Drainage From Ground Zero

The two network commentators can't stop talking about it, and for good reason — the field is a marsh. It starts bad and gets worse. The grounds crew does everything possible, but their efforts are futile.

Sixteen hard-fought games for each of the two teams lead up to this, a mud bowl that looks more like a year-end blooper highlights film than a championship contest. The winning team is relieved when the final gun sounds. The loser is simply angry.

How many times has this scenario been played out over the years? How many times has a sloppy field seriously affected the outcome of a game, from the National Football League to high schools around the country?

While drainage certainly isn't the answer to all athletic field problems, it is the solution to many. Drainage affects not only the obvious, such as field playability, safety, and aesthetics, but the subtle, including the turf's ability to root, pest and disease susceptibility, compaction, and nutrient availability. If water is both life and death for turf, drainage is often the difference between the two

Stuck in a problem situation and short on funds, you may have to live with whatever drainage, or lack of, you inherited with your field. Regular aeration, topdressing, and use of soil amendments will help improve your situation. But if you're fortunate enough to be in a new field construction or rebuilding situation, understanding what's available, and how it works, will go a long way toward helping you make a choice.

Nobody argues the importance of drainage. How to achieve it, however, is matter of some disagreement. What follows are the drainage approaches, the hows and whys, of four athletic field design and construction companies.

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Installation of liner, vacuum drainage tubing, irrigation lines, moisture sensors, and specially selected sand for the P.A.T.™ system at Florida State University. Photo courtesy Prescription Athletic Turf.

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GraviTURF™ subdrainage installation at the Denver Broncos practice facility and headquarters in Englewood, CO. Photo courtesy Randall & Blake, Inc.

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Turf Diagnostics' Physical Perspectives

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Good drainage is the result of planning and good design. On-site materials are seldom suitable, from a physical perspective, to promote a durable field. Proper design and material selection are a critical process in building high-performance sports fields or maximizing the effectiveness of low budget fields. No matter what the design or cost, however, several physical principles are common to sports field success or failure.

Any turf system has limitations on the amount of traffic it can withstand during adverse conditions. Deep rooting and a strong sod mat are necessary to offer the best surface stability and traffic wear tolerance. To have deep, vigorous roots, good aeration in the root zone is essential. Drainage and aeration are actually flip sides of the same coin!

"Drainage" is a catch-all term that usually relates to the moisture status of the soil at various times. The moisture content of a turf system is as dynamic and ever-changing as the weather. During prolonged irrigation or precipitation, the system will be in a saturated flow state. The rate at which water moves into the soil depends on the root zone composition, such as soil texture and organic matter content. The driving force during saturated flow is gravity.

Sand-based systems usually drain quicker than native materials higher in silt and clay. Lab reports for evaluating materials usually note a saturated flow rate or infiltration rate in inches per hour. Water will pond on the surface when the rate at which it is applied is greater than the rate at which it moves through the soil profile. There is no doubt that a turf manager is going to want a high infiltration rate on a field to make sure water is removed from heavy rains before or during a game.

Once the free (or "gravitational") water is removed and the field starts to dry, the system will transition to an unsaturated flow condition. Here, the driving forces are evapotranspiration and wicking (matric potential) in the root zone. Wind and temperature have the greatest effect on water removal at this point,

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along with moisture used by the turf. Stadium fields often do not have good wind movement, which slows the drying process. Water evaporating at the surface creates a gradient that will start the movement of water to the surface. Roots will also extract water.

As mentioned before, the flip side of drainage is aeration. Once the gravitational water is removed, water left in the pore spaces is critical. Root zones need air for microbial activity and maintaining a healthy root mass. Air diffuses into the root zone or is sometimes pulled into it by a wetting front moving through the profile. The water-holding capacity affects the rate of air moving into root zones.

The root zone's soil volume has "solid" and "void" components. The void component is referred to as Total Porosity or Total Pore Space. Soil texture and bulk density will affect this. Air diffusion will be slow if the majority of pore space is filled by water. If air consumption in the root zone exceeds the rate of air recharge, roots will often start to prune toward the surface, which makes fields prone to compaction and diveting.

The percentage of pore space that holds water is usually called the percentage or degree of saturation. Root zones with more than 85 percent saturation after removal of gravitational water are at risk to root pruning and surface stability problems:

The bulk density of the soil is used to calculate total pore space and is also an indicator of compaction. Bulk density is usually reported in grams per cubic centimeter or pounds per cubic foot. The greater the bulk density number, the more compacted the soil. Soil particle density is the weight per unit volume of the solid phase only. Bulk density is the weight per unit volumes of the solid and void components of a soil sample.

Increasing bulk density decreases total pore space as well as adversely effecting the soil's water-holding capacity. When a soil is compacted, the volumetric water usually increases and has a greater impact on water retention and saturation. Also, the rate at which water moves during saturated conditions is also greatly reduced. Core aerification and topdressing programs can improve bulk density, reduce excessive water holding, and improve aeration.

More expensive fields will generally have some kind of drain pipe system, either in gravel or sand. However, root zones must be able to conduct water to the drain system at a rate that will drain the surface. It is not uncommon for us to see elaborate field drains that could move 50 to 100 inches of water per hour, with a root zone above the drain field that has an infiltration rate of 0.01 inches per hour. The system must be designed to meet site-specific needs, and materials have to be evaluated and selected with those objectives firmly in mind.

P.AT.'s Positive Approach

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Prescription Athletic Turf's natural turf drainage system provides positive (vacuum) drainage. The use of vacuum drainage accelerates and enhances drainage capability along with automatic moisture control (with manual override).

In terms of basic design and installation, after a complete engineering work up is done, the existing field is excavated to create a level subgrade 12 inches below what will be the final playing field. An extensive network of trenches are then cut into the subgrade to later accommodate P.A.T.™ drain lines.

Waterproof plastic sheeting is then laid over the entire field, and up to the surface at the outer edges, to create a barrier between the subgrade and the system. This prevents the loss of moisture and nutrients to the subgrade, providing uniform moisture conditions at the surface throughout the entire playing field.

Drain lines consisting of narrow, slitted tubing are installed on top of the plastic liner into the trenches, and tightly fitted to the collectors and main drain lines, which are installed in their respective trenches. Surface irrigation pipes are placed on the barrier and pairs of moisture sensors are implanted in the root zone in pre-selected locations throughout the field, with insulated wires extending to the site where the control panel will be placed.

P.A.T.'s vacuum system, which contains all valves, controls, and modern self-contained suction pumps are then installed. Main lines from the field are connected to the P.A.T. vacuum system that has an outlet to the facility's main storm drain. Moisture-sensing wires and vacuum controls are incorporated into the control panel, which is placed in a convenient location for easy access.

A bed of washed sand is placed between the plastic barrier and the turf surface. Analyzed for proper particle size and percolation rate, this carefully selected sand diffuses the suction uniformly and holds moisture and low tension. A proportionally balanced top mix is added to the surface of the sand and laser-leveled. Strict quality control standards are maintained to ensure the field surface has no more than 1/2-inch variance throughout. Once the final inspection of the laser grading has been approved, the selected grass is then sodded, sprigged, or seeded.

RBI's Irresistible Force

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Although we pay particular attention to the exact selection of the sand root zone medium material, the design of the subdrainage system is the backbone of the sand-based athletic field. Addressed incorrectly, through either improper design or implementation, the athletic field will surely fail.

When designing subdrainage systems for sports fields, you must first obtain accurate information with respect to site topography, existing storm sewer systems, drainage basin areas, geotechnical (soil and soil borings), reports, and historical information related to the average rainfall of the area. Because many of the Gravi-TURF™ athletic fields we design and install are for stadiums, stadium-related information is useful, particularly in older venues where surface runoff from seating areas often drains down to the athletic field. These elements will have direct bearing on the size and spacing of subdrainage pipe materials used in the design of the subdrainage system.

In Gravi-TURF subdrainage system design, we simply rely on gravity to assist us with removing water from the field. Based on collected site data, we will located the lowest elevation point within the subgrade to discharge the water flow from the subdrainage piping system. This is typically a proposed or existing storm sewer line that is being utilized to facilitate stormwater movement from stadium parking lots and adjacent landscapes. To determine the lowest point in the subdrainage system, we establish the desirable finish grade of the athletic field and work down from there.

The design and layout of the subdrainage piping system is then prepared and based on site data previously collected. We then determine where to discharge the water from the piping system. Generally, we design subdrainage piping with a minimum 1 percent slope on the pipe. The spacing and sizing of the

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perforated pipe is driven by the amount of rainfall and surface runoff the field will receive during a peak rain (i.e. a five year rainfall). Usually, the pipe sizes utilized will range from four- to 18-inch diameters. Pipe spacing can range from 15 to 20 feet, depending on the rainfall/runoff requirements of the site. In our experience, using perforated pipe without a filter fabric wrap is optimal for maintained desired flows into the pipe.

Once a subdrainage system is designed, it is equally important to make sure the subdrainage pipe is properly installed. This is best achieved by using laser-operated survey equipment and machinery to assure uniformity with trench depth and width. It is best to provide a trench that will allow at least two inches of bedding material on the sides and bottom, as the trench will also help facilitate water movement from the sand root zone medium. In addition, it is critical not to allow heavy machinery to cross the trenches after pipe installation, to eliminate the possibility of crushing the pipe.

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Proper selection of materials (i.e. sand and gravel) cannot be overemphasized when it comes to assuring optimum athletic field drainage. It is important to consider drainage materials that are clean and sized properly to assure correct moisture and nutrient retention, as well as excellent drainage. Careful monitoring of the materials imported to the site, along with proper testing to assure uniformity, are critical to the success of proper field drainage and subdrainage, which ultimately insure the overall success of the athletic field.

H.O.K. Inside Out

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The long-term performance of any sports turf is related to the physical characteristics of the root zone, subsurface drainage, and control of the subsurface water table.

Ideally, the root zone will be resilient, resist compaction, and provide excellent drainage. Sand-based fields provide these qualities when the performance and gradation of the mix is carefully defined. Organic matter must be included as part of the mix to aid in nutrient and water retention.

The USGA has developed specifications for greens construction, which can be used as guidelines when sourcing materials within a particular region.

The realities of budget may require using native soils as the turf growing medium. Natives soils are often less than ideal for sports turf—even the predominantly sandy soils found in Florida. While the physical properties of these soils can be improved, no one should expect them to perform as well as a high quality mix. A topdressing program, diligent management and maintenance, or wholesale modification of the root zone may yield beneficial results. However, even with a soil test as a basis for modification, quality control, and a consistent growing condition are difficult to achieve.

To a large degree, selection of the root zone material will dictate the parameters of surface and subsurface drainage. Sand-based fields provide the most latitude in surface drainage design. These fields can be dead level or sloped to accommodate the requirements for their respective sports.

Flat fields in spectator facilities usually have areas within the playing surface that are designed with a minimal slope. Sloping a portion of the field promotes runoff from a tarp or prevents the surface from appearing concave to the people in the stands.

Fields using native soils should be designed to provide positive surface drainage. Baseball requires a "turtleback" field configuration with the high point located near the pitcher's mound, and 0.5 percent slopes to the dugouts and outfield fences.

Football fields are crowned to form a ridge line between the hash marks. These fields should sloped from the centerline to the sidelines at a minimum of 1 percent. To promote rapid surface runoff, slopes of up to 2 percent are common.

The crown of a football field creates a land form that is undesirable for soccer. Soccer requires a playing surface with a maximum slope of 0.5 percent. Because soccer is best served by a level playing surface, utilizing native soils for competition fields is not recommended.

Most fields developed from native or man-made soils should include subsurface drainage for control of the water table. Water tables can be temporary, caused by infiltration and saturation of the soils, or seasonal, created by a fluctuating groundwater level.

It is critical to understand the infiltration characteristics of the root zone mix. Modifying the existing soils or using an artificial mix causes layering within the soil profile. This break in the soil strata may cause infiltrating runoff to be perched above the unmodified subgrade.

Seasonal groundwater levels vary from year to year, and typically occur at inconsistent elevations across the playing field site. A soils engineer can predict a theoretical high water level based on the site location and historical data. Water tables that consistently rise within two to three feet of the surface may adversely affect the stability or viability of the playing field.

Vertical trenches, with porous backfill and a system of drain tile or pipe, are one subsurface drainage option. Trenches and pipes must be spaced properly to effectively evacuate subsurface water. Consult with a civil engineer who is knowledgeable about drainage lateral design.

A second option is to place a gravel drainage layer below the root zone mix. This solution is effective in controlling both temporary and seasonal water tables. The drainage layer creates a consistent break in soil continuity, draining a saturated root zone and intercepting rising ground water. Combined with a perforated pipe lateral field, this system provides a reliable drainage solution. ❑