All the bunkers were done that way.

"It helps reduce washouts," Kutt says. "We're in a canyon and get a little more rain than surrounding areas during the rainy season. That led to occasional problems with washouts and contamination. Billy Bunkers might be overkill in a normally dry area like this, but they work well."

HYBRID BLUEGRASS

Silva and Kutt also worked closely on another of the project's key creative aspects – the sodding of a hybrid bluegrass in 47 acres of rough area. This turf choice was an unusual one for the West Coast, but this particular strain was bred to survive hot summers, and its visual contrast with Bermudagrass provides definition of the fairways and greenside features.

"People are drawn to the bunker work and the angles Brian created coming into these new greens, but it's amazing how the definition helps you see the line of play," Sarkisian says. "People ask me, 'What were your expectations?' I have a pretty good imagination, but I'm amazed by the difference that grassing decision has made and what Brian accomplished here overall."

Annandale is the first course in Southern California to use a four-way Scotts blend consisting of Thermal Blue, Thermal Blue Blaze, Dura Blue and Solar Green, Kutt says.

"Most courses don't sod roughs, but we were really up against it with our soil conditions and topography," he says. "And we needed some sod anyway for the green and bunker surrounds. With the slow germination of bluegrass, it made sense to bite the bullet and sod 100 percent of the roughs, too."

Sod installation started around April 1 and finished in the middle of July.

With the help of turf consultant Andrew Curtis, Kutt contrived a preplant fertilizer to ensure the early establishment of the bluegrass sod and stolonized fairways. It consisted of a stabilized nitrogen source (Nutralene), pasteurized poultry manure (Bio Basics 4-2-3 composted chicken manure), Mycorrhazae fungi and seaweed extract. The goal of the blend was to give short-, mid- and long-term release of nutrition to increase rooting significantly and aid the development and promotion of strong soil microbial populations.

EXCEEDING EXPECTATIONS

Annandale's greens were constructed using an

improved USGA root-zone material, although they still met all the specifications for a USGA green. Peat moss was omitted and replaced with high-quality chicken manure because of its nutritional content and ability to provide adequate water holding for the grow-in.

The final mix consisted of 80 percent locally mined sand, 17 percent Rhyolite – a product imported from Las Vegas that improves the air porosity and infiltration rate of the mix while holding nutrients with its high cation exchange capacity – and 3 percent pasteurized poultry manure.

The bentgrass on the greens is Dominant Xtreme, a Seed Research of Oregon blend combining the cold-weather performance and disease resistance of Providence SR1019, the fast-establishing and putting quality of SR1119 and the darker color of SR1120 bentgrass.

"The grass performed extremely well during grow-in and, as it matures, it appears to be exceeding all expectations" Kutt says.

A MORE NATURAL STATE

The construction team removed numerous trees and planted others during construction, encouraging areas of formerly manicured turf to return to a more natural state. Stress on the golf course increased infestation of numerous Canary Island Pines by an insect called an ips beetle, a type of engraver beetle. Workers removed many of those trees and planted more native trees such as oaks, sycamores and California buckeyes, as well as low-growing ground cover.

Kutt is overseeing the return of about 15 acres to a more natural state. The contractor planted an eight-way seed blend – four varieties of warm-season grass and four varieties of cool-season grass – on the inside natural areas, and a chaparral mix of shrubbier plants lending

The hybrid bluegrass in the rough provides a contrast with the Bermudagrass fairways. Photo: Annandale Golf Club

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a more desert-like appearance on the outside natural areas.

"We expect to see a maintenance and water savings there over the long haul," Kutt says. "Trying to get those areas to look consistent will be a challenge. You often get contamination from the true native grasses and Bermudagrass."

Christie estimated the course part of the renovation cost about $6 million, which he says is pretty typical for that part of the country.

CONSIDERABLE SAVINGS

Adapting to the bluegrass rough will be one of Kutt's primary challenges in the future.

"The grass selection certainly has caused discussion and is providing challenges, but there were no realistic alternatives that anyone could sell me on," he says. "The issue was some rust we spotted heading into last fall. I didn't feel it was appropriate to spray. With the help of some added fertilizer and micronutrients, the grass bounced back rapidly.

"We're trying to balance our soils the best we can to prevent that again. In this instance, they might have been low on copper, and that likely had something to do with the occurrence of rust. But the rapid recovery has shown me that the turf selection has some merit, especially with its contribution to the aesthetic value of the course."

The new irrigation system coupled with encouraging more natural areas should increase watering efficiency. It's too early to tell exactly how much water will be saved because additional water still is needed to grow in the native areas to the desired look and consistency. Ultimately, Kutt expects to reduce his water use by at least 10 percent compared to prerenovation levels. Labor also should decline with fewer manicured acres to maintain.

Water and labor are Annandale's two largest budget items, with less than $300,000 projected annually for water and more than $1 million annually for labor. Considerable savings in those two areas would be significant to the club's financial health.

A SILVA LINING

Even though Silva is new to the West Coast, he made friends and supporters during the project.

"I give the committee a ton of credit," he says. "It took them several years to get this project approved, and when we wanted to do a little more once the project was under way, they went for the changes with enthusiasm. As a result, the good folks at Annandale ended up with a course they're intensely and justifiably proud of."

The feeling is mutual.

"We interviewed several architects whose names you could say were more prominent, but Brian overwhelmed us with his ideas and enthusiasm," Sarkisian says. "He's so hands on. He was here once a week for 25 to 30 straight weeks. No one else does that – maybe an assistant, but not the architect himself. Brian handcrafted our course." **GCI**

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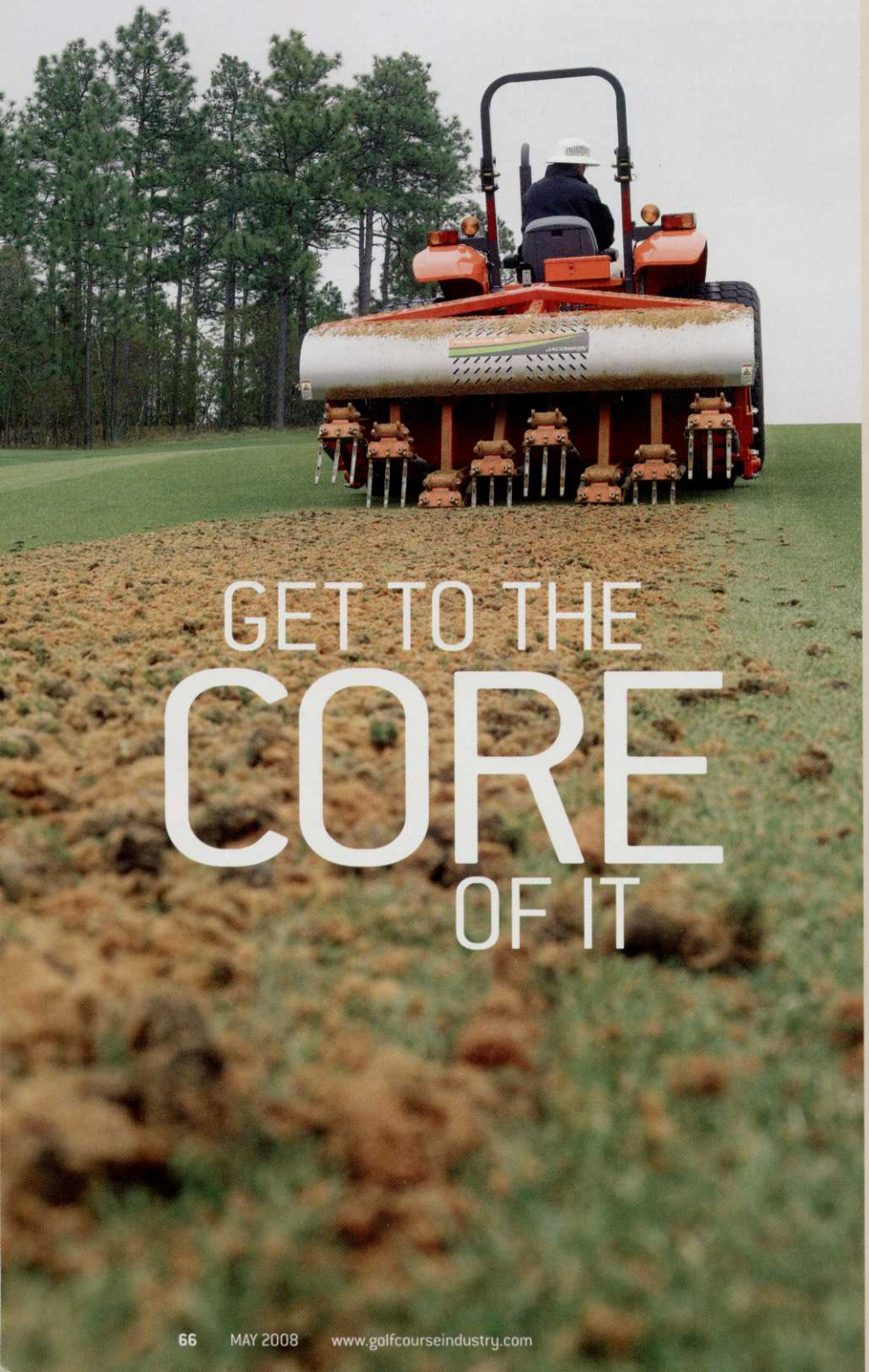

GET TO THE CORE OF IT

No one has to convince golf course superintendent Mark Burchfield about the effectiveness of an aggressive aerification program. When he arrived at The Victoria Club in Riverside, Calif., five years ago, his first task was to revive the *Poa annua* greens, which were built in 1903.

"The greens didn't drain very well and the subsurface was old, so we couldn't be aggressive with our cultural practices," Burchfield says.

The superintendent had to combat an arid climate and lack of rainfall, which inhibit downward water movement and allow sodium to migrate back up to the root system and crown of the plant.

"Leaching the greens has been key to our survival," Burchfield says. "*Poa annua* is very susceptible to salt. When mowing at one-eighth inch or lower, the root system is shallow, and the plant is sensitive to any outside influence, which throws it into stress and makes it prone to rapid blight. The sodium-based disease comes in over a short period of time. It can hit in late evening, and within 12 to 16 hours, the greens can be almost engulfed and losing turf."

Once that situation was diagnosed and controlled, the maintenance staff pursued an aggressive aerification program. Greens are deep-tined twice a year, simultaneously core aerified to 3 inches with half-inch tines. The staff also verticuts and hydrojects throughout the year.

"We're trying to keep the greens open," Burchfield says. "With our older greens and subsurface, aerification is the most important thing we do."

The Victoria Club members support the aerification program, largely because of a disastrous episode in 2003.

"Instead of pulling cores, we just sliced, so we didn't disrupt a special event," Burchfield says. "The result was a catastrophic loss of turf that hurt us. Aerification is no longer a four-letter word at this club, and the results speak for themselves. Our greens are the best they've ever been."

MORE OXYGEN, LESS HEAT

Good agronomic practices necessitate aerification of the soil profile to maintain a high level of macropores in the root zone. A well-aerated soil is cooler during summer because air is a better insulator from heat than water. In contrast, water is an excellent conductor of heat where root zones with excessive water hold more heat and less oxygen.

The aerification process:

1. Extracts excessive accumulation of organic matter.
2. Reduces compaction.
3. Improves soil/gas exchange.
4. Stimulates new root development.

Aerification doesn't have to include extracting cores. It also can be accomplished by using solid tines to create vertical shafts in the root-zone profile. Photo: David Wolff

5. Stimulates microbial activity.

6. Improves the plant's ability to withstand biotic and abiotic stresses.

But for all its benefits, aerification is one of the most despised cultural practices for golfers because it disrupts the playing surface. Aerification usually is done during the prime playing seasons, and according to most golfers, has no redeeming features other than to decrease green performance and raise one's golf score, says M.C. Engelke, Ph.D., professor and faculty fellow at the Texas AgriLife Research Center in Dallas, which is an agency of Texas A&M University.

"On the other hand, aerification is likely the most important cultural practice a golf course superintendent can perform," Engelke says. "Why? Simply put: It maintains a root system under the target plant. The plant's response is to maintain density, enabling it to tolerate traffic and resist ball marking; maintain a deep, effective root system to withstand limitations on water quantity and quality; and maintain healthy plant growth to tolerate biotic and abiotic stresses."

REMOVE ORGANIC MATTER

As plants grow, roots, stolons and rhizomes will develop, increasing the level of organic material in the upper soil profile. The more plant growth, the healthier the plant is, resulting in a superior playing surface.

The down side of plant growth is organic accumulation. Left unchecked, the level of organic matter can create a high organic layer, which, by itself, can change the dynamics of the root zone. Periodic monitoring of the root zone is proactive when maintaining a uniform balance in the amount of organic matter, sand, silt and clay throughout the soil profile.

"If an organic layer accumulates near the surface, it can restrict water and air flow into the root zone," Engelke says. "During periods of high abiotic stress, the plant demands much more plant-available moisture and soil oxygen. Restrict either, and the root also will be restricted."

Organic matter will seal the soil surface from water and air infiltration and accumulate salts from evapotranspiration, suffocating the root zone.

"Ever wonder why roots are shorter in the heat of summer?" Engelke asks. "In short, they suffocate. The organic material restricts the availability of soil oxygen, which, under high soil and air temperatures, is quickly depleted because of a rapid level of root respiration. A simple solution to this problem is to recognize aerification isn't an annual event. It's an event that should occur frequently and with a purpose."

AERIFY DURING HIGH GROWTH

Root growth and maintenance require a lot of soil oxygen. One of the best ways to deliver this is to aerify, especially during periods of high growth. Aerification for the purpose of organic

The Victoria Club's 100-year-old *Poa annua* greens were revived with an aggressive aerification program. Photo: David Wolff

material extraction should be done during the period of time the plant is most active, Engelke says. This ensures the physical hole created by removing organic material will heal rapidly.

"The USGA suggested 20 percent of the upper root-zone cavity should be extracted annually," he says. "If we take this as a given, machines on the market equipped with a modified quad tine holder and half-inch tines on 1-inch centers will remove 11 to 12 percent in a single pass, thus requiring only two aerifications per year."

A single aerification during the most active growth period of the year will help extract organic material. Timing is species dependent. Bermudagrass, zoysiagrass and paspalums have their most active period during summer, whereas bentgrasses and even *Poa annua* are most active in early spring or late fall.

"Periodic monitoring of the organic layer will help determine how frequently core aerification is required," Engelke says. "Maintaining an organic material layer of three-eighths inch to one-half inch is acceptable and will provide good plant response. Depth greater than one-half inch could cause problems during the heat of the summer."

VENTING

Aerification doesn't always have to include extracting cores. It also can be accomplished by using solid tines to create vertical shafts or air space deep into the root zone profile. These vertical shafts are vents. The term "venting" is used instead of aerification frequently.

"These vent shafts are macropores, the site of gas exchange, excessive moisture evaporation, and points of moisture and soil gas infiltration,"

Engelke says. "Using solid tines throughout the growing period creates new macropores, which are essential to supply adequate soil gases to developing roots and microorganisms."

This cultural practice goes hand-in-hand with aerification, but it's not a substitute for core aerification. Venting greens through the summer months generates and maintains active macropores. Because the macropores of aging greens tend to close quickly, it's equally important venting is done frequently.

Along with providing excellent moisture and gas exchange, the improvement in soil gas exchange also supports and stimulates microbial activity, enhancing the rate of organic material decomposition.

"Combined with light, frequent topdressing, core removal and supportive microbial activity, the root zone will be supportive of a deeper, more effective root and healthier turfgrass plant," Engelke says.

FIRM UP THE GREENS

Golf course superintendent Ron Pusateri had an experience similar to that of Burchfield. When he arrived at St. Clair Country Club in Upper St. Clair, Pa., three years ago, turf conditions needed considerable improvement. The 40-year-old, push-up *Poa annua* greens have native soil and no internal drainage.

There were other considerations, too. St. Clair is a private club with a large membership whose handicap ratings represent a wide range of golfing abilities. Pusateri's greatest challenge was to find a happy medium for course conditions and playability.

"The club wants championship conditions, but, during my first year, I learned taking that approach didn't please everyone," Pusateri says. "If there was too much roll in the fairways, the course played too short for some golfers. And the greens might have been too slick for a membership that averages a 20 handicap."

Pusateri's first task was to firm up the greens with an aggressive topdressing program. Heading into his first winter, he covered greens with sand. By the time the staff was ready to aerify in the spring, the sand was almost gone. The staff aerified with three-eighths-inch tines on a 1.5-inch-by-1.5-inch spacing. Later a DryJect process punched sand directly into the surface in two directions on a 3-inch-by-3-inch spacing. A drill-and-fill process was executed twice in the fall using three-fourths-inch drill bits at a 12-inch depth.

The staff applied two heavy topdressings in the winter. The following spring the staff completed a deep-tine aerification and performed another DryJect process, as well as core aerification.

"We've amended the soil profile on the greens with sand to firm them up," Pusateri says. "The membership is pleased with what we've done." **GCI**

BY CALE BIGELOW, PH.D., AND DOUGLAS SMITH, PH.D.

How they measure up

Lab study analyzes physical properties of bunker sand

Because of the high variability and artificiality of the test set-up regarding penetrometer resistance, a revised version of this study, first printed in the March '08 issue of GCI, *is presented regarding physical analysis of sands. In light of new methods recently introduced to test surface penetration (Brame, B. 2008. Affirming firmness. USGA Green Section Record 46(2):17-20), it was decided the data regarding penetrometer resistance determined from the use of the pocket penetrometer test wasn't sufficiently robust.*

A lab study at Purdue University evaluated the physical properties and visual characterisitcs of more than 20 bunker sand materials.

Most golf hole architectural designs incorporate sand bunkers to add dramatic visual contrast and enhance aesthetic beauty while also adding challenge and strategy for golfers. Technically, golf course bunkers are considered hazards. However, for many of the courses in the United States, the demand for manicured perfection throughout the entire golf course has resulted in unrealistic player expectations for perfect lies, even in areas defined as hazards. For golf course managers, this results in the pursuit of consistently firm, smooth bunker surfaces.

Many recently constructed courses contain a few smaller well-positioned bunkers and vast bunker expanses. At many golf facilities, the amount of maintenance resources spent on bunker management rivals that spent caring for putting greens. Where sand is installed on steep slopes, regular erosion repair costs can be substantial and are compounded when improperly selected, highly erodable bunker sands are chosen.

Numerous sand-sized materials are available commercially and marketed for use in golf course sand bunkers. Often a particular sand might be chosen based on subjective characteristics, such as aesthetic appearance (many golf course architects prefer bright white sands), or subjective functional characteristics such as how a particular golfer perceives the playability of the sand. Generally, firm sand is preferred because it allows the golf ball to sit on top of the sand surface, resulting in an easier play from the hazard.

Sometimes the long-term consequences of these decisions based on subjective criteria, such as color, might not be realized immediately. A sand that's the desired color but is too coarse or has a predominance of round particles might necessitate additional labor to maintain playability. From a golf course manager's perspective, an appropriate sand for golf course bunkers is one that maintains firmness, drains quickly and doesn't easily erode from slopes after moderate rainfall or irrigation. It's similar in size to that used for sand-based root zones, so when it's splashed onto putting surfaces, it does minimal damage to equipment when picked up during mowing and doesn't impact the composition of the sand-based root zone negatively over time.

Currently, there are no clear specifications for golf course bunkers sands, and the information that exists serves primarily as a guideline based mostly on sand particle size distribution and a measurement of surface firmness. In general, bunker sands particles should be mostly in the 0.25 to 1.0 millimeter range. In terms of sand mineralogy, silica sand is often preferred because silica resists weathering and retains its original shape longer. Other materials also might be suitable. Limestone sands, however, are more prone to weathering over time and might result in significant fine particles that can affect drainage and playability.

In terms of sand particle size distribution, previous research has documented that particle size distribution greatly influences sand strength and, specifically, that the quantity and ratio of fine textured particles can have a strong influence on strength. The authors suggest, when evaluating a particle size distribution based on its coefficient of uniformity, higher coefficient of uniformity values for sands are