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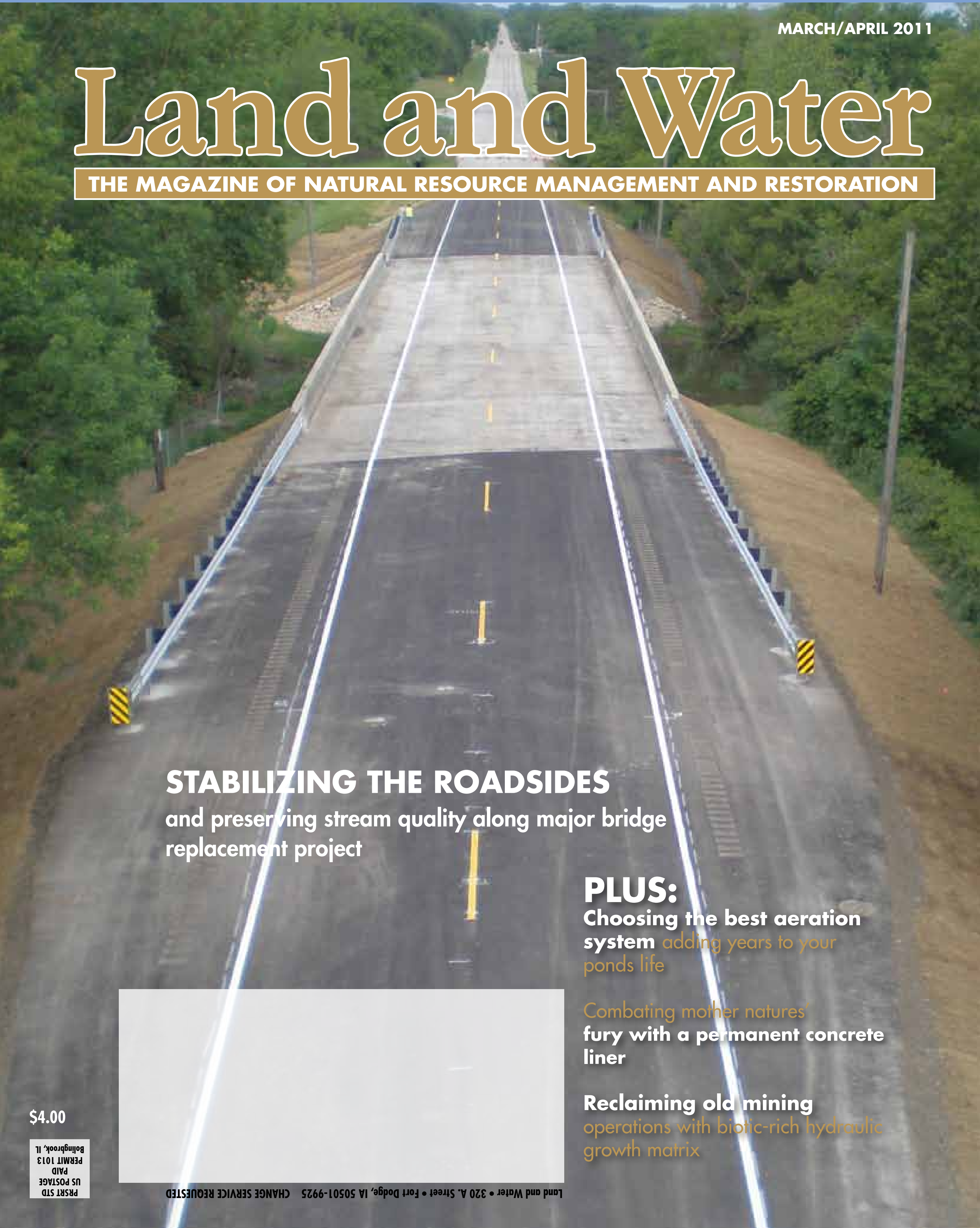

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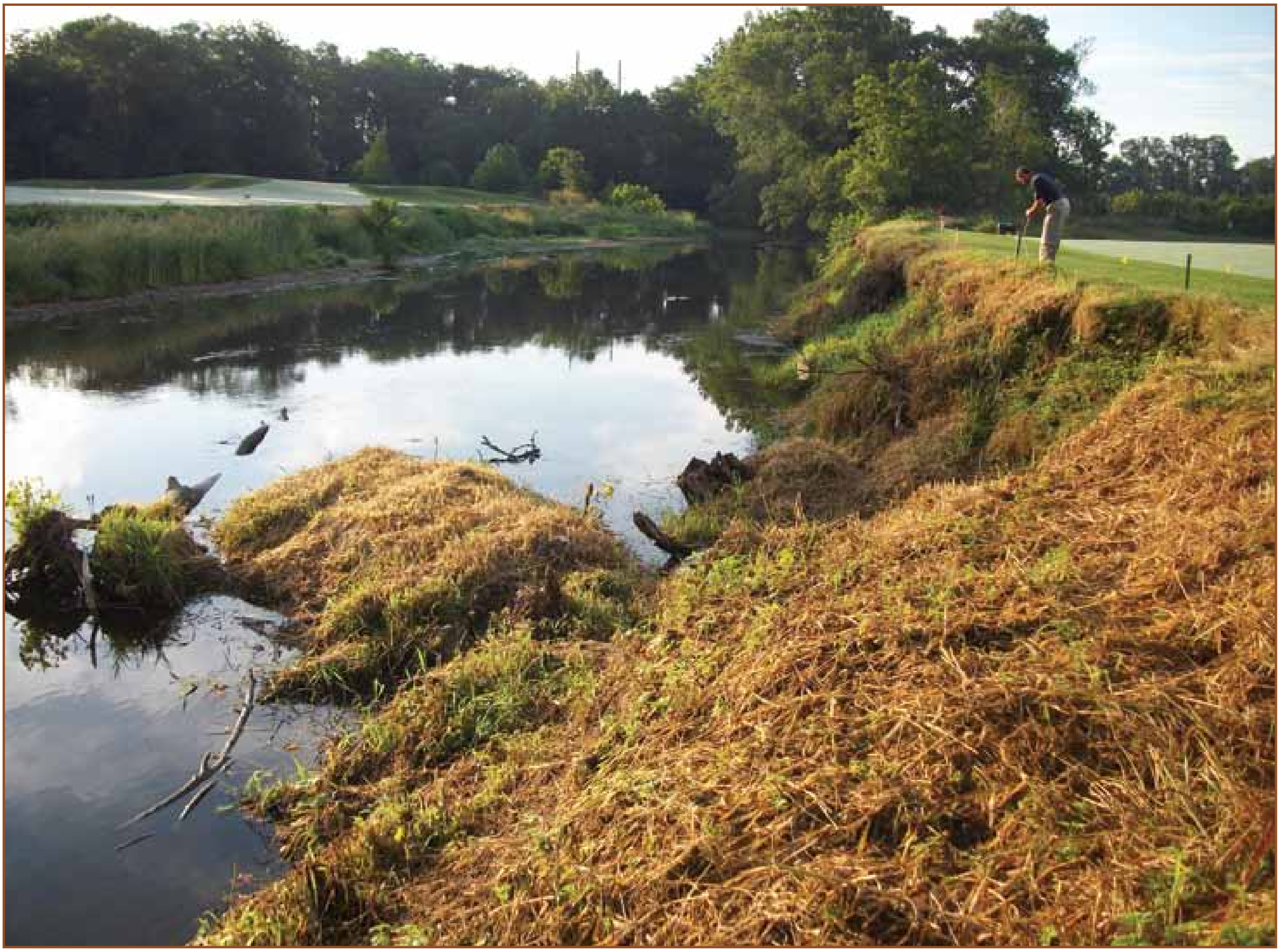
Modifying Traditional Stream Stabilization Techniques Based on Project Needs

Tweaking the traditional design tool box



Stream bank at the start of the project, demonstrating severe high bank erosion, undercutting and slumping as well as invasive vegetation.

The vast majority of the stream stabilization designs in the Mid-Atlantic region consist of some arrangement of readily acceptable stabilization techniques (e.g., cross-vanes, J-hook vanes, stone weirs, etc.). The primary reasons being:

- When designed and installed correctly, they work;
- They are generally accepted approaches by the regulatory agencies, which simplifies the permitting process; and
- They have a documented history of success which provides a heightened level of confidence for the land owner/client.

However, relying strictly on "routine"

or "cookbook" application of historically accepted techniques can result in design shortcomings where the project incurs unnecessary costs or involves inappropriate technique selection relative to the needs of the water course being stabilized. It is not uncommon for a project to be over designed or over sized in terms of stabilization, stream length and/or quantity of materials. This may lead to unnecessary land disturbance, unnecessary project costs, unnecessary impacts to healthy reaches of the water course, and/or failure to meet project goals.

Why does this occur? To answer this question, we must recognize that each stream or water course is a complex and dynamic system with no two streams being the same. Therefore, solutions to equally complex and dynamic stream instability problems cannot be adequately addressed through the application of a hand-full of standardized stabilization techniques. Limiting our designs by using a pre-defined set of techniques is like tasking a master chef to develop a gourmet menu of dishes, but limiting his spices to salt, pepper, garlic, and a sprig of parsley. Just like salt, pepper, garlic and parsley for a chef, the existing standardized techniques represent a good base, but more is needed to enable stream stabilization designs to meet their full potential.

Solutions to equally complex and dynamic stream instability problems cannot be adequately addressed through the application of a hand-full of standardized stabilization techniques.

An effective and efficient approach for developing an effective concept, and ultimately the design, for a stream stabilization project involves the following steps.

Identifying the Problem

The "problem" is usually a combination of symptoms of erosion and causes of erosion, and how the symptoms and causes impact the surrounding environment. Since the erosive dynamics within the stream are greatly influenced by changes in flow rates, the best way to characterize the problem is to observe the site during both base flow conditions and storm flow conditions. Causes should be segregated from symptoms. Causes are typically associated with the source of energy or some manipulation of energy; and may include severe flows, log jams, boat wake action, man-made structures, etc. Symptoms are typically observable conditions associated with how the energy impacts a stream system; and may include undercut banks, sediment deposition, scouring, braiding, etc.

For example: Boat wake action causes the symptom of under cut banks. The wake action is an energy that impacts the stream bank.

A certain level of stream instability is a natural process and necessary for the health of a stream. Stream instability only becomes a problem when the instability is severe enough that the stream is unable to naturally correct itself within a set of applied parameters (such as time and space). While identifying causes and symptoms, the designer should avoid those which are minor and focus on those that are moderate to severe.

Identifying the Potential Solutions

Once the problem has been adequately characterized, the designer can begin the identification and selection of potential solutions. There may be multiple solutions to a given problem. However, there are usually one or two solutions that offer the optimal fix or return on investment. When identifying potential solutions, it is recommended to initially focus on those approaches which target the causes thereby removing/reducing the energy from the problem area by dispersion or relocation. In cases where sufficient energy cannot be dispersed or relocated, then the problem area will need to be reinforced utilizing green techniques and/or by relying upon more traditional armoring. Symptoms, such as bank erosion, can be a chain-reaction process that can extend hundreds to thousands of feet downstream. However, the associated cause can be restricted to a relatively localized area. Therefore, by focusing on the energy aspects (cause) of the solution first, establishing the physical limits of the project is easier and more reliable.

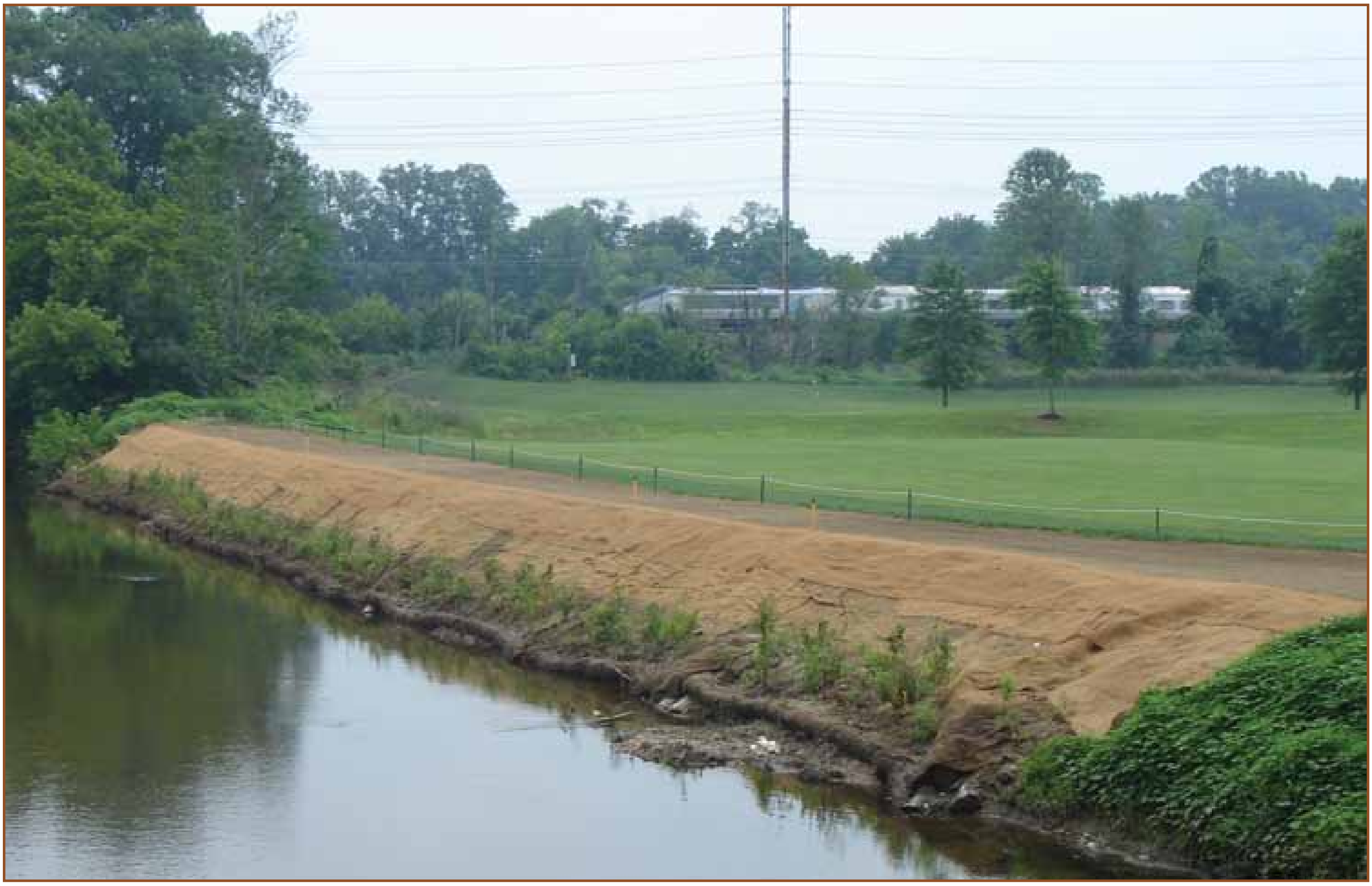
Continued example: The optimal solution for wake action is to disperse the energy to a point where it is no longer capable of causing the bank erosion. The less preferred option is to strengthen the stream bank (e.g., armoring) to make it less susceptible to the energy, remembering that energy within a stream channel that hits a hard linear surface tends to deflect rather than be absorbed.

Identifying the Techniques to Be Used

When considering established techniques, there is value in understanding all the benefits that a particular technique provides. For example, a weir or vane offers in-channel and bank stabilization through the addition of bank structure, habitat creation, localized energy reduction, energy flow direction modification, oxygenation, and possibly aesthetics. But what if a project does not need or should not have in-channel modification? Should the designer discount the use of a weir or vane? Or should the designer modify the standard specifications to fit the identified need? To answer these questions, the designer should determine what functions are required in a structure to meet the project goals. Once the desired functions of a structure are identified, the designer is then able to modify standard design specifications or create new design specifications for the selected structure. This approach allows the desired functions to be retained and/or maximized and the unwanted functions to be reduced or eliminated.

This three-step thought process drives the designer to better understand the project and its needs. It provides a logical foundation for a design concept, yet allows the designer a great deal of flexibility. It also allows previously developed or regionally-specific techniques to be modified toward the project goals.

For Example: A mudsill was originally designed for streams in mountainous or plateau settings. Using this process, a mudsill standard may be modified and applied to



The final piece of the design was to maintain a stable toe of bank using a combination of coir fiber logs, low growing shrubs and a heavy jute mat (same area as photo on page 8).

tidal coastal plain settings.

APPLICATION OF THE APPROACH

The Setting

The site, referred to as the Hole #1 site, was located along the White Clay Creek, in the Delaware Coastal Plain, a little more than four river miles from where the creek becomes tidal. The site is within the fly-over area of a golf course (an area where golf ball are hit over the stream) that crosses between the fairway and the green of the first hole of the White Clay Creek Country Club (WCC CC) at Delaware Park. The White Clay Creek Watershed is a Federally designated National Wild and Scenic Watershed. This watershed encompasses portions of southeastern Pennsylvania and northern Delaware. The soils along the seven to 10 foot high stream banks within the golf course portion of the watershed consist of silts, sands, and schists, making them highly susceptible to severe erosion.

The managers of Delaware Park, inclusive of the WCC CC, have been proactive stewards of the White Clay Creek. Over the past decade, Delaware Park has performed numerous stream stabilization and restoration projects, managed its buffers along the stream, and employed golf course best management practices to limit the amount of nutrients that may enter in the creek. Full funding of this project was provided by the WCC CC.

During a high flow period, a large log became lodged into the bank at a downstream angle. The log eventually collected other large debris and began directing storm flow energy into the down gradient bank. Over a short number of months, more than 300 feet of stream bank had been eroded. At certain locations the bank erosion went 10 feet deep into the bank, creating a safety hazard and fairway hazard at the adjacent golf hole.

The identified causes consisted of the log jam and storm flows. The symptoms consisted of severe bank scouring, undercutting, and slumping.

The location, relative to being on the golf course, placed some unique restriction on the design. Being a fly-over area, the bank slope would not be able to be planted with woody vegetation to provide natural soil stability. Along this reach of the White Clay Creek the banks consisted of seven to eight-foot high "soft" soils dominated by heavily invasive annual plants, especially Japanese hops. Finally, the solution would have to be aesthetic because of its visibility to the public utilizing the golf course.

A significant portion of the golf course is located within the 100 year floodplain. During severe storm events, this segment of stream will experience considerable over bank flooding. As such, the entire high bank is susceptible to erosional forces.

The Problem

The identified causes consisted of the log jam and storm flows. The symptoms consisted of severe bank scouring, undercutting, and slumping. Further considerations involved the bank located on the opposite side of the channel. Since the opposite bank was equally susceptible to erosional forces, the solution would need to ensure that it did not impact the opposite bank.

A closer view of the jute mat, which was seeded and stapled down.

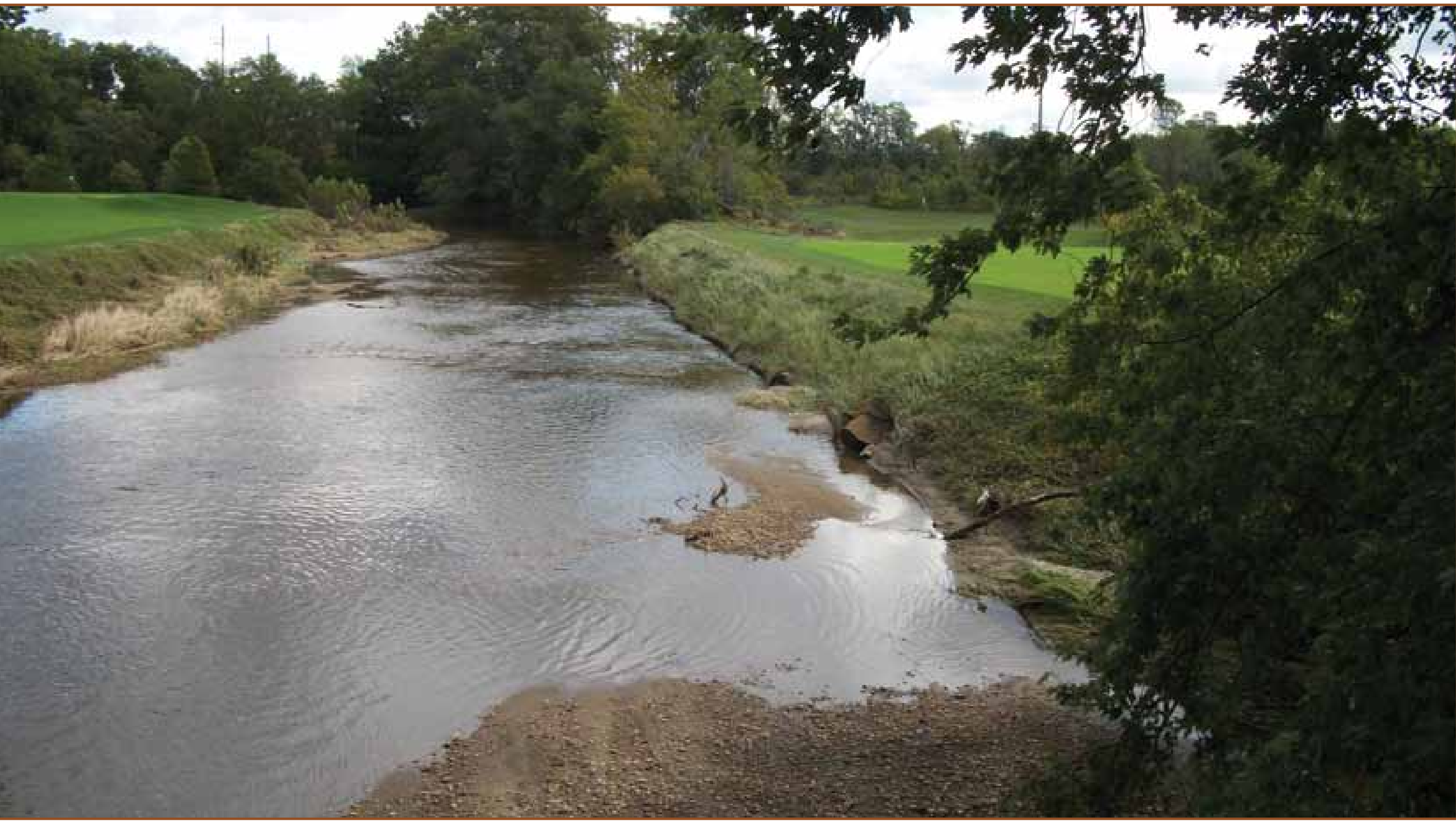
Identifying the Potential Solutions

Since this site is located near the bottom of the watershed and the majority of the flood volumes originate upgradient and off-site, little could be done to reduce storm flows. However, the log jam could be removed. The project goals included restoring the lost 300 feet of bank in a manner that would be permanent and natural. Therefore, the symptoms would also need to be addressed. The solution consisted of three elements:

- Removal of the log jam;
- Restoration and stabilization of the eroded bank; and
- Sufficiently reducing the high energy flows impacting the bank to enable the bank to remain stable.

Identifying the Techniques to Be Used

In this project, removal of the log jam offered little difficulty for the design. As such this discussion will focus on the bank-related work. The solution needed to incorporate considerable bank structure in order to be able to withstand future severe flood events, and to support a natural herbaceous community similar to that occurring on the opposite bank of the creek. Accordingly, the project design had to address both structural and aesthetic elements. This stream reach had a relatively straight channel shape, making it susceptible to deflected flows toward the opposite bank. Traditional weirs and vanes offer a high level of bank structure and stability, but also deflect flow energy. The selected solution was to use what was dubbed as "stunted log vanes". A stunted log vane is very similar to a traditional vane but lacks the portion of the log that extends into the channel.



Two months after project completion, a 7.5 inch storm event resulted in over bank flooding. The entire bank was under two feet of water for nearly 36 hours.

Stunted logs vanes are able to be placed at much steeper angles along the bank and are embedded just below the bank surface. These vanes also provide stability along the entire height of the bank, providing structure during a range of storm events. The final piece of the design was to maintain a stable toe of bank. A combination of coir fiber logs (short-term toe protection) and low growing shrubs (long term protection) were chosen for this application. Since the height of woody vegetation could not extend beyond the top of bank, the shrubs were planted at the toe of the slope so, at maturity, the tops of the shrubs would be level with the top of bank.

Sizing of the stunted logs was a significant consideration. Due to access for materials and equipment and the need to work between the creek and the ten to 15-foot wide fairway corridor, the design employed 12 to 15-inch diameter logs in ten-foot lengths. The logs were bound and anchored in triads to form large stunted vanes.

As the vanes were set and anchored, the coir fiber logs were set at the base flow elevation. A heavy jute mat was anchored behind the coir fiber logs and soil was backfilled in lifts between the vanes. A lift of top soil was placed along the slope and the disturbed area was seeded with a native perennial rye mix and a wildflower mix. Once seeded, the jute mat covered the bank and was stapled down. At the toe of the slope, the openings were cut in the jute mat to enable the shrubs to be planted.

Agencies and Issues

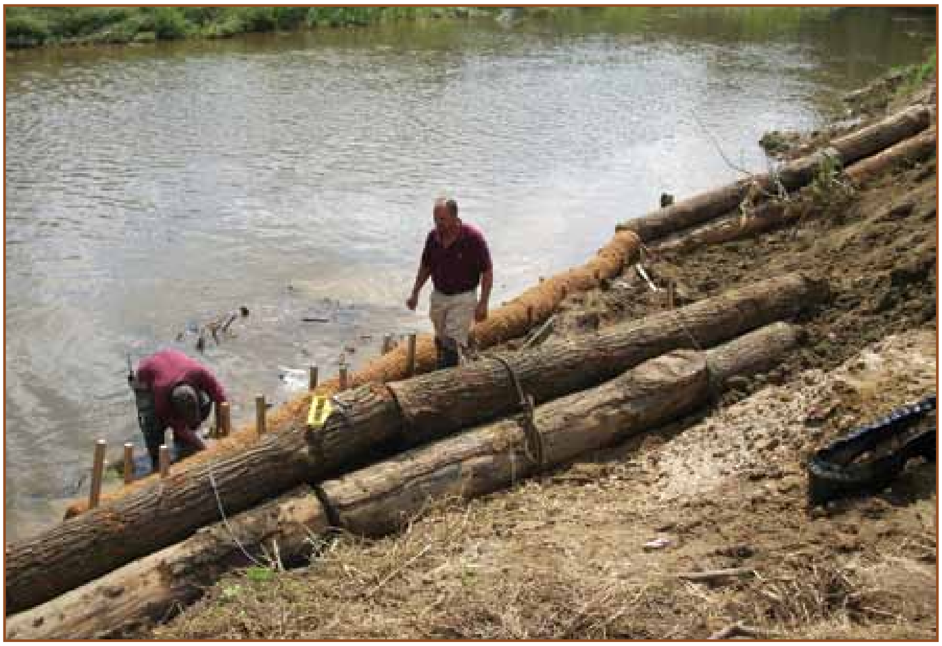
The primary agencies involved, the U.S. Army Corps of Engineers, Delaware Department of Natural Resources and Environmental Control, and the National Park Service, were generally supportive of the approach taken on this project. However, since stunted log vanes were not previously employed in Delaware and because of concern for high storm flows, the agencies had some reservations about the success of the project. However, all agency approvals were obtained.

Construction Effort

In an effort to minimize project costs, it was decided that the project would utilize the golf course staff to implement the design under the oversight of the designer. Intense, short lived storm events occurred during the first days of the project, resulting in a slow start. The project was also initially slowed because the work crew was learning on-the-job. After the first section of the project was completed, the remainder of the project continued smoothly. The design and permitting of the project occurred during the winter and spring of 2010. The project was completed within two weeks during June and July of 2010.

Cost Savings

This project was executed using a hybrid-design/build approach. Duffield Associates, Inc. prepared the design and acquired the necessary permits. Following acquisition of the permits, Duffield Associates' professional staff provided site management and technical guidance for the WCC CC staff that performed the construction. This approach eliminated



Placement of stunted log vanes and bank toeing (the bank structure) that was covered with lifts of soil.

the need for bid documents and bid-level design, and reduced many additional subcontractor costs. The project was performed for approximately $50,000.00, and realized a cost savings, conservatively estimated, of approximately 30-40% when compared to a traditional design-bid-build project. In addition, the use of stunted log-vanes was considerably cheaper than tradition hard armoring using stone. Specific to this project, the material cost was much less than half of what it would have been if stone were used in place of the stunted log vanes.

The Storm

During the first week in October, approximately two months following the completion of the project, a severe 7.5-inch rainfall event occurred, representing a worse case scenario test. The golf course experienced the worst flooding in its history. The site was under nearly two feet (over bank) of flood water for more than a day. When the flood receded, the project was completely intact.

Future Work

Due to the success of this technique, designs are underway for another section of stream within the golf course. **L&W**

by Douglas Janiec, M.S.

Project location:
Latitude: 39.6986
Longitude: -75.6673

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