and Litter
- Management Measure 8: Work with Area Schools to Develop Water Quality and Conservation Programs for K-12 Students
- Management Measure 9: Continue and Expand Water Quality Monitoring along La Nana Bayou and Banita Creek

Management Measure 1: Mitigate Urban Stormwater Runoff Issues

Stormwater is runoff from rain events in urban areas or in large areas of impervious surfaces. Rain that falls on permeable surfaces like grassy areas in parks is mostly absorbed into the soil. However, rainfall in urban areas flows directly into waterbodies, taking with it any pollutants that are on the surface like trash, oils, chemicals, and fecal matter. 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 can be 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.

Pollutant Source: Urban Stormwater Management			
Problem: Fecal bacteria, nutrient loading, and erosion from stormwater runoff in developed and urbanized areas			
Objectives: • Organize general stormwater management education and outreach program • Educate residents about stormwater BMPs • Work with city government and local institutions to identify and implement 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 and 4			
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 the city of Nacogdoches, Nacogdoches County, public works, and property owners			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
	Identify and install stormwater BMPs as funding becomes available	2022-2031	$4,000-$45,000/acre (estimate)
City of Nacogdoches, AgriLife Extension	Deliver education and outreach to landowners	2022-2031	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 High: Urban stormwater management is a priority for the city.
Needs	Moderate: Support in the form of financial and technical assistance is needed to identify the best application of and promote the adoption of stormwater management policies.

Management Measure 2: Promote the Development of Water Quality Management Plans or Conservation Plans

Bacteria from livestock waste is usually transported from deposition in upland areas and transported to water bodies as runoff during rain events, so much of the *E. coli* dies before it reaches the water. However, livestock will spend time around and wading in water if they have access to it, which allows for direct deposition of fecal matter and direct impact on water quality. Their activities highly influenced depending on the availability of drinking water, feed, and shade structures, so livestock can be managed by providing alternative sources of water and shade away from riparian areas. This can effectively reduce potential bacteria loading from runoff and direct deposition.

The most appropriate management practices for a property will vary depending on a variety of factors but water quality management plans (WQMPs) and conservation plans (CPs) can be developed with technical assistance from NRCS, TSSWCB, and local SWCDs. Common practices include brush management, fencing, filter strips, grade stabilization, stream crossings, heavy use area protection, watering facilities, and more. Some CP programs also include financial assistance for the landowner, which helps convince The La Nana Bayou Watershed stakeholder group has a goal of supporting the development of an additional 25 WQMPs or similar conservation plans developed in the watershed.

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 to properties near waterbodies			
Critical Areas: Properties with creek and tributary access, especially those using them as a livestock watering source			
Goal: Develop up to 25 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 25 plans	2022-2031	$375,000
AgriLife Extension, SWCD, City of Nacogdoches	Deliver education and outreach programs and workshops to landowners	2022 - 2031	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 25 WQMPs and CPs is estimated to reduce annual loads from livestock by 1.03×10^{12} cfu *E. coli* per year in the watershed (Appendix B).	
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 3: Technical Assistance for Urban Waterfowl Management

Stakeholders requested assistance in addressing waterfowl living near detention ponds and riparian areas along the Bayou as their fecal deposition directly into and near the waterbodies could be contributing to the bacteria issues. The Upper Cibolo Creek Watershed Protection Plan included a thorough investigation into the types of waterfowl living along the creek and expert-recommended management strategies that could foster a manageable waterfowl population. This included short-term strategies such as capture and relocation, and long-term strategies like educating the public about feeding birds and egg oiling (for invasive species only) to reduce the number of eggs that hatch.

Using the Upper Cibolo WPP as a guide for La Nana, the management measure will include conducting a population survey of waterfowl in areas with a perceived population issue and working with technical experts to reduce population if needed.

Pollutant Source: Urban Waterfowl
Problem: An overpopulation of waterfowl contributes bacteria to waterbodies due to direct fecal deposition
Objectives: • Conduct a study to identify the types and numbers of waterfowl in perceived problem areas

- Work with bird experts to develop and implement best course of action to address potential population issue
- Educate public on issues related to feeding wild waterfowl populations

Location: Subwatersheds 3 and 4

Critical Areas: Public parks, SFASU Campus Detention Pond (Ag Pond)

Goal: To reduce waterfowl populations to improve water quality and sanitary conditions around public use areas.

Description: Overpopulation of waterfowl can exacerbate water quality issues and cause sanitation concerns in public use areas. Establishing a baseline for the type of waterfowl (domestic, invasive, resident, migratory, etc.) and population numbers will allow waterfowl experts to develop a plan that will foster a manageable population in the watershed, improve water quality, and improve bird population health. Education and outreach to residents and park visitors will address issues caused by feeding wild waterfowl, such as impacts to their health and water quality.

Implementation Strategy

Participants	Recommendations	Period	Capital Costs
Residents, AgriLife Extension, TPWD, Environmental Engineers	Conduct a waterfowl census survey; work with experts to manage population; educate public on egg health.	2022-2031	$5,000 – $30,000 depending on extent of management efforts

Estimated Load Reduction

Reductions will be dependent on the plans developed by technical experts that is adopted by the city, SFASU, and other landowners that have bird populations on their property.

Effectiveness	High: Decreasing the number of waterfowl living around riparian areas and ponds in the watershed will result in an immediate improvement of water quality and sanitation issues.
Certainty	Moderate: Manageable waterfowl populations is a priority to many groups across the area for both the health of the animals and the watershed.
Commitment	Moderate: Stakeholders are actively seeking ways to achieve manageable waterfowl populations at SFASU and in some public areas.
Needs	Moderate: Technical assistance and some financial support is needed to support planning, implementation, and education and outreach efforts.

Management Measure 4: Promote BMPs for Managing Feral Hog Populations

The overpopulation of wildlife species, both domestic and invasive, increases *E. coli* and nutrient loading across the watershed. Like other types of wildlife, feral hogs and wild pigs primarily live in riparian areas, preferring the dense habitat, food resources, and water availability along a waterbody to open areas. This can also contribute to water quality issues due to the degradation of ground cover and soil disturbances from activities like wallowing and rooting.

The most immediate impact to water quality is the physical removal of feral hog populations through hunting and trapping. Trapping can successfully remove large numbers of hogs with proper planning and consistency. With the fast growth rate of an average 21% per year (Timmons et al. 2012), shooting pigs and using dogs during hunting is less effective than trapping, but is still a helpful strategy to implement to manage populations.

Education and outreach can help landowners learn about BMPs they can implement themselves to keep feral hog populations low. Promoting resources like AgriLife Extension's Wild Pig website (https://wildpigs.nri.tamu.edu/) can teach landowners about practices like exclusionary fencing to block feral hogs from having access to deer feeders, trapping techniques and designs, and pig biology. Public participation in these BMPs is crucial to the success of reducing issues caused by feral hogs.

Pollutant source: Feral hogs

Problem: Direct and indirect fecal loading, riparian habitat destruction, soil damage, and erosion from rooting

Objectives:

- Reduce fecal contaminant loading from feral hogs through population reduction
- Reduce easily accessible food supply for feral hogs
- Provide education and outreach to stakeholders on BMPs to deter the presence of feral hogs on their property

Location: Entire watershed, with highest priority in subwatersheds 1, 5, and 6

Critical areas: Riparian areas and travel corridors from cover to feeding areas

Goal: Manage the feral hog population through available means to reduce the total number of current hogs in the watershed by 10% and maintain them at this level over 10 years of implementation.

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.

Implementation strategy

Participants	Recommendations	Period	Capital costs
Landowners, land managers, and lessees	• 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	2022–2031	$200/feeder
AgriLife Extension, counties	Provide support for a feral hog extension associate to trap and hunt feral hogs in the watershed as well as provide educational resources to stakeholders	2022–2031	$75,000/year

Estimated load reduction

Removing and maintaining feral hog populations directly reduces fecal loading potential to water bodies in the watershed. Reducing the total feral hog population by 10% of the current population in the watershed is estimated to reduce potential annual loads by 1.03×10^{12} colony forming units *E. coli* annually (Appendix B).

Effectiveness	Moderate: Reduction in feral hog population will result in a direct decrease in bacterial and nutrient loading to the streams; however, removing enough hogs to decrease their overall population will be difficult.
Certainty	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 10% of the

	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.
Needs	Moderate: Funds are needed to provide education and outreach to further inform landowners about feral hog management options, adverse economic impacts.

Management Measure 5: Promote Proper Disposal of Pet Waste in Urban Areas

Due to the high concentration of *E. coli* in dog waste and the dependence on pet owners to manage pet waste, reducing bacteria loads from pets will rely on promoting the proper disposal of pet waste on homeowner's property and in public areas. Making pet waste disposal extremely convenient through installation of pet waste station in parks and along the La Nana Creek Trail system will assist pet owners in this task.

Media campaigns that educate and encourage pet owners to pick up pet waste and properly dispose of it will be needed to increase adoption. Convenient pet waste stations that are well-managed are low-cost solutions with high impact on water quality and sanitation issues in public areas.

Pollutant Source: Pet Waste (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, highest priority in subwatersheds 3 and 4			
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 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**
Nacogdoches County	Install at least 10 pet waste stations in area parks and other potentially high dog concentration areas	2022-2031	$500/station
Nacogdoches County	Develop and provide educational resources to residents	2022-2031	N/A
Estimated Load Reduction			

Load reductions resulting from this management measure are reliant on changes in people's behavior. Assuming 12% of targeted individuals respond by properly disposing of pet waste, an annual load reduction would be around 1.53 x10^{15} cfu *E. coli*/yr (Appendix B).	
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	Moderate: There are trails along La Nana Bayou and many public parks in the area and installing pet waste stations is a low-cost, high-impact management measure.
Needs	Low to Moderate: Pet waste stations are relatively inexpensive. Additional work required to maintain stations should be minimal.

Management Measure 6: Identify, Inspect, and Remediate Failing On-Site Sewage Facilities

On-site sewage facilities, otherwise known as septic systems or OSSFs, treat wastewater at the household level in areas that are not serviced by centralized wastewater treatment facilities. A failing septic system, especially in proximity to a waterbody, can be a health hazards to the residents and the waterbody. Coming into contact with human wastewater is the biggest potential risk to human health compared to bacteria from other sources, so education on proper maintenance for homeowners and identifying and repairing failing septic systems in the watershed will prevent untreated wastewater from entering the watershed.

Pollutant Source: 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 • Provide education and outreach to homeowners			
Location: Subwatersheds 1, 2, 5, and 6 with priority to households close to perennial waterbodies			
Critical Areas: OSSFs situated on soils that are not suitable for OSSF drain fields and within 500 yards of Banita Creek and La Nana Bayou			
Goal: Because they pose a higher human health risk than some of the other potential pollutant sources, stakeholders expressed a desire to identify, inspect, and repair or replace (as appropriate) up to 85 of the potentially 851 failing OSSF systems in the watershed.			
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**

Nacogdoches County	Administer OSSF repair/replacement program to address deficient systems identified during inspections	2022-2031	$10,000/yr
Nacogdoches County	Identify and inspect failing OSSFs within priority areas; increased priority for OSSFs near water body	2022-2031	$750/inspection
AgriLife Extension, Nacogdoches County	Deliver education and outreach programs and workshops to homeowners	2022-2031	N/A
Homeowners	Repair/replace OSSFs as funding allows	2022-2031	~$7,500 each

Estimated Load Reduction	
At a minimum, repair, or replacement of 85 failing OSSFs in the watershed, or 10% of the failing systems. This would result in a potential load reduction of 1.29 x 10^{15} cfu *E. coli*/yr (See Appendix B).	
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 7: Reduce Illegal Dumping and Litter

Stakeholders have expressed concern about the presence of litter and animal carcasses in the watershed. Trash provides more surface area for bacteria to live and grow on, and animal carcasses dumped into the waterbody will decompose and add to water quality issues. While impacts to water quality in the watershed are likely minimal from dumping alone, education and outreach can reduce the nuisance and associated bacteria loadings.

Pollutant Source: Litter and pollution from illegal dumping
Problem: Illegal dumping of trash and animal carcasses in and along waterways
Objectives: • Promote and expand education and outreach efforts in the watershed • Install and maintain trash receptacles in public areas and along waterbodies • Support cleanups and other efforts to reduce illegal dumping
Critical Areas: Entire watershed with focus on bridge crossings 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. Also work with responsible parties to lessen the impact of illicit dumping and improper animal carcass disposal.			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
AgriLife Extension, Nacogdoches County, City of Nacogdoches	Develop and deliver educational and outreach materials to residents	2022-2031	N/A
Nacogdoches County, City of Nacogdoches	Install and maintain trash receptacles and promptly remove dumped trash and carcasses from common dumping areas	2022-2031	$500 - $1,000 per receptacle
Nacogdoches County Residents	Support efforts to reduce illegal dumping; initiate clean-up days; promote protecting the waterways and public spaces	2022-2031	N/A
Estimated Load Reduction			
Load reductions are likely minimal from this management measure and were not quantified.			
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.		

Management Measure 8: Work with Area Schools to Develop Water Quality and Conservation Programs for K-12 Students

The stakeholder group that developed this WPP has several members that are part of the local ISD including teachers, parents of young children, and school board members. Integrating watershed education into the schools is important to the group. This management measure is not expected to impact water quality immediately but will instill the idea that watershed protection is everyone's responsibility. Integrating water quality and quantity lessons into schools starting at an early age will hopefully protect water resources in the future and develop future watershed coordinators.

Youth Watershed Protection Education
Objectives: • Develop and expand education and outreach efforts for K-12 students in the area

• Provide technical assistance and training to teachers on watershed education			
Critical Areas: Entire watershed, at schools			
Goal: Increase awareness of watershed protection topics among K-12 students			
Description: Work with Nacogdoches ISD educators to determine what kind of programming already exists in their schools and what would be helpful. Develop or integrate existing educational materials for schools. Provide "train the trainer" opportunities for teachers to learn the materials and how to administer them effectively.			
Implementation Strategy			
Participants	**Recommendations**	**Period**	**Capital Costs**
AgriLife Extension, Watershed Coordinator, Nacogdoches ISD	Develop and deliver educational and outreach materials to teachers and students. Train teachers on watershed protection planning.	2022-2031	~$5,000 - $10,000 to get started with development
Estimated Load Reduction			
Load reductions are likely minimal from this management measure and were not quantified.			
Effectiveness	Low to Moderate: While there may not be a direct correlation to water quality improvement, education and outreach is an effective tool to create awareness.		
Certainty	Moderate: Predicting behavior change is difficult but can be tracked through surveys, tests, and other evaluation methods.		
Commitment	Moderate to High: There is a lot of interest in the watershed in working with youth to develop environmental conservation programming.		
Needs	Moderate: Some financial and technical resources will be required to develop educational materials and coordinate training.		

Management Measure 9: Continue and Expand Water Quality Monitoring along La Nana Bayou and Banita Creek

The watershed stakeholders indicated a need to expand water quality data collection through additional bacteria sampling along La Nana Bayou as well as include Banita Creek in the monitoring regimen. Stakeholders would like to add at least one station on Banita Creek to capture water quality information before it enters La Nana Bayou. Additionally, monitoring for just bacteria in more spots along both waterbodies is desired to create a higher spatial resolution of data. This will allow watershed stakeholders to better direct outreach resources to bacteria hotspots.

Continue and Expand Water Quality Monitoring
Objectives: • Continue monitoring La Nana Bayou, adding more sampling events to the current quarterly regimen • Add a monitoring station on Banita Creek • Increase number of sampling sites along both waterbodies to collect more bacteria data
Critical Areas: Along La Nana Bayou and Banita Creek
Goal: Increase spatial resolution of data and better direct technical and financial resources
Implementation Strategy

Participants	Recommendations	Period	Capital Costs
ANRA, SFASU	Identify best monitoring site along La Nana Bayou and Banita Creek to collect more data	2022-2031	N/A
ANRA, SFASU			
Estimated Load Reduction			
Load reductions are likely minimal from this management measure and were not quantified.			
Effectiveness	Moderate: This management measure will not directly impact water quality.		
Commitment	High: Water quality monitoring is already ongoing, and ANRA and SFASU are ready to increase their presence along the waterbodies to add additional monitoring events.		
Needs	Moderate to High: Financial assistance is needed for personnel, equipment, and lab costs.		

Management Measure Summary Table

Management measure	Participants	Unit cost	Implementation goals (years after implementation begins)						Total cost
			0-1	2-3	4-5	6-7	8-9	10	
1. Urban Stormwater Management									
Identify and install stormwater BMPs as funding becomes available	City of Nacogdoches, Nacogdoches County, Property Owners, Environmental Engineers, Contractors	$4,000 to $45,000/acre treated	As many as possible						Varies
Deliver education and outreach to landowners	City of Nacogdoches, AgriLife Extension, Watershed Coordinator	N/A	As often as possible						N/A
2. Develop WQMPs and CPs									
Provide financial and technical assistance for CPs and WQMPs	Producers, NRCS, TSSWCB, SWCDs	$15,000 per plan	2	3	5	5	5	5	$375,000
Education events and outreach	AgriLife Extension, SWCDs, NRCS, City of Nacogdoches, Watershed Coordinator	N/A	Approximately once every 3 years						N/A
3. Urban Waterfowl Management									
Conduct a waterfowl census survey; work with experts to manage population; educate public on egg health.	Residents, AgriLife Extension, TPWD, Environmental Engineers, Watershed Coordinator	$5,000 to $30,000	At least 1 census, at least 1 management plan including outreach and education efforts						$5,000 to $30,000 depending on scope
4. BMPs for Feral Hog Management									
Feral hog removal workshop	AgriLife Extension, Watershed Coordinator	$7,500 each	3						$22,500
Provide resources to support a county feral hog trapper	AgriLife Extension, Nacogdoches County	~$75,000/year	1						~$750,000*

Install feral hog enclosures	Landowners	$200 per feeder	As many as possible						Varies
Feral hog removal	Landowners	Varies	10% reduction						Varies
Bounty program	AgriLife Extension, Nacogdoches County, landowners	Varies	As many as possible						Varies
5. Proper Pet Waste Disposal									
Install and maintain 10 pet waste stations	City of Nacogdoches	$500 per station	1	1	1	1	1		$5,000
Develop and deliver educational and outreach materials	City of Nacogdoches, Nacogdoches County	N/A	As many as possible						N/A
6. OSSF Remediation and Education									
Develop OSSF remediation outreach materials	Nacogdoches County, ANRA, Watershed Coordinator	N/A	1						N/A
Repair or replace at least 85 failing OSSFs	Homeowner, county designated representative, or contractor	$7,500 per system	5	10	10	20	20	20	$637,500
Deliver education and outreach programs and workshops to homeowners	AgriLife Extension, County DR, Watershed Coordinator	N/A	3						N/A
7. Reduce Illegal Dumping and Litter									
Develop educational and outreach materials	Nacogdoches County, City of Nacogdoches, ANRA, Watershed Coordinator	N/A	Develop and deliver annually						TBD
Install and maintain trash receptacles in public areas and along waterbodies	Nacogdoches County, City of Nacogdoches, Watershed Coordinator	$500 - $1,000 per receptacle	1		1		1		~$3,000 +

Host clean-up days; promote protecting the waterways and public spaces	Nacogdoches County, City of Nacogdoches, ANRA, Residents, Watershed Coordinator	N/A	1	1	1	N/A
8. Water Quality Education for Students						
Develop and deliver educational and outreach materials to K-12 Students and Teachers	AgriLife Extension, Watershed Coordinator, Nacogdoches ISD	$10,000	1			$10,000
9. Water Quality Monitoring						
Identify sites along La Nana Bayou and Banita Creek to Monitor	ANRA, SFASU, Watershed Coordinator	N/A	Once at beginning of project			N/A
Water quality monitoring at La Nana Bayou and Banita Creek	ANRA, SFASU, Watershed Coordinator	$2,500 per year per site	5 - 25 sites per month per year			~$12,000 - $60,000 per year
General watershed management						
Provide resources in support of a watershed coordinator	TCEQ, TSSWCB, Nacogdoches County, City of Nacogdoches, ANRA, SFASU	~75,000/year	1			~750,000*
Semi-annual meetings	Watershed Coordinator	$300/meeting	Semi-annually			$6,000

*Includes salary and fringe over 10 years

Expected Load Reduction Summary

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. Improvements in urban stormwater management, urban waterfowl management, and reduction in illegal dumping are expected to add to the total load reduction outlined below.

Management measure	Summarized *E. coli* load reduction
Agricultural management measures	3.77×10^{15} cfu/year
Feral hog population management	1.03×10^{12} cfu/year
OSSF remediation	1.29×10^{15} cfu/year
Pet waste management	5.73×10^{13} cfu/year
Total reduction	**1.73×10^{15} cfu/year**
Total reduction needed (from Ch. 5)	*2.81×10^{14} cfu/year*