Mt. Airy Rain Catchers - Rain Barrels and Gardens in a Suburban Watershed

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ABSTRACT

Stormwater runoff from urban and suburban areas can damage the environmental health of receiving streams from increased flow rates during rain events, reduced base flow, and increased loading of pollutants associated with the runoff. Low-impact or green infrastructure techniques that are decentralized or dispersed throughout the watershed can mitigate these impacts. The U.S. Environmental Protection Agency, Office of Research and Development, Sustainable Environments Branch (EPA) developed a field research project to measure the effects of green practices on stream hydrology and quality on a watershed scale.

The suburban watershed selected for this study includes both single-family residential land use and a forested park. The hydrology and water quality of Shepherd Creek have been monitored by EPA and found to be showing the effects of urbanization in the reaches downstream of developed areas. The use of dispersed Best Management Practices (BMPs) that infiltrate or detain runoff were planned and implemented for this area, with continued monitoring during and after the implementation to show the effects on Shepherd Creek.

In 2007, Tetra Tech, as contractor to EPA, implemented a reverse auction to solicit participation by area residents and then installed 50 rain gardens and 100 rain barrels on the selected residential sites. This presentation summarizes the methods and results of both the site selection and construction activities to date.

KEYWORDS

stormwater management, best management practice, low impact development, green infrastructure, rain garden, rain barrel, private property, reverse auction, EPA, research, construction, outreach

INTRODUCTION

For the past few decades, the accepted practice in stormwater management has been to control the peak flow rate of the stormwater with large, centralized systems such as regional detention basins. In the past few years, some stormwater managers have begun using low-impact or green infrastructure techniques that are decentralized or dispersed throughout the watershed. These BMPs are based on a more natural hydrologic regime where the volume of runoff is reduced through interception, detention, and retention.

Recognizing a need for quantitative information on the effects of these green practices on stream hydrology and quality, especially on a watershed scale, EPA developed a field research study focused on Shepherd Creek in the Mt. Airy township area of Cincinnati, Ohio (Roy, et al, 2005). The 20 km^2 watershed, once mostly orchards and farms, has been urbanized over the past few decades. One large portion of the watershed, Mt. Airy Forest, has not been developed because of its protection as a city park. The 2 km^2 (460 acre) subwatershed selected for BMPs installation has relatively uniform land use as single-family residential and has 13 percent impervious area, with 56 percent of that area connected to stormwater systems (Roy and Shuster, 2007). EPA has monitored the flow and water quality of Shepherd Creek, a headwaters stream, and found that the stream health is impaired by silt embedding the stream substrate, high levels of indicator bacteria such as fecal coliform, and high peak flows (Roy, et al, 2006).

EPA developed a plan to install and study the effects of site-level BMPs distributed across the watershed and selected Tetra Tech to implement the project. The project goals include research into public attitudes about these practices, development of information on the cost and feasibility of large-scale dispersed BMP programs, and determination of the BMPs' effects on stream health and water quality.

METHODOLOGY

The project began with the development of a Quality Assurance Project Plan (QAPP) and installation of two rain gardens and a rain barrel at a demonstration site in late 2006. This demonstration site at the Mt. Airy Arboretum would serve as an example of the planned BMPs. In the spring of 2007, EPA and Tetra Tech sought permission for access for construction, monitoring, and maintenance through outreach, a reverse auction solicitation, a selection process, payment of subsidies, and an access agreement. In the summer of 2007, rain barrels and rain gardens were installed. Maintenance of these BMPs is now underway and will continue for three years while EPA monitors Shepherd Creek and site-level hydrology on a subset of BMPs.

Reverse Auction

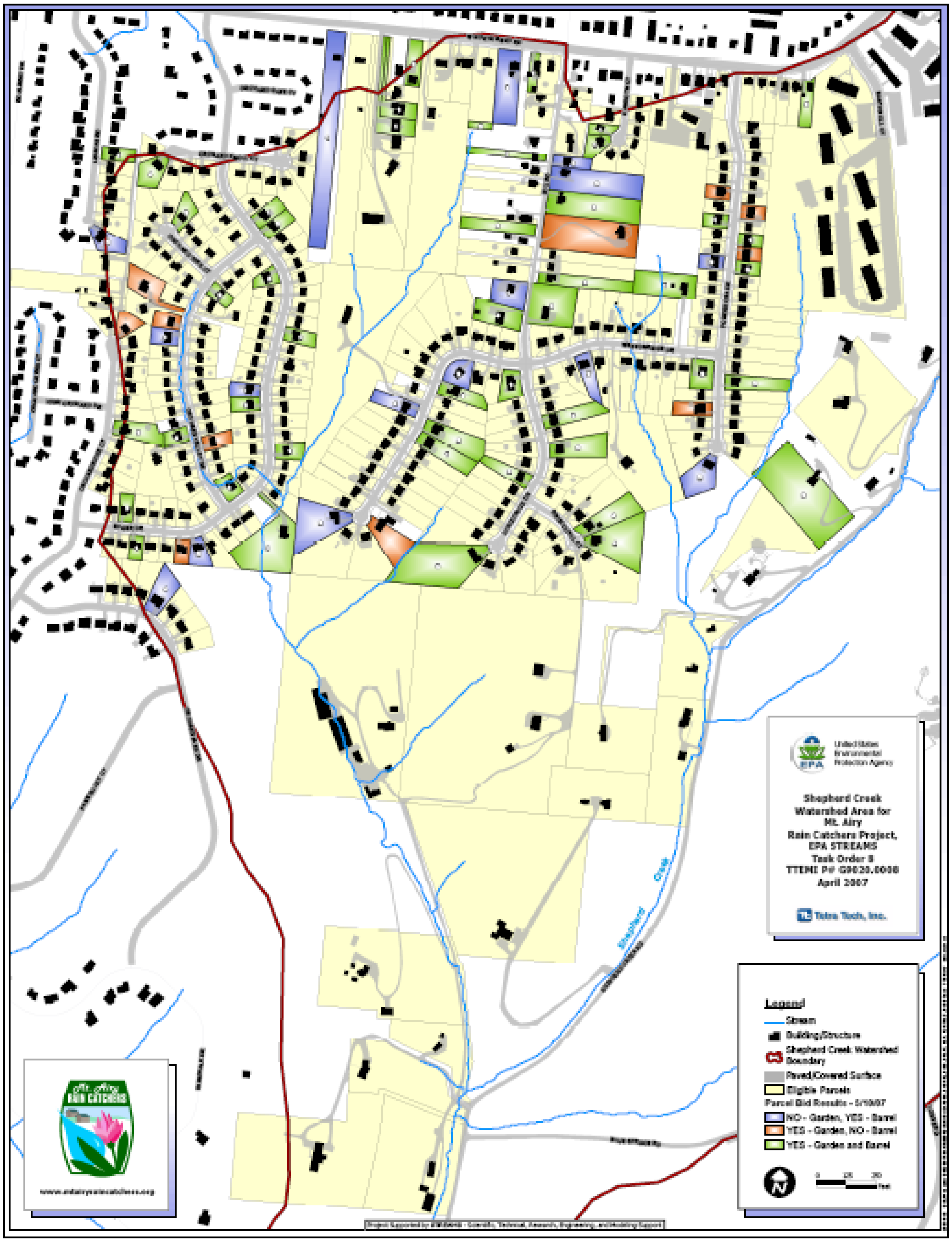
A key objective of the project is to test a market mechanism to elicit private property owner participation. EPA developed a reverse auction process that offered a rain garden and up to four rain barrels to each homeowner in the project watershed at no cost (Parikh, et al, 2005). The homeowner was additionally offered the opportunity to request a payment, known as a *reverse bid*.

Tetra Tech began with outreach activities designed to explain and generate interest in the auction. Then, bid forms were distributed, bids were evaluated, and finally specific locations were selected for installation. Outreach activities included installing a demonstration rain barrel and rain gardens at Mt. Airy Arboretum and a public information Web site www.mtairyraincatchers.org.

The auction was conducted through mailings, with minimal additional contact with residents. An introductory letter and informational brochure was mailed to each resident in March 2007. The letter described the project, summarized some benefits of rain gardens and rain barrels, and notified residents that they would be receiving a second mailing with an opportunity to participate. About 2 weeks later, each resident was sent a solicitation package by mail. Each one included an offer letter, property map, $5 bill, and reverse auction bid form. The residents were asked to complete the bid form, draw their preferred rain garden location on the property map, return the bid form and map to Tetra Tech, and to keep the $5 regardless of whether they bid. A few days prior to the second mailing, door hanger notices were distributed to each house to remind them that the bid forms would be arriving soon by mail.

Because initial response was slow, another bid offer was sent to residents that had not yet responded and the deadline for bidding was extended. At the end of bidding in May, the results were 73 bid responses with 46 of these requesting both rain barrels and rain gardens. Another 16 requested only rain barrels and 11 requested only rain gardens. The majority of the bids were $0, meaning that the resident did not request any subsidy payment. Of those that bid for payment, 72 percent were $100 or less and the highest bid was $500. Figure 1 shows the locations of parcels in the project area from which bids were received.

Figure 1 – Project Area Map With Bidder Parcels Highlighted



Selection and Planning

EPA evaluated the bids on the basis of the bid amount and ecological functions, ranking each rain garden bid and rain barrel bid separately. This process eliminated some bids and resulted in an accepted list of 56 rain gardens and 117 rain barrels. Tetra Tech then met with each property owner to gain access to the property through a formal agreement. Upon execution of the agreement, if the bid was greater than $0, Tetra Tech provided a check for the subsidy amount to the owner.

Tetra Tech and our subcontractor, Horticultural Management, staked out the proposed location of each rain garden, taking into account owner's preferences, topography, proximity to buildings, property lines, trees, and other factors that might affect the installation or functioning of the garden. Once sites were selected and access agreements were completed, the local utilities locator service, OUPS, was contacted to mark underground utilities at each site. The sequential process of getting access approval, selecting a garden location, marking utilities, and testing the 2-foot depth infiltration rate required planning, coordination, and accurate record-keeping to avoid slowing the work progress or damaging underground utilities.

In some cases, utilities caused a change in the proposed site location and in one case, the owner requested a location that had a utilities conflict, resulting in withdrawal of that site. Some other sites were withdrawn because of owners' decisions and site constraints. Two sites were added to the list after bidding. The net result of these changes was a reduction of 6 rain gardens and 18 rain barrels.

Rain Barrel Installation

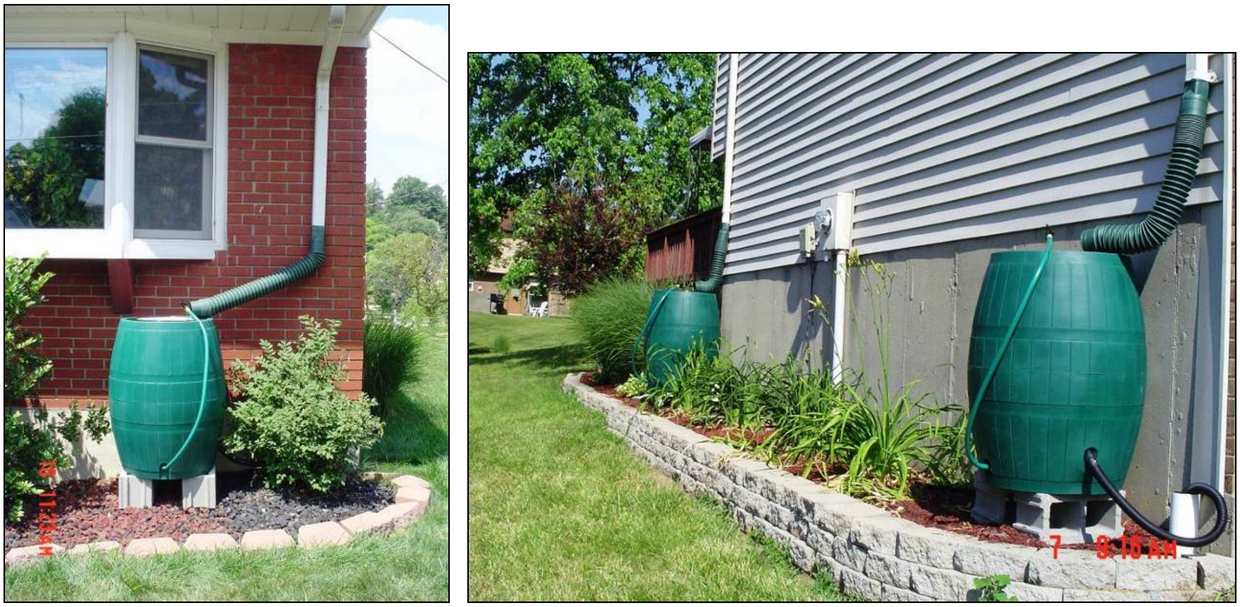
Rain barrels were installed by Tetra Tech staff after access was granted by the owner. This required cutting the downspout; attaching a flexible downspout section that directed flow to the barrel; placement of two concrete blocks as a stable, elevated base for the barrel; and placement of the barrel itself.

Tetra Tech evaluated several types of rain barrels and suppliers. A supplier found on the Internet was selected because of the quality of the barrel (a sample barrel was provided for evaluation), a molded color that did not require painting, and a reduced price because of the bulk purchase. Most of the rain barrels installed were 75-gallon capacity; a 55-gallon capacity model was used in the later phases of the project when the supplier could not supply 75-gallon barrels.

The City of Cincinnati has an ordinance that prohibits the disconnection of downspouts from stormwater sewers or piping systems. Most of the project watershed is in the Cincinnati city limits, although some of the area is in Green Township and not subject to the ordinance. Tetra Tech requested permission to disconnect downspouts to install rain barrels and received approval from the Building Inspection Division of the Cincinnati Business Development/ Permit Center.

Tetra Tech distributed a manual to each owner that describes the project and how to maintain the rain barrels. After installation, barrels were found to perform well by most owners. Some barrels developed leaks and had to be replaced. In colder weather, we have found that some rain barrel hoses have become disconnected. This seems to be a result of reduced flexibility in lower temperatures.

Figure 2 – Photographs of Rain Barrel Installations



Rain Garden Installation

After selecting locations for the rain gardens and marking the underground utilities, Tetra Tech and subcontractor, Horticultural Management, planned the installations using lists and maps. The installation process began with infiltration testing at a 2-foot depth, excavation and construction, planting, and finally surface infiltration testing. For the 2-foot depth testing, a Mini-Disk Infiltrometer (Decagon Devices brand) was chosen because of its suitability for tightly cohesive, low-permeability soils. A double-ring infiltrometer (Turf-Tec brand) was chosen for surface tests because of its larger test area and broad use for this type of testing.

Tetra Tech tested the soil infiltration rate at a depth of 2 feet below existing grade at about half of the planned garden locations. The testing results on the infiltration rates of native soils beneath the amended soil of the rain gardens showed that they ranged from 0.1 to 4 millimeters per hour (mm/hr), with a median rate of 1 mm/hr. After the rain gardens were completed, the infiltration rates of the amended soils were tested at the surface of most rain gardens. Initial testing of gardens soon after construction showed that results were highly variable, so surface testing was delayed for about 2 months to allow the soil structure to stabilize after some exposure to rains and temperature changes. Testing was performed at two or three locations in each garden because of the variability. Surface infiltration rates had a median value of 50 mm/hr. Tetra Tech plans to test the surface infiltration rates of gardens annually as part of maintenance over the next 3 years.

Figure 3 – Infiltration testing at 2-foot depth (left) and on surface of completed garden (right)

At each planned garden, Tetra Tech and Horticultural Management determined the location and elevation of the rain garden overflow and whether a drain was feasible. These features determine the depth of excavation and size of the garden. Type A rain gardens were planned to be 150 square feet in area and a minimum of 18 inches of amended soil in the planting layer, with an underdrain to prevent ponding. On sites where underdrains were not feasible because of site topography, a Type B garden was installed. Type B gardens were 160 square feet with an amended soil depth of 24 inches.

The design of the underdrain was modified during the initial phase of installation, in consultation with EPA. Initially, the drain was designed to be placed in a trench at a depth lower than the amended soil layer with an outlet that rose to a level just below the surface of the garden planting layer and discharged to the lawn near the garden. After considering the time and expense of this method, as related to its effectiveness, Tetra Tech decided to install the underdrain collection pipe (perforated section) at the bottom of, but within, the planting layer, rather than in a trench that is deeper than the planting layer. This change functions as well as the initial design, greatly reduces the amount of soil generated for disposal, and reduces the time and complexity of the installation.

The soil planting layer was amended to promote a higher infiltration rate by adding peat moss and sand at the ratios of 9 percent (4 to 6 bales) and 6 percent (half ton), respectively. These amounts were considered the highest practical volumes that could be mixed well into the existing soil with the Dingo excavator and tillers. After amendments were mixed into the soil, the surface was tilled with a small tiller/cultivator to create a more uniform planting surface. The amended soils were covered with mulch and then organic fertilizer was added. Bare soil on the berms was seeded with grass seed, covered with straw, and then covered with netting to hold the materials in place.

Figure 4 – Photograph of rain garden installation – underdrain installation

Figure 5 – Photograph of rain garden installation – mixing in soil amendments

Figure 6 – Completed rain garden before planting

The average construction contractor cost for installation of rain gardens was about $1,500. About half of the cost was for excavation; planting costs were about 30 percent of the total.

Rain gardens were constructed from late June through August of 2007; planting was done in August and September 2007. More than 3,000 native plants of various species were planted on 50 gardens, an average of about 60 plants per garden. The species were selected for suitability to rain gardens, presence as native species in the region, and avoiding known species that deer prefer. Because of the serious drought in the summer of 2007, each rain garden was watered daily for a week or more after plants were installed. Some plants were lost to predation from deer and possibly other animals such as squirrels, skunks, dogs, and cats. Evidence of moles was observed in some gardens as well.

Tetra Tech and the subcontractor will maintain all rain gardens, but owners' manuals were distributed to each BMP owner. The manuals described the project and solicited communications with Tetra Tech.

DISCUSSION

The reverse auction response rate was approximately 21 percent. The bidding results showed that most residents of the area that were interested in rain barrels and rain gardens were willing to accept them without additional payment. Most communications with the potential bidders was written, through mailings and the web site. A more extensive and engaged outreach program may improve the response rate and reduce the bid amounts.

Installation of rain barrels was relatively simple, but some locations needed follow-up visits to re-secure drain hoses or reset foundation blocks. Despite the screened openings, some barrels did harbor mosquitoes. Owners were primarily responsible for rain barrel maintenance, but Tetra Tech did need to provide some assistance.

Rain garden installation required close coordination with the contractor and property owners. From the site selection visit, to the date of installation, to follow-up visits for inspections, we made an effort to talk with each resident to explain the project and how their rain garden would be installed. The drought conditions made working conditions difficult, but there were few rain delays. Excavation of the gardens generated substantial amounts of soil, usually more than could be incorporated in the berms around the gardens. A disposal site in the project area helped to reduce the cost of handling and transporting excess soil. Observations of the gardens this spring indicate that most plants have survived the drought, deer, and winter.

CONCLUSIONS

Rain gardens and rain barrels have been well-accepted in this project area. Tetra Tech and our subcontractor gained a great deal of experience in planning and installing rain gardens, finding that these BMPs can be adapted to different sites and conditions. Communication with the private property owners is a critical component of continued success.

REFERENCES

Roy, A. H.; Cabezas, H; Clagett, M.; Hoagland, T.; Mayer, A.; Morrison, M.; Shuster, W.; Templeton, J.; Thurston, H. (2006) Retrofit Stormwater Management: Navigating Multidisciplinary Hurdles at the Watershed Scale. *Stormwater,* May/June 2006.

Roy, A.; Mayer, A.; Shuster, W.: Thurston, H.: Clagett, M. (2005) A Multidisciplinary Approach To Stormwater Management At The Watershed Scale. Presented at 10th International Conference on Urban Drainage, Copenhagen, Denmark, August 21 - 26, 2005.

Roy, A.; Shuster, W. (2007) Optimizing Stormwater Management Retrofits Based on Impervious Surface Connections to Sewers, presentation at the 55th Annual Meeting of the North American Benthological Society, June 5, 2007.

Parikh, P.; Taylor, M.; Hoagland, T.; Thurston, H.: Shuster, W. (2005) Application of Market Mechanisms and Incentives to Reduce Stormwater Runoff: An Integrated Hydrologic, Economic, and Legal Approach, Environmental Science & Policy 8 (2005) 133-144.