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Drainage: The Safety Net of Sports Turf Management

Compaction, disease, annual bluegrass encroachment, salt buildup, shallow roots-all these turfgrass problems can be attributed largely to one cause, poor drainage. Turf managers spend millions each year treating its symptoms without digging beneath the surface to find and correct the real cause.

If golf course superintendents are expected to keep high-use recreational turf areas in play, they must have adequate control over soil moisture. It is remarkable that they have been able to apply technology to temporarily overcome seasonal drainage problems. They have skillfully concealed the oversight of architects who had failed to incorporate adequate drainage into their designs, as well as overcoming the effects of time on properly designed drainage systems.

They have also learned that drainage is a safety net for irrigation, allowing them leeway in estimating how much water sports turf requires. Drainage not only guards the turf from surface-applied water, it also protects it from high water tables and salt intrusion from subsurface water.

Drainage systems are more than conduits that remove excess water. Taken as a whole, they include the surface, the soil, gravel, numerous types of pipe, filter material, moisture barriers,

soil layers, and even pumps to create suction. Each component can alter the effectiveness of a drainage system. For this reason, the turf manager needs a basic understanding of how each component contributes to the overall effectiveness of a drainage system.

The drainage needs of high-use recreational turf are unique. They are considerably different from those for agricultural production, commercial landscaping and residential turf. Control over water in the root zone is essential to enable turf to recover from traffic abuse and to assure playability.

OUR OBJECTIVE: The collection, preservation, and dissemination of scientific and practical knowledge and to promote the efficient and economical maintenance of Golf Courses.

"DRAINAGE: (con't from page 1)

The United State Golf Association was one of the first organizations to explore drainage systems designed specifically for sports turf. It sponsored university research into combinations of soil mixes and drainpipe to improve the condition of golf greens. This led to the development widely recognized USGA Green Section method, a fairly complex procedure of complete modification of the top 18 inches of soil combined with an arrangement of drainpipe.

Most research in sports turf drainage has centered around golf courses. Other methods developed for golf courses include the Purr-Wick and Cambridge systems. This technology has crossed over into athletic field construction and modification, perhaps most notably with the development of the Prescription Athletic Turf (PAT) system and other methods incorporating large quantities of sand.

At the same time, manufacturers of drainpipe have developed new products to give the sports turf manager more options when it comes to constructing or modifying drainage systems. Among these is smaller and thinner perforated drainpipe, which can be installed in narrow trenches to minimize surface disturbance. They have also begun to wrap perforated pipe or plastic cores with filter fabric to keep fine soil particles out of drain lines. Equipment to install new drain lines and to inject sand into existing root zones is also more widely available.

Simply installing drainpipe or replacing soil with sand will not completely solve drainage problems. These techniques may help, but they should be considered as just part of the solution. The sports turf manager needs to understand the strengths and weaknesses of every component of the drainage system. But first, he must distinguish between the different sources of excess water.

Surface Water. The most obvious way to control soil moisture is to restrict surface water. Natural rainfall, runoff from another site, and irrigation can be managed to varying degrees.

Frequently drainage problems are caused by runoff from adjacent slopes, paved surfaces or structures. Critical turf areas must be isolated from other areas with interceptor drains designed to remove both surface and subsurface water.

The slope of a turf area plays a major role in surface drainage. A one-to-two-percent slope is generally recommended. Soils are only able to absorb water at a certain rate. When rainfall or irrigation exceeds this rate, the excess water will flood the area unless the slope of the surface causes it to run off. Surface drainage also contributes to the effectiveness of subsurface drainage.

Great advances have been made in the past few years toward applying only the amount of water that sports turf needs. Advanced controllers now enable turf mangers to adjust irrigation cycles to fit weather conditions. They allow turf managers to repeat short cycles with a delay to prevent runoff.

Poor infiltration is often the result of a heavy thatch layer in moderate- to low-maintained areas.

Sprinkler heads and pumping stations have been refined to apply water at a rate that the soil can absorb. Soil moisture sensors are being used to override irrigation schedules, and on-site weather stations can feed data to controllers to help the manager regulate water use. These advances have taken much of the guesswork out of irrigation.

Subsurface Water. Controlling surface water is not even half the battle. One source of moisture to which turf managers are beginning to pay more attention comes from below. . .subsurface water. Golf courses and recreational areas are frequently built on flood plains, coastal land and other low-lying areas. High water tables and subsurface water can confound efforts to control soil moisture. You will understand why later in the article. Poor-quality subsurface water can also contaminate the root zone and complicate turf management.

"The presence of a water table within six feet of the surface indicates the need for improved subsurface drainage," warns Dr. James Beard of Texas A&M University. A high water table interferes with the removal of excess water from beneath the root zone he adds.

A network of drainpipe prevents subsurface water from saturating the soil above-in addition to removing excess water that percolates down from the surface. So drainpipe can be used to artificially lower a high water table. As long as the water collected by the drainpipe flows or is pumped away, a new, lower water table will be created.

Water Movement . The most difficult aspect of drainage to understand involves how water moves in through soils. By observation, we know that water is pulled downward by the force of gravity. But there are many other forces which can counteract gravity. For example, water will move in a sponge or cloth from a wet area to drier areas regardless of direction. The same forces are at work in soils.

One of the best explanations of soil-water movement was presented by Albert Marsh of the University of California at Riverside in the book *Turfgrass Science,* published by the American Society of Agronomy. Marsh brought a refreshing clarity to the complicated subject.
Water movement depends greatly on soil texture. That texture is determined by the size and shape of the solid particles in the soil and the amount of open space around them. This space is commonly referred to as pore space, and may total 35 to 70 percent of the total soil volume.

Turfrass roots grow in these spaces by utilizing the air, water and dissolved nutrients found in them. When a soil becomes compacted by frequent surface traffic, the volume of pore space is reduced, hampering root growth, aeration and drainage. This is the primary justification for regular mechanical aeration of the top two to three inches of soil, the portion of the soil most susceptible to compaction.

Clay soils consist of very small, plateshaped particles. While the total volume of space around these particles may be the same as in other soils, the individual spaces are much smaller. Pore spaces arre larger in loam soils and largest in coarse, sandy soils.
Under normal circumstances, water does not flow through soil pore spaces like sand through an hourglass.

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Instead, water coats the soil particles as a film and flows from one particle to another in film form.

This *film flow* is slowed and even stopped by two forces. The first is the force that holds one water molecule to another, called *cohesion.* Examples of cohesion are when a drop of water builds up at the end of an eyedropper without falling. . .or the presence of droplets on a cold glass on a hot, humid day.

Soil particles hold onto water molecules by a second force called *adhesion.* The attraction between the soil particle and the water is greatest when the film is very thin, and decreases as that film gets thicker. As the amount of water in the soil increases, so does the thickness of the film.

Contact between soil particles and film allows the forces of cohesion and adhesion to interact to move water from wetter to drier particles. Since the contact between particles is greater in fine-textured soils than in coarse soils, *film flow* is also greater. This is also why fine-textured soils hold water more tightly than sandy soils.

When soils of different texture are in layers within a root zone, the contact between soil particles between layers is not as great. For that reason, film flow is disrupted. This is why a fine soil will not drain well into a coarser soil, or vise versa. Subsurface layers area major cause of poor drainage.

Film flow is sometimes referred to as capillary movement or unsaturated flow. When all pore spaces are filled with water, the soil is called saturated. This is an unhealthy situation for turf since the water occupies the space previously available for vital gases. Beneficial microorganisms in the soil which require oxygen can't function properly, and the necessary exchange of gases between the roots and soil air is disrupted.

At the point of saturation, the forces of cohesion and adhesion approach zero. It is at this point that water will begin to flow by gravity through large pore spaces in the soil. Since sand has the greatest percentage of large pore spaces, saturated flow is greatest in sandy soils. Saturated flow is poor in fine-textured soils.

This is also the point at which water will move from a fine soil into a coarser one, or from soil into perforated drainpipe or French drains.

Marsh cautioned that the soil immediately above a subsurface layer or drainpipe will be wetter than the rest of the soil. He advises that drainpipe or layers of gravel be placed beneath the root zone of turfgrasses. Marsh said many people presume that a gravel layer should provide excellent drainage and are surprised when excessive wetness above the layer is revealed.

For this reason slit trenches filled with sand should extend all the to the surface to the soil. If soil is placed on top of the sand, it will have to become saturated before water will begin flowing into the trench. Sand will also filter out fine soil particles that can plug the openings in drainpipe or filter fabric wrapped around them.

Percolation. The flow of water through the soil is known as percolation. When designing a green or field, the architect should select a soil mixture that will provide a percolation rate approaching the rate of a typical rain shower. Since the uniformity of the soil mixture over the area is important, attention should be paid during construction to make certain that all soil components are thoroughly mixed.

Under favorable conditions turfgrass roots will grow a foot or more deep. When poor soils and inadequate drainage shrink this depth to less than two inches, the turgrass plant is stressed and is not able to recover from sport-related wear. It will also be more prone to drought, winterkill, diseaes and tearing.

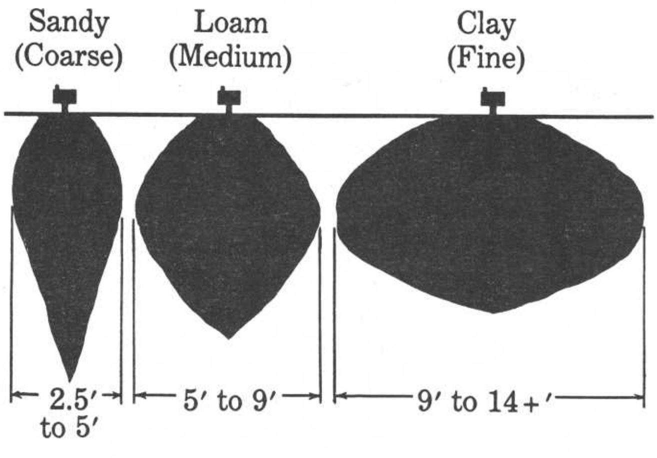
Resodding the area will accomplish little since the new sod will suffer the exact same fate. New sod can further complicate drainage if its soil texture is different from the root-zone mix.

Part of the advantage of having subsurface drainpipe is lost if water is not able to percolate down to it at a reasonable rate. Soil and drainpipe must work together to be effective.

Water moves more slowly in finer soils. It can take water in a clay-based field more than a day to reach drainpipe installed four feet below the surface, explains Steve Helmrich of Advanced Drainage Systems, Columbus, OH. Superintendents and sports turf managers rarely have the luxury of that much time. To overcome this problem, soils with higher percolation rates are used and drainpipe is installed at shallower depths.

Beard cautions that the artificial water created by tile should be as deep as possible when salt intrusion is likely.

SOIL TYPES VS. WETTED PATTERN



Soil texture	Infiltration rates, inches/hour Level	Sloping	Steep
Sand	1.0	0.5	0.3
Sandy loam	0.5	0.3	0.2
Loam	0.25	0.18	0.12
Clay loam	0.15	0.1	0.07
Clay	0.10	0.08	0.06

In such cases drainpipe may need to be installed as deep as six feet instead of the more common 18 inches to three feet.

The shallower drainpipe are installed, the closer they must be together, says Helrich. "The old rule of thumb is ten feet apart for each foot of deep." Again this depends greatly upon soil texture. Water movement to the drainpipe can be improved by sloping their subgrade toward the pipe. Some drainage systems include grading the subgrade in a series of "Hogbacks" to facilitate the water movement to the drainpipe.

Infiltration. A soil may have a reasonable percolation rate, yet puddles still form on the surface following rainfall or irrigation. The problem is poor infiltration. Many things can slow infiltration. They include compaction, an increase in the amount of organic matter in the surface soil, resodding with turf grown in soil of a different texture, and development of a heavy thatch / mat layer.

"Poor infiltration is frequently the result of a heavy thatch-mat layer that has developed over time in moderate-to low-maintained areas," reveals Don Hogan, an engineer of sports surfaces in Seattle, WA. Furthermore, fields or turf areas that have been flooded will often suffer from a deposit of silt. For this reason, regular maintenance of the surface and surface soil to maintain infiltration is critical for the protection of the drainage system.

The infiltration rate also depends upon the texture of the soil surface. A level sand surface will allow roughly an inch of water per hour to infiltrate, while a level clay surface allows only a tenth of an inch to infiltrate in one hour (See table for other rates).

The slope of the surface also affects infiltration . Sloped portions of large, undulating greens may have a percolation rate half that of level areas. For this reason, irrigation schedules should be set to the slowest infiltration rate on the green, which would be the sloped portion.

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Infiltration can vary within a turf area for other reasons, complicating both drainage and irrigation. Some surface soils and thatch can actually repel water by interrupting film low. This condition is called hydrphobia. It is detectable by noticing turf that shows wilt symptoms before surrounding turf and by taking soil core samples. Wetting agents can be applied to restore film flow to hydrophobic soils or thatch.

Aerification, slicing and light verticutting can be utilized to open up hydrophobic soils. Mixing soil cores and topdressing into the surface following aerification will also help reestablish film flow of water.

The spacing on sloped sites should be closer than on flat sites. Since heavy, fine-textured soils hold onto water longer, spacing for these should also be closer.

Manufacturers and their distributors can tell you how much water a particular drain structure transports in gallons per minute. They can also help you calculate how many gallons of water fall over an area per minute to match drainage with rainfall.

Excerpts from the Drainage: The Safety Net of Sports Turf Management" in the Feb. 1989 Sports Turf Magazine.

Pictures provided by Brian Bagley, Saratoga CC

Bypass drainage is proving to be a practical way to renovate older, poorly designed systems without major reconstruction.

Better drainage and irrigation give the Superintnendent control he needs to increase the durability and condition of natural sports turf. Superintendents can speed up greens for tournaments and sports turf managers can reduce compaction and improve durability of fields by reducing soil moisture before events.

They can lower surface moisture to discourage encroachment of annual bluegrass or the development of diseases. They can also increase soil moisture temporarily when aerifying, overseeding, or applying fertilizers, insecticides and soil herbicides. The control provide by drainage reaches nearly every phase of turf maintenance.

That is why drainage is said to be the most important aspect of sports turf design, construction and maintenance. Good drainage is an inescapable precondition of high-use recreational turf. Without it, the superintendent is trying to balance on a tightrope-without a safety net to catch him if he falls. It's too risky.

The bottom line is, according to Hogan, "If you can't afford proper drainage, you're going to waste money on everything else."