Drainage: Through the Green

The fundamentals of successful golf course drainage.

BY JIM SKORULSKI AND PATRICK O´BRIEN

"The best greenkeeper in the world cannot maintain perfect turf unless their course is well drained," declared Wendell Miller, a drainage engineer, in his advertisement in the *National Greenkeeper* in 1924. Miller's statement is even more relevant today, as many golfers have higher-than-ever expectations of course conditioning. Poorly drained areas are challenging to maintain at a high level of conditioning on a consistent basis. Unfortunately, it is easy to underestimate the negative effects of poor drainage until playing conditions deteriorate or regular maintenance is disrupted.

Poor drainage directly impacts golf courses in many ways. Excessively wet areas usually require additional maintenance inputs and can further reduce revenue due to course closures, cart restrictions, and poor playing conditions. In short, poorly drained golf courses struggle to provide good conditions on a consistent basis and are more reliant on favorable weather conditions to remain successful. Providing firm, consistent playing surfaces requires good drainage. This article details how golf courses can address drainage problems in areas Through the Green.

DEVELOPING A PLAN OF ACTION

Regardless of scale, all successful drainage improvements begin with a good plan. Some drainage projects can be designed and installed in-house — e.g., repairing or replacing failed drains and draining isolated areas with nearby functioning drainage outlets. Facilities that have widespread or complex drainage issues often seek the expertise of a drainage engineer or specialist. Drainage engineers can determine the cause of saturated conditions, select appropriate solutions, and develop a master plan based on

Curbing along a cart path can collect surface water and divert it away from playing areas.

Extensive drainage improvements may need to be done in phases, so proper planning is essential.

their evaluation of existing drainage infrastructure, surface contours, soil conditions, and estimates of water flow onto and off the golf course.

A master plan is comprehensive and offers systematic solutions to address drainage issues while identifying, prioritizing, and guiding the work that needs to be done. Furthermore, a master plan will provide specifications for the drainage work and detailed costs for materials and installation. In-house staff can often implement parts of a drainage master plan, but some areas may require the help of an experienced contractor. The article Planning a Golf Course Drainage Project provides greater detail on developing master plans for drainage projects.

DO NOT OVERLOOK THE BASICS

Do not discount the importance of sound cultural practices when dealing with poorly drained areas. Where possible, implementing aggressive core cultivation and deep aeration can improve water movement through compacted soils and hardpan layers. Topdressing also helps surface soils dry and reduces the water-holding capacity of thatch. Sunlight and air movement can further facilitate the drying of wet areas, so selectively removing trees to increase sunlight and air movement should always be a priority around consistently wet areas. Making minor grade changes also can improve the flow of water away from playing areas.

DRAINAGE PROBLEMS

Understanding the cause of a drainage problem is the first step to finding a solution. The most common causes of drainage issues on golf courses are inadequate surface drainage, impermeable soil conditions, side-hill seepage, and high water tables. Identifying the causes of drainage problems can be challenging, but it is the key to a successful drainage project.

SURFACE DRAINAGE

As the name implies, surface drainage involves the flow of water over a surface, including playing surfaces, cart paths, roadways, and the swales and open ditches that are used to carry water through a golf course. Surface drainage is a critical component of

Puddling is disruptive to play and can have long-lasting impacts on the condition and quality of playing surfaces.

Standing water above a sunken drain line is a good indication that the pipe has failed and needs to be replaced.

The combination of impermeable soils and runoff from a neighboring property can leave areas too wet for mowing or golf during wet weather.

every golf course and is the most economical type of drainage. Adequate surface drainage allows areas with soils of low permeability to perform relatively well during periods of moderate precipitation and can reduce the need for costly subsurface drainage. Surface depressions that collect water can be problematic, but sometimes small grade changes can be made to re-establish effective surface drainage.

In areas where surface drainage is insufficient and cannot be easily improved, subsurface drainage provides a solution. Subsurface collector drains equipped with surface inlets are the most common subsurface drainage system. The inlets, placed in the lowest part of a water-collecting depression, allow surface water to reach underground collector pipes. The inlets and collector pipes are sized according to the volume of water that will reach each inlet. Inlets should be durable and equipped with a sediment trap for maintenance, and collector pipes must be installed sufficiently deep to avoid damage during aeration. Collector pipes should be surrounded with sand when using wrapped pipe or gravel when using a geotextile-lined trench. The upper 6 inches of drainage trenches should be backfilled with a sandy loam soil.

IMPERMEABLE SOILS

Fine-textured soils that contain high proportions of silt and clay are inherently slow to drain. These soil types also are prone to compaction, which further slows water infiltration. Hardpan layers within a soil profile also can inhibit water infiltration. Cultivation practices that alleviate compaction or break through sealed surfaces can improve water infiltration, provided the subsoil is permeable. However, if the entire soil profile is relatively impermeable, water will linger near the surface, causing frequent ponding in depressions. Often, the upper soil profile will remain saturated while the subsoil remains relatively dry.

Subsurface drainage is used when impermeable soils cannot be drained by surface methods. Sand-slit drainage, also referred to as sand-channel, bypass, or sand-banding drainage, is a commonly used form of subsurface drainage. Variations of sand-slit drainage often are used to drain aging soil-based greens. Similar systems have been designed to drain larger areas in fairways and rough, which is the focus of this article.

Sand-slit drainage systems typically utilize 2-inch-diameter, perforated, corrugated pipes. Geotextile fabric is wrapped around the corrugated pipe in some cases to prevent contamination. The small-diameter pipes can be installed in narrow, 3-inch-wide trenches to minimize surface disruption. Drain lines are installed at a 5.0- to 6.5-foot spacing in flat areas with heavy soils, or at 6.5- to 8.0-foot spacing in contoured areas or when soils are more permeable.

Drainage trenches should be installed across slopes to help intercept water flow. Pipes in sand-slit drainage systems typically are installed at depths of 12-15 inches and connected to larger collector pipes that transport water to an outlet. The narrow drainage trenches are backfilled with sand or a sand-based soil. Backfilling drainage trenches with sand provides an excellent medium for turfgrass establishment while allowing excess water to rapidly move into the underlying subsurface drain lines. However, backfilling with pure sand typically is suggested only for irrigated areas because supplemental irrigation will be necessary to limit turf stress during extended periods of dry weather.

Larger, 4-inch perforated pipes also are used to drain impermeable soils. Larger pipes can handle more water, making them suitable for removing excess water from collection areas — e.g., swales — after runoff has occurred. When placed in swales, large subsurface drainpipes usually are backfilled with soil and equipped with surface inlets located at strategic points along the swale. Keep in mind that larger drainpipe requires wider trenches that are more disruptive than the narrower trenches of sand-slit drainage systems.

SIDE-HILL SEEPAGE

Side-hill seepage occurs when an impermeable layer lies beneath a more permeable soil. Water flowing down through the permeable soil hits the impermeable layer and is forced to flow horizontally until it reaches the surface, often along a hillside. Seepage water can be especially problematic during spring snow melt or extended periods of wet weather.

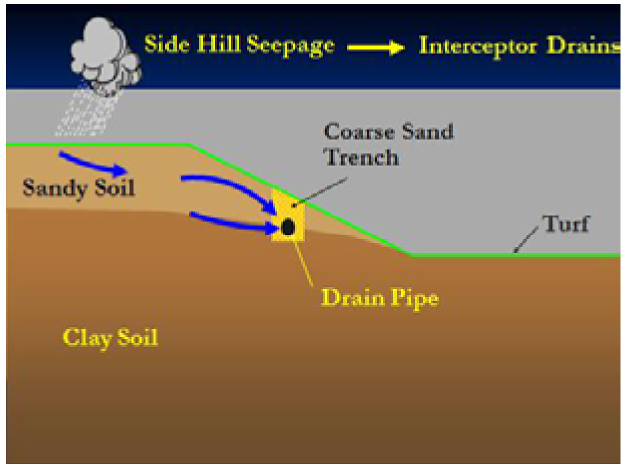

Diagram courtesy Kelly Ami Inc.

Subsurface drains are an effective way to intercept side-hill seepage. A subsurface drain should be installed across the hillside immediately above the upper limit of where the side-hill seepage reaches the surface. The drainage trench must be deep enough to reach the impermeable layer and usually is backfilled to the surface with coarse sand. Occasionally, gravel also is placed against the trench wall.

HIGH WATER TABLE

A high water table is another cause of chronic surface wetness. High water tables — often found adjacent to bodies of water — become problematic when they reach within 12 to 16 inches of the surface, causing chronic wet conditions that reduce playability and promote the establishment of sedges and other water-loving plants. Digging a test hole will help confirm the presence of a high water table; if water seeps into the bottom of the hole and remains indefinitely, a high water table exists.

When possible, the most effective solution to a high water table is lowering the level of the water body responsible for the condition. Otherwise, the wet area must be elevated or the water table lowered using subsurface drains.

If subsurface drains are necessary to lower a high water table, they should be installed at depths of 2.5-4.0 feet. Also, the perforated collector drains must have a free-flowing outlet to be effective. Water may have to be transported long distances if a nearby outlet is not available, sometimes requiring the aid of a pump.

A high water table can make installing subsurface drainage difficult because saturated soils and collapsing trenches are likely. Specialized equipment may be necessary, or subsurface drainage work may have to be scheduled at a time when the water table is lower.

GOOD DRAINAGE GONE BAD

There are several reasons drainage systems fail. Poor design or improper installation can lead to drainage failures. The effectiveness of existing drains also can be compromised by lack of maintenance or accidental damage during construction projects. Furthermore, tree roots can clog drain lines, rendering them useless.

Sometimes existing drainage can be overwhelmed by increases in stormwater flow. Entire drainage systems can be compromised by changes that occur outside the golf course property. These can be the most complex and difficult problems to contend with, especially when the solutions require cooperation from adjacent property owners or government entities. Challenging or not, drainage issues should not be ignored. Conditions will only get worse if drainage issues are not resolved.

DESIGN

Drainage design and installation are extensive topics that cannot be fully covered in the framework of this article. The fundamental principle of drainage design is simple: water flows downhill. However, challenges can arise when adapting this principle to local conditions because every golf course is unique. Fortunately, there are various design solutions available for addressing drainage issues.

A natural design is one in which drain lines are laid out to follow the contours of the ground and capture water from low areas. A grid design is typically used to drain large, flat areas and places pipes in a uniform pattern with lateral drains that are perpendicular to main drain lines. Herringbone designs, often used to drain irregularly shaped features, are a hybrid of natural and grid designs featuring lateral pipes that meet main drain lines at an angle.

Drainage design can become very complex in low-lying areas of a watershed or where topography is flat. An effective design has to account for the volume of water entering the drainage system, where water enters and exits the property, and the natural pathways water follows. Observing the golf course during a heavy rain event can help identify problem areas and provide valuable insight into how water moves across a property. Golf courses that receive large quantities of stormwater, are subject to flooding, or have challenging terrain typically will require more complex drainage systems that should be designed by drainage specialists.

MATERIALS

There are many pipe options available for subsurface drainage projects. Most slit and seepage drainpipe is perforated high-density polyethylene (HDPE) pipe. However, solid pipes are used to transport the water collected by a drainage system and also are useful where tree roots are a concern. Generally, drainage pipes are corrugated and either single or double walled. Double-wall HDPE pipe is stronger than single-wall pipe and is becoming more popular for golf course applications. Single-wall corrugated pipe is flexible and easy to work with but is not as strong as double-wall pipe. Single-wall pipes should be buried with a minimum of 20 inches of backfill to prevent crushing. Double-wall corrugated pipe can be safely buried with a minimum of 12 inches of backfill. Keep in mind that double-wall smooth-interior pipe can discharge water more quickly than pipe with a corrugated interior.

For seepage drains, 4-inch perforated pipe is the most common choice. However, 2-inch perforated pipe can still be used to address seepage issues. Smaller pipes typically are used when seepage lines are installed at shallow depths or when minimal disturbance is desired. Larger pipe is utilized to drain larger volumes of water.

Most drainage engineers and specialists recommend using geotextile-wrapped pipe encased in sand for subsurface drainage projects. Using sand and fabric together creates a stable system in virtually all soil types, extending the performance and work-

Only a few months after installation, turfgrass has nearly covered the trenches of a slit drainage system. This system follows a grid pattern and utilizes 2-inch, perforated, wrapped pipes in a sand envelope.

Surrounding a gravel envelope with non-woven geotextile fabric will prevent fine soil particles from migrating into the gravel and perforated pipe.

Cleaning open ditches to reestablish water flow maintains a good outlet for subsurface drains and speeds water flow through the property.

ing life of the drain lines. It is important to note that not all geotextile fabrics are the same. Knitted or non-woven geotextile fabrics are strongly recommended over woven alternatives. In addition, wrapped pipe should never be installed in a wet trench where more than 0.125 inch of the pipe is under water during installation. Backfill sand should immediately be placed in direct contact with a dry, wrapped pipe to ensure a long life.

There are arrays of basins or inlets available today. Grates with large openings are less susceptible to clogging with debris and typically are used in rough areas, especially where heavy water flow is expected. Also, basins with permeable sidewalls are specifically made for turf applications. Manufactured fittings should be used wherever possible. Connections between large-diameter pipes (larger than 6 inches) are ideally made at surface inlets.

Selecting the proper backfill material for trenches is critical to the performance of a drainage system. Porous backfill materials act as a conduit allowing surface water to reach the drainage pipe below. The backfill material also protects drain lines from crushing and filters fine particles that could potentially clog the system.

Traditionally, gravel has been used to encase drainage pipe and open stone drains still remain popular in non-play areas. However, there are potential problems with using gravel as a backfill material. Gravel is a poor filter of fine soil particles. The migration of soil particles into the gravel envelope and eventually into drainpipes can significantly limit the effectiveness of a drainage system.

Additionally, the migration of soil through gravel can cause drainage trenches to settle, creating depressions that disrupt surface uniformity. Therefore, sand is the preferred backfill material for most subsurface drainage projects. However, gravel can be used if it is sized to ensure that trenches will remain stable and there will be no migration of fine particles.

A physical soil testing laboratory can determine if gravel is appropriately sized for native soils. If there is any doubt, a non-woven geotextile fabric should be used to line drainage trenches and cover the gravel envelope.

INSTALLATION

The trenching process varies with the drainage objective. Trenching machines are appropriate for installing small-diameter pipes at fairly shallow depths, provided rocks are not a major concern. Drainpipes that are 4 inches in diameter and larger require wider and deeper trenches that are usually made with a mini-excavator or small backhoe.

Start digging drainage trenches at the discharge point and work uphill to the end of the line, ensuring there is sufficient slope within the drain line for water to reach the discharge point. Drainage trenches should be dug wide enough to provide a 1- to 2.5-inch gap on both sides of the pipe to allow backfill material to surround the pipe and protect it from crushing. However, trenches should not be overly wide to avoid unnecessary cost and disruption. Trenches for 4- and 6-inch drain lines should be dug with a standard 12-inch wide bucket.

The slope of a drain line will depend on the elevation difference between the highest point of the drain line and the outlet. Ideally, drain lines should have a minimum slope of 1 percent — i.e., fall 1 vertical foot for every 100 feet of horizontal run. Though not ideal, drain lines can function with slopes as low as 0.1 percent — i.e., fall 1 vertical foot for every 1,000 feet of horizontal run, but they require precise installation with lasers and an experienced crew. The slope of each drainage trench

Workers install a 4-inch, wrapped, perforated pipe while a small excavator digs the drainage trench. The trench is checked with a grade laser to ensure a consistent slope. Note that the excavator operates on plywood to avoid damaging the playing surface.

should be frequently checked during installation. If necessary, sand or gravel can be used to create a smooth and uniform trench bottom prior to installing the drain line. However, bedding drainage pipe in a layer of sand or gravel is not necessary.

ALTERNATIVES TO GRAVITY SYSTEMS

There are three options when it comes to transporting water: gravity, pumps, and siphons. The vast majority of drainage systems use gravity to transport water. However, there are times when sufficient relief is not available and alternatives to gravity drainage are necessary.

One alternative to gravity drainage is to use a pump system to transport water to a higher elevation where it can be piped away from the site. There are two basic types of pump systems — electrical pumps and irrigation-driven pumps (IDPs). Electrical pumps are the most common, but they can be expensive to install, particularly if they need to be located far from an electrical source. IDPs are typically less expensive than electric pumps and utilize energy from the irrigation system to pump water by connecting to the nearest lateral irrigation line. As a result, IDPs are only operational when the irrigation system is pressurized. Although less common than pumping, siphoning offers another alternative to gravity drainage systems.

MAINTENANCE

No drainage system is maintenance-free. One of the most often overlooked areas are the ditches and swales that are in place to move water through a property. Open ditches should be clear of downed trees, leaf matter, silt, and other debris that impede water flow. Also, check for free flow at drainage system outlets. Slit or bypass drain systems must be monitored to maintain adequate water infiltration into the sand trenches. Frequent light fairway topdressing can maintain the integrity of sand drainage trenches. In cases where trenches begin to lose their effectiveness, drainage trenches can be recapped with new sand. Also remember to periodically check and clean catch basins, keeping surface inlets free of debris and making sure grates are intact.

Electric pumps and IDP systems also require regular maintenance.

Northern golf courses may have to winterize pumping systems to protect them from damage during cold temperatures.

CONCLUSION

Successfully addressing drainage issues requires the ability to identify the underlying causes of poor drainage and a good understanding of general drainage principles. Though never glamorous, successful drainage remains a key component to the sustainability and success of a golf course operation. The old adage "you can pay me now or pay me later" comes to mind when assessing drainage problems — the longer they are put off, the more problematic and expensive they become.

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Tree roots can quickly clog a drain pipe, rendering it ineffective. Solid pipes with sealed joints are recommended near trees with aggressive root systems. In these areas, surface inlets can be used to capture surface water where necessary.

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