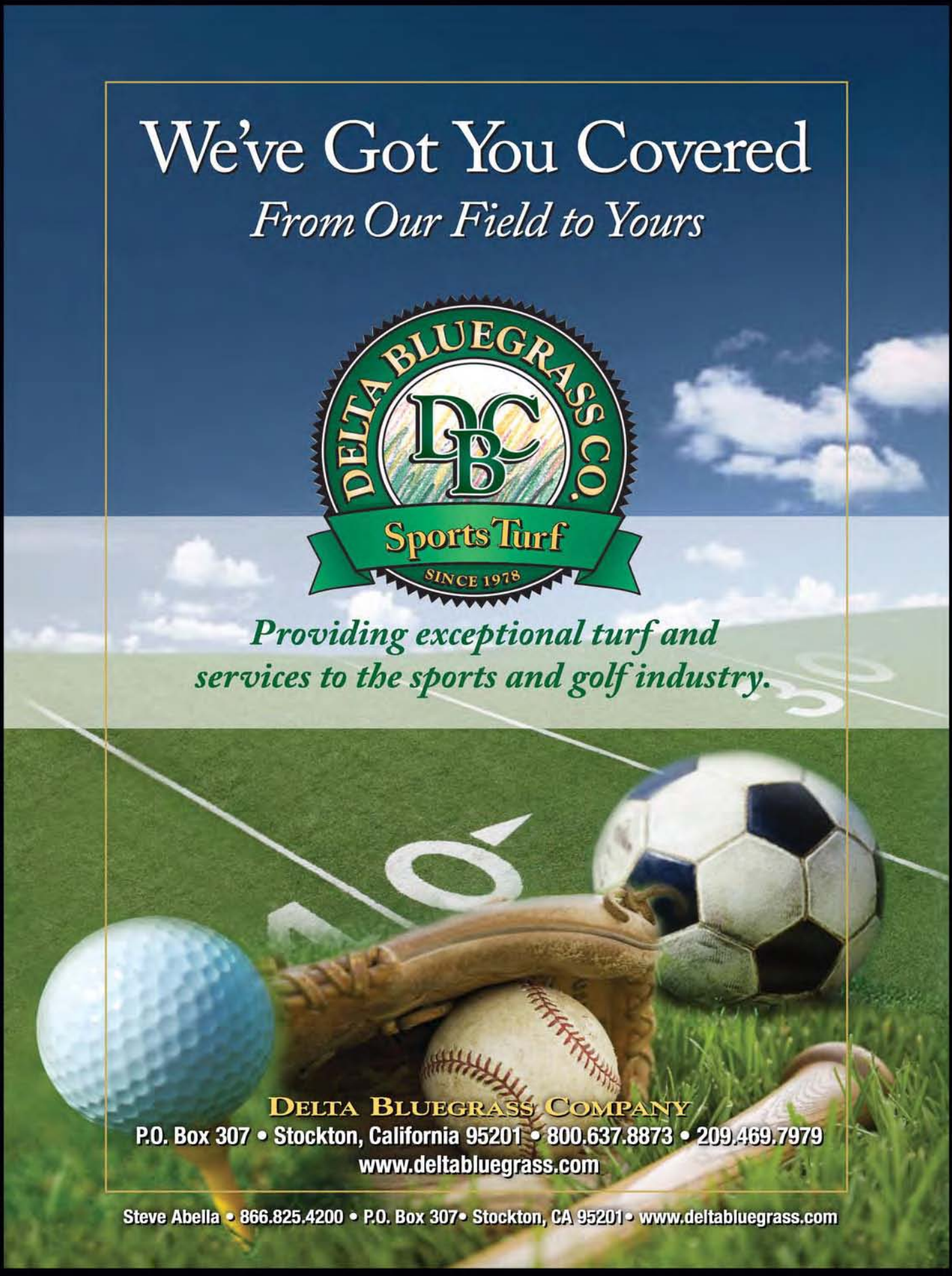
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face. If that is not the case, birdbaths will form, or in the case of sandy mixes, a quagmire. Laser guided grading is recommended. Also, the infield mixes should be compacted when placed, again to prevent vertical drainage and facilitate surface drainage.

PAUL ZWASKA, general manager, Beacon Athletics & former MLB head groundskeeper

For many years, it was believed that a 60% sand, 20% silt, 20% clay was the optimal infield soil. And in many cases it is. But I have tested many infield soils through the past 25 years that failed even though those percentages were met. Through continued trial and error and evaluation, the shortcomings were uncovered and adjustments were made to the generally accepted beliefs.

Sand in an infield soil provides the structural integrity in the soil much like the skeletal system provides the structural integrity of the human body. Sand is needed in the highest amounts in the soil to create the proper structure. However, it can't be any sand. In order to have the proper structure for what we desire to use the infield soil for, we must look at the distribution of the various sand particle sizes more closely.

In the past decade, it has come to light that an infield soil performs best when the majority of the sand in the infield soil is in the medium to very coarse range. The amounts needed depend on the level of maintenance these fields will see. In general, the lower the maintenance level, the higher the volume of sand, especially that of the medium to very coarse range. What is equally important is that the amount of fine to very fine sand in the soil be kept at a low level. High amounts of the finer sands is one area where many harvested infield soils have failed in the past, even those that had the right overall percentage of sand, silt and clay.

For a professional level soil, which usually sees a high level of maintenance, the overall sand content should fall in the upper 50 to lower 60% range. The medium to very coarse sand content for the professional level should be between 38 to 45%.

Silt has had its share of blame in bad infield soils and rightfully so, for too much silt creates serious problems in infields. I have tested infield soils from all over the US, and unfortunately, most have too much silt. Because we use mostly medium to coarse sand in the infield soil with just small amounts of fine to very fine sand, there is still a fair amount of large pore space left that needs to be filled to provide the proper soil density. If we leave too much pore space in the infield soil, it may not be stable enough for the soil to provide the proper traction for the player.

To return to the human body analogy, silt is like the organs that fill the large cavities of our skeletal system like the brain, heart, lungs, liver, and stomach. In the past, silt was looked at as its own entity in the soil; however, in recent years we have come to understand that for proper density, the silt needed to be looked at in concert with the amount of clay in the soil. Clay is the glue that holds soil together and keeps silt under control. It has been determined that the silt content in an infield soil should ideally equal half the amount of clay to as much as equal to the amount of clay.

To make this easier to understand, the Silt to Clay Ratio, or SCR as it has come to be known, was developed to make it easier for groundskeepers to make the decision as to whether their infield soil has the proper amount of silt and clay. The SCR is achieved by taking the percentage of silt in the soil and dividing it by the percentage of clay. An SCR of 0.5 to 1.0 is optimum. Infield soils with an SCR slightly above 1.0 to about 2.0 can work provided a topdressing is used in conjunction with that soil to help nullify some of the negative effects of slightly elevated silt content. Infield soils with SCRs greater than 2.0 or less than 0.5 will need some amending with other soils to bring them into balance. So whether you are looking for a professional level soil or something more on the recreational end, the target SCR should always be between 0.5 and 1.0.

If we know that the SCR should always be in the 0.5 to 1.0 range, then adjusting an infield soil to different maintenance levels simply involves adjusting the overall sand levels and the amount of medium to very coarse sand in the soils. For instance, park and recreation fields or school fields that see little regular maintenance or have volunteers working on the field require an infield soil with a much higher sand content. This helps to compensate for the lack of maintenance by keeping these fields a little softer or resilient since they won't be nail dragged or watered very often and probably have no topdressing on the skin like a collegiate or professional field. These fields will need the overall sand content to be between 70 and 75%. The medium to very coarse sand should make up greater than 50% of the overall soil.

There have been some very big changes in the recommendations and manufacturing of infield soils in the past decade. But we are merely playing catch-up to our equals in the golf industry when it comes to engineering the specific soils we need for our infield skins. Advances by some suppliers in the past 5 years have finally brought what ball field groundskeepers have been clamoring for decades. Infield soils engineered and manufactured to very precise specifications that can be replicated exactly, at any time.

The days of settling for the best harvested soil that you can find in your area will become a thing of the past in the next decade as groundskeepers will be demanding engineered infield soils more and more from their soil suppliers. These balanced soils make managing an infield so much easier. Those suppliers who educate themselves and update their manufacturing will thrive, but it is up to groundskeepers to keep the pressure on suppliers to perform. Groundskeepers have the responsibility of testing their infield soils and those that are supplied to them to know what is in their field and what is being added. You want to know that the soil you are adding is improving the makeup of the skin and not negatively impacting the performance of it. Creating the perfect infield soil is all science, period. The art is in maintaining it while dealing with all of the variables that weather, player preference and scheduling throw at you.

DAVE DWIZLEWSKI, consultant, Gail Materials, Corona, CA

Standard Specifications for Infield Mix: One of the most import points to recognize is that a standard methodology for testing needs to be established. As of now I prefer the ASTM F-1632 or ASTM D422 procedures for testing infield dirt. Standardizing the acceptable methodology is the only way to compare "apples to apples" when you are comparing infield mixes.

The basic infield mix for city parks, youth leagues, high schools and even some colleges should fall into the range of 70-75% sand with combined silt plus clay ranging from 25-30%. The silt to clay ratio should be in the range of .5-1.2. The fine gravel content should not exceed 2% and the distribution of sand particles should have the highest percentage in the medium particle size fraction. Since a 2 mm particle size is the maximum sand size (very course sand) it comes to reason that to achieve this particle size distribution, the parent material should be processed with a 2 mm mesh or smaller screen.

Gail Materials starts our screening process with 1.8 mm mesh screens. Many infield mixes are quite course and are often screened at ¼ inch or 1/8 inch. Screening to a texture of 2mm or finer is difficult especially in wet climates therefore in certain parts of the country it may not be feasible to produce infield

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mix in this manner. Be aware, however, that the wider the distribution of particles the more a soil will tend to consolidate. Courser particles are also abrasive. Higher end colleges or professional facilities tend to prefer a higher combined silt plus clay content in the range of 35-45%. With this type of mix the same rules apply for the silt to clay ratio and gravel and sand distribution.

Tips for Best Performance on Low Budgets: This is a tough one because if having a nice infield skin was easy then everyone would have them. The fact is that it's a lot of work. I do not believe in "silver bullets" products that are sold as "no maintenance" or "reduced maintenance." We try to educate the end user on Best Management Practices but we also try to manage expectations. We constantly are providing literature, holding work shop clinics and we even produced a free educational DVD on infield skin care. At some point the client has to except some responsibility. We find that cities or schools that value their baseball or softball programs put the time into taking care of the fields. You cannot have great fields without effort.

One management tool that can eliminate many issues is the simple step of tilling the infield skin before placing new material. All too often companies that offer infield skin care simply place new infield mix on top of hard dry skins without incorporating the old and new infield mixes. This causes a layering problem that can affect soil bonding, sheer strength and water movement. Tilling the existing skin is an extra step that is often skipped. All too often we have experienced this skipped step related to poor performance of the infield mix and the end user incurs extra cost to repair. If any contactor states it's not necessary then that contractor doesn't understand basic soil physics or they do not offer that service.

Questions to ask you supplier: In order to know if your supplier is educated about their materials then you need to put the time into being educated as well. If you don't know then how can you tell if what you are being told is the truth? The tools are out there. I think anyone who puts in the time to learn just the basics about soil science and how it applies to infield mix may find out that many suppliers may not know about their materials all that well. Request updated soils tests and check for references, if this information cannot be provided, that should raise a red flag. Ask if the supplier screens their material or is it done for them at a local quarry. Companies that screen their own material tend to have better control on the quality. Also you can always ask for a sample.

JAMES HERMANN, CSFM, Total Control, Inc., field consultant

After 25 years working on infields I have come to the conclusion that there is no perfect infield mix. The perfect infield mix would be like the perfect soil. Talk to five different groundskeepers and you will get 10 different opinions on what works best. A safe playable infield is not the result of the products used; it is the result of how those products are used.

A quality infield mix is an infield mix that is consistently an accurate depiction of the professed sand, silt, clay ratios. Far too often suppliers will end a discussion on sand, silt, clay content with the phrase "plus or minus 10%." In reality that makes the analysis worthless.

The more sand a mix contains, the more that infield will erode as the slope and the distance the water travels to exit the field increase. I would not recommend a sand content of more than 80% for a field with 1½% slope, especially if that slope initiated on one side of the infield and continued all the way to the other side of the field.

A skinned infield is more forgiving than a grass infield and can withstand a mix with more sand content since there is less perimeter turf area to be affected by lip buildup. The aggressiveness of the predominant level of play is also a consideration. A men's softball field requires a mix with less sand and more stability than a children's T-ball field.

I believe that before you can decide on the sand content of any infield mix you have to decide on whether or not you are going to be blending calcined clay with the mix. I look at it as "sand sized particles" not just sand. If a groundskeeper anticipates blending calcined clay with an infield mix, that mix should start out with less sand than a mix that will not ultimately be blended with calcined clay. When calcined clay is dry, it is going to react much like sand in a mix except for it is lighter and moves around more creating yet another consideration.

Far too often comparisons between products are made solely on sand, silt and clay ratios without consideration for the sieve analysis of the sand. A fine sand will react in an infield mix much like silt in that the mix will have the potential to be hard as a rock and dusty when dry and gooey when wet. If the field is located in a windy location prevailing winds will blow the fine sand into the turf perimeters adding to the accumulation of a lip.

In my perfect world, less than 20% of the sand would be in the "fine" range (.1-.25mm), at least 60% of the sand would be in the "medium" to "coarse" (.25-1mm) ranges and less than 20% of the sand would be in the "very coarse" (1mm-2mm) range. The mix would have a maximum of 4% or 5% gravel with no particles larger than 4mm.

Silt is a double edged sword. I prefer less than 8% silt at no more than a 1:2 ratio silt to clay on the fields that I work on because most if not all these fields rely on mother nature for all their moisture. Silt has the potential to make a mix dusty when too dry or gooey when too wet. At higher levels of maintenance, silt can aid in moisture management.

Clay: If I could specify one clayey (silt and clay) content that works on most of the fields most of the time I would say 20%. This percentage could vary either way by 5 or 6% depending on field usage, grading plan etc. This percentage could be lowered as much as 10 or 12% if calcined clay is anticipated as a significant portion of the mix 20% clayey content would not allow much more than 6% silt based on a 1:2 silt to clay ratio.

Tips: More problems are caused on infields by improper maintenance than by no maintenance at all. Low budget facilities rely far too heavily on roll up drag mats and not enough on a spring tine or nail drags. A heavy roll up drag uncontrollably moves far too much material, creates unnecessary compaction and brings more coarse material to the top. Every maintenance procedure should support positive surface drainage. More time should be spent on lip management procedures such as blowing or sweeping loose material off the grass.

I repair a few skinned infields each fall for a local municipality. Their crew uses a $30,000 utility vehicle and a $50 drag to manage their fields. They start at the edge of the infield and go round and round, working their way to the middle at about 30 mph and then start around the pitching rubber and do the same, working their way to the outside until the two patterns meet. These fields inevitably have a depression around the perimeter that resembles a moat when it rains. At the same time the pitching rubber looks like a little island encircled by water with a mound of material build up at the point where the two patterns ultimately meet.

Questions: I believe it is the responsibility of the infield manager to have the understanding necessary to make an educated decision on the infield mix he or she desires and require a sieve analysis from the supplier to insure a product that conforms to that need.

BILL MARBET AND GLENN LUCAS, Southern Athletic Fields, Inc.

Infield mixes are the foundation to which your field is built. Just the same as a foundation to a house, the infield mix that you chose will

determine what kind of "house" you will have. When you speak to groundskeepers at various levels, from professional to high school to youth leagues, they will almost always speak of how their infield mix plays during the game, the management of the infield mix and what the players are saying about it. With various levels of play, there are various levels of expected quality to the infield mixes. We believe that the infield mix should be consistent and then can be amended to meet the groundskeepers' needs and wants with field conditioners, topdressing materials and above all, the amount of moisture in the profile.

Standards are hard to determine, due to the regional materials that are presently available on the market. We will focus on what we expect infield mixes to be and how they relate to standard materials. Infield mixes should be in the following ranges of Sand/Silt/Clay, 60-70% sand, 15-25% Silt, 15-25% Clay. The silt to clay ratio can be .5-1, determined by dividing the clay % into silt %. Particle size of sand is as important as the silt to clay ratio. Ideally, your sand should be angular in nature and 60-70% of the sand, should be in the medium to coarse range. An infield mix that has a high percentage of fine to very fine sand should be avoided as it will become unstable. The infield mix must be professionally screened to be free of all debris. Also, you can request a current textural analysis of the infield mix that is being sold to you to evaluate the above information.

Infield mixes can be adjusted to different levels of play by changing the silt to clay ratio. Low budget fields, if they have a loose infield, can, over time add a heavier clay material to the field and create a firmer, safe and more playable surface and get the silt to clay ratio back to the .5 to 1 ratio. Another factor to look into when selecting infield mixes is moisture retention. Does the infield mix retain moisture? It might be overlooked in the process of infield mix selection, but, moisture retention is just as important as the silt to clay ratio. If an infield mix holds moisture, then more than likely, the silt to clay ratio is correct. If you have a lower ratio, it will hold less moisture, thus, not meeting the standards set forth.

What questions should be asked of the company providing the infield mixes? Can you provide me with a current textural analysis of your materials? What is the Silt to Clay Ratio, based upon textural analysis? What is your sand particle size and percentages of each size? Is the infield mix screened and if so, what is the screen size that it passes? What are the routine maintenance practices that are recommended for the infield mix provided? Can we get a different material based upon what our complex needs or wants?

DENA DIVINCENZO, business development manager, Waupaca Sand & Solutions

Although there would be some positives to creating a single standard for infield mix, we don't believe that a "one size fits all" standard would be practical. Preferences, local availability of raw materials, and maintenance practices vary by region. Standards are created locally. We advise using pair of infield mix "recommendations" based on water and maintenance availability. Our recommendations are derived from our knowledge and experience in the Midwest. We recognize that these recommendations may not be appropriate for other regions of the US.

Field Type #1: Limited or no access to water management tools. Limited maintenance capabilities. Recommendation:

- Sand (2.0-0.05 mm): 65-80% retained
- Combined Silt & Clay (0.05-< 0.002 mm): 20-35% retained

• Gravel (>2.0 mm): 95-100% Passing
• Very Coarse Sand (1.0-2.0 mm): 80-95% Passing
• Coarse Sand (0.5-1.0 mm): 70-90% Passing
• Medium Sand (0.5-0.25 mm): 40-65% Passing
• Fine Sand (0.25-0.15 mm): 25-45% Passing
• Very Fine Sand (0.15-0.05 mm): 20-35% Passing

Field Type #2: Access to water management tools. Regular maintenance capabilities. Recommendation:
• Sand (2.0-0.05 mm): 50-65% retained
• Combined Silt & Clay (0.05-< 0.002 mm): 35-50% retained
• Gravel (>2.0 mm): 95-100% Passing
• Very Coarse Sand (1.0-2.0 mm): 80-95% Passing

Coarse Sand (0.5-1.0 mm): 75-90% Passing
• Medium Sand (0.5-0.25 mm): 50-70% Passing
• Fine Sand (0.25-0.15 mm): 40-55% Passing
• Very Fine Sand (0.15-0.05 mm): 35-50% Passing

Regarding silt-to-clay ratio, the 0.5-1.0 ratio we hear being promoted is not universally available. When field managers in our service area request a mix that meets this ratio, the raw materials often need to be trucked longer distances, adding significant freight expenses. We recommend that the ratio currently being promoted either be considerably widened, or that field managers be educated on exactly why meeting a certain silt-to-clay ratio is worth paying a premium price. In the Midwest, there are hundreds of fields with silt-to-clay ratios higher than 4 which perform very well because the field managers know how to manage this common local material.

Generally speaking, we recommend that an infield mix being maintained by field managers with low budgets contains a higher percentage of sand (between 65-80%). Players can play on a dry field, but not a wet one. Therefore, the first priority of a field manager is often to simply have a dry field surface, and fields with higher sand content dry faster. Field managers in this situation will likely have less access to tarps, water, manpower to drag fields, field drying amendments, or other tools to manage the excess moisture retained by infields with higher silt & clay contents.

To get the best performance from an infield skin, ensure that the field is graded with at least 0.5% slope to promote surface drainage of water off of the field. When puddles and low spots form, remove any topdressing from the affected area, then fill the area with infield mix, compact and grade it, then return the topdressing to the filled area. Remove lips so they do not block water flow and to avoid player injury.

Insist on receiving a current soil texture analysis from your infield mix supplier. Ask them to provide more than one so you can check the consistency of their mix over time. The soil texture analysis should include percent sand, silt, and clay, as well as sand particle size breakdown. Also ask the supplier what size screen they use to remove larger particles from their infield mix.

When considering a new infield mix supplier, ask them for names of organizations that use the mix you are considering. Contact those references to ask how the infield mix performs, how they maintain it, etc.

CLAYTON HUBBS, director of operations, Stabilizer Solutions, Inc.

What should the standard for infield mix be? It depends. The first criteria to keep in mind when selecting an infield mix has to do with matching the needs of your athletes' legs. In engineering terms, load bearing capacity is the capacity of the soil to support the load applied to the surface. The load bearing capacity determines whether we can support the runner's running motion. Shear strength is the ability to resist failure, usually a sliding or tearing failure along a plane. The shear strength shows us whether we can support the fielder's side to side movements. The load bearing and shear strength requirements needed to support a professional athlete are much different than they are to support a child or recreational athlete, and your particle size should reflect this.

Other considerations that need to be taken in your decision include the amount of play, available staff, regional weather/available moisture for the infield. Usually, for K-12 and many parks and rec, we see the answers to these questions being: too much, too little, and too much or too little depending on the region. Moisture really is the most critical element. It changes the load bearing capacity and shear strength of our infield.

A study that we conducted with the Massachusetts Institute of Technology shows that at the ideal moisture content of 4%-12% water (depending on clay content), soil receives natural moisture binding by surface tension forces of attraction. This simply means that the right moisture content, a *damp soil consistency*, is ideal for an athlete to play on. If you are in a very wet climate or a very dry climate, how can we build an infield mix that allows you to maintain that 4-12% moisture in your infield for the longest possible time frame?

Throughout our company's 30 years of business, we have engineered mixes for new regions. Some regions we work in receive minimal rainfall, some receive heavy rainfall, and some receive their annual rainfall all in a couple of big storms. We have found across the country that for K-12 and Parks & Rec type applications, a good particle size guideline to start with is 70% sand, 15% silt and 15% clay. This clay content provides us with the cohesion needed for our load bearing capacity and shear strength to meet the needs of our athletes. The silt content provides the bridge between sand and clay particles. The silt-to-clay ratio should be around 1. Too much silt and too little silt can cause alternate problems. The sand particles should be properly distributed throughout the fine, medium and coarse distributions. This will provide us with some additional structure, but will also create pore space.

Finally, remember the infield receives 70% of game activity. That means it should be able to stand up to quite a bit of abuse. When in doubt, err on the side of firmness. As long as you stay under the Major League minimum of about 40% silt and clay, you should be safe. It is easier to work a firm field into shape than a soft one.

CHARLIE VESTAL, Turface Athletics business manager, Profile Products

It has always been our belief that an infield mix should match the level of play and level of available maintenance. Beginning with the premise that there always needs to be as much or more clay in the mix than silt, the percentage of sand can vary based on the level of play. Parks and recreation fields with sand content in the 65-75% range will require less maintenance than an MLB maintained field with 55-60% sand. Care should be taken to consider the particle size of the sand since fine and very fine sands tend to behave more like silt than sand. At all levels of play the performance of the infield mix is directly related to moisture management. The incorporation of a soil conditioner will help maintain the proper amount of moisture in the mix. While used at all level of play the need for conditioners is especially important on fields where tarping is not an option.

When considering a new infield mix, in addition to looking at a current test report which gives percent sand, silt and clay and particle size of the sand, I would ask for references of who have used their mix and have similar field usages and maintenance practices as mine. Then go visit the facility and talk with the groundskeeper. ■

JOHN MASCARO'S PHOTO QUIZ

John Mascaro is President of Turf-Tec International

Can you identify this sports turf problem?

Problem: Marks on turf
Turfgrass area: Soccer Stadium Field
Location: Qabala, Azerbaijan
Grass Variety: Mixture of perennial ryegrass and Kentucky bluegrass

Answer to John Mascaro's Photo Quiz on Page 33

Background illustration courtesy of istockphoto.com

>> **PERENNIAL RYEGRASS STUDY AREA** at the University of Massachusetts-Amherst used to evaluate the effects of five rate levels of nitrogen on shoot and root growth under simulated traffic.

Enhancing nitrogen use efficiency of sports grass

A MAJOR CONCERN of society is to limit the application of water and nutrients such as nitrogen (N) to grassy surfaces including residential lawns and recreational turf. Water is a limited natural resource that must be conserved and protected. To that end, professional turf managers need to limit the use of N in order to protect surface and ground water from unnecessary contamination associated with the use of nitrogenous fertilizers when applied to turfgrass systems.

The conservation of N and water applied to turfgrass systems are closely related because the acquisition of water and N from the soil is dependent on rooting depth and density. As such, any cultural factors or conditions that inhibit rooting may reduce the turf system's ability to exploit the soil for these growth limiting resources. Eliminating any stresses that create an unfavorable environment for rooting will in turn allow the community of turfgrass plants to maintain turf function with less water and N. Sustaining turf function with less input from water and N fits nicely into "sustainable" turfgrass management practices, which is a term that has grown in popularity among turfgrass scientists and turf practitioners.

NUMEROUS OPPORTUNITIES

The opportunities to enhance N uptake by promoting rooting are numerous. All aspects of turfgrass maintenance practices such as height of cut (HOC), irrigation, and N fertilization directly influence rooting. In addition, there are as many conditions that exist in turf systems that are unfavorable to rooting such as excessive thatch, soil compaction, and strongly acidic soil pH, which can further impede rooting and reduce nitrogen use efficiency (NUE) of the turfgrass system. These unfavorable conditions and practices when considered alone may be harmful to rooting. Moreover, when these root-related stresses are active in combination they can interact and can be more inhibitory to rooting depth than any one practice or condition when considered alone.

In addition, many conditions (thatch and soil compaction) or practices (excessively close HOC, excess N and over-watering) that inhibit rooting and the efficiency of the turf system to acquire water and N can also promote waste as runoff and leaching. While runoff and leaching events are wasteful of water, these same practices or conditions can move fertilizer N into surface and ground water, respectively. By maximizing rooting depth and the turf system's NUE, the ability of the turf system to minimize N leaching is also enhanced, especially for irrigated turf in summer, when high soil temperature stress inhibits rooting of cool-season turfgrass.

The key to sustainable turfgrass management is to keep costly inputs such as N and water to their lowest possible level while sustaining optimal turf function. For optimal function under intensely trafficked sports fields, good shoot density and vigor is essential for wear tolerance and recovery. Furthermore, high turf density is also critical for keeping field related injuries to their lowest possible level. Nitrogen has competing affects on shoot growth and root growth and therefore "balancing N" to achieve optimum turf density and wear tolerance without diminishing rooting depth and NUE of the turfgrass system is important.

Five years of study was conducted at the University of Massachusetts-Amherst to evaluate the response of perennial ryegrass to incremental increases in N from 1 to 9 pounds per 1000ft2 per year. Perennial ryegrass was maintained at 1.25 inch HOC, irrigated to prevent drought stress and fungicides were applied to prevent disease. Our published research indicated a linear response to N in shoot growth (leaf growth rate and shoot density) and root growth (total mg root dry wt. cm-3 to a soil depth of 18 inch).

Each incremental increase in N caused sig-

While the gains in leaf growth are large in response to N there are diminishing returns with added N.

nificant increases in shoot density (no. cm-2) and leaf growth rates (measured as clipping yield, g dry wt. m-2 day-1). Leaf growth rates increased with N at a greater rate than shoot density. Shoot density increased with N by only 27% while leaf growth rates increased by a factor of 4.44 (444%). The gains in leaf growth with increasing N exceeded shoot density while rooting depth decreased by a factor of 2 in response to increasing N.

While the gains in leaf growth are large in response to N there are diminishing returns with added N. Unlike shoot and root responses to N, which are linear, acceptable wear tolerance (>6, 9=no injury) peaked at 3 to 5 lb N 1000ft-2 yr-1. Any opportunities to reduce N within this optimal range can provide the benefit of promoting 20% greater rooting and increase NUE without any loss in wear tolerance or recovery. In addition, greater rooting can improve the water use efficiency (WUE) of the turfgrass system by improving soil moisture acquisition with soil depth.

An incremental increase in leaf growth (leaf area) promotes higher evapotranspiration (ET) rates, which accelerates soil moisture depletion and wilting tendencies. The relationship between leaf area and N and their effect on turf ET in cool-season turfgrass is well established. Therefore, keeping N to its lowest possible level without compromising turf function (i.e., higher NUE) helps to promote deeper rooting while minimizing ET. The overall effect of less N is the potential for deeper rooting with lower ET, which may help to lengthen the irrigation cycle (days between irrigation). Any opportunity to add as many days to the irrigation cycle as possible can increase the potential for natural rainfall events to meet the water requirements of our turf system, rather than relying on costly (supplemental) irrigation. Like NUE, WUE can be improved by eliminating as many root related stresses as possible for maximum acquisition of either N or water.

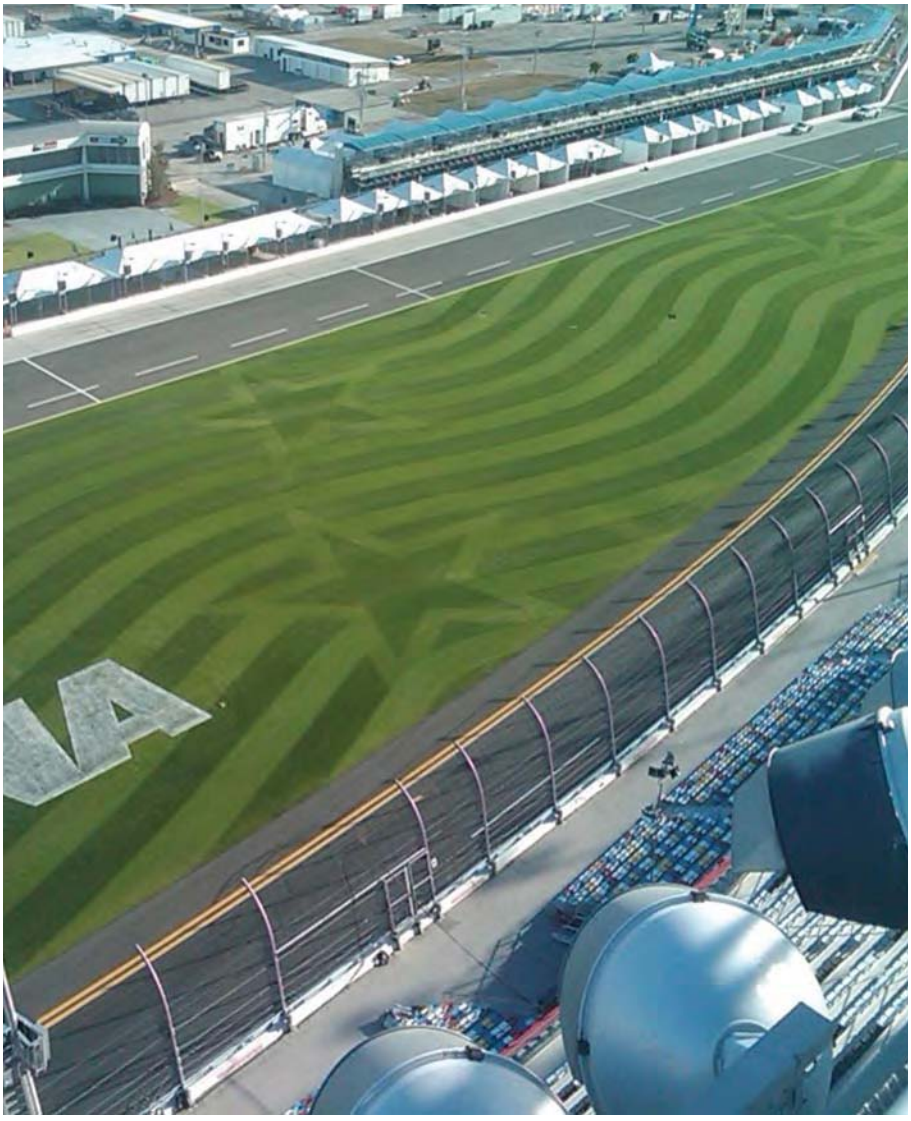
Irrigating using ET replacement (recharging the rootzones based on turf ET) helps to minimize leaching losses of N and water, thus improving the NUE and WUE of the turf system by alleviating waste. Furthermore, irrigating using ET replacement applied at mild wilt (tissue dehydration indicated by leaf roll or leaf fold) has been shown to length the irrigation cycle by enhancing rooting depth in perennial ryegrass. The use of slow release N (SRN) or spoon feeding at reduced N rates are other opportunities to improve the NUE of the turf system by eliminating waste as leaching. So, the opportunities to enhance NUE (and WUE) of turf systems are numerous because there are many practices and conditions that exist in turf that either affect rooting or promote waste or both; most of which are manageable by the turf practitioner. ■

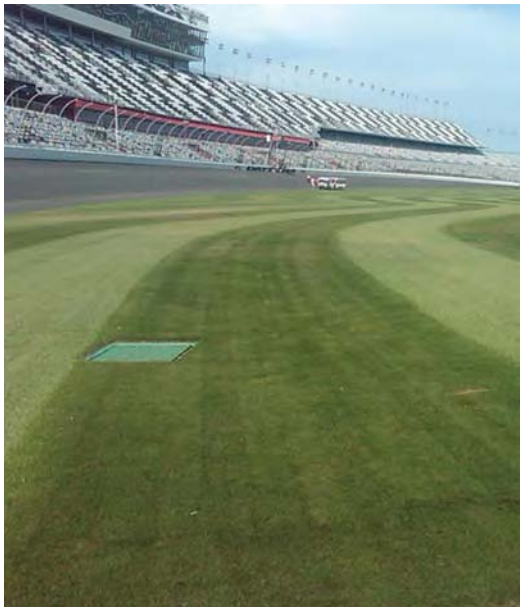
J. Scott Ebdon and Michelle DaCosta are faculty members in the Turfgrass Science and Management program at the University of Massachusetts Amherst. References for this article are available at www.sportsturfonline.com.

DAYTONA infield turf overseeded to produce stunning visual

THE GORGEOUS TURF SHOTS on this page, courtesy of Gary Morgan from Agrium Advanced Technologies, of the 6-acre grass infield at famed Daytona International Speedway, reflect thinking outside the box by Sam Newpher, the Speedway's grounds supervisor; his crew, Dan Brown, Bob Pearson, Perry Horton and Chris Hanson; and Speedway President Joie Chitwood, who suggested sowing stars and stripes across the field.

Newpher said he was asked by his boss, director of track operations Andrew Gurtis, to get creative a few years ago in trying something different in prepping for the Daytona 500, the Super Bowl of stock car racing and, almost by accident, he ended up alternately striping with annual bluegrass and darker-colored perennial ryegrass, which worked well. "We wanted to get even jazzier this year," he said.





"It was fun to do," Newpher said. "The five of us have a lot of experience getting ready for Speed Week and we were blessed with perfect weather, good temperatures and virtually no rain, so we could irrigate only when we wanted. The grass grew in perfectly."