Building the USGA Green:

Tips for Success

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by the USGA
Green Section Staff

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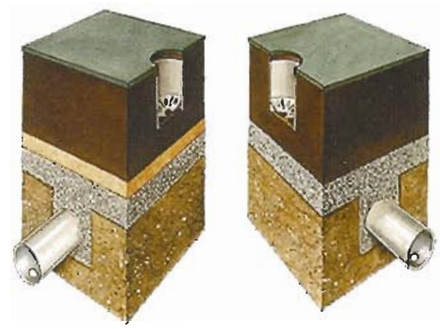
The Green Section staff first published the USGA Green Section method of golf green construction in 1960. It has been successfully used throughout the world in a wide variety of environments. The method is periodically updated to reflect the knowledge gained through scientific research, new technologies in golf course construction, and broad construction and maintenance experiences in the field.

The USGA Recommendations For A Method of Putting Green Construction[1] (hereafter referred to as the *Guidelines*) include specific details and parameters regarding putting green construction and are not intended to be a "how to" document. For example, they include scientifically based performance values for the rootzone mixture, organic matter selection, gravel size, etc. However, the *Guidelines* do not describe exact procedures for how best to dig the cavity, lay out the drainage design, or install the gravel and rootzone mixture. This document addresses the practical side of green construction. It also includes suggestions for planting and grow-in.

When it comes to building a golf green there is almost always more than one construction technique that can be used to get the job done. Equipment, soil conditions, contractor experience, crew size, architectural style, budget considerations, and even the weather, all influence how the work is accomplished. Years of industry experience with the construction of USGA greens have yielded many good ideas. Some make the construction process easier while others prove more helpful later in the life of the green. The tips for success included in this document are from the combined input of experienced agronomists, architects, builders, and golf course superintendents. The tips are organized by the various stages of green construction.



The USGA method employs two profiles – one with the intermediate layer and one without – depending on the materials used for construction.

The Planning Stage

Tip 1: Evaluate the growing conditions of the proposed green site

Prior to beginning the actual construction of the new green, or renovation of the existing green, there are very important steps that should be taken to help ensure the success of the construction project. One of the most important is the evaluation of the site on which the green is to be constructed.

Great care must be taken to select a site that provides favorable growing conditions. Factors that should receive a high priority include light, air movement across the putting surface, traffic onto and off of the green, and surrounding drainage patterns. An article entitled *Helping Your Greens Make the Grade*[3] provides additional insight into the comprehensive assessment of these and many other factors. While this document should be reviewed prior to the construction of any green, it also can prove invaluable in identifying why an existing green has performed poorly.

Although this tip might seem obvious, it is a fact that many times poorly performing greens are completely rebuilt, only to fail again in spite of the efforts of even the most talented turfgrass manager. Even the best of construction techniques cannot compensate for poor growing conditions. Conversely, it is not uncommon to find greens that are poorly built by today's standards, but located in such an ideal growing environment that the turf thrives in spite of the construction limitations.

A putting green located in an environment such as this is almost certain to experience increased disease pressure and limited light.

Tip 2: Valuable construction information can be found at www.usga.org/green/coned

There is a common misconception that the rootzone in a USGA green is a standard composed of 80% sand and 20% peat moss. In fact, sands, organic materials, and other amendments vary so widely in their makeup that the proper percentages can be determined only through scientific analysis. Thus, a critical step prior to construction is the collection and testing of potential construction materials. An accredited, physical soil-testing laboratory should perform this testing. The USGA Green Section maintains a current list of accredited laboratories4 and recommends that one of these labs be used throughout all aspects of the project. The current list can be obtained from any Green Section office as well as by visiting the USGA Web site at www.usga.org/green.

There also is lots of other construction-related information on the site. Case studies provide step-by-step examples of various types of construction projects. There are numerous articles, including how to select the proper bunker sand, how the USGA's Guidelines for Putting Green Construction originated and have been improved over the years, and a quality control checklist for green construction projects.

Tip 3: Visit the sand and gravel supplier

When collecting potential gravels and sands, it is a good idea to make a personal visit to the suppliers. A visit to the site where the materials are mined and stockpiled provides a good opportunity to get to know the supplier and discuss various issues important to the project. In many cases, sand and gravel suppliers do not have much experience with golf course construction and may be unaware of the stringent requirements of the *Guidelines*. These requirements may well exceed those of a supplier's more typical customers. Provide the supplier with a copy of the *Guidelines* and determine which laboratory will be used. If the rootzone components will be blended on the supplier's site, be sure to select a location on which the rootzone mixture can be stored without contamination from other materials.

A visit to the sand and gravel plant will help everyone involved with the project better understand the needs of the project and good quality control procedures.

Tip 4: Collect samples in the proper manner

It is very important to follow proper procedures when collecting samples from a stockpile for laboratory analysis. Improper sample collection can result in significant variability in test reports, even though the samples may have come from the exact same pile. A document entitled *Quality Control Sampling of Sand and Rootzone Mixture Stockpiles*[5] details the correct collection method.

It is extremely important that a sound, consistent sampling procedure be followed throughout the project.

Tip 5: Know how to interpret and use test results

Without a doubt, testing potential construction materials is a critical process. It also is one that can result in a great deal of controversy if not performed and interpreted properly. Accredited soil testing laboratories follow very specific protocols to accomplish the various tests necessary to evaluate construction materials. Like all testing procedures, these protocols have scientific limits in terms of how accurate the results can be. In recent years, unfortunately, many golf course construction contracts have been written in a manner that demands test results of greater accuracy than the testing protocol and/or the laboratories can deliver. This results in confusion, disruption of the construction project, lost revenue, and even civil action.

Table 1: USGA Confidence Intervals for Quality Control Testing

Test parameter	USGA Confidence Interval
Fine Gravel	50%
Very coarse sand	50%
Coarse sand	10%
Medium sand	10%
Fine sand	15%
Very fine sand	30%
Silt	25%
Clay	25%
Total Porosity	10%
Air-filled Porosity	10%
Capillary Porosity	10%
Saturated Conductivity	20%
Percent Organic Matter of Mix	0.2*

*The confidence interval for percent organic matter is not represented as a percentage. Thus a reported value of 0.7% organic matter could range from 0.5 – 0.9 %.

The USGA Green Section has identified the maximum amount of variation for key test parameters measured during quality control testing. The document Guidelines for Establishing Quality Control Tolerances[6] goes into greater detail regarding this subject. The following table is an excerpt from that document and details the variability percentage for each parameter. This variability percentage is more accurately referred to as the **confidence interval** and is used to establish plus or minus values for each measured parameter.

For example, assume the laboratory test indicates a value for fine sand to be 10%. Using the confidence interval percentage for fine sand of 15%, the acceptable value is 10 plus or minus 1.5 for an acceptable range for quality control testing of 8.5 to 11.5%.

It is important to correctly interpret and utilize the results of physical soil testing. For help with this analysis, discuss the results with the lab personnel, and contact one of the USGA Green Section staff agronomists.

Tip 6: Select one accredited lab and stick with them throughout the project

There are a number of key points to keep in mind during the testing process.

The first is to select one accredited laboratory and utilize only that lab throughout the entire project. Attempts to compare one lab's results against another will likely result in confusion. There is enough variability in the current laboratory protocols to result in significantly different numbers between labs in spite of their best efforts. It will be impossible to determine which lab is *right*. It is very important for everyone to realize that although the numbers do vary from lab to lab, all of the labs are achieving and reporting agronomically sound information. In other words, if one lab finds that the rootzone mixture drains at 14 inches per hour and another lab determines the rate to be 20 inches per hour, this variance will not result in failure of the green due to drainage problems. However, if a contract calls for the mix to drain at 14 inches per hour, plus or minus 1 inch per hour, legal problems are likely to arise.

Also, variability in laboratory test reports is not due solely to weaknesses in the testing protocol or differences in how the labs perform the tests. Variability also stems from improper sample collection, different blending techniques, mishandling of samples, collections of samples from different places and at different times and, most importantly, from the fact that materials can change as they are loaded, installed, and worked with heavy equipment. As long as the testing indicates the materials meet the USGA's *Guidelines*, moderate changes in the reported results do not signify poor workmanship or quality.

A current list of laboratories that maintain American Association for Laboratory Accreditation (A2LA) can be found on the USGA's web site at www.usga.org/green.

Tip 7: Don't overemphasize infiltration rate results

Physical soil testing labs test and report on numerous physical aspects of the rootzone mixture, including gradation of the sand, percentage organic matter in the mixture, moisture retention, bulk density, infiltration rate (also referred to as saturated hydraulic conductivity or Ksat) and both air- and water-filled porosity percentages. All of these numbers provide insight into how the mixture will perform. Unfortunately, too much emphasis is often placed on the infiltration rate number. This probably is due to the fact that it is easier to visualize water moving into a green at a certain pace than it is to understand porosity values. Predictably, the lab's ability to determine these numbers depends on the "ruggedness" or degree of accuracy of that particular test. The test for infiltration rate is one of the least rugged of the entire process. Even with the best efforts of the lab, the number reported can vary as much as 10% within the lab. When field variability is added in, the number for infiltration rate has a variability range (or confidence interval) of 20%.

On the other hand, particle size gradation and percentage organic matter tests are much more accurate. This greater accuracy makes these numbers better suited for use in quality control programs written to ensure that the rootzone mixture remains as consistent as possible throughout the blending and installation processes.

Tip 8: Institute a quality control testing program

Quality control (QC) testing is the best means to ensure that materials used in the construction of the new green remain reasonably consistent throughout the project. The document, *Quality Control Guidelines*[7] offers a detailed checklist for use during the construction of golf greens.

Quality control of the rootzone mixture is one of the most critical aspects of the project. A typical program involves the following steps.

1. Visit sand and gravel suppliers in the area and collect 1-gallon samples of the sand, gravel, and other amendments if used. Follow the procedure for sampling rootzone stockpiles referenced in quality control sampling procedure referenced in Tip Four. Submit these to the accredited laboratory chosen for the project.

2. Based on the laboratory testing, the lab will offer their advice on the best combination of materials at a particular mixing ratio. After the best materials and mixing ratio have been identified, the bidding process can be much more accurate, since all bids will be based on the use of the same materials.

3. When the actual construction of the greens begins, the selected materials will be blended. Collect a sample from the first 200-ton pile of blended rootzone mixture. Submit this sample for analysis to the same laboratory that did the preliminary identification work. Keep in mind that it is very unlikely the test results of the 200-ton pile will exactly match the preliminary results. Many months may have elapsed between the two sets of tests, during which time the make-up of the sand and/or amendments may have changed slightly. The goal of the 200-ton test should not be to match the preliminary test results exactly but rather to ensure that the current materials and blending processes are yielding a rootzone mixture that is agronomically suitable for the project and within the *Guidelines*.

4. After the laboratory verifies that the blending operation is producing an acceptable rootzone mixture, remove samples from each 1000-ton pile and submit them back to the laboratory. Typically, the lab will measure the particle size distribution and the organic matter percentage (by weight) to ensure the blending process has remained consistent. The blending of additional mix can continue while these tests are performed. However, the 1000-ton pile that is being analyzed should be isolated until the testing indicates it meets the quality control parameters identified in Table 1. Each 1000-ton pile can be tested in this manner, and after meeting the quality control parameters, combined into a larger pile for hauling to the construction site. (Note that it may be necessary to reduce the sampling size to every 500 tons if the test results indicate borderline numbers or wide fluctuations in the nature of the materials).

Many of the accredited laboratories offer quality control testing services and can advise the consumer on how best to design the entire QC program.

Tip 9: Allow plenty of time for testing and blending

Allow plenty of time for the preparation of the construction materials. Sand and gravel plants vary widely in the quantity of materials they can harvest and clean per day. The quality of the sand and gravel may also vary from place to place within the pit or river that is being mined, requiring the re-calibration of equipment. Laboratory analysis of quality control samples takes time, as does the shipping of the materials to the lab. Contact the lab to determine how much time will be required to perform the tests and what quantities of the materials should be shipped for analysis. Should the lab tests indicate problems with the mixing process, time will be needed for the reblending process. Equipment breakdowns and uncooperative weather should be expected.

Tip 10: Perform the blending operation at the sand plant if possible

Often, the blending of the sand and other amendments is best accomplished at the sand plant. Key advantages of this arrangement include the availability of sand without trucking and, in most cases, enough room to store stockpiles of sand, organic matter, and other amendments if necessary. While it is certainly possible to stockpile and mix materials on the golf course itself, great care must be taken to keep the materials free of contamination from the underlying soil. Many courses have tried to prevent contamination by stockpiling the materials in the parking lot. Although this can be effective in preventing contamination from weed seeds and other plants, there is also the possibility that the large equipment utilized for hauling, blending, and loading of the materials will cause damage to the lot itself. Regardless of the site, a clean storage area must be identified on which to stockpile the final mixture.

Another advantage to blending at the sand plant involves waste. When transferring stockpiles of the rootzone mixture to trucks for hauling, it is important to load only the mixture and not any of the material upon which the mix is stored (particularly if the mix is stored over soil and/or turf). To avoid contamination, the loader operator should keep the bucket at least a couple of inches above the base. Some mix will be lost as it is dumped into the trucks and transferred to the construction site. Most blenders and golf course contractors factor in a waste factor of 10 to 20%. If the blending is accomplished at the construction site, at least 10% more material will be needed. However, when the blending is accomplished at the plant, the consumer is normally charged only for the material that crosses the scales as the trucks exit the plant. Although some material is lost during trucking and installation, the majority of the waste occurs within the confines of the plant, resulting in a better value for the consumer.

Blending the rootzone materials at the plant provides numerous advantages over blending on the construction site.

Tip 11: Save a one gallon sample of the final rootzone mixture in a glass jar for comparison purposes.

Although certainly not a scientific test, a jar of the approved rootzone mixture can be used to visually assess the material as it is delivered to the site. The project superintendent can compare the color and texture of the mix in the truck with that in the jar. If there is a significant difference in appearance, the material in the truck can be temporarily stockpiled (instead of being installed into the green cavity) until further testing is performed. Be aware that differences in moisture levels can change the color of the mixture, so care must be taken not to overemphasize this simple test.

Tip 12: Collect and store a five-gallon sample of the final blending rootzone mixture.

As a green ages over the years, periodically remove rootzone mixture samples for physical analysis. This type of testing will determine if undesirable changes are occurring to the rootzone – particularly in terms of its ability to drain. For example, if the percentage of clay is increasing rapidly in the green, the source of the clay must be identified and reduced or eliminated. By saving some of the original rootzone mixture, it will be easy to compare the samples removed from the greens to the original material. The physical soil-testing laboratory will use the original mixture to calibrate their testing procedures to more closely match the original test results. This allows a more accurate assessment of how the mixture has changed over the years.

Tip 13: Utilize the expertise of the Green Section staff

There are many other aspects of green maintenance and construction planning that should be tended to prior to beginning the actual construction process. The USGA agronomic staff has dealt with these issues many times and is an excellent source of additional information. Anyone considering a project as large as the construction or reconstruction of a putting green is urged to contact the nearest Green Section office and visit with one of the USGA's agronomists. To find the office nearest your location, simply call 800-222-8742 or visit the USGA Web site at www.usga.org/green.

The Subgrade

Like the foundation of any structure, proper construction of the subgrade is critical to the success of the green. Extra care and effort at this stage helps ensure that all subsequent construction steps can be accomplished effectively. In many cases, construction of the subgrade is the most difficult aspect of the project. Often, the soils utilized are of poor quality and difficult to grade smoothly. When existing greens are rebuilt, the subgrade frequently is saturated and must be excavated and spread out to allow it to dry sufficiently. Since it is imperative that the subgrade be well compacted to avoid future settling or shifting, the grading equipment must repeatedly work every foot of the subgrade area.

Once the proper preparations have been completed, the construction process can begin. Although every job is somewhat different, the following sequence of even ts is common to greens built to the USGA's *Guidelines*.

Tip 1: Take the care and time to build the subgrade properly

Like the foundation of any structure, proper construction of the subgrade is critical to the success of the green. Extra care and effort at this stage helps ensure that all subsequent construction steps can be accomplished effectively. In many cases, construction of the subgrade is the most difficult aspect of the project. Often, the soils utilized are of poor quality and difficult to grade smoothly. When existing greens are rebuilt, the subgrade frequently is saturated and must be excavated and spread out to allow it to dry sufficiently. Since it is imperative that the subgrade be well compacted to avoid future settling or shifting, the grading equipment repeatedly must work every foot of the subgrade area.

The extra time spent preparing the subgrade will result in a smooth, well-compacted base on which to build the remainder of the green.

Tip 2: The subgrade does not have to exactly mirror the finished grade

The *Guidelines* states that the subgrade *should conform to the general slope of the finished grade.* Prior to the 1993 revision, the *Guidelines* stated the subgrade must conform to (or mirror) the final grade of the green, plus or minus 1/2 inch. In fact, each successive layer above the subgrade of the USGA profile was required to be a consistent depth. In the process of the reviewing the *Guidelines*, it was realized that varying the depth of the gravel layer would not adversely impact the way in which water moved through the USGA profile as long as a minimum of four inches of gravel was maintained. Since, in most cases, it is much easier to shape the contours of the green with gravel rather than with the heavy soil that makes up the subgrade, the USGA relaxed the subgrade contouring requirements.

Preparation of the subgrade differs depending on the type of construction. When a new green is constructed from scratch, the subgrade usually is prepared during the rough shaping of the green site. Fill material (often obtained during the excavation of a future water feature on the course) is used to shape the new green site. Typically, a large track-loader is used during this phase. The operator is guided by the grade and center stakes, which usually are laid out by the golf course architect and golf course builder.

Additional grade stakes should be used to help the operator achieve the general contours of the finished green. The density of the staking depends on severity of the contouring and the experience of the operator. As a general rule, install grade stakes on 20-foot intervals to provide enough guidance to the operator, while still allowing enough maneuvering room.

Some green reconstruction efforts require the new green to conform exactly to the contours of the original green. Usually, this occurs when there is a desire to preserve historically significant architecture. In such cases, a much more intensive staking scheme is employed (perhaps as close as five-foot intervals). In addition, the subgrade is constantly surveyed with a transit or other surveying instrument to ensure contours are as precise as possible.

When existing greens are being rebuilt, the work often is limited to the excavation of the existing green to a depth of at least 16 inches. This is often referred to as *shelling*. The green typically is shelled out using a *grade-all* or similar piece of heavy equipment equipped with an articulating bucket (which allows more precise excavation of the old green). The green's existing rootzone, gravel layer (if present), and drainage tile are removed. The subgrade floor is graded as smoothly as possible with the large shovel and is finish-graded with smaller equipment. To achieve a sharp, well-defined edge, some hand shoveling invariably is necessary.

Shelling is a process that is frequently employed on existing greens when the previous contours of the green are to be preserved. In most cases, little work is done to the surrounding areas.

Tip 3: Work the subgrade to achieve smoothness and compaction

After the subgrade has been rough shaped, smaller equipment is used to develop a smooth, well-compacted floor. The most commonly used equipment is a rubber-tired tractor equipped with a box blade. Ideally, the blade should be fitted with hydraulic rams, allowing easy adjustment of both the blade angle and depth of cut. The operator repeatedly works the entire subgrade surface, eliminating large clods (greater than 1 inch in diameter) and filling low areas in which water might accumulate.

Tip 4: If the subgrade is unstable, a geotextile fabric liner may be necessary

The *Guidelines* indicate that a geotextile fabric may be necessary when working with unstable subgrade soils. Every effort first should be made to stabilize such soils. For example, when completely rebuilding an existing green (including the surrounding banks and mounding), it is not uncommon to find the soil in the base of the green to be quite wet. The best option is to remove the base soil and spread it out in an adjacent area to encourage rapid drying. The soil can be turned every day or two to speed the drying process even further. As the subsoil from one green is drying, other greens can be excavated to reduce construction delays. After the soil has dried enough to be worked with the tractor, it is placed back on the site.

There are sites in which the native subsoil is inherently unstable due to high water tables, highly expansive clays, and other geologic conditions. Although rare, it is possible for such sites to be so unstable that the gravel layer, and even the rootzone layer, may shift and settle into low-lying pockets or depressions. By laying the geotextile fabric over the subgrade, the gravel layer is prevented from sinking into the underlying soil. If this option is utilized, do not cover the drainage pipe with the geotextile fabric. Either install the fabric beneath the pipes, or install the fabric between the ditches, over the floor of the subgrade.

Tip 5: Build the subgrade in lifts to reduce settling at a later date

To prevent settling of the green at some later date, it is imperative the subgrade is constructed in stages. This is often referred to as building in *lifts*. The subgrade contours are gradually raised, typically 1 to 1.5 feet at a time. The tractor operator repeatedly works the subgrade at each level, practically eliminating any air pockets. Although the process may appear inefficient to the untrained eye, this compacting process is extremely important to the long-term stability of the putting green.

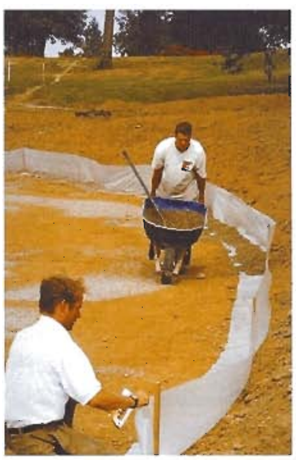
Tip 6: The cavity walls should be vertical or steeply sloped

The Green Section staff often is asked whether the sides of the cavity should be vertical or constructed with a slope. In our opinion, either method works fine, and there are no significant advantages to either technique. Vertical sides are usually easier to create when shelling a green, since a backhoe, grade-all, or similar piece of equipment typically is used to excavate the old rootzone mixture. Sloped sides are more common on completely new green sites where the cavity often is created by building up the surrounding mounds rather than excavation. The degree of slope should be steep enough to prevent large differences in the depth of the mix near the edge of the green. If the slope were to be extended over a distance of several feet, the rootzone mixture could feasibly vary from a depth of 12 inches to a very shallow depth of an inch or two. This could result in water management problems.

Wicking Barrier

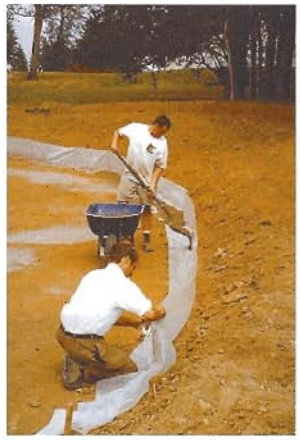
The wicking barrier is an option in USGA greens. It usually is composed of a plastic membrane that is impervious to water movement. Its purpose is to prevent water from being drawn out of the very porous rootzone mixture and into the much more finely graded, native soil that surrounds the green. Much like a sponge, the native soil can draw or wick water from the rootzone mixture to the point that drought stress may occur on the turf located just inside the cavity of the green.

Wicking to the point of drought stress does not occur on all greens. Rootzone mixes that are on the coarse end of the *Guidelines* (and therefore usually retain less water than a more finely graded mix) are more prone to the problem, particularly if surrounded with a native soil that is high in clay. The problem is exacerbated when a cool season turf such as bentgrass is maintained on the green, and a warm season turf such as bermudagrass is maintained adjacent to the greens.



6 to 8 ml plastic sheeting is readily available from hardware stores and works fine for the wicking barrier.

Installation of the wicking barrier is fairly straightforward. Most often, grade stakes (1x2x36 inches) are driven into the subgrade at the edge of the cavity. Polyethylene plastic sheeting (6 to 8 ml and usually 18 to 36 inches wide) is stapled to the grade stakes extending 4 to 6 inches above the cavity. Excess material is laid over the subgrade floor. Soil is carefully added to the outside of the barrier while gravel is added to the inside. After the green cavity has been filled with rootzone mixture, a carpet knife is used to cut the excess material flush with the surface of the green. Extra hand tamping of the materials on both sides of the barrier will help prevent settling at a later date.



Gravel is added to the inside of the cavity over the plastic to keep it in place.

Tip 1: Keep the wicking barrier upright during sodding

Most projects require that sod be laid around the circumference of the green, often extending outward to include the green's banks. This excellent practice prevents erosion of sloped areas in spite of the frequent watering utilized when growing in the new green. When laying sod immediately adjacent to the green cavity, care must be taken to ensure the plastic barrier is kept upright and not allowed to flatten beneath the sod. Should this occur, the turf will not be able to root down properly.

Tip 2: Use an 18-inch high wicking barrier and install it so approximately 4 inches of the barrier extends above the surface to help control erosion.

While the plastic sheeting is inexpensive and readily available in hardware and paint stores, it is possible to purchase a much heavier plastic material made especially for use as a wicking barrier. The most popular among golf course builders is the 18-inch wide, 30-ml material. The heavier weight makes the material easier to install than plastic sheeting, since it is more rigid and stands up better while staking. The additional thickness is believed to provide longer-term protection against subsurface encroachment of bermudagrass rhizomes into bentgrass or hybrid bermudagrass greens. Also, by leaving the 4 to 6 inches of the thicker barrier extending above the rootzone mixture, the greens mix is much better protected against washouts and/or contamination from runoff from the surrounding area. The extra four inches is left in place through seeding or sprigging, up until the time the green is ready for the first mowing. A carpet knife is then used to cut off the excess, slightly below the surrounding grade

30 ml plastic can be purchased that makes the installation easier due to the stiffness of the material.

Notice that approximately four inches of the barrier has been left above the surrounding grade to help prevent soil from the surrounds from washing onto the green. It is removed later with a carpet knife or similar tool.

Tip 3: Contact the regional Green Section office to determine if use of the wicking barrier is recommended for your project.

The wicking barrier is optional and not necessary in all areas. Check with the agronomists in your regional Green Section office for advice on whether the barrier may be needed.

Drainage

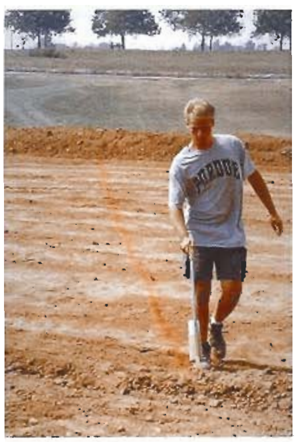
The drainage pipe (also referred to as tile) serves an extremely important function to the USGA green – the removal of excess water from the cavity. Given the high infiltration rate of the rootzone, excess water quickly moves downward into the gravel layer. It then moves laterally through the gravel and across the surface of the subgrade until it intercepts a drain line. Without a functioning drain pipe system, the rootzone would quickly become saturated. The greatest opportunity for damage to the drainage system occurs during installation. The extra time and effort taken to ensure the system is installed correctly will be rewarded with many years of trouble-free service.

Tip 1: Design drainage pipe layouts specific to the needs of each green

The layout and installation of a top quality drainage system is accomplished through the combination of drainage engineering and feel. Years ago, many greens were designed with limited contouring and a fairly uniform grade from the rear of the green to the front. These designs lent themselves to the classic *herringbone* drainage pattern. The center pipe exited the front of the green and was extended away from the green site to an out-of-play area. Many of today's greens are designed with multiple tiers, moving water in many directions. As a result, it may be necessary to have two or more drainage systems in a single green. It is important to remember that the main lines should follow down the slope of the subgrade, while the lateral lines should extend across the slope to better intercept water.

Tip 2: Use marking paint to lay out the entire system before beginning the trenching operation

Once the subgrade has been thoroughly compacted, the layout of the drainage lines can begin. Use marking paint to mark where the ditches are to be excavated. Given the flexibility of today's drainage pipe materials, it is not necessary to have perfectly straight lines. However, keep in mind the limited ability of ditching equipment to dig on a curve. In most cases, it is easier to install an extra few feet of straight lateral line to ensure complete drainage than to attempt to curve the ditch.



Spray paint and a marking gun make it easy to lay out the drainage line pattern.

Tip 3: Utilize the right trenching equipment

Normally, a 6-inch wide trenching machine is used to dig the ditches. Although larger equipment (8 inch) can be used, this results in a much larger volume of dirt (or spoil) being excavated, greatly increasing the amount of labor necessary to complete the work. Although a 4-inch machine usually results in a ditch that is at least 5 inches wide, avoid using anything less than the 6-inch machine, since a smaller-width ditch is very difficult to clean properly.

Tip 4: A small tractor can be a big help

After the ditches have been dug, the labor-intensive jobs of removing the spoil and cleaning the ditches begin. There is really no easy way to accomplish either of these tasks. Plenty of handwork will be necessary to load the spoil into wheelbarrows or trucksters and remove it from the cavity. On large greens, it may be possible to use a small tractor equipped with a box blade and a front-end loader bucket. Back up the tractor perpendicular to the ditch and use the box blade to carefully pull the spoil away from the trench. These piles are then scooped into trucksters using the bucket attachment. Removal of the spoil is important to ensure the unimpeded movement of water across the subgrade to the drainage ditches.

Since removal of the spoil is so labor-intensive, many contractors opt instead to spread the spoil over the subgrade floor. This is perfectly acceptable as long as the spoil is spread evenly and does not result in high spots that might prevent surface flow of water to the drainage lines. Break up any large clods (greater than two inches in diameter) to maintain a smooth cavity floor. Large clods can be kept to a minimum by operating the trenching equipment properly. Digging on straight lines, keeping the digging chain at a high rpm (revolutions per minute), and keeping the ground speed very slow helps grind the spoil into smaller particles that can be spread more easily.

The bottoms of the drainage ditches also must be cleaned. Narrow shovels and hoes are the most effective tools. Although the floor of the ditch does not need to be perfectly smooth, it is vital that no large clods be left. Large clods can cause the drainage pipe to buckle and may result in the loss of the minimum of 0.5% grade necessary to ensure proper drainage. Clods also can put stress on the joints in the drainage pipe, particularly as the ditch is back-filled with gravel. As a general rule, break up clods in excess of 1 inch in diameter.

Tip 5: Maintain a minimum 0.5% slope on drainage ditches by checking with a level

Next, a bed of gravel is laid in the bottom of the ditches. This layer of gravel must be a minimum of 1 inch in depth to prevent the drainage pipe from lying directly on the soil floor. If necessary, the gravel can be deeper to maintain proper drainage pipe slope. In addition to insulating the drainage pipe from the floor of the drainage ditch, the gravel serves another purpose. It is much easier to prepare a smooth base for the drainage pipe using gravel. After the gravel is added, use a transit or surveying instrument to make sure all ditches have the minimum 0.5% fall outlined in the *Guidelines*.

Use a surveying instrument to ensure the drainage ditches have at least 0.5% slope to the exit points.

Tip 6: Select the style of drainage pipe best suited to your project

The next step is to lay the drainage pipe in the ditches. There are numerous drainage pipe materials on the market, but the vast majority of projects will use one of three types of pipe. By far the most popular today is the semi-rigid, double-walled pipe that is smooth on the inside and corrugated on the outside. This pipe is not easily crushed, and the smooth interior better facilitates future cleaning, if necessary. Its rigidity makes it is easy to work with, assuming the ditches are reasonably straight. The pipe has narrow slits cut around its circumference to allow water inside. The only drawback (when compared to the other materials) is cost, although it is not tremendously more expensive.

The next most commonly used material is the flexible, corrugated pipe. This pipe is corrugated on the inside and outside and is the most flexible of the drainage materials. It is also the least expensive of the three choices and the easiest to install (due to the reduced need for joints). However, the increased flexibility comes at the cost of strength. This pipe is more easily crushed, so care must be taken when backfilling and crossing ditches with equipment. The curled nature of the pipe can also result in the pipe bowing in the ditch prior to being covered with gravel. Extra care must be taken to ensure the pipe is lying flat on the gravel that lines the bottom of the ditch. The pipe must be held down as the remainder of the ditch is filled with gravel. Like the double-walled pipe, drainage slits are cut into the pipe around its circumference to allow water to move into the pipe.

Rigid, PVC sewer pipe also is used on occasion. This pipe is commonly used in septic line installations and therefore is readily available at local plumbing supply outlets. The pipe has large holes drilled into it (usually 1/2 to 3/4 inches in diameter). Given the size of the holes, it is quite possible for gravel to sift into the pipe. It is therefore critical that the pipe be installed with the holes facing downward toward the bottom of the ditch.

Lengths of pipe are joined together using specialized connection fittings. These connections should be made carefully to ensure the pipe does not pull from the joint during the gravel back-filling operation. Many contractors secure each joint with duct tape to prevent this from happening.

The Green Section staff is often asked for its opinion on the "flat" drainage material that has been utilized in a number of green construction projects. At this point we do not recommend this type of product for putting green drainage. If unbiased, scientific research proves that these alternative materials are equivalent or superior to tube-style drainage materials and can reduce construction costs, we will adjust our recommendations accordingly.

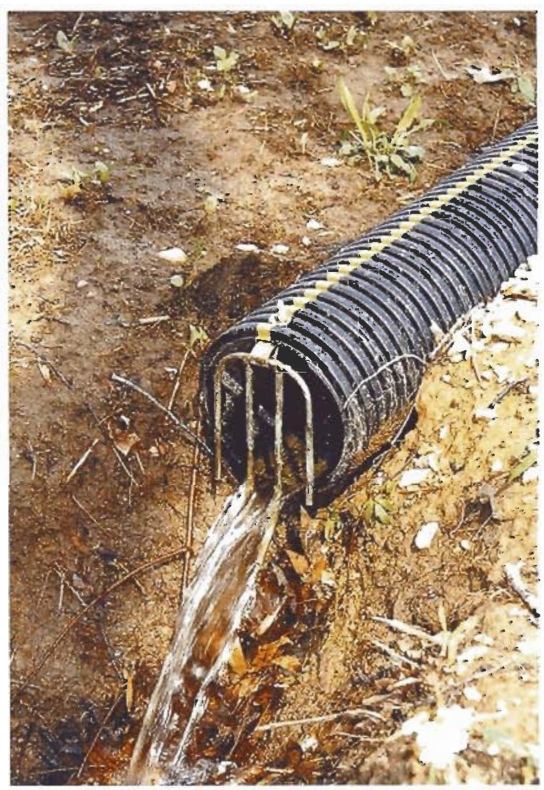
Tip 7: Use heavy plywood to prevent damage to drain lines

In the process of preparing the trenches and installing drainage pipe, equipment will have to navigate within the confines of the cavity. Such traffic actually aids in the packing and smoothing of the subgrade. However, as equipment moves about, it will be necessary to cross the drainage ditches. To prevent damage to the trenches and drainage pipe, use 3/4 to one-inch thick plywood sheets as small bridges over the trenches that must be crossed frequently. The plywood should be removed prior to installing the gravel layer.

Heavy plywood is used to prevent damage to drainage lines from heavy equipment.

Tip 8: Protect the terminal point of the drainage pipe

Locate the terminal points of all drainage lines in an area where the pipe is protected from crushing and/or blockage. Many a good green has literally turned sour as a result of drain line openings left unprotected from blockage by sediment, leaves, and animals. The simplest way to protect the terminal point of the drain line is to install a screen or grate, available through the drainage pipe manufactures. Another option is to terminate the drain pipe into a valve or meter box. This is a particularly useful approach when the drainpipe terminates in a gravel sump (a hole filled with gravel). The box extends into the sump, allowing visual inspection of the drainpipe to ensure it is still functional. Even a large diameter irrigation or drainage pipe (at least 10") can be used in this manner, placing a grating on the surface to allow visual inspection.



The end of drainage lines must be protected to prevent animals from entering the pipe.

Tip 9: Avoid extending drainage lines into bodies of water

If at all possible, do not allow drainage water to exit directly into any body of water. Although nutrient leaching of a properly built green can be kept to a minimum through sensible fertilization practices, contamination of the water can occur during grow-in of the new green when high amounts of nitrogen and phosphorus are utilized. Ideally, the drainage line should be extended to the surface in an out of play area. This allows the drainage water to be distributed over a large area.

Tip 10: Bury a locator wire or tape with the drainage pipe to allow easy location at a later date

In spite of the best efforts to protect the drainage lines, sometimes they can become damaged or blocked. Unfortunately, once the lines are buried, they are very difficult to find. Placing a metal locator wire or metal tape in the same ditch with the drainage pipe can solve this problem very inexpensively. Fourteen-gauge irrigation wire works well and often is readily available since irrigation work frequently accompanies green construction projects. The wire should be included in each drainage pipe trench and electrically connected or spliced at each intersection. It also is a good idea to lay the wire just inside the green cavity, connecting it to the wires laid in the drain-pipe system. This allows ready location of the original perimeter of the green and helps prevent the loss of valuable green surface and hole locations. After the locator wires or tape have been installed and connected, they should be terminated in a small junction box (usually located near a sprinkler head or flush-out). If a drainage pipe or green cavity perimeter needs to be pinpointed at some time in the future, a wire-tracking device can be connected to the wire, allowing rapid and accurate location.

Lay a #14 irrigation wire in each ditch to allow easy location at a later date using a wire tracking device.

Exit the wire near the "clean-out" or near a sprinkler so the end of the wire can be found easily.

Tip 11: Install a flush-out point on the high side of the green to allow easy access and cleaning

Another useful device to install at the time of drainage line installation is the flush-out point. The flush-out allows an irrigation hose to be inserted into the main trunk of the drainage system. When the hose is turned on, silt and debris can be washed out of the main drain line. This flush-out point also allows the insertion of a small video camera system (now commonly used by professional plumbers) to view the integrity of the drainage system at a later date. Simply extending the main line out of the high side of the cavity and turning it up to the surface usually create flush-outs. It then is capped, covered with a grate, or covered with an irrigation valve box.

Tip 12: Install an inspection port on the low side of the green

Yet another good idea involving the green drainage system is to install an inspection port near the point at which the main drainage line exits the lowest portion of the green. A tee connection is installed in the line, extending the riser to the surface. The riser is capped with a drainage grate. This provides a quick view of the drainage system and can give valuable insight into watering practices. This port also can serve as an access point for drain cleaning and inspection tools. If a bunker drain is to be connected to the green drainage line, be sure it is downstream from the inspection port so that the port reveals green drainage flow rather than the combination of the green and bunker drainage.

Tip 13: Use the right type of pipe for the job

It may seem obvious, but it is important to use the right type of drainage pipe for each area. Within the cavity of the green, slotted or perforated drainpipe should be used to collect drainage water. When the pipe exits the green, however, solid or non-perforated pipe should be employed. Clearly, solid pipe used within the green cavity can't collect drainage water! Perforated pipe laid in a soil trench may plug up or result in a constantly wet area along the ditch line.

Tip 14: Green and bunker drains should be separate systems

The best practice is to keep green and bunker drainage systems separate from one another. Bunker drains are far more subject to blockage as a result of the washing of silt and clay into the pipe when sand is washed from the bunker face. This occurs so frequently that a green drain line should never be run through a bunker cavity to tie into the bunker drain. Occasionally, it is necessary to tie the bunker drain into the green drain line. However, this should be done only after the green drain line has exited the green cavity.

Tip 15: No matter how good the subsurface drainage system is — positive surface drainage is still critical

Although drainage obviously is critical to successful putting green management, there are some who believe that the combination of the drainage lines and the gravel drainage blanket provide so much subsurface drainage that surface drainage is no longer necessary. As a result, there are greens constructed that have low, water-collecting areas on the putting surface. As long as the rootzone mixture drains rapidly and the gravel and pipe are functional, even these low areas will drain quite well. However, the internal drainage ability of the rootzone mixture inevitably decreases as the green ages. Therefore, every green should have excellent surface drainage in addition to the subsurface drainage.

Gravel Drainage Blanket

The gravel layer in the USGA green provides the extremely critical function of allowing the rapid movement of excess water from the rootzone into the drainage tile. Since the gravel covers the entire subgrade, drainage from the rootzone material into the gravel layer is quite uniform. This results in much more uniform moisture levels in the rootzone itself. Research has shown that without the gravel layer, the moisture levels in the rootzone can vary widely and are strongly influenced by the location of the underlying drainage lines. The gravel also creates a perched or suspended water table in the high-sand content rootzone, increasing its ability to retain nutrients and moisture. This occurs as a result of the significant change in texture between the gravel and the much finer rootzone materials. In addition, the gravel provides a barrier to salts that might otherwise be drawn from the subsoil into the rootzone mixture via capillary action. Finally, the gravel prevents migration of finer sized materials into the drainage tile, which might affect the functioning of the tile.

Tip 1: Finding the right gravel can save money and work

To accomplish all of these goals it is imperative that the gravel be properly sized in relation to the rootzone sand. The 1993 *Guidelines* include a scientifically based method of particle size measurement. The physical soil-testing laboratory performs the testing necessary to ensure that the rootzone mixture and the gravel are compatible.

Tip 2: Crushed stone can make an excellent gravel layer

Earlier versions of the *Guidelines* called for the use of pea gravel. Although this material is still suitable for use in the gravel layer, the current *Guidelines* also allow the use of crushed stone. This permits a greater range of materials to be used, which may reduce costs. Crushed stone also has the advantage of being more stable beneath construction equipment. In contrast, rounded stone shifts easily beneath tires and tracks, resulting in rutting that must be smoothed prior to the installation of the rootzone mixture. However, crushed stone materials vary widely, ranging from limestone to granite, and must be tested to be sure they are suitable not only in size, but in physical and chemical stability as well. The physical soil testing laboratory can run tests to ensure that an appropriate material is used.

The installation of the gravel layer is fairly simple. Assuming the subgrade is well compacted, the gravel can be hauled onto the green site with a front-end loader or a small dump truck. However, great care must be taken to avoid collapsing drainage ditches and/or crushing the drainage pipe when crossing the drainage lines with the gravel-hauling equipment. Such damage can be almost completely avoided by using 3/4 to 1-inch plywood sheets to cover drainage lines whenever they must be crossed and crossing the ditch perpendicular to the direction in which it is dug.

Tip 3: Varying the depth of the gravel can ease the establishment of final contours

Once the gravel is installed, it should be smoothed carefully to eliminate tracks and establish the proper depth. At least 4 inches is required by the *Guidelines*. However, greater depths can be utilized without adversely affecting green performance. The option to make the gravel deeper often can simplify green construction. In many areas, subgrade soils are very difficult to work due to their high clay content. The *Guidelines* require only that the subgrade roughly mirror the finish grade, be firmly compacted, and have no water-collecting hollows or low areas. So, instead of having to match the final grade with heavy soil, the depth of the gravel can be varied. It is much easier to "float" gravel to a precise depth than it is to work with heavy soil. Keep in mind that once the gravel layer has been fully installed, the contours of the layer should mirror the proposed finish grade of the putting surface. The thickness of the intermediate layer (if necessary) and the rootzone mixture layer is consistent across the entire green and should not be varied to create other contours.

The gravel should be spread to a minimum depth of four inches and according the grade stakes. The surface of the gravel layer should "mirror" the finished surface of the putting green.

Tip 4: Use a golf club shaft marked with paint or tape to check the depth of the gravel layer.

Cut the head off an old club and paint the bottom four inches of the shaft (a shovel handle works well too). This makes it easy to quickly check the depth of the gravel to ensure it is at least four inches.

Tip 5: You might find it easier to lay "tile" rather than "carpet"

Gravel (as well as the intermediate layer and rootzone mixture) is usually spread in one of two ways. The most common option is to spread the gravel over the entire subgrade before starting on the next layer. The green cavity is filled one layer at a time. An analogy can be made to how carpet is normally laid. First the floor of the room is completely covered with the cushioning pad. Carpet is then laid over the pad completing the job. The main advantage to this technique is that once the subgrade has been completely covered, the operator can easily see what the final green surface contours will look like when finished. This method allows gravel to be moved about (as long as the 4 inch minimum depth is maintained), creating minor changes in contouring. Low areas are easily spotted and can be filled with additional gravel. Since the intermediate layer and rootzone mixture are installed to consistent depths, filling low areas in the gravel blanket will help ensure good surface drainage on the putting surface.

There are also disadvantages to spreading all the gravel at once. The biggest drawback is that equipment will have to traverse over the gravel layer to spread the subsequent layers of the green. Since the gravel blanket covers the drainage lines, they will be impossible to see, and there is a risk of damaging the pipe. Hauling equipment also create ruts and uneven areas in the gravel layer that need to be filled and smoothed prior to adding the intermediate sand or rootzone mixture.

The second method occasionally used for filling the cavity of the green with the various layers is to add all of the layers as the crew works its way across the green. For example, gravel is spread over a small portion of the subgrade, usually encompassing an area of about 10 feet by 10 feet. If the intermediate layer is to be used, it is next spread over the same area. Finally, the rootzone mixture is then spread over the same area. In this case, an appropriate analogy can be made to laying tile rather than carpet. When a floor or wall is covered with tile, adhesive is first applied to a fairly small section of the total area and then tiles applied to the same section. The process is repeated until the floor or wall is completely covered. When building a green in this manner, the crew normally finds the point of easiest access in and out of the cavity and begins the spreading process on the opposite side of the green. Thus they can work their way across the green, filling the cavity as they go.

The main advantage to this method is that the hauling equipment travels over the subgrade, eliminating rutting and reducing the likelihood of damaging drainage lines. A disadvantage of this method is the need to have all construction materials on site for the construction of each green.

Intermediate Layer

The intermediate layer has long been one of the most difficult aspects of building the USGA green. The concept of the layer is simple — to serve as a mid-sized barrier between the rootzone mixture and the gravel drainage blanket. It is necessary to use the intermediate layer when the gravel and rootzone components are sized such that there could be migration or movement of the finer rootzone mixture into the much more coarsely graded gravel. To better understand the need for the intermediate layer, imagine a layer of basketballs a couple of feet in depth. If you poured marbles over the layer of basketballs, they would quickly move into and fill all the large gaps between the basketballs. You could prevent this migration by first placing a layer of tennis balls between the basketballs and the marbles. Although a few marbles might move into the gaps between the tennis balls, they would not move very far into the tennis ball layer before becoming trapped. These "trapped" marbles would then prevent other marbles from moving downward. This process is referred to as *bridging*.

An intermediate layer should be used in greens where the rootzone mixture and the gravel are incompatible in terms of size. It can be spread to the proper depths using pipe and a mechanical sand rake.

Tip 1: Locate gravel that is compatible with the rootzone mixture so that the intermediate layer can be eliminated — it is almost always worth the extra expense (if any).

Laboratory analysis of the gravel and rootzone mixture to be used in the green determines if bridging will occur without the intermediate layer. If not, the intermediate layer should be included. However, another option is to search for another source of gravel that is compatible with the rootzone mixture. This may or may not involve greater expense in trucking. This added expense should be compared to the savings involved in not having to use the intermediate layer. Since the *Guidelines* were modified in 1993 to allow the elimination of the intermediate layer (assuming all laboratory tests have verified it is not necessary), it has been seldom used.

If the intermediate layer is necessary, it will take additional time and effort to install. Since the layer usually is installed to a depth of approximately two inches, it is difficult to spread with machinery, and greater handwork is required. Keep in mind that the depth of the layer must be consistent and that the final contours should mirror the finish grade of the green.

Rootzone Mixture

The next layer of the green to install is the rootzone mixture. The rootzone material should be installed to a settled depth of 12 inches. Like the gravel layer, the rootzone layer can be spread over the entire green at once or in stages. The most important points are to maintain a consistent depth and to avoid rutting the underlying layers and/or crushing drain tiles. Track-equipped loading equipment is better suited for the spreading operation. The wider "footprint" of the track reduces rutting and aids in the uniform compaction of the rootzone mixture. Rubber tired front-end loaders can be used but often result in severe rutting, particularly when the bucket is full of sand.

Tip 1: Carry the rootzone mixture into the cavity over already installed mix rather than over the gravel

Equipment should work as much as possible on top of the mix rather than on top of the gravel. In other words, the spreading equipment should push additional mix into the green over the top of mix that has already been installed. Again, since the equipment will traverse over the mix many times, the need for further compaction will be minimized.

Spreading and dumping equipment should remain on the rootzone mixture instead of the gravel to avoid damage to the drainage system.

Tip 2: Test the mix to predict how much it will compress or settle

Rootzone sands vary in the degree to which they will compact or compress. Sands that are very angular and narrowly graded (meaning that most of the sand particles are approximately the same size) will compress the most. Rounded sands and sands with a wide gradation compress the least.

The degree of compression is important when trying to determine how much sand is needed for the project and when filling the cavity. Some laboratories will test for compression and offer advice regarding how much extra material must be produced (purchased). If the selected lab does not perform the test, a rough estimate can be made in the field. Fill a 5-gallon bucket with dry rootzone mix. Place a weight on top of the mix. A 12-inch diameter concrete paving stone works well. Set the bucket on a running piece of heavy machinery that will apply strong vibration to the bucket. After a few minutes of intense vibration, measure the amount of settling. This will provide a rough idea of how much extra mix must be placed in the green cavity so that after settling, the surface grade of the green will closely match up with the surface grade of the surrounding area.

Tip 3: Repeated watering and mechanized raking will speed compression and firm the surface

After the rootzone mixture is placed in the cavity, a mechanized bunker rake is most helpful in smoothing the surface. Working in a continuous circular motion, the rake should pass over the entire surface many times. Hand watering the mix will help in firming the surface and hastening the compression process. Grade stakes should be checked frequently, and mix added or removed to achieve the desired final contours.

Tip 4: If the green is not to be planted immediately, use a cover to prevent erosion or contamination

On most projects, the green is planted shortly after the mix has been placed into the cavity. However, many times it may be days or even weeks before planting takes place. If planting has to be delayed, it is a good idea to cover the finished rootzone with hay straw, plastic sheeting, or a geotextile fabric. This helps prevent or at least reduces erosion of the rootzone due to heavy rains. If the green is surrounded by mounding that channels water onto the green surface, hay bales or an erosion fence should be used to prevent washing of soil from the surrounds onto the green surface.

Tip 5: Use a golf club shaft or some other type of probe to check the depth of the rootzone.

The USGA *Guidelines* call for the depth of the rootzone mixture to be 12 inches, plus or minus 1/2 inch. This is a tight tolerance and must be constantly monitored to ensure compliance. By painting the bottom 12 inches of a golf club shaft, a person can easily probe the mix to check the depth. This should be done repeatedly as the mix is spread to ensure the 12-inch depth is maintained.

Fumigation

Fumigation of the rootzone mixture is not a mandatory part of the USGA *Guidelines* for green construction. Fumigation is most often needed in parts of the country where nutsedge, nematodes, and other difficult to control pests and weeds are prevalent. It also is used frequently in the replanting of bermudagrass greens to achieve the most complete control possible of the previously grown turf. To determine if fumigation is recommended on your project, contact the regional Green Section office in your area.

Tip 1: Soil fumigation should only be performed by professionals using specialized equipment.

Handled properly, soil fumigants can safely sterilize the new rootzone, ensuring the cleanest stand possible. Eliminating competition from weeds also can result in more rapid establishment. However, the chemicals utilized for fumigation are extremely dangerous and need to be applied correctly. It is highly recommended to hire experienced, licensed fumigation contractors to complete this task.

Fumigation should only be attempted by licensed professionals.

Planting

With the construction completed, the new green is ready to be planted. Seeding and sprigging techniques vary widely, often depending largely on the type of planting equipment available. Regardless of the method used, a key to success is good seed or sprig contact with the rootzone mixture. Scientific research has proven that extremely high seeding or sprigging rates do not result in early opening dates and can actually lead to a weaker plant. Ideal rates depend on the species and even the variety of the turfgrass to be planted. Be sure to check with the local Green Section office for the rates and procedures that have proven most successful in your area.

Tip 1: Don't underestimate the importance of favorable planting dates.

Planting dates have a tremendous impact on the success of the newly established turf. Although bentgrass and bermudagrass varieties used on greens have a fairly wide range of dates over which they can be successfully established, both species perform much better when planted in favorable climatic conditions. This improved performance includes more rapid establishment and reduced susceptibility to stresses, including insect and disease-causing organisms.

Ideal planting dates for each species vary depending on the local climatic conditions. To obtain the best date range for your area, it is best to contact the local Green Section agronomist or university extension specialist.

Tip 2: Mix seed with a non-burning, organic fertilizer to ease spreading.

The very small size of bentgrass seed makes it difficult to spread in windy conditions. This same small size makes it difficult to see where the seed has fallen, which can result in skips and overlaps during spreading. Mixing the seed with a darkly colored, organic fertilizer can significantly reduce both problems. Mixing percentages should be based on the desired seeding rate and the fertilizer analysis. For example, let's assume that the seeding rate is 1.5 pounds per thousand square feet and the desired fertilizer rate is 1.5 pounds of nitrogen per thousand square feet. If the fertilizer analysis is 6-2-0, this would require 25 pounds of the fertilizer per 1000 square feet (1.5 / .06 = 25). Therefore, mix 1.5 pounds of bentgrass seed with every 25 pounds of the organic fertilizer. Since it is best to apply the mixture over the green in two directions to ensure more even coverage, the spreader should be calibrated to apply 12.5 pounds of the seed/fertilizer mixture to every 1000 square feet.

Tip 3: Plant seed in two directions to ensure better coverage.

Whether using a drop or rotary spreader, it is best to apply the seed in two directions (usually perpendicular to each other) to ensure more even coverage.

Sow the seed in multiple directions to achieve a more even distribution.

Tip 4: If you are uncertain about the seed or sprig purity, have it analyzed by a seed-testing laboratory.

Only certified seed or sprigs should be used to establish the new green. However, even certification cannot guarantee that all contaminants (particularly weed seeds and other turfgrass seeds) have been screened out. Even very small percentages of *Poa annua* and *Poa trivialis* in stands of creeping bentgrass can result in a significant reduction in the purity of the stand. In the case of bermudagrass sprigs, the most frequent contaminants include common bermudagrass and weeds such as goosegrass and sedges.

There are laboratories that specialize in examining the purity of bentgrass seed. Your regional Green Section agronomist can point you to a lab capable of such testing. Unfortunately, no such testing process is available for bermudagrass sprigs. The best option to ensure a pure stand of bermudagrass is to use a combination of efforts.

- Purchase only certified sprigs.
- Make a personal visit to the supplier's farm to visually inspect the professionalism of their operation.
- Ask about the age of the fields. Fields that have recently been fumigated and reestablished are less likely to be contaminated with "off types" of bermudagrass.
- Contact other courses that have purchased from the supplier, and determine the success of their plantings.

Tip 5: Improve seed-to-soil or sprig-to-soil contact by walking-in the sprigs or seed with knobby tires.

The knobby tires utilized on most mechanical bunker raking machines do an excellent job of pushing the newly sown seed or sprigs into the upper portion of the rootzone mixture. This same equipment often is used to lightly compact and smooth the rootzone. Typically, the operator makes large, gentle circles on the green, covering the entire surface at least three or four times. In the case of bentgrass seed, germination frequently occurs first in the small depressions left by the knobby tires, giving the green a checkered appearance. Although these depressions gradually disappear with the frequent irrigation required to grow-in the new green, the initial lack of uniformity is distracting to some. This can be reduced greatly by following the mechanical bunker rake with a roller to smooth out any depressions.

A mechanical sand rake with knobby tires can improve the seed-to-soil contact.

Bermudagrass sprigs should be "cut" into the rootzone with a small, straight disc.

Tip 6: After seeding, use leaf-rakes to work the seed into the upper 1/2 inch of the rootzone.

Some individuals do not like the tracks left when "walking in" the seed with the knobby tires as discussed in tip #54. The smoothest finish can be achieved by using a leaf rake following seeding. This typically is done by walking across the green and dragging the leaf rake behind to smooth footprints and work the seed into the mix. This creates small furrows that quickly settle out as the green is irrigated.

Tip 7: If the new green is to be sodded, take great care not to seal-off the rootzone.

Ideally, greens should be established from seed or sprigs. However, when time constraints demand that sod be used, great care must be taken to prevent sealing off the new rootzone. The best choice is to use sod grown on the same sand used in the rootzone mix. Sod that is grown on a soil or sand that is finer in texture than that used to build the rootzone will almost certainly cause severe drainage problems. The finer materials will result in excess water being retained very near the surface of the green. This can lead to increased disease susceptibility, reduced rooting, and black layer (soured soil).

Although sod grown on a more coarsely textured rootzone will be less likely to cause problems, the best option is to use a sod that has been washed free of all soil and sand. Washed sod is available from many growers. Another option is to purchase sod that is grown over plastic sheeting, often referred to as *soilless sod*.

Grow-in

Sometimes, growing in the new green can be as challenging as building it. This is particularly true for the turf manager whose previous experience may have been limited to dealing with mature greens or soil-based greens. More than a few good superintendents have found themselves struggling to keep the new green on an even keel during the first three to six months following planting.

The most common difficulties encountered with the grow-in process involve fertilization and irrigation. Since the rootzone of the USGA green invariably is composed of a high percentage of sand, nutrient and water retention characteristics are much lower than that of a soil-based rootzone. As a result, a green that appears to be adequately fed one day may appear to be underfed just a couple of days later. Irrigation is even more demanding, since the high-sand content rootzone is prone to drying out on the surface — particularly during windy conditions.

For additional information on dealing with new greens, please read the document A

Troubleshooting Checklist for New USGA Greens found at www.usga.org/green.

Tip 1: Use a combination of slow-release and rapidly available fertilizers.

Both types of fertilizer have advantages and disadvantages (in terms of grow-in) and therefore a combination of the two results in the best fertilization regime. Composted sewage sludge products provide a constant source of nitrogen that is less prone to leaching and can be applied in larger amounts without fear of burning young turf. Products with readily available sources of nitrogen provide the quick burst of nitrogen necessary to encourage rapid growth and achieve complete coverage.

The key is to fertilize often but in very small amounts. As a very general rule, establishing putting surfaces will need 2 to 4 pounds of nitrogen, 1 to 2 pounds of phosphorous, and 1 to 2 pounds of potassium, per thousand square feet per month until complete coverage is achieved (usually within three to four months). Although the exact amounts of fertilizers to apply must be adjusted to every grow-in situation, many successful grow-ins have used a rotation of products similar to that depicted in the following table.

Table 2: Sample Grow-in Fertilization Schedule

During blending	If adjustments need to be made to pH, it is best to do so during the blending process. This allows lime, sulfur, or gypsum to be incorporated into the entire rootzone mixture. The amount of amendments necessary can be determined only through laboratory testing. When adding lime to a rootzone mix that will be planted to bentgrass, keep in mind that take-all patch disease is more severe on high pH soils. If pH values do not need to be lowered, but calcium levels are low, gypsum is a better choice.
Prior to planting – usually 1 to 3 days before seeding or sprigging.	Apply a "starter" fertilizer (typically on a 1:2:1 ratio of N:P:K) at a rate to provide 2 pounds of P2 O5 per thousand square feet. This also is the time to apply a micro-nutrient package to ensure trace and minor elements are available in sufficient quantities. Also apply a slow-release, composted product (e.g. Milorganite) at a rate to provide 2 pounds of nitrogen per thousand square feet. Ideally, these materials should be incorporated lightly into the upper 1 to 2 inches of the rootzone. This is easily done with a mechanical bunker rake or even by hand using a garden rake. Further incorpo ration will occur as the new green is smoothed or "floated" out to the finished surface and readied for planting.
1st week following planting (week 1)	Apply a complete balanced fertilizer (typically a 12-12-12 or equivalent) to provide 1/2 pound each of nitrogen, phosphorous, and potassium per thousand square feet. This provides a readily available source of nutrients for the emerging plants.
2nd week following planting (week 2)	It is likely new green leaves may already be surfacing. To apply a light feeding of nitrogen and phosphorous without burning the turf, Milorganite (or equivalent) is applied at a rate to provide 1/2 pound of nitrogen per thousand square feet.
3rd week following planting (week 3)	By now, the turfgrass should be well enough rooted to withstand its first mowing. This is a good time to apply another 1/2 pound of nitrogen per thousand square feet. An analysis on a 3:1:2 ratio (e.g. 15-5-10) will provide enough of each element but in small enough amounts to avoid burning new leaves.
Each week thereafter until complete coverage is achieved.	Continue the rotation of applications beginning with week 1 and through week 3.

There is no universal grow-in regime that fits all greens. There are simply too many variables. For example, a sprigged bermudagrass green must be managed differently from the seeded bentgrass green. A new green located in a climate that includes heavy rains will require more frequent fertilization to help compensate for nutrient leaching. Even microclimates can result in different grow-in regimes. A green exposed to strong winds will be more prone to drying than a green on the same course that is tucked into a grove of trees. Greens whose architecture includes steep mounding will be more difficult to manage from an irrigation standpoint than the green that is more subtle in it's contouring.

Tip 2: The physical soil analysis can provide insight into the grow-in requirements of the new green.

Major differences in water and nutrient requirements can occur depending on the make-up of the rootzone material itself. For example, a green that drains faster (in the accelerated range) almost certainly will have significantly higher fertilizer and irrigation requirements than a green in the normal range. These factors make the very fast draining green more difficult to manage during the first year or so.

All of these factors result in the grow-in process being one in which a high level of feel is required of the turf manager. Constant inspection of the new green is an absolute necessity to develop this level of agronomic instinct. And, as is the case in many skills, experience is perhaps that best teacher. A superintendent with significant grow-in experience often has the new green ready for play weeks before the less experienced manager.

Tip 3: Monitor pad development to help determine when the new green is ready to be opened for play.

Greens vary in the amount of time necessary for them to reach a level of maturity capable of withstanding play. In other words, how long must the players wait before they can get on the new green? One of the best ways to evaluate when the new green is ready for play is to measure the layer of organic matter (often called the pad or mat) that accumulates between the crown of the plant and the rootzone mixture. This pad is crucial to the new turf's ability to withstand traffic. Without a thick enough pad, the new turf wears severely in areas of concentrated traffic – frequently the entrance and exit points of the green.

The necessary thickness of the pad depends on the amount of play the green will receive, the ability to disperse entrance and exit traffic over numerous points, and the time of the year the green is opened. For example, a course that is very heavily played will need a more fully developed pad (approximately 1/4 inch in thickness) than the course that receives limited play. Keep in mind, however, that almost every course that has been closed long enough to rebuild the greens is likely to get unusually heavy play after it first reopens. Greens with numerous entrance and exit points fare better after opening since traffic can be dispersed over a wider area. In like manner, greens with an abundance of hole locations can withstand play much better than the green that has only a few places to cut a hole. And, of course, the green that is located in a favorable environment and opened for play at a time of the year that the turf is actively growing will tolerate much heavier traffic loads without severe wear and tear. All of these factors must be kept in mind when determining when the green is ready to be opened.

Time must be allow for the accumulation of a thin layer of organic matter between the rootzone and the leaves of the turf. The profile must be closely monitored to ensure this "pad" does not get too thick, resulting in a thatch layer.

Tip 4: Institute sectional maintenance for the entire grow-in process. Ideally, individuals should be assigned not more than six greens each.

These individuals should be charged with the hand watering of the newly planted greens. They also should be trained to watch out for disease and insect outbreaks. By providing this level of management, problems can be identified much earlier and thus controlled much easier. Another benefit to sectional maintenance is the feeling of ownership each of the section managers quickly develops. Within a matter of a few weeks, each section manager knows his or her greens better than anyone else.

Tip 5: Keep in mind that greens do not mature exactly at the same pace.

Although planted at the same time, the rate of turfgrass establishment will vary from green to green. This is due largely to variances in the microclimate of individual greens. It can be a source of frustration to everyone concerned with the project. Some courses choose not to reopen the course until every green is ready. Others choose to open individual greens for play as soon as they are ready, and rely on temporary greens on those holes where the grow-in is progressing more slowly.

Tip 6: Rather than using overhead sprinklers, hand water the newly planted greens as much as possible.

Overhead sprinklers apply large amounts of water in a short period of time and are more likely to cause erosion, making the green surface uneven. Proper hand watering applies water in a much more gentle fashion. Overhead irrigation also has the disadvantage of applying water to areas other than the green. Since the surrounds of greens are often sodded (and often need water less than the green surface), frequent overhead irrigation can result in extremely wet green banks, making mowing difficult, if not impossible.

Tip 7: Measure the pad development frequently.

As a general rule, 1/4 inch of pad is sufficient to withstand moderate traffic loads (~30,000 rounds per year). A cup-cutter, pocketknife, or soil profile tool can be used to evaluate pad development.

Tip 8: After reopening the green(s), play is likely to be unusually heavy since golfers are understandably anxious to try out the new surfaces.

Since the new turfgrass is highly prone to wear and tear, steps should be taken to keep play to reasonable levels. One way of doing this is to spread out the tee time interval to 10 or even 15 minutes. Another option for private courses is to limit play to the membership only — saving guest play for much later. Traffic control must be especially diligent. Use ropes, signs, and barriers to direct players to as many different entrance and exit points as possible.

Tip 9: Prior to opening the new green(s), inform the players that some wear and tear on the new surfaces is unavoidable.

The greens will go from not having to endure traffic at all to having to tolerate what will likely be heavier than usual play. It is very likely a few of the green will show excessive wear in areas where traffic is concentrated, and it may be necessary to close these greens temporarily to give them a few more weeks to mature. For this reason, it is a good idea to continue to maintain the temporary greens (for those courses that utilize them during reconstruction).

Tip 10: Institute a spikeless shoe policy for at least the first 8 to 10 weeks following opening of the new green(s).

Better yet, this is a good time to join the thousands of courses across the country that have instituted this policy on a year-round basis.

Tip 11: Mow with walk-behind equipment for at least the first full season following planting.

Walk mowers are far less likely to cause wear injury or create rutting in the new rootzone and will provide a superior cut. If necessary, triplex mowing can be reinstituted once complete coverage has been achieved and the rootzone has become compacted enough to support the heavier equipment.

Tip 12: Begin mowing as soon as the turf is well rooted.

Initial cutting heights on new bentgrass greens should be no higher than 1/4 of an inch. Bermudagrass settings should be 1/2 inch or less. The setting of the first cutting depends largely on the smoothness of the surface. For both creeping bentgrass and bermudagrass, low, frequent cutting encourages the rapid lateral spread that is critical to obtain complete coverage. Since it is almost impossible to keep the greens surface perfectly smooth (due to the frequent irrigation necessary during establishment) some scalping is inevitable. However, it is better to scalp the new turfgrass plants early (and have time to recover) than wait to lower the cut just prior to opening.

Tip 13: Aeration should be unnecessary on the new green since the rootzone is composed of a high percentage of sand, and is therefore highly resistant to compaction.

However, the combination of aeration and rolling can be very effective in smoothing a rough surface. A common practice (on greens that have been grow-in to the point that the new turf covers the green) is to aerify the new green with solid tines, irrigate, and then roll with a small asphalt roller (typically less than 1000 pounds). The roller compresses the rootzone mix into the voids created by the aerifier. Irrigation provides a "lubricant" to allow the mix to compress. The end result is a smoother surface.

Tip 14: Aeration and rolling can make transition areas less severe and reduce mower scalping.

Occasionally, the transition area from one level of the green to another may end up more severe than planned, resulting in severe scalping. The steepness of this transition area can be "softened" through a combination of aeration and rolling. Hollow-tine aeration (typically with 1/2 to 5/8 inch tines) should be performed on the crest of the transition area. Remove the cores and irrigate the area. Roll with a 500 to 1000 pound roller to compress this specific area of the green, making the transition less steep. Allow the aerified area to completely recover. Repeat as often as necessary to create a more gradual slope that is resistant to scalping.

Tip 15: Topdressing is a critical procedure for smoothing the newly established green.

In the past, the Green Section encouraged topdressing with the exact same material that comprised the rootzone mixture — typically a mixture of sand and organic matter. However, today's turfgrass varieties tend to be quite aggressive in terms of organic matter production. Therefore, it is therefore most often recommended that the topdressing material be composed solely of the same sand used in the green construction.

Conclusion

The process of successful green construction is much more than the mechanical steps from subgrade to grow-in. For example, this document does not address the architectural aspects, which have a definite impact on the agronomics of the green and, obviously, have a tremendous impact on players' enjoyment of the game. In like manner, talented golf course builders can adjust to the constantly changing conditions and unexpected challenges that arise in every major construction project. For existing courses that are dealing with the issue of rebuilding their greens, one of the most difficult aspects of the project is educating the golfers who are going to be asked to give up their course for the duration of the construction and grow-in.

Fortunately, there are many excellent resources available to everyone interested in the subject of putting green construction. The following organizations should be contacted for additional information and support.

USGA Green Section
P.O. Box 708
Far Hills, NJ 07931
(908) 234-2300
www.usga.org/green

American Society of Golf Course Architects
221 N. LaSalle St.
Chicago, IL 60601
(312) 372-7090
www.asgca.org

Golf Course Builders Association of America
727 "O" Street
Lincoln, NE 68510
(402) 476-4444
www.gcbaa.org

References and Additional Reading

All of these documents are available on-line at www.usga.org/green

1 The USGA Recommendations For A Method of Putting Green Construction. *USGA Green Section Record*. 1993 31 (2): 1-3.

2 Helping Your Greens Make the Grade. *USGA Green Section Record*. 1998. 36 (2): 1-7.

3 Physical Soil Testing Laboratories — Accredited Laboratory List. USGA Web site.

4 Quality Control Sampling of Sand and Rootzone Mixture Stockpiles. 2001. United States Golf Association.

5 Guidelines for Establishing Quality Control Tolerances. 2001. United States Golf Association.

6 Quality Control Guidelines. James F. Moore. www.usga.org/green.

7 A Troubleshooting Checklist for New USGA Greens. James. F. Moore. 1996. www.usga.org/green.

Additional Reading:

The History of USGA Greens. by James Latham. 1990. www.usga.org/green.

The following articles are from the *USGA Green Section Record*. 1993. 31(2):

The Whys and Hows of Revising the USGA Green Construction Recommendations. by James T. Snow. pg 4-6.

Rational for the Revisions of the USGA Green Construction Specifications. by Dr. Norman W. Hummel . pg 7-21.

ASTM Procedures Required for Testing Putting Green Materials. Compiled by Dr. Norman W. Hummel. pg 23-33.

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