

White Paper

Draft Variable –Depth Root Zones for Golf Putting Greens

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## Variable-Depth Root Zones for Golf Putting Greens

### Introduction

The current USGA specification for golf putting greens includes a uniform 300 mm layer of a sand-based root zone mix be placed over a 100 mm layer of pea stone or gravel. The sand-based root zone mix provides adequate aeration and maintains macropores to promote drainage. Placing the sand mixture over gravel (smaller pores over larger pores) increases the amount of water in the lower portion of the root zone while avoiding complete saturation following irrigation or rainfall (Dougrameji, 1965). Putting greens constructed to USGA specifications function very well on a level surface (Taylor et al., 1993); however, when the green has undulating areas, moisture extremes in the root zone often lead to turfgrass decline (Prettyman and McCoy, 1999).

Moisture extreme problems on USGA putting greens can be attributed to the uniform depth of the root zone layer. In theory, on a level surface, equal gravitational potential results in minimal lateral flow of water, and excess gravitational water within the putting green drains at a uniform rate. However, Nektarios et al. (1999) showed that due to fingered flow tendencies in the root zone, drainage in the profile is not uniform. There are two primary mechanical categories of lateral flow, saturated interflow and funneled flow. Funneled flow refers to the situation in which a capillary barrier develops in the relatively fine pores of the upper layer which lie above the relatively large pores of the underlying layer (Kung, 1990). In an unsaturated putting green profile, the matrix potential at the textural interface (interface of root zone and gravel layer) is so high that water cannot enter into the gravel layer, thereby forcing the water to move laterally along the gravel layer. Due to funneled flow, water moves down slope to lower elevations.

Prettyman and McCoy (2003) studied the drying of a 4% sloped USGA putting green and found that upslope drying of the root zone was not necessarily accompanied by soil water accumulation down slope. Prettyman and McCoy (2003) found there was only a slight increase in water contents at down slope locations when greens were sloped at 4% as compared with 0%. Furthermore, the authors speculated that water moving laterally within the root zone was able to effectively exit the system on reaching the down slope drainage elements.

Research completed by Frank et al. (2005) where volumetric water contents were closely monitored on sloping putting greens with both uniform and variable-depth root zones showed the importance of variable-depth root zones to control soil moisture uniformity across the surface. The consistency of volumetric water content (VWC) data for the variable-depth putting greens, for all root zone mixes used in the study, was clear. At the beginning of a dry-down cycle, the greatest difference in VWC across the putting surface for all root zone mixes within the variable-depth putting greens was 4%. On day three, the greatest difference across the putting surface was still 4%. Differences in VWC across the surface remained consistent as the greens dried. In contrast, for the putting greens with consistent-depth root zones, the greatest difference in VWC across the putting surface on day zero was 6% and for day three was 11%. The differences between the consistent-depth and variable-depth construction types on day

zero was small (2%) but by day 3 was large (7%). This data supports the conclusions that the variable-depth putting greens have greater VWC uniformity across the slope of the green.

### Baltimore CC Case Study

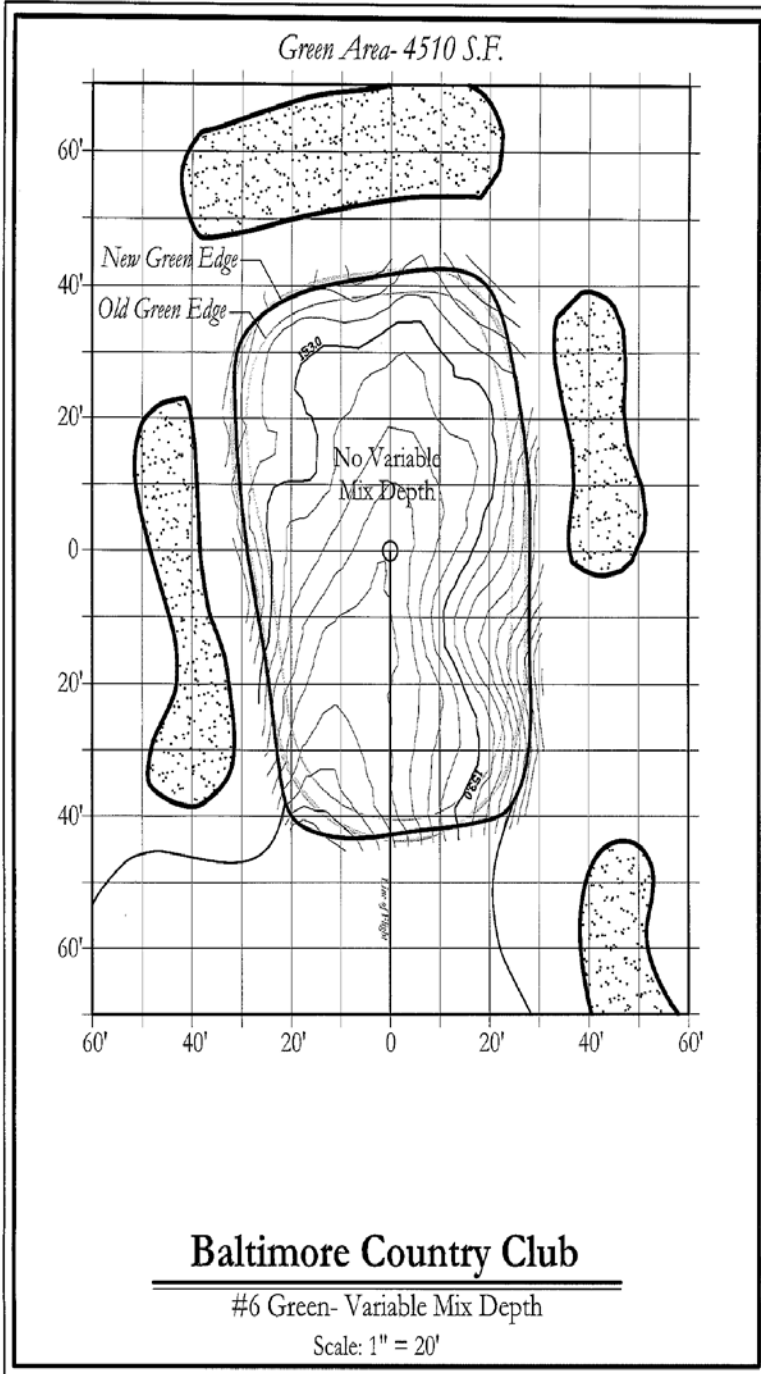
The East Course of Baltimore Country Club recently completed a renovation where seventeen of the eighteen putting greens were constructed with variable-depth root zones. Putting green number 6 was constructed with a consistent 12-inch root zone following USGA specifications. Volumetric water contents were measured within specific time periods during the Summer and Fall of 2015 on selected putting greens. These data allow for the comparison of volumetric water contents of putting greens with different construction styles within the same property and with the same management.

The methodology used involved a member of the crew determined volumetric water content of the upper 4 inches of the root zone within 9 quadrants of selected putting greens by averaging 6 TDR measurements within each quadrant. An example of these data along with a topographic model of each putting green is below.

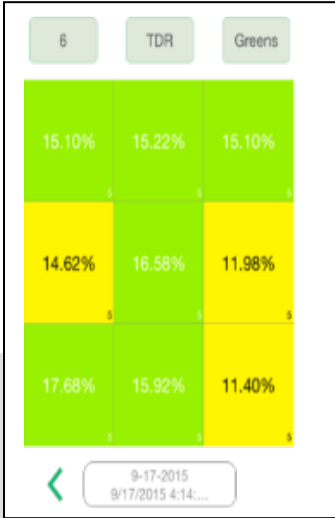
Past research suggests water contents will vary more on a sloping, consistent depth putting green as compared to a putting green built with a variable-depth root zone. Putting green number 6 (consistent depth) and putting green number 11 (variable-depth) moisture for a short period in September, 2015 are given below. The main topographic slope of putting green number 6 moves from the upper right to the lower left portions of the green with the lower left being the lowest portion of the green. On September 17, 2015 Baltimore Country Club began their Club Championship with the putting greens firm and fast with water contents approaching Field Capacity. Observe the water contents the next day along the main axes (upper right to lower left) where it is 8.6% in the highest, upper right portion to nearly double at 15.9% in the lowest, lower left portion of the green.

Putting green number 11 generally slopes from back to the front with small, relatively high surfaces on the left-middle and right-middle to back of the green (see topographic map below). Following the general rules to deepen the root zone in any portion of the green that subsurface water will drain and to decrease root zone thickness in any higher portions of the green with slope gradients greater than 3% with slope lengths less than 15feet long, 14 inches of root zone was used in the front portion and 10 inches of root zone was used on the middle-left and middle to upper right when the green was constructed. Volumetric moisture contents for September 17 and 18 are shown below and to the right of the topographic map of the putting green. It is clear the 14-inch root zone in the lowest portion of the green decreased the moisture content in the upper 4 inches of the root zone. It is also clear, the 10-inch root zone added to the consistency of volumetric water contents across the putting green on September 18, as compared to putting green number 6.

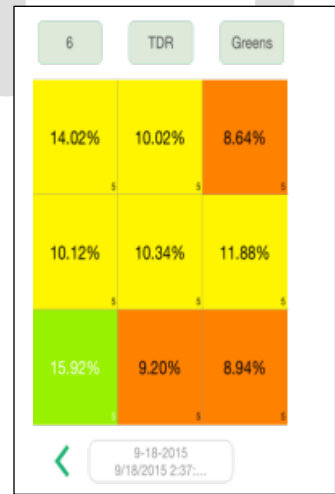
The average water contents across the 9 quadrants of the putting greens show the greater control variable-depth root zones add. On putting green 6 the average water content on Sept 17 was 15% and on Sept 18 11%, for a difference of 4% change in the average water content. On putting green 11 the average water content on Sept 17 was 12.1% and on Sept 18 11.4%. Standard deviations were also lower for the water contents measured on putting green 11, as compared to putting green 6.



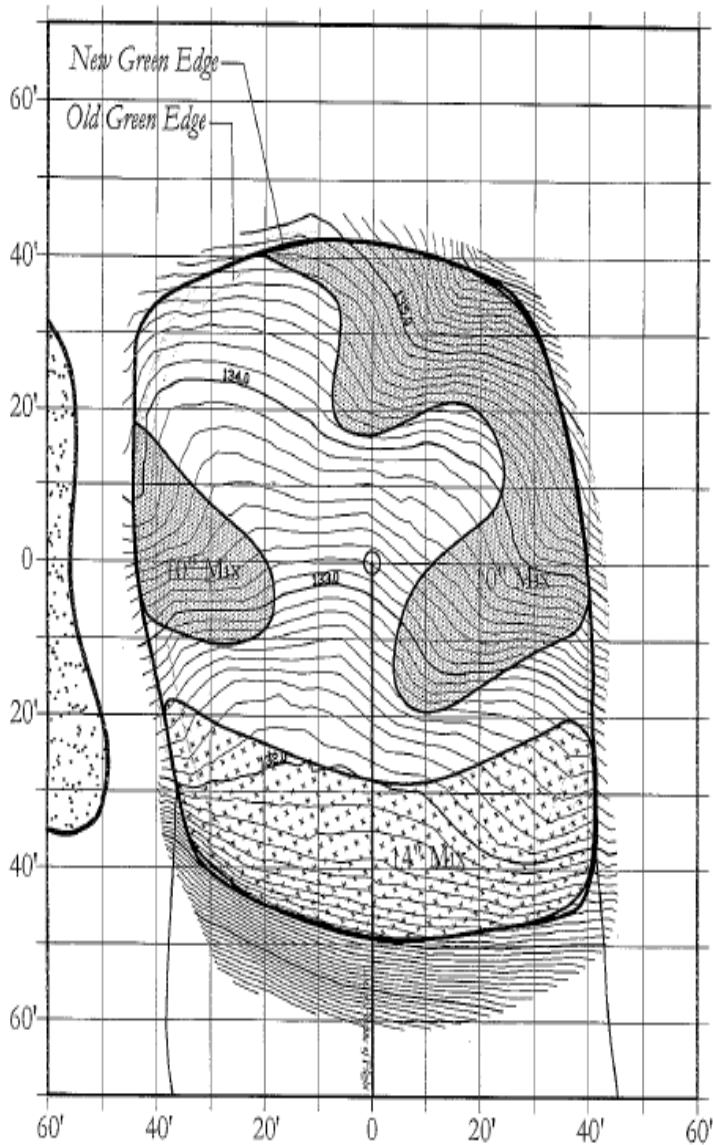
September 17, 2015 at beginning of tour.



September 18, 2015 following drying.



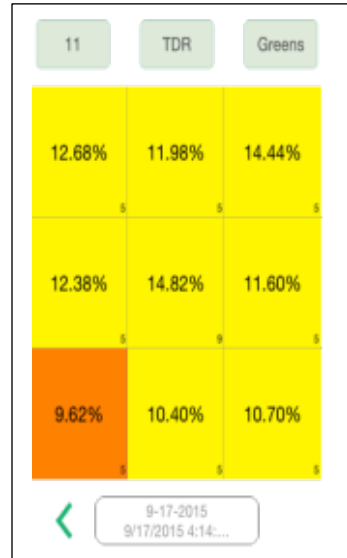
Green Area- 6785 S.F.



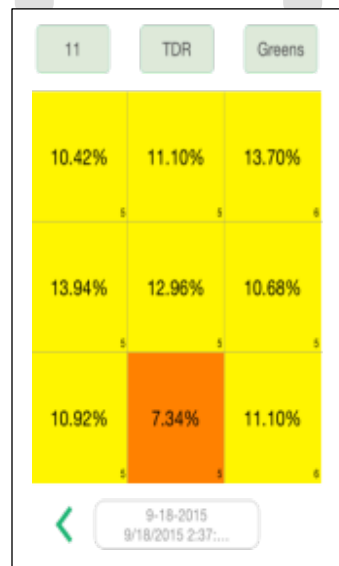
**Baltimore Country Club**

#11 Green- Variable Mix Depth

September 17, 2015 at beginning tour.



September 18, 2015 following drying.



## Construction of Variable Depth Putting green.

It is our experience, at least in humid climates where rainfall is greater than evapotranspiration, any sloping putting green where surface and subsurface water move downslope and off the green will benefit from variable-depth root zone construction. One approach is to place shallow root zone depths where hand watering is likely to occur and hole location is not. In bowled, areas leading to low areas (the most likely location for hole settings), the deeper depths should be considered

We propose the following guidelines for the selection of root zone depth.

1. On lower portions of putting greens where surface and subsurface water are intended to exit the green, deeper root zones with subsurface drains be installed. We suggest root zone thickness be increased by at least 3 inches to total approximately 15 inches (14-16 inches).
2. The greater thickness root zone should be extended "upslope" and in all directions until slope gradient exceeds 2%. At that point root zone thickness can to "feathered" to 12-inch thickness.
3. Relatively high in elevation, relatively small areas (generally not large enough for a cup to be placed) can benefit from thinner root zones that bring plant available water closer to the surface. We suggest where slope gradients exceed 3% and slope length is less than 15 feet and lead to relatively small areas, root zone thickness be feathered and reduced by at least 3 inches to total approximately 9 inches (8-10 inches).
4. In all other areas of the putting green we suggest a root zone thickness of 12 inches and standard USGA Specification construction.

## Advantages and Disadvantages of Variable Depth Root Zone Construction.

We see very few disadvantages and believe the advantages far outweigh the disadvantages.

Let's start with the disadvantages. I guess you could say our guidelines for selecting where root zones are thicker or thinner are complex and open to interpretation. We know putting greens in humid parts of the world benefit from thicker root zones in lower portions of the green where water flows. We also believe these areas are relatively easy to detect and plan for. As far as where thinner root zones should be constructed, we believe simply asking whether a relatively small area would potentially need much hand-watering will indicate these areas.

Also, to implement variable root zone thickness the putting green must be built as designed. To maintain the integrity of the variable depth root zone, major changes in surface elevation cannot be done.

Advantages include much greater water content uniformity across the putting green, higher quality putting surfaces for the player, and a system that provides greater control to the golf course superintendent.

We strongly believe variable depth root zone construction improves putting green quality and performance and should be implemented where warranted.

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