5.0 MANAGEMENT MEASURES

Management measures can be defined as activities that are implemented within the watershed to support or achieve the goals of the WPP. Both structural and non-structural activities can achieve goals, including educational programs, inspection programs, land management programs, livestock fencing, catchment basins, construction projects or other behaviors.

As part of the WPP process for submission of plans to the EPA, an evaluation of all possible management measures is necessary to allow identification of most practicable measures for the site-specific watershed area. The analysis of management measure alternatives described in this report addresses three elements of the EPA's Nine Element WPP:

2. Estimate load reductions with each alternative
3. Proposed management measures
4. Technical and financial assistance needs

The Lake Granbury stakeholder group evaluated many possible management measures and, based upon that evaluation, recommended and prioritized measures they felt could achieve their goals. The recommendations include both a suite of lake-wide measures and a suite of site-specific measures tailored to reduce bacteria levels within particular subdivisions and small sub-watersheds.

Presented in later sections of this chapter are descriptions of structural and non-structural management measures, the criteria used to evaluate the alternative measures, and the location-specific recommendations. Technical and financial assistance needs are discussed at the end of this chapter.

5.1 PRIORITY MANAGEMENT MEASURES

In February 2009, the Lake Granbury WPP Best Management Practice (BMP) Work Group identified potential management measures to address bacteria pollution in lake and canal waters. Through a series of four stakeholder meetings held between June and September 2009, a suite of management measure alternatives, specific to each area of concern, were presented to the stakeholders. Stakeholders provided comments and guidance through this series of meetings leading to development of a final set of management measure alternatives presented to the stakeholder group in October 2009. Based upon stakeholder evaluation and input on the final set of alternatives, the following list of management measures represents stakeholder priorities, in order of priority:

1. **Watershed coordinator**
    a. A watershed coordinator should oversee implementation of this WPP; the coordinator should be capable of identifying funding sources, summarizing monitoring, coordinating with local entities and assembling the stakeholders, as necessary.

2. **Regional wastewater collection and treatment**

a. The stakeholder group is in support of regional wastewater treatment options over on-site sewage facilities (septic systems) for areas surrounding Lake Granbury and within Hood County.
b. Implementation of the Port Ridglea East collection system is a particular priority, given that infrastructure extensions are currently in-process.

3. Pursue funding for all management measure alternatives

a. Funding for Community education programs
    i. One full-time position within Hood County for an education coordinator
    ii. Monitoring education effectiveness: Follow up surveys after education is complete to determine effectiveness in achieving goals (e.g., did homeowners discover need for repairs and/or perform maintenance?)
b. Funding for Regional wastewater collection and treatment infrastructure
    i. Funding availability for area sewer service providers (AMUD, C.O. Granbury, etc.)
        1. TWDB
        2. ORCA
        3. EPA, TCEQ, etc.
c. Funding availability for Oak Trail Shores alterations
        1. Drainage re-routing
        2. Dredging and opening additional outlets
d. Funding availability for Sky Harbor catchment basins

4. Implementation of Community Education and Management

a. Implement Lake Granbury WPP Educational Workplan
b. Educate on existing NRCS programs to maximize implementation
    i. Area conservation plans
    ii. Small-acreage landowner plans
c. Educational focus areas
    i. Urban – Septic and Pets
        1. Rolling Hills Shores
        2. Port Ridglea East
        3. Oak Trail Shores Home Owners Association (HOA) area (includes surrounding areas, Lake Granbury Estates)
        4. DeCordova Estates (Pet education)
    ii. Agricultural and/or small acreage land-owners
        1. Sky Harbor
        2. Long Creek
        3. Walnut Creek
    iii. Water fowl feeding education

5. Support record keeping activities to assist Hood County Health District ensure compliance with existing health codes

a. Support routine and scheduled maintenance activity (e.g., pump-out) record keeping, enforcement or ordnances, particularly in Rolling Hills Shores where holding tanks are common

b. Maintain database of Health District inspections and activities to assess linkage between activities and bacteria improvement

6. **Support development of HOA rules requiring all new development or expansion projects to consult with Hood County health department in advance of HOA approval**

7. **Implement regional wastewater collection and treatment –priority areas, in order of importance**
    a. Port Ridglea East (PRE) with surrounding areas – improvements are in-process for PRE
    b. Oak Trail Shores HOA area (OTS) – existing infrastructure is nearby
    c. Sky Harbor – existing infrastructure is nearby
    d. Indian Harbor and surrounding areas (Ports O' Call) – no existing treatment facilities are near
    e. Areas surrounding Port Ridglea East, including Port Ridglea West, Nassau Bay II, Sandy Beach, Holiday Estates
    f. Blue Water Shores
    g. +/-100 homes to the east of DeCordova Estates near Lusk Branch
    h. Rolling Hills Shores (RHS) and areas between RHS and OTS

8. **Improve cove circulation**
    a. Indian Harbor – install a circulation pump/fountain
    b. Oak Trail Shores HOA area – subdivision drainage re-routing and/or construction of an additional canal connection to the lake
    c. Sky Harbor – circulation, existing irrigation pumps discharging back into canal

5.2 IDENTIFYING ALL POSSIBLE MANAGEMENT MEASURES

A special workshop for brainstorming potential BMPs in the lake watershed was held in February 2009 by the Lake Granbury WPP BMP Work Group. The outcome of this workshop was a list of possible management measures that were to be evaluated (Table 24 and Table 25) for each area. The technical evaluation provided information on factors including cost and effectiveness that led to the stakeholder priority recommendations described in the previous section.

Whether arising from point or non-point sources, bacteria survival depends on moisture, temperature, pH and availability of nutrients, among other factors. Management measures, sometimes called Best Management Practices (BMPs), should be effective and practical means of preventing or reducing bacteria from entering water bodies. Non-structural measures may include public education programs, septic system maintenance, pet waste management and livestock manure management. Structural management measures may include constructed wetlands, buffers, sand filters, infiltration trenches, livestock fencing and municipal infrastructure. Implementation of structural measures clearly requires considerable planning and resources; therefore, non-structural measures may be the most practical and near-term approaches to achieve bacteria goals.

Table 24. Site Specific Non-Structural Management Measures Identified at BMP Workshop

Location	Septic Maintenance and Education for Local and Neighboring Communities (including Graywater)	Septic Management (records, inpsectors)	Urban Education on Fertilizer Application and Products	Pet Waste Education	Area Conservation Plan and Education for Ranchette/small acreage land owners	Livestock/Range Management Education	Feral Hog Education Program/ County-wide bounty program	Waterfowl Breeding Control Program/ Deter Bird Roosting Under Bridges	Waterfowl and Wildlife Feeding Ordinances and Education	Waterfowl Breeding Control Program	Collection System Sewage Lines-Maintenance and Repairs
Rolling Hills Shores	x	x		x		x			x		
Long Creek	x			x	x	x		x	x	x	
Oak Trail Shores	x	x		x					x		
Sky Harbor	x			x	x	x			x		
Nassau Bay II	x		x	x					x		
Waters Edge			x	x					x		
Indian Harbor	x		x	x					x		
Port Ridglea East	x		x	x	x				x		
Blue Water	x			x					x		x
Lake-Wide	x		x	x		x	x	x	x		

Table 25. Site Specific Structural Management Measures Identified at BMP Workshop

Location	Septic Cluster Systems	Septic System Replacement	Septic Maintenance Pump-out pilot program	Local Centralized Wastewater Treatment-Independent	Local Centralized Wastewater Treatment-Aggregate	Regional Wastewater Treatment	Cove Dyanmics: Dredge, Fill	Drainage Re-route	Cove Circulation Systems (Fountains, etc)	Catchment Basin	Property Buy Out	Filter Strips for Livestock
Rolling Hills Shores	x	x		x	x	x	x				x	
Long Creek	x	x		x	x	x						x
Oak Trail Shores	x	x		x	x	x	x	x				
Sky Harbor	+	+		x	x	x			x	x		
Nassau Bay II				x	x	x						
Waters Edge						x						
Indian Harbor				x	x	x			x			
Port Ridglea East	+	+	x	x	x	x			x			
Blue Water												
Lake-Wide						x						x

x Requested BMP Investigation

\+ Additional EC Analysis

5.3 NON-STRUCTURAL MANAGEMENT MEASURES

5.3.1 Watershed coordinator

The stakeholder group expressed a desire to have a full-time Lake Granbury WPP Watershed Coordinator which will work side-by-side with the stakeholders to implement the recommended management measures in the Lake Granbury WPP. This person's role would be to coordinate efforts of the stakeholder group and community decision-makers, as well as to keep main priorities of the WPP in the forefront of planning efforts and public awareness. Specific tasks expected of the watershed coordinator are outlined below.

- Project Administration including project oversight; quarterly progress reports to TCEQ and Stakeholders; project administration; project fact sheet; and annual report article.
- Stakeholder Group Facilitation to include coordinating meetings; update Lake Granbury WPP Webpage with Agendas, Meeting Materials and Minutes; engage stakeholders; and maintain stakeholder list and general public notification list.
- Resource Identification, Grant Writing, Funding Requests and Procurement of Services to include identify resources; assist stakeholders in grant writing and preparing funding requests; assist stakeholders in procurement of services; and track implementation of construction-based management measures as outlined in the WPP.
- Local Orders, Ordinances and Homeowner's Association Regulations to include drafting and presenting a County Order and City Ordinances prohibiting the feeding of wildlife and waterfowl within one mile of the reservoir; recommend Homeowner's Association Regulations regarding OSSF expansions; and track implementation of Local Orders, Ordinances and Homeowner's Association Regulations.

5.3.2 Public Education Programs

Public awareness of the importance of bacteria level control is important for the water quality management in Lake Granbury area. Educated residents are more concerned about the water quality condition, are aware of their personal responsibilities and are more willing to help on funding initiatives or field study participation. A comprehensive, detailed summary of watershed education and outreach programs is provided in a separate section of this watershed protection plan. The vision of the stakeholders is to have a dedicated education coordinator for Hood County and the Lake Granbury watershed who can participate in implementation of the education program. The Education Coordinator will develop, track the implementation, and evaluate the effectiveness of the education plan management measure requested by the Stakeholder's as well as publicize the WPP efforts.

For other areas in Texas, bacteria-targeted educational programs similar to those outlined in the Lake Granbury Education and Outreach Plan (see Section 6.0) have been shown to be very effective. For example, 100% of individuals responding to post-course surveys indicate an increase in knowledge of septic system operation. Of those respondents, 54% to 65% indicate willingness to change practices that include performing regular septic system maintenance, particularly to aerobic disinfection units (TAES 2009). While literature or studies are not available to translate educational effectiveness to load reduction effectiveness, it is anticipated that educational programs will provide load reductions in two ways: (1) through actual load

reductions realized through increased efforts to repair and maintain OSSF systems, and (2) through increased awareness and participation in associated strategies that manage and reduce bacteria loading (e.g., pet waste or livestock manure management programs).

5.3.3 Septic System Maintenance and Record-keeping

Septic system malfunction is a major potential source of bacteria within the coves of Lake Granbury. By maintaining a septic system regularly and repairing problems as they are discovered, likelihood of malfunction and contamination to receiving waters is less likely. Routine maintenance also extends the longevity of the septic system, reducing costly repairs or replacements.

In practice, septic system management includes routine septic inspections and pump-outs. Conventional septic tanks should be inspected every three years and pumped as needed, or when the tank solids level increases to about 1/3 filled. The inspection and service records can be tracked and reported, particularly in areas with holding tanks requiring frequent pump-outs (this may be weekly pump-outs for full-time residents). A requirement for permit holders to maintain and annually submit pump-out records would promote compliance with existing regulations.

The most significant constraint for this measure would be the limited staff available through the local health departments to perform routine inspections for all systems within the watershed .

5.3.4 Pet Waste Management

Unlike other bacteria sources, pet waste can be simply and economically managed by individual residents. This measure conveys the importance of cleaning up after pets and ensuring proper disposal of pet wastes through the distribution of marketing materials such as signs, radio and TV advertisements, and mail outs.

5.3.5 Livestock Manure Management

Livestock manure, particularly from cattle populations, are a significant source of bacteria and in some areas can be a significant source to Lake Granbury. Runoff from barnyards or livestock areas may have the highest potential of any agricultural operations to contaminate waterbodies. Moreover, livestock access to streams results in direct discharge of bacteria into water. An additional potential source is runoff from fields where manure is applied as fertilizer. The proper collection, storage, transportation, and application of animal waste can significantly reduce potential bacteria contamination.

Agencies such as the local Texas AgriLife Extension agent, NRCS, and SWCD already have programs established to work with individuals to develop conservation plans and seek cost share funding. The Texas Farm Bureau currently maintains a website dedicated to sharing information and providing links to these publicly available resources. The biggest challenge is motivating landowners to voluntarily seek available help. This will be addressed in the Lake Granbury watershed through the educational programs recommended by the stakeholders.

5.3.6 Other Watershed Management Approaches

Several other management options were proposed by the Work Group including education on fertilizers and pesticide applications; discouraging waterfowl and other wildlife feeding in the watershed, wildlife control programs such as feral hog bounties; education for property owners of small acreage plots as well as "ranchette" conservation practices; and range management education and incentives for large acreage lands with agricultural practices. The combined effect of implementing these suggestions across the lake and surrounding watershed are anticipated to reduce the bacteria contributions to the lake. In addition, many of these practices will also reduce nutrient contributions arising from the same sources.

5.4 STRUCTURAL MANAGEMENT MEASURES

5.4.1 Septic Replacement

This management measure consisted of replacing aging septic systems, which would minimize potential for bacteria transfer to water bodies. The average life span of a septic system is approximately 20 years and many near-lake subdivisions were established over 25 years ago. Replacement of the drain field is likely required if the system has not been maintained properly over time (e.g., pumped every 3-5 years). Additionally, the design of most existing systems in the area would not meet current standards and all repairs, revisions or replacements must meet current standards.

In the Lake Granbury area, the typical onsite sewage facility consists of a conventional septic tank and drain field. Typically, the soil types in most areas surrounding the lake are not suitable for conventional systems so alternative treatment systems, such as aerobic tanks with drip emitters, would need to be installed if these communities remain on individual OSSFs/OWTFs. More suitable alternative treatment systems are often more expensive than conventional systems and may be a financial burden on the economically disadvantaged citizens in these communities. Because of awareness and collaboration among WPP stakeholders, grant assistance was provided by the Texas Department of Rural Affairs (formerly the Office of Rural and Community Development, ORCA) at the outset of this WPP process. The grant was for replacement of malfunctioning septic systems owned by disadvantaged citizens within the project area.

5.4.2 Local Collection Systems

Another measure that minimizes bacteria transfer to water bodies is installation of community-wide sewage collection systems.

Service pipes for sewage collection are either designed for gravity flow or under low pressure. Gravity lines require a positive slope and are the most efficient collection system. However, gravity collection is less suitable in areas with hilly terrain, negligible slope, within the floodplain or where the water table is high. Given all of these conditions in the vicinity of Lake Granbury, a low pressure system is most appropriate in most areas. Low pressure lines require a grinder pump & water-tight small diameter pipes that minimize wet weather peak flows. The use of small diameter pipe at shallow depths minimizes installation costs. An efficient combination of low pressure and gravity collection could be utilized in some areas where appropriate.

For planning-level conceptual design of the collection systems for areas near Lake Granbury, the maximum assumed total dynamic head allowable is 185 feet, wastewater discharge rate for each residence of 200 gallons per day, and one grinder pump per connection (for low pressure lines). Lift stations to deliver waste to off-site Waste Water Treatment Plants (WWTP) are sized per TCEQ regulations for peak design flows.

Once collected, two options were considered for treatment of waste. Construction of a small local package plant may be an efficient option for communities distant from existing treatment infrastructure. For communities near existing or proposed regional treatment facilities, construction of trunk lines and lift stations from the community to the facility may be more efficient and preferred.

5.4.3 Local Centralized Wastewater Treatment

Treatment of waste collected from a small community or subdivision may be handled by a nearby package plant or mini-wastewater plant. These plants are defined as facilities which treat up to 0.5 MGD. These plants are generally steel or concrete construction, depending on anticipated life-cycle need. Steel construction is typically less expensive and has an approximate 20-year lifespan whereas concrete construction has a longer lifespan but is more expensive. This option may be appropriate for communities located long distances away from existing infrastructure or where other physical and economic limitations exist. Stakeholders indicated that vigilant maintenance and operation of these types of small facilities is imperative to reduce threats to the lake if a malfunction were to occur.

5.4.4 Regionalized Wastewater Treatment

Several WWTPs already exist in the Lake Granbury area that could potentially provide treatment capacity to additional communities needing service. The active sewer utilities in Hood County include:

- Acton MUD
- Aqua Texas, Inc.
- City of Cresson (proposed)
- City of Granbury
- Fall Creek Utility Company, Inc.
- Laguna Vista LTD
- Texas H2O, Inc.

Two entities, the City of Granbury and Acton Municipal Utility District (AMUD), currently have additional capacity and/or plans to add future capacity that may help fulfill needs to the Lake Granbury area. In addition to their existing facilities with permitted waste treatment capacity of 2.0 MGD, the City of Granbury (2009) is developing plans for a 10 MGD plant north of Granbury. AMUD has existing treatment capacity on the southeast side of the lake and is currently developing plans to add capacity. Additionally, AMUD has a sewer Certificate of Convenience and Necessity (CCN) on the south west side of the lake so may be able to provide sewer service to that area if funding for infrastructure construction is available and attractive.

5.4.5 Cove/Canal Dynamics

The stakeholders expressed interest in evaluating the effects of construction projects involving modification of existing canal systems that would improve the cove water exchange dynamics. The concept is to improve water movement through coves to decrease stagnant water, encourage "flushing" of pollutants, and improve cove aesthetics. Modification projects could include partial filling or dredging (or some combination of both), or creation of additional connections to the lake to physically change the cove designs.

Some concerns related to the "fill" option are reduction in water frontage, flood zone impacts need to be considered per NFIP Rules, and permitting requirements per USACE 404 and TCEQ 401 Water Quality Certifications. Considerations for the "dredge" option include increasing the depth or water frontage, sediment removal and continued maintenance cycles.

5.4.6 Cove Circulation Systems

To promote water movement and decrease stagnation within canal water bodies, cove circulation systems could be constructed to improve water quality. These systems typically consist of floating water fountains, aeration systems, or more complex systems incorporating pipe network and water intake-discharge components.

A floating fountain feature, the cheapest option, would provide improved circulation to only a small area of the cove near the water surface. This would improve the oxygen in the immediate vicinity of the fountain but not provide any movement or flushing out of pollutants. An aeration system would be comprised of a compressor at the bottom of cove, creating air bubbles and is effective for increasing dissolved oxygen and improving circulation for a larger area than a simple water fountain. These options are not anticipated to provide significant reduction in bacteria levels.

A water intake-discharge system would convey water from the lake and discharge at the head of the canal/cove promoting circulation and flushing. This option requires a more complex design, and more expensive equipment, but could reduce bacteria concentrations in the canals by dilution with low-bacteria concentration lake water.

5.4.7 Off-site Drainage Bypass

Drainage patterns can be modified to redirect runoff away from the canals and coves. This may prevent pollutant loading from pesticides, pet waste, etc. Modifications may include adjustment of infrastructure (swales, culverts, storm drains, etc.) to re-direct the path of stormwater with associated pollutants.

5.4.8 Catchment Basin

Catchment basins are a type of structural management measure to "catch" and temporarily store runoff from the watershed before discharging to the coves or lake. Wet ponds, a type of catchment basin, can be highly effective at reducing both bacteria and nutrient loads if properly

designed and maintained. Wet ponds treat runoff constituents by allowing solids to settle and through biological uptake from plants.

5.4.9 Vegetative Filter Strips

A vegetative filter strip (VFS) is an area of vegetation that is intentionally planted to help remove sediment and pollutants from storm water runoff. Engineered strips of vegetation slow and filter runoff allowing plant uptake of nutrients. Similar to sediment capture, bacteria is also trapped by settling allowing exposure and sunlight to facilitate the die-off rate.

5.5 CRITERIA FOR EVALUATING ALTERNATIVES

The stakeholders evaluated all management measure alternatives using four criteria to prioritize and select area-specific best management measures. These criteria included each measure's potential to reduce pollution; time to implement; annualized cost per residence (including O&M); and site-specific feasibility considering constraints.

Funding is not included as a criterion for choosing appropriate management measures but was recognized as one of the most important considerations when it comes to actual on-the-ground implementation. Ability to fund projects will become the primary factor in determining which stakeholder-determined priority management measures become implemented.

5.5.1 Pollutant Reduction Potential

The percent reduction of bacteria level was evaluated using the Lake Granbury models as appropriate for each management measure. For predicting the change in concentration of bacteria considering cove interactions, the lake modeling tools were utilized. Where changes in pollutant source loading were predicted, the results from the watershed modeling tools were utilized. Where these models were not appropriate for determining the effectiveness of management measures and expected reductions, assumptions were based upon researched literature values specific to each management measure.

The current WPP goal is to obtain water quality at or below 53 MPN/100 mL geometric mean concentrations for *E. coli* bacteria. This goal is much more conservative than the state standard of 126 MPN/100 mL and promotes increased recreational health and overall health of the waterbodies. Unfortunately there are limitations in predicting the reductions of concentrations based on model results, and evaluation of model predictions against the numerical goal is challenging. For example, the watershed model determines the total potential bacteria colonies on the land surface on a given day. Logic suggests that a reduction in this total load will result in a reduction in the amount of bacteria transporting into the water body; however, this is not a direct 1:1 reduction in concentration since this would depend upon the size and timing of rainfall events as well as understanding more precisely the die-off mechanisms of the bacteria as they move from one environment (in fecal matter on the land surface) to another (overland runoff and eventually the larger cove waterbody).

The lake modeling tools can predict the expected change in concentration for a given event and change of scenario such as modifying the cove dynamics. The limitation of these models is that they are based upon literature values for input bacteria load but do not account for the variability of bacteria load according to storm event magnitude. Thus these tools are helpful for determining the change of concentration in the cove for constant source concentrations but evaluation of variable bacteria loading is challenging.

Despite the limits of the model predictions, these tools can effectively evaluate which management measures would have the greatest potential for bacteria reduction and ability to achieve stakeholder goals. An example evaluation matrix for possible management measures for the Oak Trail Shores subdivision is provided in Table 26.

5.5.2 Cost of Management Measures

The Lake Granbury WPP Financial Workgroup was formed to evaluate the economic assessment conducted by the project team. Composed of stakeholders or their designees, work group the stakeholders appointed members whom they felt had appropriate experience with finance, economics and proposed management measures. The Financial Work Group met to discuss and evaluate the BRA and EC project team's proposed economic analysis method and assumptions. The Work Group approved the project team's assumptions and approach to estimating costs, as outlined below.

A robust economic model must consider varying cost parameters such as initial capital investment, operation and maintenance costs, interest, and financing. The Equivalent Annual Cost (EAC) method considers these varying parameters in calculating the per-year cost of owning an asset over its entire lifespan (Equation 3). EAC is a common method for comparing alternatives using present value to consider different life cycles, different initial capital, and different O&M expenses (Figure 44).

$$EAC = \text{Capital Cost} * \text{Annuity Factor} + \text{Net Present Value of O\&M} \qquad \text{Equation 3}$$

Where:

$$\text{Annuity Factor} = r * (1+r)^t / [\,(1+r)^t - 1\,]$$

r = weighted cost of capital (interest rate)

t = lifespan in years of capital project

The cost of management measures is determined through a series of conceptual designs and assumptions. For example, conceptual collection system layouts were developed for each of the subdivisions; capital cost estimates were developed from materials estimates considering sewer line lengths, preliminary sizes, manhole spacing, lift station sizing and other factors as appropriate. Land costs were estimated where right-of-way or facility construction was anticipated and professional costs were included as associated with design, administration and permitting. A contingency factor was also added to account for unanticipated costs that may arise during a less conceptual design process or during construction.

Operations and maintenance (O&M) costs were developed and applied annually considering life cycle of system components (e.g., grinder pump replacement interval), by industry standard estimates or by estimates provided by stakeholders. Similarly, sources of capital costs included

information provided by local entities (particularly City of Granbury and AMUD), recent experience in Texas and a materials and labor cost estimating tool RS Means. Appropriate area-specific adjustments were applied for the project area within Texas.

All cost estimates were based upon 2008 averages. Given the fluctuation and adjustment of financial markets in 2009, significant uncertainty may exist in carrying absolute costs forward into the future. However, since nearly all sectors were affected by the fluctuations, it is anticipated that relative future costs will remain similar to relative 2008 costs.

Finance costs were not included because of uncertainty related to methods of financing projects. Some areas with greatest needs may qualify for grants, low-interest or no-interest government loans. Other areas may need to finance projects entirely based upon tax or bond revenue.

Assumptions specific to each area and each management measure alternative are provided in Appendix F.

To consider economies of scale, the total EAC for each management measure was divided by the number of homes it would benefit. This step allowed for consideration and comparison among different areas having different home densities.

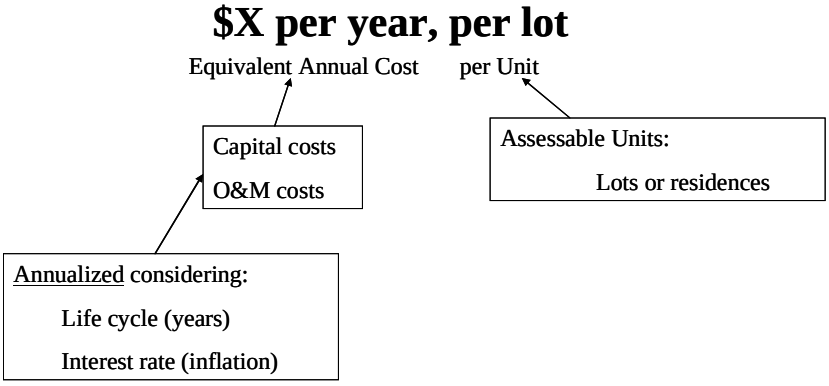

Figure 44. Diagram of Equivalent Annual Cost Inputs

The conceptual nature of these cost estimates and the economic instability in 2009 led to uncertainty in future capital costs and finance rates in comparison to historical costs and rates. To keep focus on relative comparative costs between alternative management measures, the EAC is presented as an annualized cost index (Figure 45). The index allows comparison of costs among alternatives (e.g., how much more expensive is one alternative than another) without focus on absolute costs or out-of-pocket dollars. While stakeholders did express considerable interest in absolute anticipated costs, they understood how planning-level conceptual cost estimates are less accurate than an on-the-ground construction bid for a project ready to break ground. So rather than focusing on absolute costs for this planning-level evaluation, the stakeholder group chose to focus on relative costs. The Financial Work Group agreed that the project team's approach to relative cost was suitable for their comparative purposes.

$$COST\_INDEX = \frac{[alternative\_\text{cost}]}{[\text{max}imum\_\text{cost}]}$$

Figure 45. Cost Index

5.5.3 Time to Implement

An important consideration for planning management measures is the amount of time required to fully implement the measure to achieve full expected bacteria reduction. Depending upon the complexity of the alternative, the evaluation and decision-making steps alone can take considerable time, potentially years. For major projects like construction of multi-million dollar waste treatment facilities, involved parties must formalize agreements to move forward with a particular alternative, conduct conceptual preliminary planning, land acquisition, seek funding, obtain funding, and pursue inter-local agreements to move forward. Permitting (e.g., such as establishing CCN boundaries for new utilities or NPDES permitting) and full engineering designs must be pursued prior to the start of construction.

This factor was used to identify and consider how complex infrastructure may take years to implement, whereas educational measures or placement of a simple water fountain may become implemented in less than a year.

5.5.4 Constraints and Other Considerations

Throughout the management measures analysis, the feasibility of each measure was considered for each specific site. This evaluation criterion was qualitative which allows stakeholders to address items not easily quantified in other categories. Active participation of stakeholders allowed identification of constraints affecting particular areas. Some examples of design constraints and considerations include compatibility with existing capital improvement plans; compatibility with local ordinances; floodplain considerations; discharge permitting; and navigability within the cove/canal systems.

5.6 SELECTION OF MANAGEMENT MEASURES

This section presents for one area, Oak Trail Shores, an example of how the stakeholders evaluated, selected and prioritized management measures appropriate for including in this WPP. A similar process was completed for each of the remaining areas; corresponding detail for remaining areas is included in Appendix F.

Numerous management approaches were considered for the Oak Trail Shores area because of the complicated interaction of drainage patterns, lot density, development patterns and subdivision age. Other subdivision areas exhibit different characteristics than Oak Trail Shores; this generally resulted in fewer management measures being evaluated for the other areas.

A matrix table summarizing the four major evaluation criteria (i.e., bacteria reduction, time to implementation, cost index and constraints) was developed (Table 26). The list of alternatives was sorted first according to bacteria reduction potential, then according to cost index, then

according to implementation time. Additional considerations and constraints were discussed as they related to feasibility of implementation. Bacteria reduction associated with educational programs was not quantified in this exercise; however, all stakeholders are in strong support of educational initiatives. While stakeholders anticipate load reductions based upon studies showing the effectiveness of related educational programs in changing public practices (e.g., TAES 2009), their expectation of the magnitude of load reduction is realistic in that anticipated education-based reductions are not as high as those anticipated from structural measures.

Stakeholders compared and considered management measure alternatives, giving higher priority to measures targeting reductions in source bacteria (e.g., sewage collection systems). Lower priority was given to measures targeting infrastructure changes resulting in reduced bacteria concentrations without reducing source bacteria (e.g., re-routing stormwater drainage, or increasing circulation within cove water bodies).

Significant input was provided by HOA members in this area resulting in additional management measures being considered and incorporated into the priority list. A priority should be to promote HOA regulations requiring, prior to HOA approval, health department approval of plans to increase the size of any existing dwelling.

While priority management measures for each area were not explicitly identified, discussion and evaluation of area-specific alternatives, in conjunction with identification of priority areas, led to development of the list of regional priorities in Section 5.1.

Table 26. Example matrix of alternative management measures, Oak Trail Shores Subdivision

Area	BMP Alternative	% Reduction Bacteria	Time to Implement	Equivalent Annual Cost index	Cost/ Reduction Ratio	Feasibility (Constraints/ Considerations)
Oak Trail Shores 1,653 units	Cove Dynamics: Dredge, Add Outlet	65%	2-5 yrs	0.84	1.29	Does not address source(s);
	Regional Wastewater Treatment (include neighboring areas)	54%	10-15 yrs	0.26	0.48	
	Local Centralized Wastewater Treatment - Aggregate	54%	5-10 yrs	0.33	0.62	
	Regional Wastewater Treatment	54%	10-15 yrs	0.35	0.66	
	Local Centralized Wastewater Treatment - Independent	54%	2-5 yrs	0.38	0.71	
	Drainage Re-route	51%	<1 yr	0.07	0.14	
	Septic System Replacement Section 1			0.38	0.94	
	Septic System Replacement Section 3			0.73	1.81	
	Septic System Replacement Section 2	41%	<1 yr	0.50	1.24	
	Cove Circulation: Intake/Discharge	39%	1-2 yrs	0.20	0.51	Infrastructure may impede navigation; Does not address source(s)
	Cove Dynamics: Dredge	30%	1-2 yrs	0.57	1.91	Does not address source(s)
	Septic Maintenance and Education		<1 yr			
	Pet Waste Education		<1 yr			
	Septic Management (records, inspectors)		1-2 yrs			
	Waterfowl and Wildlife Feeding Ordinances		1-2 yrs			

5.7 SELECTION OF PRIORITY AREAS

Recognizing that resources may not be available to implement management measures for all of the areas in the near timeframe, the stakeholders prioritized which areas they felt should be addressed first (Table 27). Prioritization of areas was based largely upon existing bacteria levels in comparison to the identified goal of 53 MPN/100mL. Additional consideration was given to areas located near existing facilities capable of satisfying needs, or to subdivision groups that could benefit from economies of scale.

For example, Indian Harbor is not the top priority despite the highest bacteria levels. The most likely source of bacteria is from septic systems, so a collection system and treatment plant would provide the best potential reduction in bacteria; however, treatment facilities would need to be developed for this area since none currently exist or are proximal. Adjacent areas (Ports O' Call and Rough Creek Cove) should be considered during development of plans for new facilities, so are at the same priority level.

In contrast, higher priority areas currently have plans under way to provide service (Port Ridglea East) or have near-by existing sewer lines with sufficient capacity (Oak Trail Shores and Sky Harbor). In addition, both Oak Trail Shores and Sky Harbor areas have multiple potential bacteria source mechanisms that may require multiple management measures to address; these areas may take more work and resources to achieve improvements than Indian Harbor.

Acton Municipal Utility District (AMUD) provided the following information in consideration of prioritizing efforts: For each of the last 3 years, AMUD has filed an IUP with the TWDB under the CWSRF to provide first time sewer service for residents of Port Ridglea East, Port Ridglea West, Nassau Bay II and Holiday Estates – all within a single project. Just as Ports O' Call and Rough Creek Cove have been tied closely with Indian Harbor in this table due to their close proximity to each other, the Nassau Bay II, Holiday Estates, Sandy Beach and Port Ridglea West should be tied closely with PRE. Receiving facilities are already in close proximity to this area, a concept plan with related costs has been developed, and the project could move quickly given adequate funding.

5.8 SOURCES OF FUNDING

Successful implementation of management measures outlined in the Lake Granbury Watershed Protection Plan is dependent on acquisition of funding. Some high priority measures will require significant funding for both initial implementation as well as future sustainability. Other management measures may only need minor adjustments to current activities. Traditionally, funding is available at the federal, state and local levels of government. Creative approaches to satisfying funding requirements (e.g., matching) will be needed. A number of potential funding sources should be investigated; a collection of some potential funding avenues are provided in Appendix G.
The stakeholder group was provided with information on several relevant programs. Staff from state and federal funding agencies made presentations during stakeholder wpp meetings.

Table 27. Priority areas and bacteria concentrations (geomean in MPN/100mL)

Area	E. coli Range (MPN/ 100mL)	Geometric Mean (MPN/ 100mL	% Samples Above 53	% Samples Above 126	% Samples Above 394	Stake-holder Priority*
Port Ridglea East	1 - >2420	73	58%	31%	10%	1
Oak Trail Shores	1 - >2420	70	50%	34%	17%	2
Sky Harbor	1 - 24000	63	50%	29%	14%	3
Indian Harbor	1 - >2420	71	55%	29%	11%	4
Ports O' Call	1 - 170	9	10%	2%	0%	4
Rough Creek Cove	1 - 249	8	9%	4%	0%	4
Nassau Bay II	1 - 921	27	36%	16%	3%	5
Port Ridglea West	1 - 1120	26	28%	14%	5%	5
Holiday Estates	1 - >2420	25	32%	17%	2%	5
Blue Water Shores	1 - >2420	37	36%	23%	9%	6
Walnut Creek	7 - >2400	124		48%	20%	7
Rolling Hills Shores	1 - >2420	27	35%	24%	13%	8
Arrowhead Shores	1 - 1733	14	19%	8%	5%	8
Canyon Creek Cove	1 - 2400	8	9%	5%	6%	
Waters Edge	1 - 1986	17	22%	10%	3%	
Mallard Pointe	1 - 410	9	16%	11%	2%	
Long Creek	10 - 24000	156		43%	25%	
Strouds Creek	8 - >2400	105		34%	20%	
Rucker Creek	5 - 6100	100		36%	23%	
Robinson Creek	4 - >2400	76		30%	16%	
Lambert Branch	1 - 1600	22	29%	11%	4%	
Brazos River at Lake Country Acres	1 - 8665	28		25%	20%	
Lake Granbury at Business 377	1 - 1400	6	7%	4%	1%	
Lake Granbury at 51	1 - 2400	5	8%	7%	2%	
Lake Granbury Dam	1 - 326	2	2%	2%	0%	

Data through May 2010
*Ranking per October 2009 Stakeholder Meeting

Table 288. *E. coli* Reductions Needed by Area to Meet Stakeholder Goals

Area	% *E. coli* Reduction
Port Ridglea East	27
Oak Trail Shores	24
Sky Harbor	16
Indian Harbor	24
Walnut Creek	57
Long Creek	66
Strouds Creek	49
Rucker Creek	47
Robinson Creek	30

USDA Rural Development has a Hood County specialist. Rural Development offers infrastructure (collection and treatment facilities) funding in two general classes: low interest loans and grants for small municipalities, and low interest loans and grants for qualifying individual low-income homeowners.

USDA Natural Resources Conservation Service (NRCS) also has a Hood County representative. The NRCS works with voluntary individuals and can provide technical assistance and in some cases cost-sharing. The EQIP program may provide funding to landowners for management of grazing lands and the WIP program may provide funding to landowners for management of wildlife areas. These programs generally apply to rural, rather than residential, areas; however, groups of landowners may choose to band together to collectively manage a number of small properties.

The Texas Department of Rural Affairs offers grants to city or county entities for community development projects like installation of water and sewer services, or related infrastructure. Funding is also available for low to moderate income areas for residential repairs or upgrades of treatment systems and yard lines.

The Texas Water Development Board (TWDB) has a number of low-interest loan programs for infrastructure development programs through the Clean Water State Revolving Fund (CWSRF).

In addition to local matching funds as required by some of the federal and state programs, local communities may also have the ability to independently fund some implementation strategies. The local city, county, and other jurisdictional districts have more flexibility and can be creative in their approaches for funding. Additionally, local funding can be quicker to acquire and would not have outside competition for funding.

5.9 POTENTIAL FUNDING NEEDS AND SOURCES

The primary management measure recommended by the LGWPPSC to eliminate bacteria sources impacting the canals of Lake Granbury is the long-term development of a regional wastewater collection system. The LGWPPSC feels this is best way to protect the lake into the future and to eliminate the concern of fecal contamination in the canals. This is an ambitious goal that will take many years to implement and will require extensive funding assistance to local communities and service providers from both state and federal sources. Some areas close to existing infrastructure, like Port Ridglea East, can be served in the near term but others, due to cost, terrain, remote citing, size of potential service area and/or lack of existing, nearby infrastructure may take up to 20 years to develop and fund.

Sewage treatment will most likely be provided by the City of Granbury, in the central and northern portion of the lake and the southern portion will most likely be serviced by AMUD. However, given the large potential service areas both the City of Granbury and AMUD will need significant financial assistance to expand their existing wastewater treatment systems to service lakeside communities. This assumption regarding most likely providers is based on the locations of existing sewage treatment facilities, sewage collection lines and existing Certificates of Convenience and Necessity for sewage service and in no way requires the City of Granbury or

AMUD to provide these services. Other existing or new entities may be able to provide effective wastewater treatment to lakeside communities in priority areas.

Based upon all of the assumptions and estimates described in other sections of this report, the aggregate capital cost of implementing wastewater collection and treatment infrastructure to serve approximately 4,200 lots located within priority areas is estimated at $59 million. To include areas adjacent to or between priority service areas (as would be anticipated to occur to take advantage of economies of scale), increases the total capital cost to an estimated $107 million and serves approximately 9,700 households.

Another strategy evaluated but rejected by the stakeholders was replacement of existing OSSF systems with new OSSF systems. The aggregated cost to replace 2,500 existing systems in all priority areas (considering characteristics unique within each area) is estimated at approximately $38,000,000. Additionally, the actual ability to replace all existing OSSF systems is highly limited in many areas due soil characteristics and lot sizes that are not compliant with current state regulations and local orders and ordinances. Stakeholders felt that strategies to provide collection and treatment services to priority areas would be more effective than replacement strategies at providing long-term reductions to bacteria loading. The preferred collection and treatment strategies more efficiently accommodate future growth anticipated in these priority areas and, because of increased operational oversight, are less likely to exhibit problems throughout the infrastructure life cycle.

These estimated costs represent an aggregation of several component projects in priority areas; it is anticipated that several different applications would be necessary to encompass all priority communities. Each estimated capital cost represents providing new sewer service to areas currently served by on-site sewage facilities (OSSFs), and also represents regionalization of treatment facilities to the extent evaluated in this report. If options representing construction of a number of smaller facilities (e.g., a package plant near Rolling Hills Shores [RHS] in lieu of connecting to RHS to City of Granbury service) are implemented then costs are anticipated to be higher.

Possible funding sources for these infrastructure projects include USDA Rural Development and programs through TWDB including CWSRF and Rural Water Assistance Fund (RWAF). For particular priority areas that may meet stringent, competitive criteria, possible funding sources may also include Community Development Block Grants from Texas Department of Rural Affairs and TWDB Economically Distressed Area Program (EDAP).

Other management measures target installation of structural best management practices within the watershed to control non-point pollution. An estimated cost of both vegetative filter strips (RHS) and improvements to drainage infrastructure (OTS) is $175,000. Additional estimated cost to construct all identified catchment basins is $5.2 million dollars. Funds to address non-point source pollution through these management measures may be sourced from federal 319h funding. EPA Targeted Watersheds Grant Program funding may also be available for projects meeting award criteria.

Watershed coordination and educational measure costs are estimated to be at least $350,000 dollars over the first 3 years; these first three years would be used to investigate and secure grant or loan funding as well as implement the educational plan. The federal 319h program is anticipated to be a partner source of funding for watershed coordination and education. For watershed coordination, the EPA Environmental Justice Small Grants Program may be another source of funding. For educational programs, the EPA Targeted Watersheds Grant Program funding may also be available. Educational measures may increase awareness and participation in programs that assist land-owner initiated measures like EQIP; this program may assist land owners to recover some costs of installing structural measures to control non-point source pollution (e.g., like catchment basins) in rural areas of the watershed.

Aggregated, estimated capital costs are summarized in Table along with potential funding partner source or sources, anticipating that local funding sources may not be available to cover all costs. It is important to note that these estimated capital costs are aggregated, meaning that the costs of many component projects are lumped together; the size, cost and timing of individual projects represent fractions of the total estimated capital costs shown. Requests for specific projects and amounts will be made as specific management measures are designed and engineered. Figure 46 provides a hypothetical funding needs schedule to implement the stakeholder recommended management measures.

One potential funding avenue would be to revisit the concept of the Lake Granbury Water Quality District (discussed on page 8). Due to failure of local voters to confirm the taxing district in 2002, stakeholders were reluctant to pursue this option for funding at this time. However, they did request to revisit the issue in five years and amend the WPP accordingly, if obtaining funding assistance through the sources discussed above is unsuccessful.

Table 29. Aggregated potential funding program needs

Management measure	Aggregated estimated capital cost of component measures, as noted	Potential non-local partner funding program(s)
Capital wastewater infrastructure		
Sewer service to 13 priority areas (4,200 households)	$59,000,000	CWSRF, Rural Development
Sewer service to 13 priority + adjacent areas (9,700 households)	$107,000,000	CWSRF, Rural Development
Non-point source structural measures		
OTS - surface drainage infrastructure	$170,000	319h
RHS - catchment basin	$1,100,000	319h, EQIP
Sky Harbor - catchment basins	$3,850,000	319h, EQIP
Walnut Creek - catchment basin	$226,000	319h
Non-point source non-structural measures		
OSSF pump-out and records keeping		319h
Watershed coordination and education		
Watershed coordination (first 3 years)	$200,000	319h
Education programs (first 3 years)	$150,000	319h

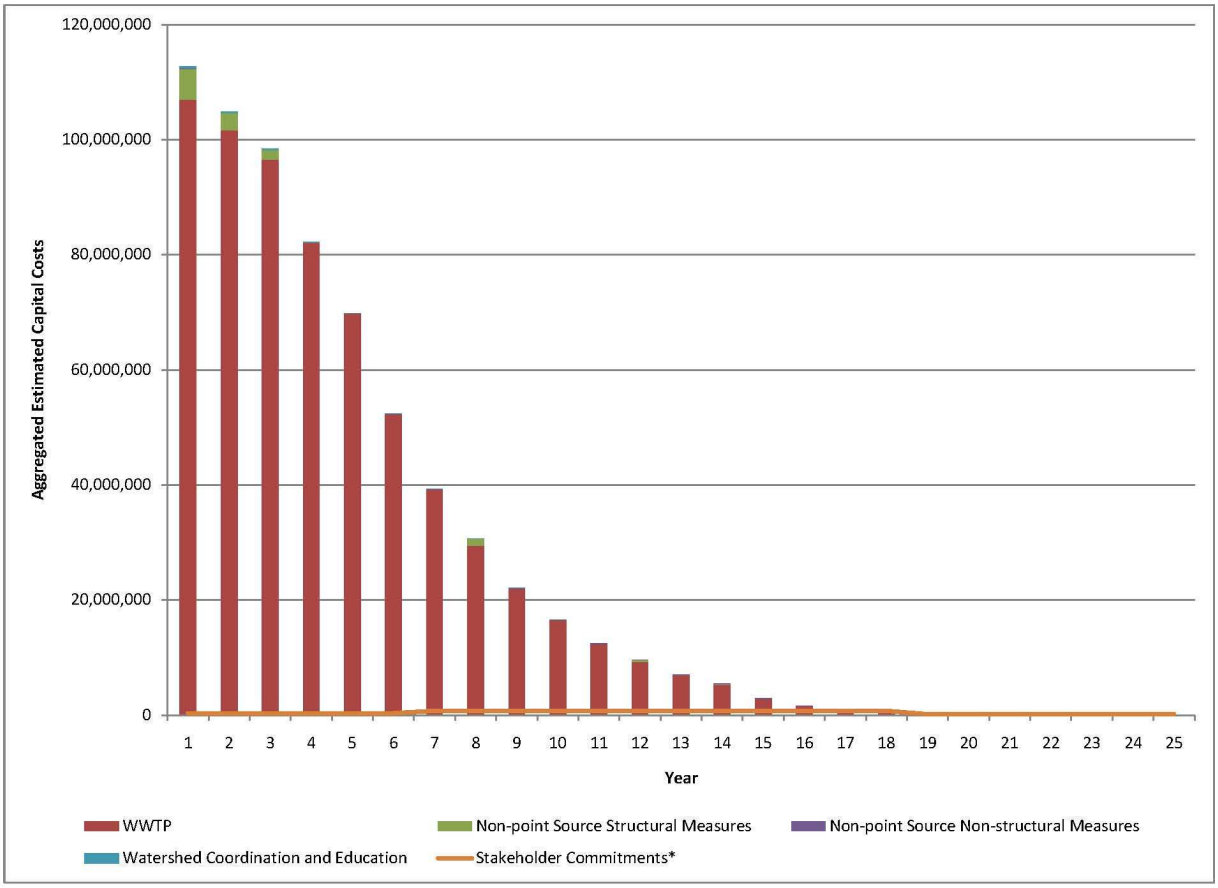

Figure 46. Hypothetical Funding Needs and Firm Stakeholder Commitments for Implementation of Management Measures

*additional stakeholder commitments have been made but are dependent on receipt of grants and/or low-interest loans, on bond issuance and are not reflected in this chart