

USGA-PT
2000 PROGRAM

15, September 2000

TO: Participants of the 2000 USGA Green Section Proficiency Testing Program

FROM: Robert O. Miller and Janice Kotuby-Amacher

RE: Results of 1st Exchange 2000

We would like to thank all participating laboratories for their cooperation in completing these analyses in a timely manner. Eleven of twelve laboratories enrolled submitted results.

Included with this report are copies of the data analysis for each sample and survey results. In the data analysis report is listed: the number of lab results reported; minimum value reported, maximum value reported; median value of reported values; median absolute deviation (MAD) of all reported values; overall reproducibility (R_d); individual reported lab values; repeatability (R_p) of lab value; and mean lab value reported. Using the median and MAD, Warning Limits are set at $\pm 2.5 \times \text{MAD}$ units. This statistical approach is less sensitive to the influence of data set extreme values and generates a better estimate of the *true value* and variance. **Note:** for 2000 overall reproducibility (R_d , precision across labs) and repeatability (R_p , precision within a laboratory) have been added to the list of statistical parameters and the mean and RSD statistics removed.

Sample USGA 00 - I as represented by sub samples 00-101, 00-102 and 00-103 is an artificial mixture prepared from five glass bead sizes, with no organic matter addition. **Sample USGA 00 - II** as represented by sub samples 00-104, 00-105, and 00-106 was obtained from TXI, Austin, TX. **Sample USGA 00 - III** as represented by sub samples 00-107, 00-108, and 00-109 was obtained from Plaisted Companies, Elk River, Minnesota. New for 2000 is the addition of Initial moisture of the sample upon reception. This test method was added for 2000 to address the impact of initial moisture on Saturated Hydraulic Conductivity. Results indicate that overall reproducibility of the industry for this test ranges from 6.5 to 22.5% for the industry.

For **sample USGA 00 - I** Saturated Hydraulic Conductivity (SHC) ranged from 13.5 to 24.8 in hr^{-1} . The range of reported values resulted in a MAD value of 14% of the median of 17.5 in hr^{-1} . For **sample USGA 00- II** SHC ranged from 5.2 - 22.2 in hr^{-1} , with a median of 15.2 in hr^{-1} . For **sample USGA 00- III** SHC ranged from 6.8 - 21.8 in hr^{-1} , with a median of 12.4 in hr^{-1} .

Precision for water retention (30 cm) indicated a relative MAD 22.8% to 10.4% of the median for the three samples respectively. Results for noncapillary and capillary pore space were variable across both samples. Values for total pore space indicated a high level of precision with MAD values ranging from 3.4% - 1.8% of the median respectively.

Results for particle density showed a high degree of reproducibility between laboratories. For **sample USGA 00 - I**, the median was 2.490 with a MAD value of 0.014 g cm^{-3} . Reproducibility (R_d) within laboratories was 0.20%. For the other two samples the median particle density was 2.644 and 2.667 g cm^{-3} with R_d values of 0.14%.

Organic matter as measured by the LOI technique MAD value was 80%, 10.8% and 8.4% of the median for the three samples respectively. **Sample USGA 00 - I**, an artificial sample, had no organic matter and generally most laboratories found near non-detectable quantities. Three laboratories provided organic matter results using the Walkley-Black (WB) method.

Generally MAD values ranged from 1.6% - 26.1% of the median across the five sand fractions for the three samples. Based on coarse sand and medium sand analyses the proficiency samples submitted to individual labs were well homogenized, for **sample USGA 00- II** and more so for **sample USGA 00- III**. Across fractions variability was less for **sample USGA 00-III**. Although variability was high for the silt and clay analyses, this is expected as these values are both approaching the method detection limit. *Rd* (precision across labs) values indicate there was less precision (higher values) across labs for silt analysis than sand or clay analyses.

pH MAD values ranged from 0.51 to 0.24 pH units for samples with a median pH of 10.75, 8.44, and 7.70, respectively. Water extract EC median values were 0.79, 0.10 and 0.07 mmhos cm⁻¹. All samples exhibited variability in EC MAD value, of more than 30%. New for 2000 is the addition of calcium carbonate percentage. Three laboratories provided results with samples ranging from 0.74 to 12.2% by weight. Generally the reproducibility ranged from 7.9 to 16% for the test method.

Analyzing the data sets subsets were made based on uniformity of values for the 1st quarter. Results indicated five labs (identified as Group I) with greater uniformity in SHC values for all samples and six labs (identified as Group II) which were less consistent (Table 1). Group I labs gave a lower median SHC for **sample USGA 00 - I** than that of the complete data set and Group II a higher for **sample USGA 00 - II**. With the exception of **sample USGA 00 - I** (the artificial mix) lower MAD values were noted for SHC for Group I. Using this data set partition of Group I and Group II water retention (- 30 cm) values were evaluated. Group I retention median values were consistent with the median of the complete data set. Water retention MAD for Group II were more lower for than Group I.

Table 1. Comparison of data subsets of SHC and water retention for samples USGA 00 - I, USGA 00- II and USGA 00 - III.

| Method | Sample | Complete Data (11 Labs) | | Group I @ (5 Labs) | | Group II (6 Labs) | |
|----------------------------|----------|----------------------------|-------|-------------------------|-------|------------------------|-------|
| | | Median | MAD | Median | MAD | Median | MAD |
| SHC (in/hr) | 00 - I | 17.5 | (2.6) | 15.4 | (2.0) | 18.1 | (1.6) |
| | 00 - II | 15.2 | (3.5) | 16.2 | (1.9) | 11.1 | (5.9) |
| | 00 - III | 12.4 | (1.1) | 12.8 | (0.7) | 12.2 | (1.5) |
| Water Retention. (%) | 00 - I | 13.6 | (3.1) | 13.3 | (2.9) | 15.4 | (1.9) |
| | 00 - II | 8.7 | (1.7) | 8.7 | (2.8) | 8.5 | (1.9) |
| | 00 - III | 11.5 | (1.2) | 11.1 | (1.1) | 13.3 | (2.4) |

@ Group I established based on uniformity in values of five laboratories and Group II established based on a lack of uniformity.

The Saturated Hydraulic Conductivity test (SHC, also referred to as the Ksat test or percolation rate) is one of the predominate test methods for the analysis of golf green root-zone materials. Results of the USGA-PT program indicate the method although highly repeatable within a single laboratory, is inconsistent between laboratories. As a result I have been collaborating with several laboratories to evaluate the impact of variation in method technique on SHC values. From this research we have found that initial green mix moisture content has significant effect on SHC value (see Figures 1 and 2). As the moisture content of the green mix increases at column loading (the first method step in the SHC test) there is an apparent change in the SHC value. From the relationship diagrammed in Figure 1, for each one percent moisture content increase there is a corresponding decrease in SHC. For Figure 2, using a different green mix the SHC initially increases and then decreases by 50%. The physical explanation of this effect is not well understood, however it is likely the effect of increased particle cohesion with increasing moisture and a change in the size of noncapillary macro pores (those with moisture tensions less than 30 cm tension). Any revision of the current method must address this effect of initial moisture content on SHC. We will be conducting further research into this phenomena.

Discretion should be used when evaluating an individual laboratory result and when reviewing specific analyses which are highly variable across samples. For most analyses the median and MAD are the most appropriate for evaluation purposes. In specific instances variation may be high on samples low in concentration, the result of measurements near the method detection limit. In light of the presence of outlier values a number of factors may result in their occurrence. Excluding the possibility of analytical bias, there are three major sources: improper reporting units, transcription errors, and confusion of sample identifications. Each of these can dramatically affect the overall mean and standard deviation. Therefore it's very important to recheck results for these potential errors when completing reporting sheets. Overall, when reviewing results it is important noting an individual laboratory analytical values which are consistently low or high relative to the mean across all exchange samples. Such trends may signify a fundamental difference in the analytical method or a systematic laboratory bias. Any transcription errors noted in reported values should be brought to our attention to correct the database. We appreciate any and all constructive comments which will improve the program and enhance its utilization.

2nd set of samples of the 2000 USGA-PT program will be shipped the 1st week of October 2000.

Any questions regarding this report should be directed to:

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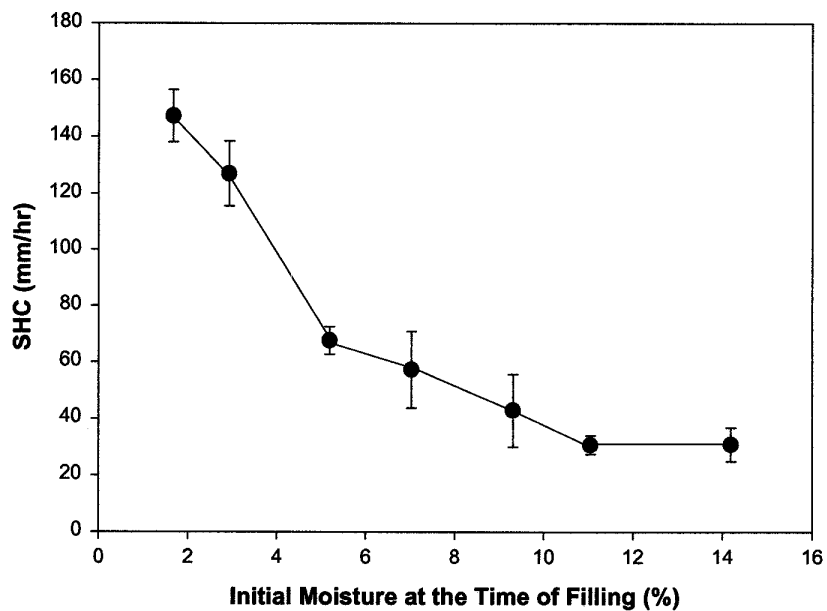


Figure 1. Relationship of initial green mix moisture (column loading) on final SHC. Data provided by Ann Murray ETL, Stirling, Scotland. Sample provided by, Hall Irwin Sand Company, Brighton, Colorado.

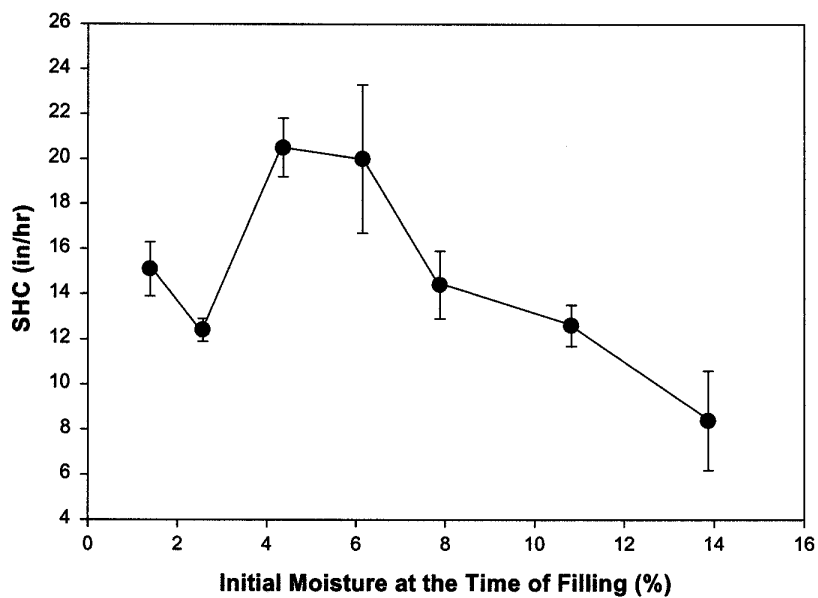


Figure 2. Relationship of initial green mix moisture (column loading) on final SHC. Data provided by Robert Oppold, ISTRC Laboratory, Olathe, Kansas. Sample provided by, TXI Industries, Austin, Texas.

USGA GREEN SECTION PROFICIENCY TESTING PROGRAM REPORT 1st QTR 2000

Sample USGA 2000 - I

September 4, 2000

| Analysis | No. | Min | Max | Median | MAD | Rd (%) | 00-101 | 00-102 | 00-103 | Rp (%) | Mean ¹ |
|--|-----|-------|-------|--------|-------|--------|--------|--------|--------|--------|-------------------|
| Pore Space | | | | | | | | | | | |
| Initial Moisture (Received) | 27 | 0.7 | 12.3 | 1.00 | 0.12 | 7.5 | | | | | |
| Saturated Hydraulic Cond. (in hr ⁻¹) | 33 | 13.5 | 24.8 | 17.5 | 2.6 | 3.7 | | | | | |
| Water Retention -30 cm (%) | 33 | 9.8 | 19.9 | 13.6 | 3.1 | 2.2 | | | | | |
| Non Capillary (%) | 33 | 4.1 | 25.7 | 15.5 | 4.3 | 2.7 | | | | | |
| Capillary (%) | 33 | 14.9 | 31.8 | 21.6 | 4.2 | 2.6 | | | | | |
| Total (%) | 33 | 34.2 | 43.7 | 37.6 | 1.3 | 1.0 | | | | | |
| Bulk Density (gm cm ⁻³) | 33 | 1.470 | 1.640 | 1.560 | 0.050 | 0.38 | | | | | |
| Particle Density (gm cm ⁻³) | 33 | 1.649 | 2.649 | 2.490 | 0.014 | 0.20 | | | | | |
| Organic Matter - LOI (%) | 33 | 0.00 | 0.20 | 0.05 | 0.04 | 34.6 | | | | | |
| Organic Matter - WB (%) | 12 | 0.00 | 0.27 | 0.02 | 0.01 | 21.7 | | | | | |
| Particle Size Analysis | | | | | | | | | | | |
| Very Coarse Sand (%) | 30 | 0.0 | 0.0 | 0.00 | 6.50 | 3.0 | | | | | |
| Coarse Sand (%) | 33 | 6.9 | 9.6 | 8.5 | 0.50 | 3.0 | | | | | |
| Medium Sand (%) | 33 | 24.1 | 35.3 | 29.5 | 1.50 | 1.5 | | | | | |
| Fine Sand (%) | 33 | 46.5 | 57.9 | 50.4 | 3.30 | 1.2 | | | | | |
| Very Fine Sand (%) | 33 | 5.1 | 121.3 | 9.5 | 2.48 | 6.7 | | | | | |
| Gravel (%) | 33 | 0.0 | 0.00 | 0.00 | 0.45 | 36 | | | | | |
| Sand -Total (%) | 33 | 96.1 | 99.8 | 98.7 | 0.60 | 0.1 | | | | | |
| Silt (%) | 33 | 0.0 | 3.2 | 1.13 | 0.48 | 18.7 | | | | | |
| Clay (%) | 33 | 0.0 | 1.6 | 0.32 | 0.22 | 15.7 | | | | | |
| Primary Particle Shape | | | | | | | | | | | |
| Angularity (Scale 1-6) | 33 | 6.0 | 6.0 | 6 | 0.0 | 0.0 | | | | | |
| Sphericity (Scale 1-3) | 33 | 1.5 | 3.0 | 3 | 0.0 | 0.0 | | | | | |
| pH (1:1 water) | 30 | 9.70 | 11.68 | 10.75 | 0.51 | 0.7 | | | | | |
| EC 1:2 Water Extr. (mmhos cm ⁻¹) | 27 | 0.21 | 1.94 | 0.79 | 0.397 | 13.3 | | | | | |
| Calcium Carbonate (%) | 12 | 0.00 | 21.50 | 0.74 | 0.960 | 16 | | | | | |

¹ Mean reported lab value, flagged exceeding warning Limits " * " based on 2.5 x MAD units from Median. " < " recorded as a null value.

USGA GREEN SECTION PROFICIENCY TESTING PROGRAM REPORT 1st QTR 2000

Sample USGA 2000 - II

September 4, 2000

| Analysis | No. | Min | Max | Median | MAD | Rd (%) | | | | |
|--|-----|-------|-------|--------|-------|--------|--------|--------|--------|-------------------|
| | | | | | | | 00-104 | 00-105 | 00-106 | Mean ¹ |
| Initial Moisture (Received) | 27 | 4.2 | 14.8 | 5.8 | 1.3 | 22.5 | | | | |
| Saturated Hydraulic Cond. (in hr ⁻¹) | 33 | 5.2 | 22.2 | 15.2 | 3.5 | 6.0 | | | | |
| Water Retention -30 cm (%) | 33 | 6.0 | 12.4 | 8.7 | 1.7 | 5.1 | | | | |
| Pore Space | | | | | | | | | | |
| Non Capillary (%) | 33 | 16.1 | 31.1 | 24.2 | 2.3 | 3.2 | | | | |
| Capillary (%) | 33 | 9.4 | 20.1 | 14.1 | 0.4 | 5.3 | | | | |
| Total (%) | 33 | 34.7 | 45.3 | 38.5 | 0.7 | 0.9 | | | | |
| Bulk Density (gm cm ⁻³) | 33 | 1.420 | 1.720 | 1.620 | 0.065 | 0.5 | | | | |
| Particle Density (gm cm ⁻³) | 33 | 2.594 | 2.673 | 2.644 | 0.015 | 0.1 | | | | |
| Organic Matter - LOI (%) | 33 | 0.21 | 0.67 | 0.37 | 0.04 | 6.5 | | | | |
| Organic Matter - WB (%) | 12 | 0.25 | 0.85 | 0.43 | 0.13 | 7.6 | | | | |
| Particle Size Analysis | | | | | | | | | | |
| Very Coarse Sand (%) | 30 | 5.7 | 9.1 | 8.00 | 0.60 | 2.4 | | | | |
| Coarse Sand (%) | 33 | 27.2 | 38.5 | 34.3 | 1.50 | 8.3 | | | | |
| Medium Sand (%) | 33 | 37.7 | 46.0 | 41.8 | 1.90 | 2.7 | | | | |
| Fine Sand (%) | 33 | 7.6 | 13.4 | 9.2 | 0.84 | 8.7 | | | | |
| Very Fine Sand (%) | 33 | 2.3 | 4.5 | 3.1 | 0.51 | 12.5 | | | | |
| Gravel (%) | 33 | 0.5 | 2.60 | 1.10 | 0.47 | 32 | | | | |
| Sand -Total (%) | 33 | 94.6 | 98.1 | 96.5 | 0.50 | 0.6 | | | | |
| Silt (%) | 33 | 0.2 | 3.4 | 1.25 | 0.35 | 13.4 | | | | |
| Clay (%) | 33 | 0.4 | 2.0 | 1.07 | 0.28 | 14.0 | | | | |
| Primary Particle Shape | | | | | | | | | | |
| Angularity (Scale 1-6) | 33 | 3.0 | 4.5 | 4 | 0.5 | 0.0 | | | | |
| Sphericity (Scale 1-3) | 33 | 1.5 | 2.0 | 2 | 0.0 | 0.0 | | | | |
| pH (1:1 water) | 30 | 6.05 | 9.08 | 8.44 | 0.24 | 1.6 | | | | |
| EC 1:2 Water Extr. (mmhos cm ⁻¹) | 27 | 0.06 | 6.06 | 0.10 | 0.030 | 11.0 | | | | |
| Calcium Carbonate (%) | 12 | 9.2 | 35.4 | 12.2 | 3.0 | 7.9 | | | | |

¹ Mean reported lab value, flagged exceeding warning Limits " * " based on 2.5 x MAD units from Median. " < " recorded as a null value.

USGA GREEN SECTION PROFICIENCY TESTING PROGRAM REPORT 1st QTR 2000

Sample USGA 2000 - III

September 4, 2000

| Analysis | No. | Min | Max | Median | MAD | Rd (%) | 00-107 | 00-108 | 00-109 | Rp (%) | Mean ¹ |
|--|-----|-------|-------|--------|-------|--------|--------|--------|--------|--------|-------------------|
| Pore Space | | | | | | | | | | | |
| Initial Moisture (Received) | 27 | 2.9 | 15.5 | 4.1 | 0.3 | 6.5 | | | | | |
| Saturated Hydraulic Cond. (in hr ⁻¹) | 33 | 6.8 | 21.8 | 12.4 | 1.1 | 5.9 | | | | | |
| Water Retention -30 cm (%) | 33 | 8.7 | 16.4 | 11.5 | 1.2 | 2.1 | | | | | |
| Non Capillary (%) | 33 | 6.0 | 33.2 | 20.7 | 1.9 | 2.7 | | | | | |
| Capillary (%) | 33 | 12.9 | 28.5 | 18.8 | 1.8 | 2.7 | | | | | |
| Total (%) | 33 | 33.6 | 49.4 | 39.0 | 1.2 | 0.9 | | | | | |
| Bulk Density (gm cm ⁻³) | 33 | 1.350 | 1.750 | 1.630 | 0.030 | 0.49 | | | | | |
| Particle Density (gm cm ⁻³) | 33 | 2.603 | 2.720 | 2.667 | 0.015 | 0.10 | | | | | |
| Organic Matter - LOI (%) | 33 | 0.61 | 1.13 | 0.83 | 0.07 | 6.2 | | | | | |
| Organic Matter - WB (%) | 12 | 0.65 | 1.23 | 0.90 | 0.16 | 8.4 | | | | | |
| Particle Size Analysis | | | | | | | | | | | |
| Very Coarse Sand (%) | 30 | 4.7 | 8.4 | 7.00 | 0.50 | 3.9 | | | | | |
| Coarse Sand (%) | 33 | 26.1 | 33.9 | 30.4 | 0.40 | 1.2 | | | | | |
| Medium Sand (%) | 33 | 40.0 | 44.6 | 42.5 | 0.70 | 1.1 | | | | | |
| Fine Sand (%) | 33 | 12.5 | 18.1 | 14.4 | 0.45 | 2.3 | | | | | |
| Very Fine Sand (%) | 33 | 3.0 | 4.4 | 3.9 | 0.20 | 2.9 | | | | | |
| Gravel (%) | 33 | 0.0 | 0.92 | 0.20 | 0.10 | 27 | | | | | |
| Sand -Total (%) | 33 | 96.6 | 99.1 | 97.9 | 0.48 | 0.2 | | | | | |
| Silt (%) | 33 | 0.5 | 2.1 | 0.93 | 0.27 | 13.0 | | | | | |
| Clay (%) | 33 | 0.1 | 1.6 | 0.78 | 0.48 | 8.4 | | | | | |
| Primary Particle Shape | | | | | | | | | | | |
| Angularity (Scale 1-6) | 33 | 3.0 | 4.5 | 4 | 0.5 | 0.0 | | | | | |
| Sphericity (Scale 1-3) | 33 | 1.5 | 2.5 | 2 | 0.0 | 0.0 | | | | | |
| pH (1:1 water) | 30 | 5.03 | 8.41 | 7.70 | 0.32 | 0.9 | | | | | |
| EC 1:2 Water Extr. (mmhos cm ⁻¹) | 27 | 0.03 | 0.22 | 0.07 | 0.030 | 6.7 | | | | | |
| Calcium Carbonate (%) | 12 | 1.01 | 45.5 | 2.40 | 1.20 | 16 | | | | | |

¹ Mean reported lab value, flagged exceeding warning Limits " * " based on 2.5 x MAD units from Median. " < " recorded as a null value.