How much water is in the PEDERNALES?

Appendix A
Conservation Strategies, Management Approaches and Action Plan

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POTENTIAL CONSERVATION STRATEGIES FOR THE PEDERNALES WATERSHED

INTRODUCTION

This document is a list of proposed Conservation Strategies within Management Measure Categories for the Pedernales watershed. Information was collected from a variety of sources, including peer-reviewed literature, scientific studies, Environmental Protection Agency (EPA), United States Department of Agriculture (USDA), Bureau of Land Management (BLM), United States Forest Service and other resources. Management Measures are defined as a category of practices that can be cooperatively implemented to achieve water quality and quantity goals and standards. Conservation Strategies, also known as Best Management Practices (BMPs), are individual practices within Management Measures that determine the most effective, practical means of preventing or reducing pollution from nonpoint sources. For example, Sedimentation Management Measures reduce the quantity of sediment from surrounding lands to receiving waters. A Riparian Buffer, on the other hand, is a Conservation Strategy that reduces sedimentation loading and falls under the Sedimentation Management Measure category. Conservation Strategies also can be practices to preserve water quantity through the protection of groundwater recharge or the conservation of surface and groundwater supplies. It is important to consider that hydrological connections exist between groundwater and surface water in the watershed and one Conservation Strategy may protect both water quality and quantity.

The following Conservation Strategies have been compiled for the purpose of inclusion in management plans to prevent or remediate current and future expected water quality pollution and reductions in water quantity within the watershed. Conservation Strategies can be implemented alone or in combination with others, across the basin or in specific areas of the basin. Descriptions, details, cost, pollutants treated, existing operational support, and complimentary strategies are provided for each item where available. In other sections, narratives and examples are provided for Conservation Strategies that are intended to be used on a larger scale or do not specify associated costs and details.

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I. RANGE MANAGEMENT

Many of the Conservation Strategies described in this section also apply to agricultural/livestock activities (Section II below). This section identifies information required to develop a Range Management Plan, best practices to consider for land use activities and potential Conservation Strategies to protect water quality and quantity.

Determine direct and indirect impacts to water quality, quantity and watershed condition of current activities or land uses:

- Evaluate sources of water body impairments, including water quantity, streamflows, and water quality, and the likelihood that proposed activities would contribute to current or future impairments.
- Identify and delineate unstable areas that require management and avoidance of activities.
- Develop site-specific Conservation Strategy prescriptions, design criteria, and mitigation measures to achieve water quality and quantity management objectives.

Design and implement project activities:

- Avoid or minimize unacceptable impacts to riparian vegetation, groundwater recharge areas, steep slopes, highly erodible soils, or unstable areas.
- Maintain or provide sufficient ground cover to encourage infiltration, avoid or minimize erosion, and to filter pollutants.
- Avoid, minimize, or restore detrimental soil compaction.
- Retain trees necessary for shading, bank stabilization, and a source of large woody debris.
- Retain floodplain function.
- Restore existing disturbed areas that are eroding and contributing sediment to the waterbody.
- Mark the boundaries of sensitive areas like riparian areas, wetlands, and unstable areas on the ground before land disturbing activities.

Determine the width of the riparian areas:

- Evaluate the condition of aquatic and riparian habitat and beneficial riparian zone functions and their estimated response to the proposed activity in determining the need for and width of the riparian zone.
- Use stream class and type, channel condition, aspect, side slope steepness, precipitation and climate characteristics, soil erodibility, slope stability, groundwater features, and aquatic and riparian conditions and functions to determine appropriate AMZ widths to achieve desired conditions in the riparian zone.
- Include riparian vegetation within the designated riparian zone and extend the management zone to include steep slopes, highly erodible soils, or other sensitive or unstable areas.

Examples of specific management activities are provided in the Range Management Plan. Costs and other details for many of these measures are provided in later sections:

- Structures can be used to stabilize the grade and control erosion in natural or artificial channels, to prevent the formation and advance of gullies, and to enhance environmental quality and reduce pollution hazards.
- Pipelines installed for conveying water for livestock or for recreation may decrease sediment, nutrient, organic, and bacteria pollution from livestock by providing water sources other than streams and lakes.
- A water impoundment (pond) made by constructing a dam or an embankment may provide alternate water sources away from streams, creeks or sensitive recharge features. Ponds are often used in conjunction with pipelines and troughs and tanks. Ponds may trap nutrients and sediment which would otherwise wash into the watershed.
- A basin can be constructed to collect and store debris or sediment. Sediment basins will remove sediment and associated materials and other debris from the water which is passed downstream. Stock water ponds often act as sediment basins.
- Improving springs and seeps may be achieved by excavating, cleaning, capping, or providing collection and storage facilities. There will be negligible long-term water quality impacts with spring developments. Erosion and sedimentation may occur from any disturbed areas during and immediately after construction, but should be short-lived. The stream source will usually be fenced.
- Vegetation or structures can be used to stabilize and protect banks of streams, lakes, estuaries, or excavated channels against scour and erosion.
- Managing and manipulating stands of brush (and weeds) on forest, range, pasture land by mechanical, chemical, or biological means or by prescribed burning can increase ground cover, reduce fire hazard, improve water quality/quantity in the long term, and improve forage production and quality, increase runoff and other objectives depending on landowner goals. Brush management may temporarily impair water quality by increasing sediment yields because of soil disturbances and reduced vegetative cover.
- Critical area planting can be used to reduce erosion, including grading, seedbed preparation, seeding, and mulching.
- Ranchers and land managers may seek technical assistance from UC Cooperative Extension, USDA Natural Resource Conservation Service (NRCS), Resource Conservation Districts or other agencies to help identify water quality problems, develop management plans, water quality goals and select specific best management practices.

Resources:

State Water Resource Control Board: California Rangeland Water Quality Management Plan

II. AGRICULTURAL MANAGEMENT MEASURES

Primary agricultural nonpoint source pollutants to surface and groundwater supplies are nutrients (particularly nitrogen and phosphorus), sediment, animal wastes, pesticides, and salts. Agricultural nonpoint sources enter surface water through direct surface runoff or through seepage to ground water that discharges to a surface water outlet. Various farming and ranching activities result in the erosion of soil particles. The sediment produced by erosion can damage fish habitat and wetlands and, in addition, often transports excess agricultural chemicals resulting in contaminated runoff. This runoff in turn affects changes to aquatic habitat such as temperature increases and decreased oxygen. Physical activities associated with land use can prevent effective infiltration of groundwater, reducing water quantity.

Soil compaction from overstocking is a common problem that results in reduced infiltration rates and increased runoff risk. There is rarely only one soil type found on any property; therefore, different areas of the farm should be managed accordingly to minimize environmental impacts while maximizing utilization for the production goals that the producer wants to achieve. In general, loamy and clayey soils are more susceptible to compaction than soils with gravelly or sandy textures. Moreover, soils around riparian zones can easily be compacted due to the higher amount of organic matter and moisture content found there in comparison to upland pastures. Producers should recognize the location of particularly wet areas that might be excluded from grazing or protected with special measures. Other causes for soil compaction are stocking density, grazing management, and vegetative growth.

Manure is very high in nutrients and microorganisms and should be kept on pastures and away from waterways through suitable grazing management and/or appropriate placement of filter strips. Filter strips are an important tool in nutrient management and are maintained to reduce the nutrient and bacterial content of runoff from the entire farm. Locating vegetative filter strips downslope from heavy use areas helps protect water resources. Quite often, pasture forage found downslope of the heavy use area serves as an effective filter strip.

Stream Crossings can impact water quality and affect infiltration rates in riparian areas. One of the simpler solutions is to cover the stream bottoms with coarse gravel at specific crossing sites to prevent further channel erosion and exclude cattle from sites along the stream that are already heavily eroded. In doing so, temporary fences made of poly- or high-tensile wires can be set up relatively inexpensively to allow for flexibility when they have to be moved. Another type of livestock crossing is comprised of an approximately 8-foot-wide concrete slab that is lined with large rocks on either side. These rocks prevent cattle from walking into the stream while catching debris and sediments during runoff events. More expensive designs of crossings consist of plastic webbing structures that line the stream bottom and are filled with gravel. Adopting an off-stream watering system for cattle, such as a water tank, can decrease erosion, direct deposit of manure, and lowers the risk of pathogens shed into surface water by young livestock.

Grazing strategies can protect water quality and quantity and are an essential component of any Livestock Management Plan.

- *Strip grazing* - confines animals to an area that is grazed during a short time period.
- *Creep grazing* - allows juvenile animals to graze areas that their dams cannot access at the same time.
- *Buffer grazing* - an approach to adjust forage supply by using temporary fencing to exclude livestock from certain areas that can be harvested either as hay or grazed during a time when environmental impacts are minimized; well-suited to make use of sensitive riparian areas by providing only infrequent access for grazing livestock yet allowing extra forage when needed.

Placement of **supplemental feeds** can result in improved water quality because it draws livestock away from streams. As most commercial supplements are highly palatable, animals will travel significant distances to consume them. Low-moisture blocks that provide additional protein to livestock when protein is

lacking in natural forage have great potential to draw and hold livestock to a target area such as steep slopes or areas more than a mile from water.

Activities to protect riparian zones:

- Monitor soil moisture content close to streams. If moisture content is high, soil is more sensitive to compaction, resulting in increased runoff during following precipitation events.
- Graze pastures to a height of no less than 4 inches.
- Avoid moving cattle to riparian zones during hot summer days. Cattle will linger in streams and may damage stream banks.
- Avoid cattle grazing during periods of flowering of native grass species.
- Avoid excessive grazing of woody species that build the underbrush in a riparian ecosystem.

Resources

Washington State University Extension: Livestock Management and Water Quality

University of Arkansas Division of Agriculture: Beef Cattle Management for Water Quality Protection in Arkansas

Livestock Water Quality/Quantity Management Plan

Livestock Management Plans utilize combinations of structural conservation strategies and management activities, examples of which are provided subsequently.

Description

A water quality management plan (WQMP) is a site-specific plan developed through and approved by soil and water conservation districts (SWCDs) for agricultural and silvicultural lands. Land treatment practices, production practices, management measures and technologies are combined in a customized suite to achieve a particular level of pollution prevention. For example, locating water troughs, tanks, or ponds at suitable distances from springs, rivers and creeks to avoid or minimize adverse effects to the instream water quality and spring and wetland vegetation from livestock trampling or vehicle access.

Details

Forested lands and wildlife are included in the WQMP, along with various grazing systems, nutrient management techniques, and erosion control to create a sustainable and low-maintenance system for the landowner.

Restricting access to waterways is a part of the Livestock Water Quality Management Plan. Photo by Clean Annapolis River Project.

Cost

$10,000/plan

Parameter Treated:

Bacteria, Total Suspended Solids (TSS)

Operational Support Available

Water Quality Management Plan (WQMP) Program - Texas State Soil Water Conservation Board (TSSWCB)

Works Well with Other Strategies

Fencing Riparian Areas

Grazing Management Strategies

Structural Farm/Range Improvements

Structural range or pasture improvements may be used to facilitate proper grazing use and keep livestock from streams and riparian areas and are often included in Livestock Management Plans. More information for two structural Conservation Strategies is provided on the following pages.

Access Roads - Roads constructed to provide access to farms and ranches used for moving livestock, produce, equipment and supplies and to provide access for management of ranch resources.

Fencing - Enclosing or dividing an area of land with a suitable permanent structure that acts as a barrier to livestock, big game, or people (does not include temporary fences). Fencing may protect riparian areas which act as sediment traps and filters along water channels and impoundments.

Grade Stabilization - A structure used to stabilize the grade and control erosion in natural or artificial channels, to prevent the formation and advance of gullies, and to enhance environmental quality and reduce pollution hazards.

Pipelines - Pipeline installed for conveying water for livestock or for recreation. Pipelines may decrease sediment, nutrient, organic, and bacteria pollution from livestock by providing water sources other than streams and lakes.

Ponds - A water impoundment made by constructing a dam or an embankment or by excavation of a pit or dugout. Ponds may provide alternate water sources away from (a) Appendix 8 -- Page 4 stream. Ponds are often used in conjunction with pipelines and troughs and tanks. Ponds may trap nutrients and sediment which wash into the basin.

Sediment Basins - A basin constructed to collect and store debris or sediment. Sediment basins will remove sediment and associated materials and other debris from the water which is passed downstream. Stock ponds often act as sediment basins.

Spring Development - Improving springs and seeps by excavating, cleaning, capping, or providing collection and storage facilities. The stream source will usually be fenced.

Stock Trails or Walkways - A livestock trail or walkway constructed to improve grazing distribution and access to forage and water. This practice may be used to reduce livestock concentration, facilitate proper grazing use and (implement) planned grazing systems.

Streambank Protection - Using vegetation and/or structures to stabilize and protect banks of streams, lakes, estuaries, or excavated channels against scour and erosion.

Troughs and Tanks - Installation of a trough or tank may facilitate improved distribution of livestock. Troughs and tanks are often an effective means of providing stock water away from streams.

Stream Crossing (Interim) - A stabilized area to provide access across a stream for livestock and farm machinery. The purpose is to provide a controlled crossing or watering access point for livestock along with access for farm equipment.

Alternative Shade Structures

Description
Alternative shade structures provide areas for livestock to utilize without causing damage to plants and streams.

Details
Negative water quality effects can occur from high concentration of animal activity in riparian areas and streambeds. Livestock animals often use these areas to escape the Texas heat by using shade and, if present, flowing water to cool their bodies.

The use of trees and wooded or shrub areas for shade can also have an effect on the health of those plants by compacting soils and damaging root systems.

If rotational grazing strategies are also used, accessibility to natural shade and cooling areas is limited.

Geneva Country shade structure. Photo by NRCS.

Cost
$75/head

Parameter Treated
Nutrients, Bacteria, TSS,

Operational Support Available
Lonestar Healthy Streams Program (LHSP) – Texas Water Resources Institute (TWRI), AgriLife Extension Service, TSSWCB

Texas Environmental Quality Incentives Program (EQIP) - NRCS

Water Quality Management Plan (WQMP) Program - TSSWCB

Works Well with Other Strategies
Fencing Riparian Areas

Grazing Management Strategies

Rainwater Harvesting Alternative

Brush Control

Fencing Riparian Areas

Livestock stream water crossing. Photo by NRCS.

Riparian Buffer with fencing. Photo by NRCS.

Description
Used to reduce bacterial contamination by protecting riparian areas, fences can keep livestock and animals from entering and degrading a stream bed. Offering limited access or creating alternative shade and watering areas can help redirect livestock and animals away from riparian areas, allowing species to recover and increasing aquatic diversity.

Details
Livestock grazing in riparian areas has been identified as a source of nonpoint pollution. Waste from livestock and animals in or near a waterway can contribute directly or leach through surrounding soils, transporting nutrients and pathogens into the water. Unmanaged grazing in or near waterways can also contribute to soil loss and contribute to sediment pollution, changing stream flow patterns and destroying aquatic habitats. Capacity of riparian areas to filter contaminants from within and around the riparian area is reduced.

Cost
$1-1.05/lin. ft. w/ EQIP

+ $1/lin. ft. for individuals

Prices include annual maintenance, no associated labor

Parameter Treated
Nutrients, Bacteria, TSS

Operational Support Available
Lonestar Healthy Streams Program (LHSP) - Texas Water Resources Institute (TWRI), AgriLife Extension Service & TSSWCB

Texas Environmental Quality Incentives Program (EQIP) - NRCS

Water Quality Management Plan (WQMP) - TSSWCB

Works Well with Other Strategies
Alternative Shade Structures

Grazing Management Strategies

Grazing Management Strategies

Impacts by different grazing strategies. Photo by TAMU.

Description
Grazing management strategies are used to improve pasture productivity, increase livestock growth, and protect riparian areas

Details
Many strategies exist to help mitigate pollution effects of livestock and animals to riparian areas. Examples include deferred rotation grazing and management intensive grazing, among others.

Managed grazing can enhance farm productivity while decreasing input expenses, all while protecting environmental conditions.

Cost
- Prescribed Grazing- $4.09/ac

Parameter Treated
- Nutrients, Bacteria, TSS

Operational Support Available
- Lonestar Healthy Streams Program (LHSP) - Texas Water Resources Institute (TWRI), AgriLife Extension Service, & TSSWCB
- Texas Environmental Quality Incentives Program (EQIP) - NRCS
- Water Quality Management Plan (WQMP) - TSSWCB
- Works Well with Other Conservation Strategies
- Fencing Riparian Areas
- Alternative Shade Structures

Resources
Grazing Management Measures

Small Steps Make a Difference: Improving Your Calf - Cow Business

Small Farms Fact Sheet Series (Livestock and Poultry Environmental Stewardship project)

Small-Scale Farmers and the Environment: How to be a Good Steward

Spanish version - Small-Scale Farmers and the Environment: How to be a Good Steward (Cómo proteger el medio ambiente en los ranchos y granjas pequeños)

The ABCs of Pasture Grazing

Riparian Area Management: Grazing Management in Riparian Areas

Rangeland Watershed Program Publications

Groundcover Establishment - Agricultural

Description
Groundcover is any vegetation that grows over an area that provides protection from erosion and drought, generally defined as the layer of vegetation below the shrub layer. Grasses, shrubs, and other herbaceous plants are generally used as groundcover.

Details
Groundcover can provide forage for livestock and minimize invasive plant growth. Water quality can be improved by providing adequate groundcover like grasses and trees on idle and degraded land, and by planting vegetation along stream banks.

Impacts by different grazing strategies. Photo by TAMU.

Cost
- Range Planting - $16.5-90/ac
- Forage & Biomass planting (Seeding of Native Grasses) - $58/ac

Parameter Treated
TSS

Operational Support Available
Texas Environmental Quality Incentives Program (EQIP) - NRCS

Works Well with Other Strategies
- Grazing Management Strategies
- Alternative Shade Structures

III. URBAN & STORMWATER MANAGEMENT MEASURES

Comprehensive Stormwater Assessment

Description
A comprehensive stormwater assessment is an excellent way for an urban area to assess its stormwater needs and incorporate LID management strategies into a system- wide plan. A Storm Water Pollution Protection Plan (SWPPP) identifies controls, unique features of urban areas, and specific pollution prevention measures designed to minimize pollutants.

Details
Stormwater pollution is untreated contaminated water that drains from streets and surrounding landscapes.

Stormwater collection systems gather the untreated stormwater runoff to be re-routed and treated before releasing into the creek, removing sediments, salts, nutrients, organics, and oil and grease. A receiving or re-routing pipeline as an integral part of a stormwater control network can be installed to reduce erosion, conserve water, and protect water quality.

Cost
$20,000-35,000/survey

Parameter Treated
Water Quantity, TSS, Oil & Grease

Operational Support Available
N/A

Works Well with Other Strategies
Low-Impacts Development

Pondless stormwater waterfalls can be incorporated into stormwater drainage or rainwater catchment systems. Photo by BJL Aquascapes, LLC.

A nativescaped garden in Salt Lake City. Photo by Wasatch Front Regional Council.

Lawn, Garden, and Landscape Strategies

Description
Ecoregion-appropriate lawn, garden, and landscape strategies can greatly reduce the potential for adverse impacts to waters receiving runoff from lawns. These strategies can help citizens and their communities to maintain healthy, attractive lawns with less maintenance and fewer chemical inputs.

Lawn, Garden, and Landscape Strategies include sub-strategies
Xeriscaping/Nativescaping

Landscape Mulching

Water-Intensive Turf Grass Regulation and/or Ban

Biofiltration/Rain Garden- yard scale

Groundcover Establishment

Habitat Conservation Areas- urban

Details
Unmanaged or poorly designed landscapes can contribute to runoff pollution through overwatering, over-application of fertilizers and pesticides, erosion from bare patches, etc.

Cost
See sub-strategies listed above

Parameter Treated
Water Quantity, Nutrients, Bacteria, TSS, Oil & Grease, Metals, Velocity Flows/Flooding

Operational Support Available
N/A

Works Well with Other Strategies
See sub-strategies listed above

Sustainable landscape design.
Photo by Platinum LEEO Home.

Landscaping principals.
Photo by Green Curb.

Sub-Strategy: Xeriscaping/Nativescaping

Description
A part of Lawn, Garden, and Landscape Strategies, xeriscaping and nativescaping promote irrigation water-use efficiency. Multi- step landscape designs and maintenance practices that use low-water-use, or drought- tolerant, vegetation as the primary element in residential and commercial landscapes to replace traditional turf grasses.

Details
Xeriscaping and Nativescaping can be used to intercept urban runoff pollution by absorbing overland flows that may contain contaminants and reduce the need for fertilizers - a source of a nutrient (nitrogen and phosphorus) pollution.

Cost
$125-270 plus $0-1/ft2

Parameter Treated
Water Quantity, Nutrients

Operational Support Available
N/A

Works Well with Other Strategies
Landscape Mulching

Water-Intensive Turf Grass Regulation and/or

Ban Biofiltration/Rain Garden - yard scale

Groundcover Establishment

Habitat Conservation Areas - urban

A nativescaped garden in Salt Lake City.
Photo by Wasatch Front Reground Council.

Sub-Strategy: Landscape Mulching

Description
A part of Lawn, Garden, and Landscape Strategies, mulch is a collection of decayed detritus, such as leaves, straw, or chipped wood, and is spread on the ground to protect the roots of newly planted plants. As mulch decomposes, it provides organic matter prompting soil to aggregate, increasing aeration, biological activity, moisture retention, and improving soil structure.

Stone walkway through mulched landscaping. Photo by First Light Landscaping, Cannon Falls, MN.

Details
Mulches perform three basic functions: reduce soil loss, suppress weeds, and protect against temperature extremes.

Mulch also helps break the impact of water droplets, reducing soil erosion from water impact and increasing infiltration of moisture into underlying soils.

Cost
$10-19/yard bulk

Parameter Treated
TSS

Operational Support Available
N/A

Works Well with Other Strategies
Xeriscaping/Nativescaping

Water-Intensive Turf Grass Regulation and/or

Ban Biofiltration/Rain Garden - yard scale

Groundcover Establishment

Habitat Conservation Areas - urban

Sub-Strategy: Water-Intensive Turf Grass Regulation and/or Ban

Description

A part of Lawn, Garden, and Landscape Strategies, water-intensive species require a lot of time, money, and resources to keep a carpet-like appearance. Several mixes of drought-adapted species exist in Texas that provide the same appearance and function of non-native monocultures without requiring high weed-management inputs or watering. Mixes of native turf grasses mean less mowing, less watering, and less weeding.

A Dallas home replaces a portion of its turf grass with xeriscaping. Photo by Dallas Morning News.

Details

Traditional lawns are often populated with non-native grasses that can be maintenance and water-intensive.

Water-intensive species such as St. Augustine succumb easily to pests and disease, while bermudagrass can be invasive and requires constant mowing.

Cost

Ordinance development + Cost to replace grass per household/ft2

Incentives = $20 for every 100 ft2 replaced with natives

Up to 1/2 staff person salary for project management/enforcement

This Buffalograss mix (L) grows slower and has fewer weeds than Bermudagrass (R). Photo by Lady Bird Johnson Wildflower Center.

Parameter Treated

Nutrients, Bacteria, TSS

Operational Support Available

N/A

Works Well with Other Strategies

Xeriscaping/Nativescaping

Landscape Mulching

Biofiltration/Rain Garden - yard scaleGroundcover Establishment

Habitat Conservation Areas - urban

Sub-Strategy: Biofiltration/Rain Garden

Biofiltration/Rain Garden slows stormwater runoff from parking lots. Photo by Temple–Villanova Sustainable Stormwater.

Description
A part of Lawn, Garden, and Landscape Strategies, biofiltration systems incorporate bioretention systems with plants and organic media with a conventional filtration system. A bioretention system is a stormwater management strategy that uses a biologically-active filtration bed to remove contaminants. This variation has been studied and utilized within the Austin area with great success. Can be development, residential or yard scale.

Details
Biofiltration provides an aesthetically-pleasing opportunity for pollutant uptake, especially nutrients, by vegetation.

The combination of the presence of plants and a submerged zone with a carbon-sourced filter helps remove pollutants from surrounding areas.

It is recommended to use this strategy in areas that are shaded, close to a water source, or within the wet portion of the watershed.

As biofiltration medium dries, gaps between soil particles increase due to cracks and macro-pore development and filtering efficiencies are reduced. Therefore, removal efficiencies may vary before and after a storm event.

Cost
$50,000/ 1 acre-foot pond

Parameter Treated

Nutrients, Bacteria, TSS, Metals, Oil & Grease

Operational Support Available
N/A

Works Well with Other Strategies
Xeriscaping/Nativescaping

Landscape Mulching

Water-Intensive Turf Grass Regulation and/or

Ban Groundcover Establishment

Habitat Conservation Areas - urban

Sub-Strategy: Groundcover Establishment- Urban

Description
A part of Lawn, Garden, and Landscape Strategies, groundcover is any vegetation that grows over an area that provides protection from erosion and drought, generally defined as the layer of vegetation below the shrub layer. Vines, grasses, shrubs, moss, and other herbaceous plants are generally used as groundcover.

Details
Groundcover can be an aesthetically pleasing method to suppress weed growth and can consist of non-living substances (for example, plastic sheeting or landscaping fabric). Water quality can be improved by providing adequate groundcover like grasses and trees on idle and degraded land, and by planting vegetation along stream banks.

Cost
Sod = $0.08-0.60/ft2

Seed = $25/lb or $120/5lb, @ 1lb/1000ft2 for short mix

$1-2/ft2 soil prep

Other groundcover plants = $5-7/ft2

Parameter Treated
TSS

Operational Support Available
Texas Environmental Quality Incentives Program (EQIP) - NRCS

Works Well with Other Strategies
Grazing Management
Strategies Alternative Shade Structures

Urban landscaping groundcover. Photo by Bonnie Plants.

Urban groundcover. Photo by Harvard University.

Sub-Strategy: Nutrient & Fertilizer Management

Description
Excess nutrients easily washed into water bodies and streams after stormwater events can deleteriously alter aquatic ecosystems and contaminate drinking water supplies. Appropriate use of fertilizers, limited exposure of soils, and disposal or processing of livestock waste can help maintain healthy habitats. As a part of Lawn, Garden, and Landscape Strategies, Nutrient & Fertilizer Management should utilize educational outreach, regulations, certification programs, and monitoring efforts to emphasize a holistic approach.

Riparian forest buffer next to farm. Photo by NRCS.

Details
Site-specific pre-application planning and calculated dosing may require Education & Outreach initiatives.

Nutrient discharges from livestock should be biologically processed through bio -retention ponds or vegetative buffer areas.

Cost
Costs of educational outreach, certification programs, water quality monitoring, and any regulatory processes Costs to livestock producers, businesses, and utilities are site-specific

Parameter Treated
Nutrients, Bacteria, TSS

Operational Support Available
N/A

Works Well with Other Strategies
Agricultural Management Measures

Urban & Stormwater Management Measures

Non-Domestic Animal/Wildlife Management Measures Sedimentation Management Measures

LID Management Measures

Figure Fertilizer spreader. Photo by Danny Lipford.

Sub-Strategy: Habitat Conservation Areas

Description
Habitat conservation helps to conserve, protect, and restore habitat areas for wild plants, animals, and conservation-reliant species to prevent fragmentation (reduction in range) and extinction while balancing water supply and commercial and residential development. Habitat Conservation Plans (HCPs) can be regional in scale or the size of a backyard.

Certified Wildlife Habitat in an Austin backyard. Photo by Joe Lamp'l.

Details
Using native plants and certain species, HCPs attract a variety of wildlife such as songbirds and can include edible plants like blackberries.

Creating backyard habitats by replacing lawns with native plants not only benefits wildlife but is easier to maintain. Programs such as the Texas Parks and Wildlife Texas Wildscapes Program and Best of Texas Backyard Habitats are excellent avenues for guidance and even offer certification.

Cost
Average land value cost of purchase (~$8500/ac) or up to $750 annually to maintain.

For urban, 1/2 ac = between $100-400 to establish

Maintenance (urban) = <$50/year

Parameters Treated
Nutrients, Bacteria, TSS

Operational Support Available
Texas Wildscapes Program- Texas Parks and Wildlife Department (TPWD)

Best of Texas Backyard Habitats- TPWD

Works Well with Other Strategies
Lawn, Garden, and Landscape Strategies (all)

Pet Waste Ordinance & Stations

Description
Effective campaigns have been developed to reduce pet waste problems by increasing awareness throughout the community, using public pressure, establishing city ordinances and fines, and providing materials such as bag stations for pet owners along popular walkways. While increased trash from picking up pet waste and the use of plastic bags has been a concern in some communities, ecologically sound alternatives like compostable bags do exist. Can be integrated into a Water Quality Protection Ordinance or passed as a stand-alone ordinance.

Details
Improperly disposed-of pet wastes can and often do wash into nearby waterways and storm drains from runoff flows.

Degradation processes of waste within the water not only deplete oxygen levels and release ammonia, a toxic combination for aquatic species, but do not break down harmful microbes such as bacteria, viruses, and parasites.

Within a populated watershed, the combined effect of multiple pets and their waste can severely impact a water body and the community that uses it.

In addition, pet waste carries nutrients that contribute to nutrient build-up and pollution.

Cost
Ordinance - formative

Collection Stations - $620/station installation, $85/annual station

Parameter Treated
Nutrients, Bacteria

Operational Support Available
N/A

Works Well with Other Strategies
Fencing Riparian Areas

Grazing Management Strategies

Sign at Bluff Lake Park, Denver, CO. Photo by Stuart Macdonald, National Trails Training Partnership.

Dog litter station. Photo by Ashley Park Homeowner's Association, Chandler, AZ.

Curbside Recycling Program

Description
Curbside recycling is recyclable waste that can be picked up in front of a home or business, with waste separated in to categories (paper vs. plastic & glass) or as a single- stream (all recyclables in one container that are separated at a facility).

Texas State University uses three sizes of recycling bins (35, 65, & 95 gal). Photo by Texas State University-San Marcos.

Details
Single-stream processing allows for more efficient collection and decreased labor costs.

In central Texas, single-stream has become very popular and is serviced weekly or bi- weekly. The largest single-stream recycling facility in North America, Greenstar, is located in San Antonio where the company has a 20,000 ton/month capacity over nine acres.

Cost
Collection = $215,000-230,000 (or $54-33 per household) + Processing Costs (contractual collection & processing strategy). Fees are often incorporated into city waste bills. Cost of service is often dependent on the level of community involvement and cost of shipping distance from pick-up to a service facility.

A student recycles plastic bottles in the recycling bins provided by her apartment complex. Photo by Erin Dyer, The University Start, Texas State University-San Marcos.

Parameter Treated
Metals, Oil & Grease

Operational Support Available
N/A

Works Well with Other Strategies
N/A

Dry Detention Pond

Description
Detention basins temporarily slow runoff flows on site prior to their gradual release after a peak storm inflow has passed. Runoff is held for a short period and is slowly released to a natural or constructed water body.

A naturalized & extended dry detention basin. Photo by F.X. Browne, Inc.

Details
Generally, detention basins do not reduce the total volume of runoff but redistribute the rate of runoff over time by providing temporary storage while allowing the water time to break down pollutants. Detention basins are different from retention basins in that their purpose is to slow the velocity of stormwater flows and allow pollutants to settle, as opposed to focusing on recharge. Engineered recharge features such as retention basins are helpful in some areas but can often fail in karstic regions, creating sinkholes and blowouts. A drain and outlet system is typically incorporated into the design to minimize standing water issues. Some minor modifications must be made for karstic areas such as the Hill Country, but the design is nonetheless effective and has been used in urbanized areas throughout the San Antonio and Austin areas.

Cost
$41,600 for 1 af pond

$239,000 for 10 af pond

$1,380,000 for 100 af pond +

Routine maintenance= 3-5% construction cost

Parameter Treated
Nutrients, Bacteria, TSS, Metals, Velocity Flows/Flooding

Operational Support Available
N/A

Works Well with Other Strategies
N/A

Parking Lot Pervious Design Strategies

Description
Establishing design strategies that reduce surface area of parking lots and integrate runoff treatment practices help to reduce adverse impacts while satisfying parking demand. Examples include: Redesigning building and parking lot layouts for efficiency.

Parking lot pervious design. Photo not credited.

Number of spaces reflecting actual demand and designing additional 'spillover' parking areas to handle peak demand (incorporated with alternative paving techniques to increase infiltration).

Converting parking lot islands to bio-retention areas.

Disconnecting impervious areas with vegetated areas or other features

Incorporating functional landscaping and runoff treatment practices installation, such as infiltration basins, filter strips, dry swales, or detention practices.

Parking lots are efficient at concentrating and delivering pollutants to receiving waters, exacerbating erosion problems, and acting as a repository for pollutants like nutrients, trace metals, and hydrocarbons.

Cost
Capital- $1.64/ft2

Operation & Maintenance- $0.16/ft2

Parameter Treated
Nutrients, TSS, Oil & Grease

Operational Support Available
N/A

Works Well with Other Strategies
Permeable Pavement Options for Light Traffic Areas

Permeable Interlocking Segments

Porous/Pervious Pedestrian Walk-ways

Vegetative Filter Strips

Permeable Pavement Options for Light Traffic Areas

Description
Permeable pavement options that are sensitive to weight and traffic but are effective fit well into development strategies and can be utilized to retrofit urban walkways, small parking lots, and heavy foot-traffic areas.

Permeable Pavement Options include sub-strategies:

Permeable Interlocking Concrete Segments Porous/Pervious Pedestrian Walk-ways

Details
Some permeable pavement options will not function under heavy vehicle traffic.

Cost
Permeable Interlocking Concrete Segments = $5-10 ft2 (scale >15,000 ft2)

Porous/Pervious Pedestrian Walk-ways = $2-7 ft2 + base material

Parameter Treated
Nutrients, TSS, Metals

Operational Support Available
N/A

Works Well with Other Strategies
See sub-strategies listed above

Alleyways are integrated with walk-ways in Ft. Collins, CO. Photo by Russel + Mills Studios.

Sub-Strategy: Permeable Interlocking Concrete Segments

Description
A part of Permeable Pavement Options for Light Traffic Areas, Permeable Pavement Options for Light Traffic Areas, Permeable interlocking Concrete Pavements (PICP) are manufactured concrete units that reduce stormwater runoff volume, rate, and pollutants.

Details
Small openings between permeable joints are filled with highly permeable, small –sized aggregates. Joints between units allow stormwater to enter aggregates to provide storage and runoff treatment.

PICPs are attractive, easily repaired, require low maintenance, and can withstand heavier loads such as parking lots and driveways. PICP is different from grid pavements (i.e., concrete units with cells that typically contain topsoil and grass; see Figure 20) that infiltrate water but at rates lower than PICP.

Grid pavements are generally not designed with an open-graded, crushed stone base for water storage and are intended for intermittently trafficked areas such as overflow parking areas and emergency fire lanes.

Cost
$5-10 ft2 (scale >15,000 ft2)

Includes pavers, jointing, bedding mats, but not base & subbase

Comparison: ashphalt = $0.50-1.00 ft2

Parameter Treated
Nutrients, TSS, Metals

Operational Support Available
N/A

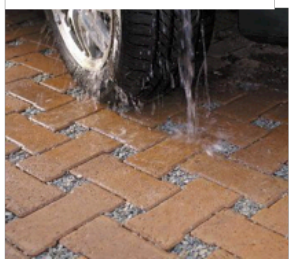
Works Well with Other Strategies
Permeable Pavement Options for Light Traffic Areas

Parking Lot Pervious Design Strategies

Porous/Pervious Pedestrian Walk-ways

Permeable interlocking concrete pavement driveway. Photo by Portland Cement Association.

Examples of grid pavements (above and below). Photo by SoilRetention.com and Toronto Home Improvement.



Sub-Strategy: Porous/Pervious Pedestrian Walkways

Description
A part of Permeable Pavement Options for Light Traffic Areas, Porous or Pervious Pavement is concrete with a high percentage of void space that allows rapid percolation of liquids through the pavement. Operating as an infiltration system, it consists of specially formulated mixtures of Portland cement, uniform graded coarse aggregate, potable water, and air entraining agents. Its purpose is to reduce volumes and peak rates of runoff associated with urban-type development which in turn reduces potentials for sewer overflows, downstream channel erosion, and subsequent sediment pollution.

Permeable interlocking concrete pavement driveway. Photo by Portland Cement Association.

Details
Water quality is also improved by filtration and bacterial action. Ground water recharge is aided. Grid pavements serve the same purpose as pervious pavement by allowing water to percolate into the soil during rain events. Grid pavements are not designed for areas with high traffic volumes or heavy equipment, but are excellent for residential driveways and overflow parking areas not used on a daily basis.

Maintenance involves periodic vacuuming or jet-washing to remove sediment from pores.

Cost
$2-7 ft2 + base material Maintenance- Vacuum sweeping

Parameter Treated

Nutrients, TSS, Metals

Operational Support Available
N/A

Works Well with Other Strategies
Permeable Pavement Options for Light Traffic Areas Permeable Interlocking Segments

Parking Lot Pervious Design Strategies

Rainwater Harvesting Strategies

Description
Rainwater harvesting, capture, collection, or reuse used as water quantity management strategy that can also be used for water quality management. Harvested rainwater can be used (and reused) in the household and with lawn, garden, and landscape activities. Can be used to retrofit existing buildings or in new development as a Low-Impact Design Management Measure.

Details
Utilizing rainwater alleviates groundwater level impacts by storing water for later use during drier times.

Groundwater abundance and associated springflows are both directly related to surface water quality in the watershed.

Without pumps, drip irrigation can be used on household properties, reducing runoff amounts that can contribute nutrient loadings to streams.

Rainwater also maintains a lower pH value, maintaining a slight acidity absent of urban chlorine treatment, conditions that native plants prefer.

Cost
Generally $1/gallon
Range of $2,500-30,000 + 2% of cost for annual maintenance

Roof RO Structure (including rain gutters & downspouts) - $3.25/lin. ft.

Rain Barrel= $50-75 + $5/year for maintenance

Parameter Treated
Water Quantity, TSS

Operational Support Available
City/County Rainwater Harvesting Program

Works Well with Other Strategies

Low-Impact Design Management Measures Water Conservation Program for Water Providers

Special Groundwater Management Area (SGMA) with Limited Drawdown

Seven hundred gallon rain cistern for the Camp Aldersgate Commons Building, Little Rock, AR. Photo by M.Littrell, Wilcox Group Architects.

A rain barrel with sealed leaf/mosquito screen lid, spigot and connection to downspout. Photo by Lake County, IL Stormwater Mgmt. Commission.

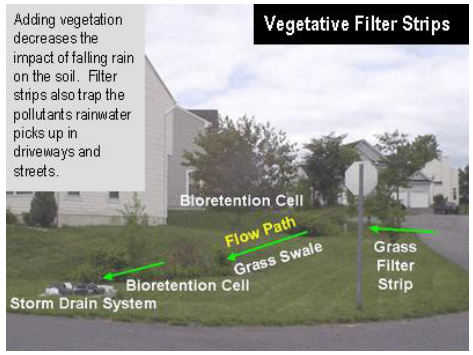
Vegetative Filter Strips

Description
"Vegetative filter strips are areas of land with vegetative cover that are designed to accept runoff as overland sheet flow from upstream development" (EPA, 2005). Vegetative cover encourages sediment settling and pollution removal.

Details
Vegetated filter strips are more appropriate for overland sheet flow (water that flows across a graded or uniformly sloping landscape) and are not as productive at filtering concentrated flows. Can be used as pre-treatment practices before water flows enter infiltration basins or trenches. Should be used on smaller areas: as runoff flows over the ground surface, flow concentrates to form rivulets, moving too rapidly to be effectively treated by filter strips. Slopes between 2 - 6% are suggested, they should not remain wet, and should not be used on soils with high clay content, which constricts infiltration for proper treatment.

Strips should be at least 25 ft. in length and should be designed with a pervious berm at the toe of the slope. Native perennial grasses should be used for vegetation.

Urban Vegetative Filter Strip. Photo by Center for Neighborhood Technology.



Vegetative Filter Strip. Photo by EPA

Cost
Average - $7/lin. ft. seed, $22/lin. ft. sod

$13,000 - 30,000/acre - $0.30/ft2 seed, $0.70/ft2 sod

($3.20 - $7.41/m2)

Maintenance - $350/acre/year

Native Filter Strip by EQIP - $255/ac

Parameter Treated
Nutrients, TSS

Operational Support Available
Texas Environmental Quality Incentives Program (EQIP) - NRCS

Water Quality Management Plan (WQMP) - TSSWCB

Works Well with Other Strategies
Low-Impact Design Management Measures

IV. NON-DOMESTIC ANIMAL/WILDLIFE MANAGEMENT MEASURES

Urban Wildlife Management – Deer

Description
Wildlife management for deer through Habitat Management (nutrition) and Population Management (age, genetics, population control) play a key role in managing deer herd health. Quality habitat provides a healthy nutritional foundation and South Texas produces quality deer because of its incredible nutritional diversity.

Details
Local biologists can assist with a census as well as with building a management strategy for an urban area.

"Healthy habitat provides the ground work for good nutrition, cover from predators and hunters alike, and protection from the hot south Texas summers" (TPWD, 2012).


Urban deer. Photo by the Durango Home Team.

Supplemental feeding to increase densities above carrying capacity is strongly discouraged. Likewise, clearing too much brush, removing desirable species, disturbing saline soils, and spraying for weeds may have detrimental effects to the quality of local deer herds.

Although selective harvesting is an effective population management tool, greater success and management options can be made through quality habitat efforts. Managing buck:doe ratios, fawn production, deer densities, and age structure are used alongside selective harvesting.

Cost
Cost of Census + consequent solutions

Parameter Treated
Nutrients, Bacteria

Operational Support Available
Texas Parks and Wildlife Field Biologists

Works Well with Other Strategies
Habitat Conservation Areas

Habitat Conservation Areas

See Urban & Stormwater Management Measures

V. SEDIMENT MANAGEMENT MEASURES

Riparian Buffer. Photo by NRCS.

Riparian Buffer

Description
Riparian buffers are areas of vegetation adjacent to water bodies that are installed and managed to maintain stream channel and shoreline integrity. Buffers reduce upland sources of pollution through entrapment and filtering activities. Buffers also help to absorb flood pulses and stabilize streambanks while providing habitat for aquatic species.

Details
Losses of riparian areas affect shoreline integrity, resulting in physically and chemically degraded streams and undermining development values.

Degraded riparian areas can lead to increased flooding, decreased aquatic life, and even soil and land loss.

Steps can be taken to preserve or enhance existing buffers; for example, delineating buffer boundaries and establishing management zones within the buffer or buffer performance augmentation through pre-flow integration.

Cost
EQIP Average- $130,000/river mile ($64,000-$350,000 range), or $70-170/acre

Parameter Treated
Nutrients, Bacteria, TSS, Oil & Grease, Velocity Flows/Flooding

Operational Support Available
Texas Environmental Quality Incentives Program (EQIP) - NRCS

Works Well with Other Strategies
Habitat Conservation Areas - rural

Alternative Brush Control - Prescribed Burns

Description
Prescribed burning is the application of fire to wildland fuel (grass & brush) under confined and controlled conditions. Using controlled burns as an alternative method of brush control is an effective technique to clear brush without destroying grass and brush root systems. When plants are living, these root systems keep fine sediments and topsoil in place. Using fire to clear brush and grass not only leaves those roots in place but contributes layers of ash and charred remains to act as aggregates and fertilizer.

Details
Native grasses and their root systems have evolved to survive wildfires in Texas; often this practice does not kill grass but rejuvenates growth.

Sediment, ash, charred remains, and leaf litter remain to help build soil and diminish sediment loss.

Prescribed burning diminishes destruction from wildfire and mimics natural processes.

Cost
$15-25/acre (excluding labor)

Parameter Treated
TSS

Operational Support Available
Texas Wildlife Association (TWA)

The Nature Conservancy (TNC)

Texas Forest Service (TFS)

NRCS

Texas AgriLife Extension Service (TAMU)

Works Well with Other Strategies
Grazing Management Strategies

Prescribed burn in Texas. Photo by The Nature Conservancy.

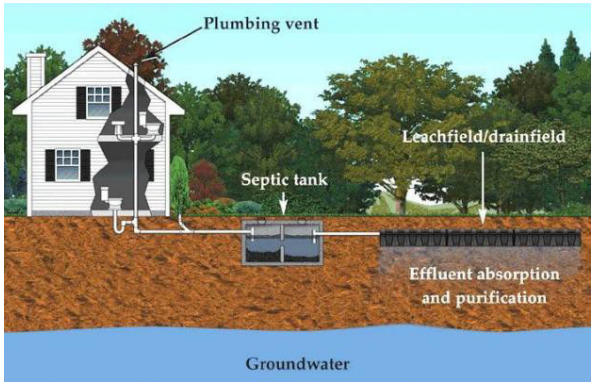
New growth after fire. Photo by Mary Ann Melton.

Erosion/Sediment Control Management Measures

This management measure is intended to be applied by States to activities that cause erosion on agricultural land and on land that is converted from other land uses to agricultural lands.

Application of this management measure will reduce the mass load of sediment reaching a body of water and improve water quality. The measure can be implemented by using one of two different strategies or a combination of both.

- Implement practices on the field that would prevent erosion and the transport of sediment from the field. Practices that could be used to accomplish this are conservation tillage, contour strip-cropping, terraces, and critical area planting.
- Route runoff from fields through practices that remove sediment. Practices that could be used to accomplish this are filter strips, field borders, grade stabilization structures, sediment retention ponds, water and sediment control basins, and terraces. Site conditions will dictate the appropriate combination of practices for any given situation.



Traditional septic system. Photo by Locally Grown Northfield, MN.

Resources

EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters

VI. WASTEWATER MANAGEMENT MEASURES

Septic Maintenance Program

Description
Septic Maintenance is an integral part of compliance and long-term functionality for on- site sewage facilities (OSSFs). New landowners lacking experience with OSSFs and lots with OSSFs of undocumented age may experience problems and be unaware of appropriate solutions. A basin-wide education and training program can be coupled with system assessments along-side inspections.

Details
A Septic Maintenance Program can help OSSF owners comply with regulations while bringing county and city records for exempt OSSFs up to date.

Results include improved water quality, improved system functionality, lower long-term maintenance costs, and planning & education opportunities for landowners.

Cost
Additional Septic Systems Inspection/Enforcement Employment - $50,000/year

Septic System Repair - $5,000/system

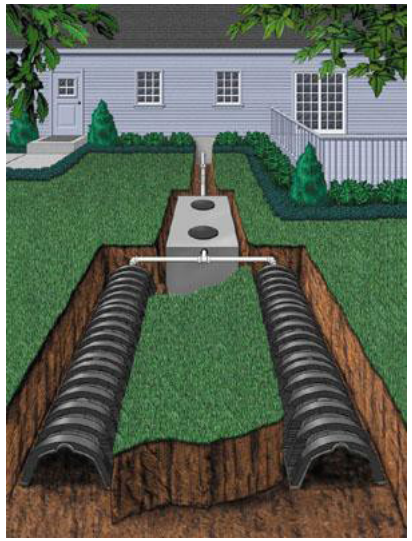
Parameter Treated
Nutrients, Bacteria

Operational Support Available
N/A

Works Well with Other Strategies
Septic Replacement Program

High-Performance Biofiltration Septic Alternative

Waste Water Treatment Plant



Traditional septic system. Photo by Genderationy.com.

Septic Replacement Program

Description
When maintenance cannot solve a septic or OSSF problem, the system might need to be replaced. A Septic Replacement Program can incentivize system owners to help pay for the cost while supporting local and county efforts to bring systems and waterways into compliance.

Details
A replacement program off-sets replacement costs while benefiting waterways as well as city, county, and local environmental health.

Assessment, guidelines, and resources (including alternatives) need to be coupled with funding and regulatory hurdles.

Cost
$3,500/5,500 - 10,000 per system

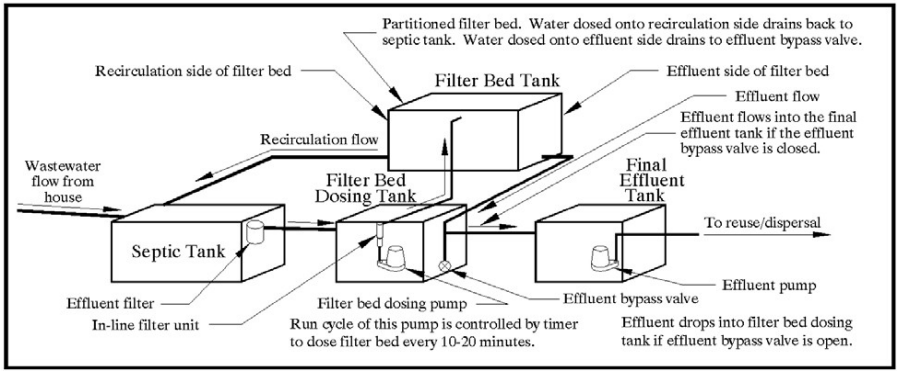
Parameter Treated
Nutrients, Bacteria

Operational Support Available
N/A

Works Well with Other Strategies
Septic Maintenance Program

High-Performance Biofiltration

Septic Alternative Waste Water Treatment Plant



High Performance Biofiltration Design engineered for the Hill Country. Photo by David Venhuizen, P.E.

High-Performance Biofiltration Septic Alternative

Description
Developed by a local Hill Country OSSF engineer, the High-Performance Biofiltration OSSF design maximizes efficiency of biofiltration processes and minimizes routine maintenance needs. This integrated system is resistant to shock loads, variable loadings, and uses water- saving small-scale treatment processes (such as drop-in-hole) that have been specially engineered for the rocky Hill Country terrain.

Details
Higher buy-in and installation costs combined with higher operational efficiency and lower maintenance costs make this system a customized long-term solution to Hill Country septic issues.

System uses a phased dosing-scheme, biologically active sand filtration, and re-circulated flows to efficiently treat and steadily distribute variable wastewater inputs.

Rainwater systems can be worked into the design.

Cost
$7500-9000 for comprehensive package

Parameter Treated
Nutrients, Bacteria

Operational Support Available
Venhuizen Wastewater- David Venhuizen, P.E.

Works Well with Other Strategies
Septic Maintenance Program

Septic Replacement Program Waste Water Treatment

Parking Lot Impervious Design Strategies can help reduce runoff as an element of Low-Impact Design. Photo by EPA.

VII. LOW-IMPACT DEVELOPMENT MANAGEMENT MEASURES

Low-Impact Development (LID)

Description
Low-Impact Development is a land-planning design approach that aims to preserve natural hydrologic regimes through innovative development while satisfying drainage and flood requirements. LID encompasses multiple design practices, focusing on new development and later shifts focus on existing developed areas to find opportunities for retrofitting (Pitzer, 2011). A LID strategy is basically a suite of development strategies such as Rain Gardens or Dry Ponds that help guide new development and retrofit existing development to reach the development goals of an area.

Effects of LID include:
Reduced flooding and erosion associated with urban runoff

Reduced 'heat island' effect

Enhance property values

Reduce costs of municipal stormwater infrastructure

Details
LID strategies help developers work with a community to achieve impact goals.

Cost
Varied

Parameter Treated
Water Quantity, Nutrients, Bacteria, Metals, TSS, Oil & Grease, Velocity Flow/Flooding

Operational Support Available
N/A

Works Well with Other Strategies
See listed LID Management Measures below.

Biofiltration/Rain Garden

See Urban & Stormwater Management Measures

Dry Detention Pond

See Urban & Stormwater Management Measures

Parking Lot Impervious Design Strategies

See Urban & Stormwater Management Measures

Permeable Pavement Options for Light Traffic Areas

See Urban & Stormwater Management Measures

- ### Sub-Strategy: Permeable Interlocking Segments

  See Urban & Stormwater Management Measures

- ### Sub-Strategy: Porous/Pervious Pedestrian Walk-ways

  See Urban & Stormwater Management Measures

Rainwater Harvesting Strategies

See Urban & Stormwater Management Measures

Vegetative Filter Strip

See Urban & Stormwater Management Measures

LID Sedimentation Measures

Description
Various physical installations and techniques can be used to reduce sedimentation problems in waterways. When utilized as a LID strategy, sedimentation measures can be required in new development processes as well as re-development or retrofitting efforts.

LID Sedimentation Measures include sub-strategies (see following pages):

- Groundcover Establishment
- Erosion Control Fabric
- Wattles
- Landscape Mulching
- Straw Bale Barriers

Jute erosion control fabric is coupled with straw wattles to minimize sedimentation. Photo by US Silt & Site Supply.

Details
Costs associated with sedimentation measures can increase overall development costs as well. Benefits include diminished flooding effects in waterways, increased aquatic biodiversity, increased property values, and increased riparian aesthetics after development is completed.

Cost
See sub-strategies listed above.

Parameter Treated
TSS

Operational Support Available
Cities and County

Works Well with Other Strategies
See sub-strategies listed abov

Sub-Strategy: Groundcover Establishment

A part of LID Sedimentation Measures.

See Urban & Stormwater Management Measures

Sub-Strategy: Erosion Control Fabric

Description
A part of LID Sedimentation Measures, Erosion control fabrics address surface erosion by keeping soils in place that have been removed of vegetation. Erosion control fabrics prevent slope erosion, minimize stream channel scouring, and help stabilize shorelines until vegetation can be established.

Details
Photo- or Biodegradable fabrics can be left on the ground while synthetic fabrics that need to be removed can disturb new vegetation growth.

Continuous contact with soil is necessary and can be achieved on rocky soils with landscaping staples or biodegradable stakes (corn-based or wood). Native vegetation seeds can be sewn underneath fabric. Care should be taken to minimize wildlife entanglement.

Cost
$35/880 ft2 (4'x220' roll) or $0.04/ft2

Price does not include labor.

Parameter Treated
TSS

Operational Support Available
Cities and County

Works Well with Other Strategies
LID Management Measures

Groundcover Establishment

Wattles

Landscape Mulching

Straw Bale Barrier

Rice straw wattle with storm drain inlet protector. Photo by EARTHSAVERS.

Sub-Strategy: Wattles

Description
A part of LID Sedimentation Measures, wattles are tubes of straw, jute, or coir used for erosion, sediment, and stormwater runoff control. Wattles help stabilize soil on slopes during development and construction by slowing, spreading, and filtering overland water flow. Sheet erosion and rill and gully development are diminished and seeds carried with flows are collected, encouraging native vegetation development.

Details
Wattles are available in different lengths with photo-degradable plastic netting or burlap casing.

Cost
$27 for 20”x10’ (straw)

$17 for 12”x10’ (straw)

$26 for 9”x25’ (straw)

Price does not include labor

Parameter Treated
TSS

Operational Support Available
Cities and County

Works Well with Other Strategies
LID Management Measures Groundcover Establishment

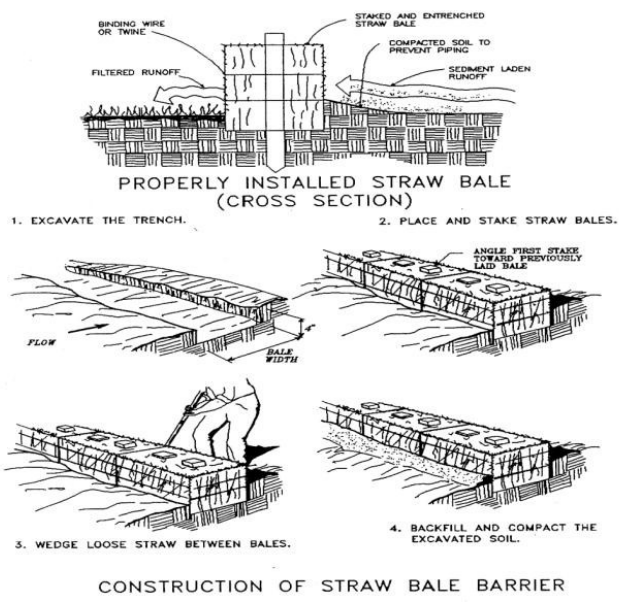
Erosion Control

Fabric Landscape

Mulching

Straw Bale Barriers

Straw Bale Barrier. Photo not credited.



Construction of Straw Bale Barrier. Photo by NRCS.

Sub-Strategy: Landscape Mulching

A part of LID Sedimentation Measures.

See Urban & Stormwater Management Measures

Sub-Strategy: Straw Bale Barriers

Description
A part of LID Sedimentation Measures, straw bale barriers use the placement of anchored straw bales end-to-end in a shallow trench to intercept sediment-laden runoff.

Details
Straw bale barriers are temporary; they tend to decompose and require staking to anchor their placement.Can be labor and maintenance intensive. May introduce non-native vegetation to an area, but conversely can be inoculated with native seeds or mycelium.

Cost
$17/lin. ft.

Parameter Treated
TSS

Operational Support Available
Cities and County

Works Well with Other Strategies
LID Management Measures

Groundcover Establishment

Erosion Control

Fabric Landscape Mulching

Wattles

VIII. LAND MANAGEMENT CONTROLS AND ORDINANCES

Regulatory controls

Examples include zoning ordinances and subdivision controls, construction and operating standards, and health regulations, such as storage tank and septic tank requirements, and permitting or inspections.

Land use controls

Land uses that pose risks to source water can be controlled or moved from sensitive areas. Local government officials can use subdivision and growth controls to reduce population density, or zoning ordinances to prohibit or restrict certain activities in SWPAs.

By acquiring the rights to development on parcels of land through purchase or donation of the land, local government officials have complete control over the activities in critical areas.

The high cost of purchasing property or development rights makes this impractical for many communities. Some States have grants for acquiring environmentally sensitive lands and non-profit organizations such as local or regional land trusts can assist communities by acquiring land within SWPAs. The American Farmland Trust and the Nature Conservancy are examples of non-profit organizations that focus on protection of water resources through land acquisition. USDA's Conservation Reserve Program also manages a program to obtain easements on environmentally sensitive land.

Often, the greatest consideration in passing regulatory land use controls is the political acceptability of limiting certain activities. However, most people consider passing zoning ordinances to be the right and responsibility of local governments, and public education about the importance of protecting water supplies can increase the acceptance of land use controls.

Subdivision growth controls

As the nation's population increases, sprawl and the proliferation of homes, businesses, and associated activities such as pesticide and fertilizer use, and septic systems, can threaten drinking water supplies.

Subdivision regulations govern the process by which individual lots of land are created out of larger tracts. Subdivision regulations are intended to ensure that subdivisions are appropriately related to their surroundings. General site design standards, such as preservation of environmentally sensitive areas, are one example of subdivision regulations.

Ways in which subdivision requirements can protect water supplies include:

- Ensure that septic systems and stormwater infiltration structures do not contaminate ground water; Manage drainage (e.g., using erosion controls) to ensure that runoff does not become excessive as the area of paved surfaces increases and to provide recharge to aquifers.

Zoning

Zoning is the division of a municipality or county into districts for the purpose of regulating land use. Communities traditionally use zoning to separate potentially conflicting land uses from one another. Examples of how zoning can be used to protect drinking water sources include requirements that limit impervious surfaces, encourage open space, locate high risk activities away form drinking water sources, or encourage cluster development to reduce runoff. For example, Brunswick, Maine, adopted a threshold that no more than 5 percent of a site to be developed in its Coastal Protection Zone may be impervious area.

Zoning is an effective regulatory tool for preventing threats to water sources from new development, and zoning ordinances are usually well-accepted as the prerogative of local governments. Unfortunately, zoning is of limited use in addressing threats from existing land uses, because they are "grandfathered" (i.e., exempt from new zoning requirements) when zoning laws take effect. Zoning ordinances may be difficult to pass where citizens want to encourage growth and economic development.

Rain sensor. Photo by Practically Green.

Land Purchase & Acquisition of Development Rights

The best way to control activities within sensitive areas is to purchase land and/or development rights to that land. Communities may purchase land outright or obtain conservation easements, which are voluntary arrangements preventing a landowner from performing certain activities or prohibiting certain kinds or densities of development. The easements become attached to the deed for the property, and remain in effect when it is sold or transferred. Restrictions in the deed make it clear that the land cannot be developed based on the rights that have been purchased.

The primary disadvantage to purchasing property or development rights is the high cost, so it is impractical for many communities. Land trusts or conservancies can purchase land outright, or be recipients of conservation easements or land donations. Land owners can also gain tax benefits from donating their land for environmental protection. Some States offer grants or loans to communities for acquiring environmentally sensitive lands. Certain non-profit organizations such as local or regional land trusts, can assist communities by acquiring land.

Land Use Prohibitions

Hazardous chemicals that are caustic, toxic, or volatile can endanger public health or water supplies. Authorities can opt to prohibit or limit the storage or use of large supplies of dangerous substances in sensitive areas.

Land use prohibitions can be very effective ways to remove potential contamination sources from water supply areas. Because they are very restrictive, local government officials should use hydrologic studies to verify their necessity. If potentially threatening land uses already exist in the area, a phased-in approach may be more acceptable. For example, a ban on underground storage tanks could ban new USTs immediately, and phase out existing tanks as their service lives expire by requiring replacement tanks to be above ground.

Land use prohibitions can be aimed at controlling either activities that use dangerous substances (source-specific standards) or the materials themselves (contaminant-specific standards).

Examples of source-specific standards include: o Prohibiting gas stations in sensitive areas, or requiring double-hulled or corrosion-resistant design of underground storage tanks. Septic system requirements, such as minimum setbacks from surface water or separations from the water table, or mandatory maintenance and inspections schedules.

Contaminant-specific standards may prohibit the use of heavy metals, petroleum products, solvents, or radioactive materials in source water protection areas. Regulations on the application of pesticides, fertilizer, manure, and sludge are also examples of contaminant-specific standards.

Rainwater Sensor Ordinance

Description
Rainwater sensors turn home and business automatic irrigation systems on and off, minimizing water waste. Rain sensors detect rainfall when it occurs and can be wired or wireless. Rainwater sensors have proven to be a cost- effective strategy to make landscape watering more efficient.

Details
High-end sensors can be cost prohibitive; an ordinance should be coupled with an incentive program.

Cost
$13-200, depending on level of technology

Parameter Treated
Water Quantity

Operational Support Available
N/A

Works Well with Other Strategies
Water Conservation Program for Water Providers

Rainwater Harvesting Strategies

Lawn, Garden, and Landscape Strategies

Wellhead Protection Areas/Groundwater Recharge Feature Protection

> "To establish wellhead protection programs, communities delineate vulnerable areas and identify sources of contamination. Through regulatory or non-regulatory controls, local officials and volunteers manage contamination sources and protect their water supply, as well as plan for contamination incidents or other water supply emergencies."

Non-regulatory Controls

Examples include purchase of property or development rights, encouraging the use of best management practices, public education, household hazardous waste collection programs, and economic incentives such as agricultural cost-share programs.

A combination of these methods is usually necessary for an effective management plan. In addition, the same end can usually be achieved through different means. For example, setbacks can be achieved through permits or local ordinances. The range of feasible tools will depend on the local authority to regulate land uses, and the nature of the contamination threats.

To see how communities are combining protection measures to protect their drinking water supplies, go to EPA's compilation of local case studies in source water protection. The local contacts listed at the end of each case study should be able to provide you with some tips on how to put together your own protection plan.

Resources
EPA Source Water Protection Case Studies

Special Groundwater Management Area or Zone

Description
The formation of a Special Groundwater Management Area or Zone (SGMA/Z) would allow groundwater within the watershed to be managed within more sensitive parameters than Groundwater Management Area (GMA) Desired Future Condition (DFC).

Details
If deemed a valid activity, investigation into legal, political and funding issues to form a SGMA/Z could be initiated by stakeholders in partnership with the residing groundwater authority and Groundwater Conservation District.

Cost
N/A

Parameter Treated
Water Quantity

Operational Support Available
Groundwater Conservation District

Local, regional, and state organizations, agencies, and stakeholders

Works Well with Other Strategies
Watershed Coordinator

Water Conservation Program for Water Providers

Description

A regionally customized Water Conservation Program for water providers within the basin should be established to not only conserve water but to help meet the community half-way on conservation efforts. Unique water problems and ongoing efforts are specific to the Hill Country area. A publicly-available and regional water conservation program should include:

- Supply side measures, Leak audit efforts, Public involvement in local and county water conservation strategies, details
- Supportive presence at local events, charities, and water conservation coordination efforts, Publicly-available increased drought contingency plan, and Publicly-available funding strategies for measures listed above.
- A Water Conservation Program for Water Providers regionally customized creates goodwill, shows matching effort to solve regional water problems on behalf of the provider, and shows fiscal and resource management responsibility.

Incentives for water retrofits can be offered in a conservation program. Photo by Brampton.

Cost
Costs are variable

Parameter Treated
Water Quantity

Operational Support Available
N/A

Works Well with Other Strategies
Water Conservation Pricing Strategies

Watershed Coordinator

Water Conservation Pricing Strategies

Description
Conservation pricing strategies utilize price signals as incentive for reducing water consumption. These strategies promote economically-efficient water use by individual consumers: incremental pricing structures and water meters increase conservation behavior. Tiered-pricing structures or increasing block rates can decrease overall water consumption without decreasing revenues if implemented properly.

Details
Tiered-pricing structures can set incremental prices sufficiently high to offset possible financial losses realized from lower water-use level prices that are set below average cost.

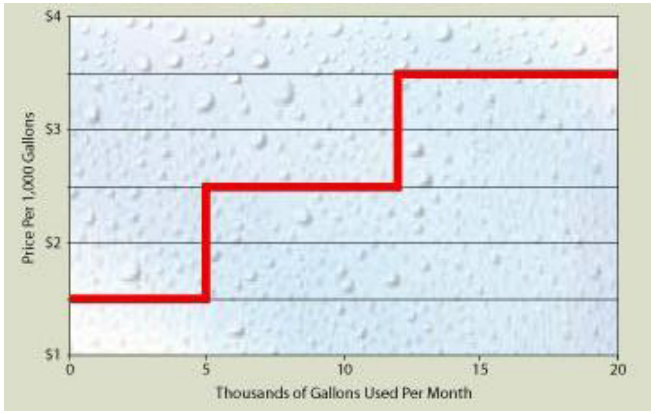
Cost
Cost of water supplier staff allocation

Parameter Treated
Water Quantity

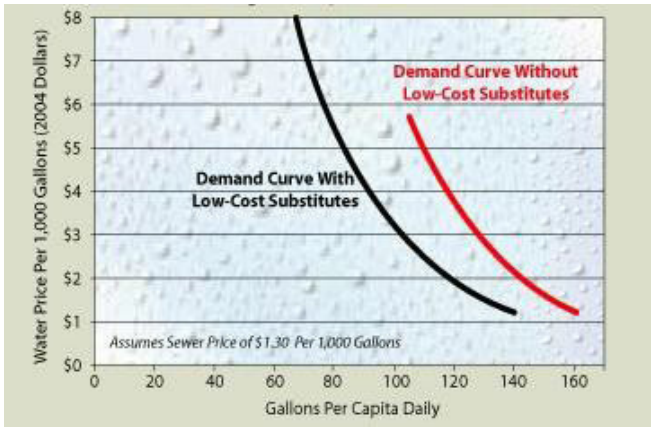
Operational Support Available
N/A

Works Well with Other Strategies
Water Conservation Program for Water Providers

Watershed Coordinator



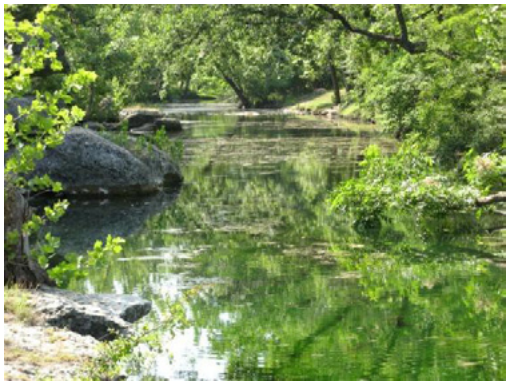
Block rate structure. Photo by Southwest Florida Water Management District.



Impact of changes in water pricing. Photo by Southwest Florida Water Management District.

Watershed Coordinator

Description
A Watershed Coordinator position is necessary to direct implementation of the Watershed Protection Plan as well as to secure funding and coordinate education and outreach efforts. Monitoring efforts will need to be coordinated to analyze conservation strategy effectiveness and to ensure water quality compliance within the basin.



Details
Coordinator will need knowledge and experience in project administration and tracking, watershed assessments, water quality monitoring and/or modeling, watershed protection management practices, obtainment and management of grant funding, stakeholder facilitation, public outreach, information dissemination (web, newspapers, radio, events) and volunteer coordination.

Skills in working with local, state, and federal agencies, organizations, technical writing, and experience in leadership are a requirement.

Cost
$60,000/year including benefits.

Parameter Treated
All

Operational Support Available
TSSWBC

Texas Commission on Environmental Quality (TCEQ)

EPA

Texas Water Development Board (TWDB)

Meadows Center for Water and the Environment

State, local, and municipal governments

Works Well with Other Strategies
Water Conservation Program for Water Providers Water Conservation Pricing Strategies

IX. WATER USE MANAGEMENT

1. Develop site-specific management prescriptions for the following practices, as appropriate:

- Encourage reuse of water, to the extent practicable, to minimize withdrawals from surface water or groundwater sources.
- Determine the water quality, water quantity, flow regimes, and water levels necessary to maintain land management plan desired conditions, goals, and objectives, including applicable water quality standards for waterbodies and aquatic and groundwater-dependent ecosystems that are affected by the proposed project.
    - Specify a range of flows and levels to support desired uses and values
- Consider the water needs for physical stream processes, water quality, aquatic biota and their habitat, riparian habitat and communities, aesthetic and recreational values, and special designations such as Federal and State wild or scenic rivers.
- Locate water production wells on high or well-drained ground at a sufficient distance away from potential contamination sources to avoid or minimize contamination.
- Locate monitoring wells according to a monitoring plan to minimize the number of wells needed to achieve monitoring objectives.
- Construct and complete wells consistent with applicable Federal and State regulations.
    - Use licensed well drilling contractors.
    - Use suitable measures to avoid or minimize well contamination, inter-aquifer exchange of water, floodwaters from contaminating the aquifer, and infiltration of surface water.
- Operate wells in such a manner as to avoid excessive withdrawals, maintain suitable groundwater levels, and minimize effects to groundwater-dependent ecosystems.
- Permanently seal abandoned wells consistent with applicable Federal, State, and local regulations and requirements.
    - Use licensed well drilling contractors.
    - Use suitable measures to avoid or minimize contaminating the aquifer or surface waters and interaquifer exchange and mixing of water.
    - Use suitable measures to preserve hydrogeologic conditions of the ground and aquifers.

2. Design, construct, maintain, and monitor permanent waters sources:

- Locate water source developments, including access roads, in such a manner as to avoid or minimize disturbance to the riparian area and streambanks and erosion and sedimentation to the extent practicable.
    - Draft from existing roads and bridges to the extent practicable to avoid creating new access roads.

    - Use existing hardened facilities, such as boat launches and campground access roads, for emergency or other short-term uses rather than native surface areas prone to erosion.
    - Locate facilities to minimize potential damage from streamflows.
    - Locate permanent storage tanks, dry hydrants, and standpipes outside of the riparian zone to the extent practicable.
    - Locate off-channel ponds in areas where they will not be inundated with sediment at high flows.
    - Locate ponds or storage tanks as close to the major water use as practicable when water must be conveyed for use at a distance from the source
- Design source developments, including access roads, in such a manner as to avoid or minimize disturbance to the riparian area and streambanks and to avoid or minimize erosion, sediment, and other pollutants to the extent practicable.
    - Design permanent facilities to maintain long-term stream function and processes.
    - Limit the size of the facility development footprint (area of bare soil with reduced infiltration capacity) to the minimum necessary for efficient operations to the extent practicable.
    - Design facility to minimize hydrologic connectivity with the waterbody to the extent practicable by providing a suitable vegetated filter strip, and designing access road slope and length, or using other suitable measures, to direct flow away from the waterbody
- Locate water trough, tank, or pond at a suitable distance from springs to avoid or minimize adverse effects to the spring and wetland vegetation from livestock trampling or vehicle access.
- Locate spring box to allow water to flow by gravity from the spring to the spring box to eliminate disturbance from pumps and auxiliary equipment.
- Design the collection system to avoid, minimize, or mitigate adverse effects to the spring development and downstream waters from excessive water withdrawal, freezing, flooding, sedimentation, contamination, vehicular traffic, and livestock as needed
    - Ensure that enough water remains in the spring to support the source groundwater dependent ecosystem and downstream aquatic ecosystems.
    - Avoid or minimize sediment or bacteria from entering the water supply system.
    - Trap and remove sediment that does enter the system.
    - Intercept the spring flow below the ground surface upslope of where the water surfaces.
    - Size the spring box sufficient to store expected volume of sediment generated between maintenance intervals and enough water for efficient operation of the system, and to provide access for maintenance and cleaning.
    - Avoid or minimize backing up of spring flow by providing overflow relief sized to carry the maximum flow expected from the spring

during periods of wet weather.

- Use suitable measures to avoid or minimize erosion at the overflow outlet.
- Maintain fish and wildlife access to water released below the spring development to the extent practicable

- Locate water conveyance structures in stable areas where they are not susceptible to damage from side drainage flooding.
- Design diversion and conveyance structures to efficiently capture and carry design flows in such a manner as to avoid or minimize erosion of streambanks, ditches, and adjacent areas.
    - Design intake and outflow structures to minimize streambank and streambed damage and minimize disruption of desired aquatic organism movement.
    - Design water conveyance structure to have sufficient capacity to carry the design volume of water with appropriate freeboard to avoid or minimize damage or overtopping.
    - Consider velocity of the water, horizontal and vertical alignment of the ditch or canal, amount of stormwater that may be intercepted, and change in water surface elevation at any control structures when determining appropriate freeboard needed.
    - Use suitable measures in the design to control velocity and slope to avoid or minimize erosion of the ditch.
    - Use suitable measures in the design to minimize water loss to evaporation and leakage.
    - Mitigate water imports and water disposal (including reservoir releases) so that the extent of stable banks, channel pattern, profile and dimensions are maintained in each receiving stream reach to meet applicable instream water quality standards.
    - Construct or install structures such as inlets, outlets, turnouts, checks, and crossings in such a manner as to maintain the capacity or freeboard of the ditch and the effectiveness of any lining or other channel stabilization measure.
    - Use suitable measures at outlets to avoid or minimize erosion downstream of the structure when design flows are released.
    - Use suitable measures on inlet structures to avoid or minimize debris entering the water conveyance structure
- Operate and maintain diversion and conveyance structures in such a manner as to avoid, minimize, or mitigate adverse effects to soil, water quality, and riparian resources from failures.
    - Limit operation of the diversion and conveyances to the established period of use.
    - Regularly inspect diversion and conveyance structures at suitable intervals to identify maintenance needs and situations that could lead to future overtopping or failures.
    - Do not flush or otherwise move sediment from behind diversion structures downstream.
    - Deposit and stabilize sediment removed from behind a diversion structure in a suitable designated upland site.

- Maintain suitable vegetative cover near canal and ditch banks to stabilize bare soils and minimize erosion. q Harden or reroute breach-prone segments of ditches to minimize potential for failure and erosion of fill slopes.
- Maintain and operate water conveyance structures to carry their design volumes of water with appropriate freeboard.
- Keep water conveyance structures clear of vegetation, debris and other obstructions to minimize potential for failures.
- Use applicable Chemical Use Activities when using chemicals to treat vegetation as a part of water conveyance structure maintenance.

3. Dams and impoundments

- Select a design and location such that the benefits of the dam are maximized and the disturbances to the environment or hazards to downstream inhabitants are minimized.
- Decommission dams and impoundments that are no longer needed
    - Remove or otherwise mitigate the sediment stored behind the impoundment before dismantling the structure.
        - Drain the impoundment before removing structures to avoid downstream flooding and channel erosion
        - Drain the impoundment slowly to minimize release of sediment downstream, allow bed of impoundment and stream to drain and stabilize, and avoid a sudden release of water that could unnecessarily damage downstream infrastructure or habitat. q Consider drawing down the impoundment during a time when exposed sediments would have an opportunity to stabilize and revegetate before structural removal of the dam.
- Stabilize or relocate affected floodplain and instream infrastructure as needed to avoid, minimize, or mitigate adverse effects

Resources

Committee on Riparian Zone Functioning and Strategies for Management, Water Science and Technology Board, National Research Council: Riparian areas: functions and strategies for management

EPA National management measures to control nonpoint source pollution from hydromodification

Jennings, G.D. 1996. Protecting water supply springs. Pub. No. AG 473-15. Raleigh, NC: North Carolina State University, Cooperative Extension Service. Available at http://www.ces.ncsu.edu/ Publications/environment.php.

Oregon Watershed Enhancement Board: Small dam removal in Oregon

USDA Forest Service, Pacific Northwest Research Station: Riparian and aquatic habitats of the Pacific Northwest and southeast Alaska: ecology, management history and potential management strategies

USDA Forest Service, Minerals and Geology Management Technical guide to managing groundwater resources

USDA Forest Service, Technology and Development Program: Water-source toolkit

USDA NRCS: Resources for Water Uses Management Activities.

Verry, E.S.; Hornbeck, J.W.; Dolloff, C.A., eds. 2000. Riparian management in forests of the continental Eastern United States. ISBN: 9781566705011. Boca Raton, FL: Lewis Publishers CRC Press. 432 p.

X. MANAGING VEGETATION AND INVASIVES

Removing and preventing the spread of invasive vegetation and other unwanted weeds in both urban and rural areas of the watershed can conserve significant amounts of water.

- To reduce the potential for the introduction of noxious weeds, clean off all lawn, farm and construction equipment after mowing, etc.
- Ensure all seed, hay, straw, mulch, or other vegetation material transported and used for site stability, rehabilitation, or project facilitation is free of noxious weeds and noxious weed seed as certified by a qualified federal, state, or county officer.
- When managing weeds, carefully consider the impacts of the treatment on such species. Whenever possible, hand spraying of herbicides is preferred over other methods.
- Consider nozzle type, nozzle size, boom pressure, and adjuvant use and take appropriate measures for each herbicide application project to reduce the chance of chemical drift.
- Disturbed areas resulting from any construction should be seeded, usually required during the fall or spring.
- Cuts and fills for new roads should be sloped to minimize erosion and to facilitate re-vegetation.
- Reclaimed or barren areas should be reseeded with native species will require a certified weed-free seed mix. Successful re-vegetation will usually require at least two growing seasons to ensure a self-sustaining stand of seeded species.
- Identified invasives in riparian areas and grazing lands should be removed using a comprehensive strategy (http://www.texasinvasives.org/professionals/management.php, https://extension.unh.edu/resources/files/Resource000988_Rep1135.pdf)
- Coordinate non-native plant removal with agencies that can offer support: NRCS, TSSWCB, TPWD and the Hill Country CISMA (http://www.texasinvasives.org/professionals/cwma.php)

XI. WATER AND RIPARIAN AREA MANAGEMENT

Properly functioning riparian areas provide clean water by filtering the pollutant load in runoff and restricting sediment from entering the stream or river. They also promote infiltration and recharge. Riparian areas allow flood waters to spread out horizontally past the channel, providing **temporary water detention and storage**.

The vegetation, debris, and porous soils of riparian areas absorb flood waters, as they slowly return to the main channel. This action can reduce the force, height, speed, and volume of floodwaters. Flood control by riparian areas can mitigate damage to downstream urban, suburban, agricultural lands, and irrigation structures.

Riparian vegetation can help **moderate water temperature** fluctuations and extremes. The riparian canopy of streams and rivers reduces the amount of solar radiation reaching the water's surface, allowing the water to remain a stable cool temperature. Increased temperatures decrease the oxygen-carrying capacity of streams and increase the rate at which nutrients become available to aquatic life.

Riparian vegetation protects the land against accelerated **erosion rates** by dissipating water energy. A deep, binding root mass holds soil in place, stabilizes stream banks and prevents excessive loss of adjacent soils. Stream banks that lack these deep roots are unstable and erode easily.

The riparian area essentially acts as a **filter** or sink, reducing the input of nutrients and sediment to surface waters from the surrounding watershed. Riparian vegetation physically traps nutrients, and the sediment to which they are attached, as it is transported via overland flow. The diverse vegetation of a riparian area can trap 80% to 90% of sediments transported by fields. Nutrient input to the stream is further reduced by the uptake of dissolved nutrients by plant roots in the shallow subsurface zone. It was found that riparian forests retained more than 65% of the nitrogen and 30% of the phosphorus contributed through overland and subsurface flow from surrounding agricultural lands. Furthermore, a study done in Maryland demonstrated that riparian areas removed more than three-quarters of the dissolved nitrate transported from croplands.

Naturally vegetated riparian areas enhance groundwater **recharge** by holding water long enough to allow it to percolate into the underlying soil. This helps maintain surface flows in rivers and streams and is vital to support late summer stream flows.

Protective measures include:

- Avoid locating roads, trails, and landings in wetlands, riparian areas.
- Locate, identify, and mark riparian management areas during design of projects that may cause adverse impacts to riparian management areas.
- Avoid equipment operation in areas of open water, seeps, and springs.
- Use low ground pressure equipment (flotation tires or tracked) as necessary to minimize rutting and compaction.
- Avoid the application of fire retardant or foam within 300 feet of a stream channel or waterway, when possible, except for the protection of life and property.
- Construct a containment barrier around all pumps and fuel containers utilized within 100 feet (30.5 meters) of a stream channel. The containment barrier would be sufficient size to contain all fuel being stored or used on site

- Limit stream crossings on travel routes and trails to the minimal number necessary to minimize sedimentation and compaction
- Conduct mixing of herbicides and rinsing of herbicide containers and spray equipment only in areas that are a safe distance from environmentally sensitive areas and points of entry to bodies of water (storm drains, irrigation ditches, streams, lakes, or wells).
- When used to pump water from any pond or stream, screen the intake end of the draft hose to prevent fish from being ingested. Screen opening would be a minimum of 3/16 inch (4.7 mm).

Factsheets:

- How to Protect Your Well Water
- Handling and Storing Pesticides
- Handling, Storing and Applying Fertilizers
- Handling and Storing Fuels
- Hazardous Waste
- Septic Systems
- Storing and Handling Livestock Manure

XII. EDUCATIONAL AND TECHNICAL ASSISTANCE

Similar efforts could be developed for landowners in the watershed:

Worksheets and Surveys

> "As the owner of a small acreage, water is important to many of your activities. If you have a private well, then you may use groundwater for drinking and other household needs, for watering your animals or irrigating your land. If you have water rights for surface water, then you are able to irrigate your pastures, gardens or lawn. If your land has running water, ponds or wetlands, you may use this water for your animals, for fishing and other recreation, or just for the aesthetic pleasures that water can bring. With these benefits comes the responsibility to protect the quality of this water. Protecting water quality not only benefits you and your family by preserving healthy drinking water and a healthy environment, but it also protects those water users downstream."

Complete **this short worksheet** to help identify activities on your property that may be contaminating your water."

"Risks to Your Water" Surveys and Fact Sheets

Surveys:
Risks to Your Well Water

Handling and Storing Pesticides

Handling, Storing, and Applying Fertilizers

Handling and Storing Fuels

Hazardous Waste

Septic Systems

Storing and Handling Livestock Manure

Managing Livestock Yards

Factsheets:
How to Protect Your Well Water

Handling and Storing Pesticides

Handling, Storing, and Applying Fertilizers

Handling and Storing Fuels

Hazardous Waste

Septic Systems

Storing and Handling Livestock Manure

Managing Livestock Yards

Simple tips on how you can be part of the solution to pollution.

Resources
Utah State University Extension: Risks to Your Water Worksheets and Surveys

Fact Sheets

New Hampshire Department of Environmental Services Environmental Fact Sheet

Groundwater Quantity Fact Sheets

Ontario Ministry of Agriculture, Food, and Rural Affairs: Managing the Quantity of Groundwater Supplies Fact Sheet

Model Ordinances

New Jersey Department of Environmental Protection Model Ordinances

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