STORMWATER RETROFIT RESILIENCY DESIGN GUIDE

Water Quality & Flood Mitigation

About This Guide

Stormwater retrofits are constructed in the existing urban environment to improve runoff quality and help mitigate flooding. Retrofits include new installations or upgrades to existing stormwater management measures where there is a lack of water quality treatment and/or management of flooding. These measures can target trash, sediment, nutrients, bacteria, or other concerns. Often, retrofits can be completed in tandem with other capital projects including roads, parks, and downtown revitalization efforts to achieve multiple benefits and manage cost. This document provides concise guidance on how to plan for, identify, locate, design, construct and maintain retrofit projects.

Retrofit Engineering: The Process

Retrofits are prioritized in areas of identified water quality problems or flood zones, then, multiple retrofit options can be evaluated to determine the most appropriate measures for the site, soil conditions, topography, existing infrastructure, and community goals. All retrofit sites are unique and no single solution fits all conditions. In the end, the final project should be attractive in appearance, satisfy the desired stormwater goals, and have minimal maintenance needs.

Retrofit Planning
Meeting with local government staff, reviewing water quality data and local drainage problems, obtaining maps and plans, considering community master plans, performing field reviews of potential sites, identifying stakeholders, defining if within a Watershed Protection Plan or Total Maximum Daily Load watershed(TMDL), and sketching potential retrofit concepts.

Water Quality/Flood Mitigation Assessment
Modeling the estimated water quality improvements and flood reduction benefits, estimating the stream/habitat benefits, evaluating potential water supply benefits, and considering other public benefits (streets, utilities, parks, etc.)

Retrofit Inventory & Evaluation
Refining conceptual designs, estimating construction and life-cycle costs, identifying potential funding sources/grants, and prioritizing top performing retrofit sites.

Design and Permitting
Performing field surveys, assessing potential cultural and environmental resources, defining soil conditions, obtaining local government guidance, preparing construction plans, sharing plans with stakeholders and obtaining input, finalizing funding sources, and coordinating with the regulatory agencies to obtain approvals.

Construction
Defining construction access, public outreach, initiating the contractor selection process, completing contracts, installing construction phase erosion controls, building the improvements, and revegetating the site.

Inspection & Maintenance
Performing periodic site inspections after major storm events, ensuring proper drainage and vegetation management, removing accumulated sediment and debris, operating a project database to track maintenance requirements, and hosting education outreach events.

Permeable Pavers

Wetland Basin

Retrofit Planning

The important first step is to develop an understanding of the local water quality challenges, drainage issues, and flooding problems.

Study Area Context	Conditions	Externalities
• Stakeholders • Jurisdictions (regulatory) • Adjacent land uses • Available land area • Land use and ownership • Other project opportunities • Community master plans • Watershed Protection Plan or TMDL	• Topography • Water quality data • Soils • Geotechnical (soil conditions) • Floodplains • Vegetation • Tidal influences • Wetlands	• Existing utilities • Public lands • Private property • Funding sources

The retrofit planning effort will target large parking lots, streets, urbanized areas and flood zones that lack stormwater management and are directly connected to rivers, creeks, and tidal waters

Water Quality and Floodplain Mitigation Assessment

To determine the potential benefits of a stormwater retrofit project, modeling and analysis is performed to define the potential reduction in pollution and/or management of flooding. The pollutants below come from single-family, multi-family, commercial, industrial, and highway systems.

Data Sources	Guiding Characteristics	Findings	
		Identify pollution sources	Quantity benefits
• Topographic maps • Aerial photography • GIS mapping (FEMA and others) • Impervious cover data • Land use plans • Water quality data • Pollution hotspots • Stakeholder input • Number of flooded structures • Road/bridge flooding	• Minimize retrofit footprint • Maximize pollutant reduction • Reduce peak runoff rates • Avoid groundwater interaction • Stable discharge to waterways • Minimize maintenance needs	• Impervious cover • Chemicals • Nutrients • Bacteria • Spills • Trash • Animal waste	• Pollution managed • Reduced flooding of homes, businesses, roads • Reduced water demands

Retrofit Inventory and Evaluation

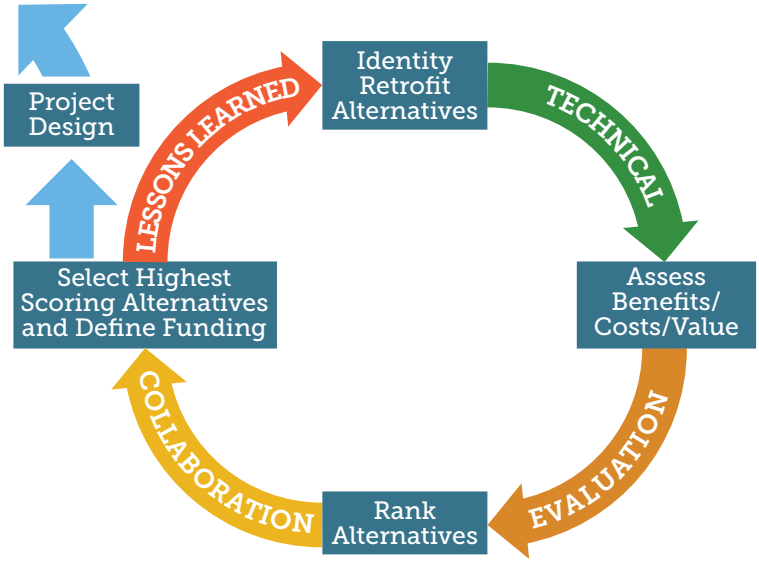
The above steps will most likely identify a number of retrofit possibilities in your community based on existing issues and available appropriately located project spaces. The concept designs will be refined based on the modeling and construction cost estimates prepared for each alternative, some sites may have several alternatives. A ranking system will be prepared to rate pollution and flood mitigation benefits in combination with cost and other benefits such as parkland, downtown redevelopment, utility, and transportation improvements.

Prioritization of Features

High	Low
• High pollutant management • Flood flow management • Manage large impervious area • Available land • Direct connection to waterways • Link with other projects • Downtown revitalization • Amenity (attractive, adds community value) • Low cost • Limited permitting needs • Low maintenance requirements • Potential for grant funding • Educational benefits (demonstration project)	• Low pollutant management • Low flood flow reduction • Limited impervious area management • Requires land acquisition • Requires conveyance system (pipes, channels, culverts) • Stand-alone project • Limited community benefits • Structural in nature • High cost • High permitting requirements • High maintenance requirements • Limited funding options • Limited educational opportunities

Commercial Center Rain Garden

RETROFIT EVALUATION PROCESS



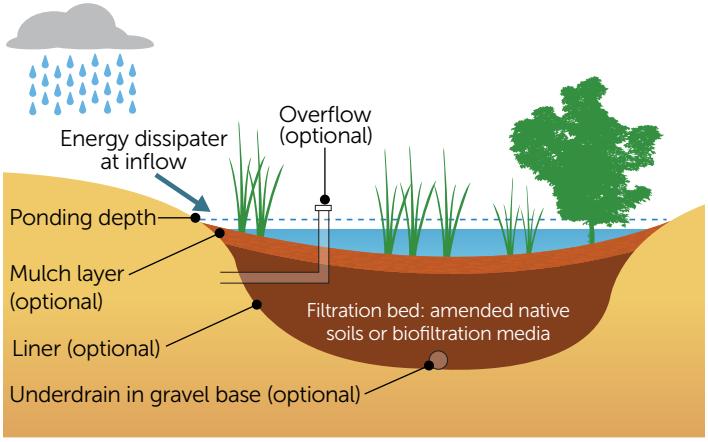
Design and Permitting

The retrofit design is based on the collection of detailed site data to ensure that the proposed project can be properly constructed and safely function while minimizing maintenance needs.

Key Data Requirements Include:

- Field survey to define ground elevations, trees, existing utilities, wetlands infrastructure, unique features, floodplains and property boundaries
- Subsurface soil investigation to determine groundwater levels and infiltration capacity
- Environmental and cultural resource studies to avoid impacts and minimize permitting requirements

Bioretention (Rain Garden) Schematic



Bioretention

Design Considerations

- Siting requirements to avoid infrastructure, trees, environmental resources, and connect with existing utilities as needed
- Positive drainage, no standing water beyond the design goals
- Slope safety accomplished through grading plans to avoid drop-offs and hazards
- Stabilize slopes so soil does not wash away during rains
- Provide construction and permanent maintenance access but use curbs and fences when necessary so that vehicles cannot enter the facility
- Maximize native vegetation, natural materials, and landscapes to improve stormwater performance and appearance
- Provide trash control features so that pipes and spillways are not clogged during floods

Permitting Considerations

While the project design will define permitting requirements, the permitting process is considered in the project design to minimize needs for needs for mitigation and is informed by the environmental and cultural resources studies.

Agencies and Their Jurisdictions	Potential Requirements
• **Local government** • **US Army Corps of Engineers (USACE Galveston):** Potential impacts to aquatic environments of U.S. waters under Section 404 of the Clean Water Act • **Texas Historical Commission:** Potential impacts to cultural resources under Section 106 of the National Historical Preservation Act • **US Fish and Wildlife Service and National Marine Fisheries Service:** Potential impacts to ("take" of) federally-protected species • **General Land Office Beach Access and Dune Protection Program**	• Drainage, public safety, traffic management, aesthetics, landscape, building setbacks, zoning changes • Avoidance and minimization • Response planning in the event of a "take" • Mitigation for "take" • Various post-construction monitoring • Within 1000 feet of the mean high tide • Any applicable Rights of Way and easements

Construction

Once the construction plans and supporting materials are permitted, specifications and bid documents are prepared by the project sponsor. This process can include advertising and distributing bid package(s), a pre-bid meeting, response to questions/comments, reviewing bids for completeness and qualifications and contract award to the selected bidder. The selection of a qualified and experienced contractor versed in the construction of stormwater projects goes a long way towards a successful project completion.

Construction Phase Erosion Controls

A key aspect of the construction phase is the proper installation of construction phase erosion controls so that dirt, sediment, fuels, and construction chemicals are retained on site. The Texas Commission on Environmental Quality (TCEQ) requires a Stormwater Pollution Prevention Plan (SWPPP) for all projects that disturb more than one acre in area. This plan guides the installation and maintenance of construction phase erosion controls and the rapid revegetation of the site. Primary techniques include silt fence, mulch logs, rock berms, stabilized construction entrances, and storm drain inlet barriers to retain sediment on-site, however, the most effective erosion control approach is to minimize and phase ground disturbance. Final stabilization of soil disturbing activities is considered complete when perennial vegetative cover reaches 70% of the native background vegetative cover.

Avoid this with construction oversight

Minimize land disturbance or phase construction to minimize soil erosion

A successfully built and revegetated project ensures long-term water quality and flood management performance and facilitates fewer maintenance concerns and costs. Frequent communication between the contractor and project team is necessary to resolve questions, adapt to field conditions, and verify environmental compliance.

Inspection and Maintenance

To achieve desired stormwater management benefits, periodic inspection is necessary to document facility conditions and guide maintenance needs. Accumulated sediment and debris removal (especially at the inflow point) will be the primary maintenance function. Other potential tasks include replacement of dead vegetation, erosion repair at inflow points, media replenishment, unclogging drain-pipes, and repairing overflow structures. An added benefit of inspection and maintenance is that lessons learned are applied to the next retrofit design effort so a process of continuous improvement occurs throughout the retrofit implementation program. Specific maintenance requirements include:

Inspections

Stormwater measures should be inspected at least twice a year (once during or immediately following wet weather) to evaluate facility operation.

Sediment Removal

Remove sediment from the facility when the depth reaches 3 inches or when it interferes with the vegetation or ability to meet required water drawdown times.

Drain Time

When the drain time exceeds 72 hours, the filter media should be removed and replaced with more permeable material. Drainage pipes should also be cleaned.

Vegetation

All dead and diseased vegetation shall be removed and replaced during semi-annual inspections. Bare spots larger than 10 square feet should be reseeded and irrigated.

Grass areas in and around the stormwater measures must be mowed at least twice annually to limit vegetation height to 18 inches.

Use non-chemical methods for maintaining vegetation health. Pesticides, herbicides, or fertilizers should only be used as a last option, and then as minimally as possible.

Debris and Litter Removal

Debris and litter will accumulate in the facility and should be removed during regular mowing operations and inspections.

Underdrain (if a project component)

Clean underdrain piping network to remove any sediment buildup every 5 years, or as needed to maintain design drawdown time.

Retrofit Techniques

Stormwater retrofits can improve water quality and reduce flood flow rates in existing urbanized areas. As noted above, one size does not fit all, potential retrofit sites are unique and in some situations only one type of solution will work while in other areas multiple solutions could function well.

Stormwater Management Measures

"Green" (Softer) Techniques

Stormwater Management Measures	Construction Cost	Recommended Drainage Area	Maintenance Requirement	Liability/ Safety Issues	Other Benefits
Buffers	N/A	creek, river and tidal water boundaries	very low to none	none	• Water quality and flood management • Water supply and resilience
Natural Area Preservation	N/A	N/A	low	none	• Water quality and flood management • Water supply and resilience
Roof-top Disconnection	low	house and business roof-top	low	none	• Water quality and flood management • Water supply and resilience
Vegetated Filter Strip	low	<3 acres or downstream of other measures	low	none	• Water quality • Resilient
Vegetated Swale	low	<2 acres	low	low	• Water quality • Resilient
Extended Detention Basins	mod	less than 128 acres	low - med	low, short term standing water	• Flood and water quality management • Promote baseflow enhancement
Bioretention/Rain Gardens	mod	<10 acres	med - high	low, shallow standing water depth	• Water quality • Promote baseflow enhancement
Infiltration	mod	downstream of BMP	med - high	mod, standing water	• Water quality • Water supply
Rainwater Harvesting	mod	house roof-top	mod	low, rainwater stored in property owner tanks	• Water quality • Water supply
Wet Basins	mod - high	>20 acres and less than 128	med - high	high, long term standing water	• Water quality and flood management • Habitat
Constructed Wetlands	mod - high	>20 acres and less than 128	med - high	mod, longterm standing water	• Water quality and flood management • Habitat
Porous Pavement	mod - high	no off-site area drains to pavement	mod	low, potential pavement issues	• Water quality • Peak flow reduction • Water supply
Water Quality Vaults on Storm Drain Systems	high	varies, typically less than 2 acres	high	limited safety issues since underground but could have moderate liability if not maintained and the storm drain system becomes clogged	• Manage water quality at hot spots such as gas stations, industrial sites

"Gray" (Harder) Techniques