HAR TRU

To Whom It May Concern:

Thank you for calling to express your concern over the potential water run-off issues involving the installation of Har-Tru (clay-like) tennis courts. To date we have manufactured surface for over 30,000 courts in the United States alone, and as the nations leading manufacturer of clay-like tennis court surfacing, we are often asked to defend the advantages of our product.

Municipalities in, and around, major U.S. cities such as Philadelphia, New York, San Francisco, Atlanta, Washington D.C. have concluded that a Har-Tru court will often provide a more absorbent medium than the soil and turf that it replaces. In Fact, San Francisco, with some of the most strictly enforced run-off rules in the U.S., allows the Har-Tru court to be built right up to a landowner's property line.

With more and more acreage being "paved over" with impervious materials such as asphalt and concrete everyday, we are often asked about alternative surfaces to reduce issues involving water run-off. While Har-Tru is often referred to as a "clay court" surface, it is in fact, a crushed stone product, and not natural "clay" at all. Har-Tru is a crushed basalt rock that is mined, crushed, screened and blended to achieve specific sizing. When constructed and cared for properly, Har-Tru makes for a fantastic tennis surface.

Attached to this letter, you will find technical data to prove these claims. When you compare the permeability data in these reports and charts to that of typical soil types, please remember that the term "clay" to a soils engineer is very different then the "clay" thought of by most people in our country. It is also very important to understand what permeability is measuring. Permeability (k) is described as the property by which water flows through a soils void place.

Based on testing done by the independent geotechnical engineering firm of Froehling and Robertson, Inc., the basic Har-Tru court offers an average permability of 0.17 x 104 cm/sec and an uncompacted void of nearly 50% (see attached data). These numbers should be compared to the permeability and void ratios of the in-situ soils at your location. Table 5.1 (attached) gives you a means by which you can compare our surface to other common soil types found in the United States. This chart shows that the Har-Tru court is most favorable compared to "medium sites" and outperforms all "clays" and "fine or clayey splits". Favorable testing data is also available on porosity, plasticity, moisture-density relations, angularity, and sand equivalency if needed.

The construction of a Har-Tru court also helps in reducing the potential for run-off. As specified by the American Sports Builders Association, Har-Tru courts are built with a very minor slope (0.28%). When compared to a typical hard surfaced court (asphalt, concrete), which are sloped over three times as much (1.0%), you can see that the velocity in which water runs off is lessened dramatically.

Once the stone base of a Har-Tru court becomes saturated, some water will indeed start to run-off. However, because of the minimal slope and the rather high permeability of the surface, we can conclude that prior to the point of saturation a Har-Tru court would "accept" more rainwater than most 4" layers of in-situ soils. In addition, the uniformity and planarity of the slope eliminates the funneling of run-off water and results in less erosion.

I hope that this has shed some light on the advantages of Har-Tru surfaces as the premier tennis court surface for areas with water run-off issues. Please feel free to contact me at 1.877.4.HAR.TRU if I can be of further assistance.

Regards,

Pat Hanssen
General Manager
Har-Tru Sports

HAR-TRU, LLC
SUMMARY REPORT 2002
PRODUCT EVALUATION

1. Finished Product (Fine Aggregate)

a. ASTM C-1252 Fine Aggregate Angularity: We ran this test on Har-Tru without binder, with binder and on Charlottesville Quarry No. 16's (the product used to make the Har-Tru product).
TEST RESULTS:
a. Har-Tru no binder 47.9% voids
b. Har-Tru with binder 50.2% voids
c. Charlottesville No. 16's 49.6% voids
This test method is to indicate the surface texture, angularity, or sphericity and compared to other fine aggregates with the same grading. We used method C that is testing the material as received. All the test results indicate that the materials tested are angular in shape. This information will be useful when we compare it to other materials supplied for Fast Dry Tennis Courts.

b. ASTM D-698 Moisture-Density relations of soils (Proctor): We performed a modified one-point proctor with 6% moisture, which gave us a unit weight of 121.65 pounds per cubic foot. We need more material to complete this test and have meaningful results.

c. AASHTO T-89/90 Liquid Limit and Plastic Limits / Plasticity Index: A liquid limit could no be achieved, it is non-plastic and the plasticity index is 0. This is true of the Charlottesville No. 16's they are also very granular with no natural fines (all dust fracture). And again this information will be useful when compared to other products used for Fast Dry Tennis Courts. If you had a product that you could achieve a liquid limit of PI you would probably experience drainage problems.

d. AASHTO T-84 Specific Gravity and Absorption of Fine Aggregates: We ran T-85 specific gravity and absorption of Coarse Aggregate which is the raw feed used to produce the fines to make Fast Dry Tennis court materials.
TEST RESULTS
a. Yorkmont No. 57's (Gray) SpGr (dry) 2.779 Absorption 0.37
b. Yorkmont No. 57's (Red) SpGr (dry) 2.765 Absorption 0.35
c. Charlottesville No 57's SpGr (dry) 2.941 Absorption 0.42
d. Charlottesville No 16's SpGr (dry) 2.846 Absorption 1.32
When converting weight into volume the Yorkmont material would have a better yield

e. Two tests were run to determine permeability. They were AASHTO T-215 Permeability of granular soils (Constant Head): We had this test run: Reference Document 1 for test results. We also had the ASTM D-5084 Hydraulic Conductivity of a Saturated Porous Material using a Flexible Wall Permeameter, (this test was recommended because it is less variable. So for comparing Har-Tru to other products this is the test to perform).

f. Roundness Sphericity Scale (Krumbein & Sloss Scale) TEST RESULTS:
    i. Classification: Angular
    ii. Sphericity: 0.5
    iii. Roundness: 0.3
g. ASTM D-2419 Sand Equivalent: This test is a rapid field test to show the relative proportions of dust and claylike materials in soils or graded aggregate. TEST RESULTS:
    i. Har-Tru No Binder S.E. = 45%
    ii. Har-Tru With Binder S.E. = 45%

    The S.E. percent is representing the amount of fine aggregate; the remaining percentage of the sample represents dust and claylike materials, the higher the S.E. the cleaner the material. This will also be a good tool to evaluate other materials used for Fast Dry Tennis Courts.
h. ASTM C-136 Sieve Analysis of Fine and Coarse Aggregate: ARI performed this test for us and enclosed are the results. This will be another good tool for comparison.

2. Sub-grade Materials Used to Construct Fast Dry Tennis Courts

a. ASTM C-131 Resistance to Degradation of Small Sized Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine: This has been done o No. 57's only from the Luck Stone quarry in Charlottesville, VA; we need more material from Yorkmont to run theirs. TEST RESULTS: 15.9% Loss on 500 Revolutions.
b. ASTM C-33 Soundness of Aggregate by use of Sodium Sulfate or Magnesium Sulfate: This has also been run only on Luck Stone Charlottesville quarry materials. TEST RESULTS: Coarse Aggregate 1.0% Loss, Fine Aggregate 5.9% Loss
c. ASTM D-698 Moisture-Density Relations of Soils (screenings) TEST RESULTS: one point proctor 125.7, Charlottesville quarry No. 16's
d. ASTM D-2434 Constant Head Permeability Test: This test was performed on #10 gravel from the Luck Stone quarry in Charlottesville, VA. Test Results can be found in Document 2 attached.
e. Mineralogy / Geological / Petrographic Analysis (screenings) NOT RUN
f. ASTM C-136 Sieve Analysis of Fine and Coarse Aggregate: AVAILABLE
g. ASTM C-1252 Fine Aggregate Angularity (FAA): Luck Stone Charlottesville Quarry No. 10's is 51.2 and the No. 16's are 49.6.

We have also developed a list of submittal request for contractors building tennis courts. This list was developed from a questionnaire Randy Futty submitted.

3. Suggested Testing Protocol for Evaluating Products

Product Testing

a. Obtain 20 random bagged samples of Har-Tru within 1 or 2 lots to build a Statistical database and check process capabilities.
b. Har-Tru, LLC QC Associate would be trained to assist in testing program.
c. Obtain random bagged samples every two weeks for 6 to 9 months check product variation over time.
d. Determine of a testing firm to validate test results.

Nothing has been done; we have received no response from Har-Tru, LLC on this recommendation. We will be happy to support you in these efforts if you would like to proceed in the upcoming year.

Performance Testing

a. Compare materials from a well performing tennis court with that of a poorly performing tennis court. To determine which of the tests might identify deficiencies in the material.
b. Effects of moisture content on the sliding capability.

Nothing has been done; we have received no response from Har-Tru, LLC on this recommendation. We will be happy to support you in these efforts if you would like to proceed in the upcoming year.

Please contact John P. Hellyer 804.784.6346 if you have any questions or comments.

SINCE 1881

FROEHLING & ROBERTSON, INC.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
ENGINEERS • LABORATORIES
"OVER ONE HUNDRED YEARS OF SERVICE"
Richmond Branch Office
3015 Dumbarton Road, Richmond, Virginia 23228
(804) 264-2701 Fax (804) 264-7862

June 19, 2002

LuckStone
P.O. Box 29682
Richmond, Virginia 23242-0682
Attention: Mr. John P. Hellyer, Assistant Director of Quality Management

Re: Laboratory Testing - Lee Tennis, Har Tru, Hydroblend
F&R Project No.: D60-0241T

Dear Mr. Hellyer:

Froehling & Robertson, Inc. is pleased to submit the results of soil laboratory testing performed on the submitted sample for the above referenced project. As requested the #10 screenings were compacted to approximately 90% of the Standard Proctor value provided to F&R by LuckStone. The Hydroblend material was compacted on top of the screenings to approximately 145 pcf dry density at 10.2 % moisture. After the compaction of the Hydroblend material, the 3 inches of #10 screenings were found to have compacted an additional 0.1 inch. Testing was performed in general accordance with ASTM D-5084 (Hydraulic Conductivity of a Saturated Porous Material using a Flexible Wall Permeameter). The test result is included as an attachment.

Should you have a question about this test result or require additional information or testing, please contact us at your convenience.

Respectfully Submitted,
FROEHLING & ROBERTSON, INC.

Frederick S. Proper
Geotechnical Engineering Staff

Attachments
(1) Permeability Test Results

HEADQUARTERS: 3015 DUMBARTON ROAD • BOX 27524 • RICHMOND, VA 23261-7524
TELEPHONE (804) 264-2701 • FAX (804) 264-1202 • www.FandR.com

BRANCHES: ASHEVILLE, NC • BALTIMORE, MD • CHARLOTTE, NC • CHESAPEAKE, VA
CROZET, VA • FAYETTEVILLE, NC • FREDERICKSBURG, VA
GREENVILLE, SC • RALEIGH, NC • ROANOKE, VA • STERLING, VA

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FROEHLING & ROBERTSON, INC.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS
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"OVER ONE HUNDRED YEARS OF SERVICE"
3015 Dumbarton Road • Richmond, Virginia 23228
PHONE (804)264-2701 • FAX (804)264-7862

Record No: B60-0723 March 8, 2002

REPORT OF LABORATORY QUALITY TESTS ON STONE MATERIALS

Made for: Luck Stone
P O Box 29682
Richmond, Virginia 23242-0682

Attention: Mr. John P. Hellyer

Sample: # 22502

Constant Head Permeability Test (ASTM D 2434)

	22502
Dry Density (pcf)	102.1
Average Permeability over 3 tests (cm/sec)	3.4×10^{-4}

Our services were limited to performing laboratory testing. These laboratory test results should be interpreted and applied using good judgement and discretion. Froehling & Robertson, Inc., appreciates the opportunity of working with you on this project. If you have questions regarding this report or if we can be of further service to you, please feel free to contact the undersigned.

Respectfully Submitted
Froehling & Robertson, Inc.

Frederick S. Proper
Geotechnical Engineering Staff

C:\My Documents\LaboratoryTesting\LaboratoryTesting\b60-0723LuckStone2434#3

Froehling & Robertson, Inc.

PERMEABILITY TEST

ASTM 5084 A

CLIENT: LuckStone
PROJECT: Laboratory Testing - Lee Tennis, Har Tru, Hydroblend
LOCATION: Richmond, Virginia
F&R NO: D60-0241T

Date: June 19, 2002

BORING: N/A SAMPLE: Seg DEPTH: N/A DESCRIPTION: 3" # 10 Screenings, 1" Hydroblend
SAMPLE PREPARATION METHO Remold Screenings @ 90% MDD Specific Gravity: 2.88 (Client Data)

INITIAL SAMPLE DATA	
HEIGHT (in.)	4.00
DIAMETER (in.)	2.85
AREA (in^2)	6.38
VOLUME (in^3)	25.52
WEIGHT (g)	840.50
MOISTURE CONTENT (%)	6.90
DRY DENSITY (pcf)	117.38

CHAMBER PRESSURE (psi)	77.0
INFLUENT PRESSURE (psi)	75.5
EFFLUENT PRESSURE (psi)	75.2
MAX. EFFECTIVE STRESS	1.8
MIN. EFFECTIVE STRESS	1.5
HEAD ACROSS SAMPLE (psi)	0.3
FINAL SATURATION (%)	53.9
INITIAL SATURATION (%)	37.2
B PARAMETER	0.85

FINAL SAMPLE DATA	
HEIGHT (in.)	4.00
DIAMETER (in.)	2.85
AREA (in^2)	6.38
VOLUME (in^3)	25.52
WEIGHT (g)	865.20
MOISTURE CONTENT (%)	10.00
DRY DENSITY (pcf)	[illegible]

Document 1 Page 2

DATE	TIME	t (sec)	h_1 (in.)	v_1 (cm^3)	h_2 (in.)	v_2 (cm^3)	delta v_1	delta v_2	i	Q (cm^3/sec)	k (cm/sec)
6/19/2002	9:10 AM		17.835	1.3	4.92	7.6			5.3055		
		5	16.195	2.1	6.355	6.9	0.8	0.7	4.5367	1.50E-01	8.03E-04
		10	13.735	3.3	8.815	5.7	1.2	1.2	3.3067	1.20E-01	8.82E-04
		10	10.865	4.7	11.48	4.4	1.4	1.3	1.9230	1.35E-01	1.71E-03
		10	8.61	5.8	13.735	3.3	1.1	1.1	0.7955	1.10E-01	3.36E-03

TECHNICIAN: FSP

Average k (cm/sec): 1.69E-03

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"OVER ONE HUNDRED YEARS OF SERVICE"
22923 Quicksilver Drive, Suite 117
Sterling, Virginia 20166
Telephone: 703-996-0123 Fax: 703-996-0124

April 3, 2006

Mr. Niza Simunyola
10513 Belmont Road
Lorton, Virginia 22079

Phone: (703) 339-4073
Fax: (703) 339-4078

Subject: **Permeability Test Results**
Luck Stone Quarry at 15717 Lee Highway, Centreville, VA
Gravel Passing #10 Sieve
F&R Project No. G72-159T

Dear Mr. Simunyola,

Froehling & Robertson, Inc. (F&R) performed a constant head permeability test on the Passing #10 gravel sample that you supplied from the Luck Stone Quarry in Centreville, Virginia. Based upon the results of the testing, the average permeability rate is 2.74E-03 cm/s or equivalently 3.88 in/hr. The test results are attached for your review.

Should you have any questions, please feel free to contact me at (703)-996-0123.

Sincerely,

Froehling & Robertson, Inc

COMMONWEALTH OF VIRGINIA
PAUL D. AGUTTER
No. 038105
4/28/06
PROFESSIONAL ENGINEER

Paul D, Agutter, P.E.
Geotechnical Manager

Attachment(s): Permeability Test Results (2 pages)

Froehling & Robertson, Inc.

Document 2 Page 2

PERMEABILITY TEST

ASTM D 2434

CLIENT: Luck Stone Quarry
PROJECT: Permeability Testing
LOCATION: Centreville, VA
F&R NO: G72-159T

DATE: March 31, 2006

SAMPLE: Passing #10 Gravel
SAMPLE PREPARATION METHOD: Remolded

INITIAL SAMPLE DATA	
HEIGHT (cm.)	15.24
DIAMETER (cm.)	11.38
AREA (cm2)	101.69
VOLUME (cm3)	1549.83
WEIGHT (lb)	6.74
MOISTURE CONTENT (%)	3.60
DRY DENSITY (pcf)	118.86

FINAL SAMPLE DATA	
HEIGHT (in.)	15.24
DIAMETER (in.)	11.38
AREA (in2)	101.71
VOLUME (in3)	1550.10
WEIGHT (g)	7.39
MOISTURE CONTENT (%)	13.50
DRY DENSITY (pcf)	118.93

Test No.	Manometers H1	H2	Head h (cm)	Q (cm3)	t (sec)	Q/At	h/L	Temp (F)	k (cm/s)
1	87.6	10.9	76.7	44.0	23.0	0.019	6.71	70	2.80E-03
2	87.6	10.9	76.7	42.5	23.0	0.018	6.71	70	2.71E-03
3	87.6	10.9	76.7	42.5	23.0	0.018	6.71	70	2.71E-03
4	88.3	11.2	77.1	38.5	20.0	0.019	6.75	70	2.81E-03
5	88.3	11.1	77.2	37.0	20.0	0.018	6.75	70	2.69E-03
6	88.3	11.1	77.2	37.5	20.0	0.018	6.75	70	2.73E-03
7	90.7	11.2	79.5	29.0	15.0	0.019	6.96	70	2.73E-03
8	90.8	11.2	79.6	28.5	15.0	0.019	6.96	70	2.68E-03
9	90.8	11.2	79.6	29.5	15.0	0.019	6.96	70	2.78E-03

Average k (cm/sec):	2.74E-03

= 3.88 in/hr

COMMONWEALTH OF VIRGINIA
PAUL D. AGUTTER
No. 038105
4/28/06
PROFESSIONAL ENGINEER

STS CONSULTANTS

STS Consultants, Ltd.
750 Corporate Woods Parkway
Vernon Hills, Illinois 60061-3153
voice 847-279-2500
fax 847-279-2510
web www.stsconsultants.com

June 23, 2003

Mr. John Welborn
Lee Tennis Products
2975 Ivy Road
Charlottesville, Virginia 22903

Re: Field and Laboratory Testing Services for the HAR-TRU Court System at the Highland Park Country Club, Highland Park, Illinois - STS Project No. 1-20850-A

Dear Mr. Welborn:

This letter summarizes the completed field and laboratory test results as outlined in our May 21, 2003 proposal. Additional permeability tests were conducted on native clay turf soils as suggested.

BACKGROUND INFORMATION

Testing at the Highland Park tennis courts was conducted to allow a comparison of the storm water run-off characteristics between seven tennis courts (over one acre in fenced area) and the adjacent golf course terrain and turf soils and a nearby parking lot. The purpose of the testing was to compare the storm water run-off potential from these different land use activities. All seven tennis courts have a HAR-TRU playing surface which is generally comprised of one to two inches of a green silty sand topping processed from rock material overlaying a 12 to 18-inch base course classified as a silty sand and gravel probably supplied from a local quarry. HAR-TRU court systems are routinely irrigated in low amounts to control dust and stabilize the playing surface by capillary action. Sometimes HAR-TRU courts are referred to as clay courts but there is really no clay involved on the playing surface as both the amount of available playing time and playing surface performance is vastly improved with the granular sand surface.

FIELD SAMPLE COLLECTION AND TESTING

STS first visited the courts on May 4, 2003. At that time we observed two dug holes on the western-most court which were apparently dug by others to examine the character of the base course and topping material. Holes of the type observed are routinely used to conduct infiltration tests or percolation tests but they were only dug about one foot deep and only partially through the base course. The following day, on May 5, 2003, STS conducted a simulated infiltration test in one of the holes following a constant head procedure in which the water level in the hole was maintained through water addition during a 41-minute test. Before the test was started the hole was cleaned and observed to be unsaturated. Overall the hole had an elliptical shape: 12 inches by 18 inches wide at the top and 12 inches deep with a 6-inch diameter at the bottom. The upper one-inch was the HAR-TRU court playing surface while the lower 11 inches were the stone base course.

The infiltration test was conducted by adding about 4-gallons of water initially to fill the hole and an additional 3.5-gallons maintaining 10-inch head over the test period. Based on the constant head condition, the dimensions of the hole and flow rates measured, we computed the permeability of the base course material to be approximately 2×10^{-3} centimeters per second (cm/sec) or about 2 to 3-inches per hour. Based on the duration of the test a saturated radius at the base of the hole on the order of 2-feet from the center of the hole was achieved with almost 8-gallons of water. Following the test, representative samples of both the topping material and the base course were collected and delivered to our laboratory for further testing.

On May 28, 2003, STS collected representative clay turf samples at various locations near the courts. The sampling locations are depicted on the attached aerial photograph. Samples were recovered in thin-walled Shelby tubes driven with a sledge hammer. Samples were returned to our laboratory and extruded for additional testing.

LABORATORY TESTS AND RESULTS

The native clay turf samples, HAR-TRU surface sample and base coarse sample were all tested for permeability in accordance with the American Society for Testing and Materials (ASTM) D5084 or ASTM D2434. The sample index testing included water content and dry unit weight for each of the samples. The bulk samples were recompacted to approximately 90% of the maximum Modified proctor energy levels to represent a very compacted condition normally encountered on the courts. Each of the soil samples were also tested for particle size distribution in accordance with ASTM D422. Atterberg limit tests were conducted on the clay samples in accordance with ASTM D4318. All test results are attached for reference.

The average permeability for the three native clay turf samples collected near the courts ranged from 1 to 8×10^{-7} cm/sec and averaged 4×10^{-7} centimeters per second. These samples had clay contents ranging from 24 to 46% and plastic indices ranging from 12 to 20. Each of the soils is classified as a silty clay with a trace of organic in a 3 to 6-inch thick topsoil horizon.

For the HAR-TRU topping and base course material, the permeability test results were 1×10^{-5} cm/sec and 9×10^{-5} cm/sec, respectively. The topping material was classified as a silty sand having 29% fines passing the No. 200 sieve while the base course was classified as a silty sand and gravel having 22% fines passing the No. 200 sieve.

From the test results, the total porosity of the native clay turf, HAR-TRU topping and base course were determined. The porosities were 37%, 25% and 40%, respectively.

Based on the above test results, it appears the permeability of the base course is approximately nine times greater than the HAR-TRU surface topping. This situation provides a well-drained condition of the surface to maximize available playing time after heavy precipitation. It is also notable that the permeability for the HAR-TRU topping surface and base course are approximately 25 times and 225 times the average permeability of the natural clay turf near the courts.

CONCLUSIONS

Based on our field observations and review of the HAR-TRU court system material properties and laboratory test results, we conclude the following points.

- HAR-TRU courts are not built with clay-like soils but silty sand playing/wearing surfaces underlain by a sand and gravel base coarse. The base course provides a suitable drainage blanket below the playing surface and the courts are routinely irrigated depending on the level of maintenance to improve the playing surface quality.

- HAR-TRU courts are more permeable/pervious than the local native clay soils which are classified as a silty clay under the Unified Soil Classification System (USCS). The silty sand playing/wearing surface and base course as tested by ASTM D5084 and D2434 was 25 times and 225 times more permeable respectively than the average local native clay turf which contains about 24 to 46% clay as measured by ASTM D422.

- The porosity/water storage of the HAR-TRU system playing/wearing surface and base coarse was also equivalent or better than the native clay soils and far better than the asphalt pavement (estimated to be 7% air voids usually) located near by. The permeability of the pavement is probably even less permeable than the native clay soils except maybe where the pavement surface is in poor condition.

- The HAR-TRU courts are likely to have superior storm water storage performance over natural clay turf soils allowing infiltration on the order of 0.01 to 0.1 inches per hour and storing up to 2 to 4-inches of water. Although the water storage properties of the natural clay turf and HAR-TRU system are similar, the infiltration properties are much lower for the natural clay turf probably providing less water storage during most precipitation events. Based on these measured conditions, runoff coefficients for Rational Method analysis in various slope configurations may be somewhat similar for a well-vegetated natural clay turf and an unvegetated flat silty sand surface. On the other hand, runoff coefficients for pavement conditions would probably be 3 to 4 times higher. For hydrological computations involving Soil Conservation Service (SCS) Curve Number (CN) selection, it is probably reasonable to consider this material to be equivalent to be between a Soil Type B and C – moderately to moderately well drained silty sand while the natural clay turf would be classified as a Soil Type D - having a low permeability clay near the surface. Based on the above soil types, CN values for pavement, turf and tennis court conditions would probably range from +90 for pavements, 70 to 80 for clay turf and 60 to 80 for tennis courts, respectively.

The above conclusions demonstrate the differences between the HAR-TRU court system and the adjacent native clay, turf and parking lot. The test results also demonstrate that the HAR-TRU courts both absorb and store storm water more effectively.

If you have any questions about our findings and conclusions, please contact us at your convenience.

Yours very truly,

STS CONSULTANTS, LTD.

Eric L. Reuscher
Assistant Project Scientist

Douglas J. Hermann, P.E.
Vice President

William J. Weaver, P.E.
Vice President

cc: Berle Schwartz
1910 First Avenue
Highland Park, Illinois 60035

Sheldon Westervelt
7374 Kahana Drive
Boynton Beach, Florida 33437

STS Consultants, Ltd.
Laboratory Services Group 750 Corporate Woods Parkway Vernon Hills, Illinois 60061 (847)279-2500 fax(847)279-2550

HYDRAULIC CONDUCTIVITY DETERMINATION
ASTM D 5084, Method C (EM-1110-2-1906 7)
Rising tailwater method in a triaxial permeameter

STS PROJECT NO.: 20850-A

PROJECT: Highland Park Tennis Courts

DATE: 6/13/2003

SUMMARY OF TEST RESULTS

SAMPLE NO. ST-2

SAMPLE PREPARATION 2 in ST, Trimmed Ends

CLASSIFICATION Silty Clay and Fine to Coarse Sand trace Topsoil, Roots - black and brown CL

	INITIAL	FINAL
DRY UNIT WEIGHT (pcf)	109.6	110.6
WATER CONTENT (%)	18.3	19.9
DIAMETER (cm)	4.712	4.703
LENGTH (cm)	7.911	7.869

HYDRAULIC GRADIENT (MAXIMUM) 20.7

PERCENT SATURATION 100.7 (Percent saturation calculation is based on final measurements and an estimated specific gravity.)

HYDRAULIC CONDUCTIVITY k (cm/sec) **8.10E-07**

STS Consultants, Ltd.
Laboratory Services Group 750 Corporate Woods Parkway Vernon Hills, Illinois 60061 (847)279-2500 fax(847)279-2550

HYDRAULIC CONDUCTIVITY DETERMINATION
ASTM D 5084, Method C (EM-1110-2-1906 7)
Rising tailwater method in a triaxial permeameter

STS PROJECT NO.: 20850-A

PROJECT: Highland Park Tennis Courts

DATE: 6/23/2003

SUMMARY OF TEST RESULTS

SAMPLE NO. ST-3

SAMPLE PREPARATION 2 in ST, Trimmed Ends

CLASSIFICATION Silty Clay little Fine to Coarse Sand trace Topsoil, Roots - dark gray and brown CL

	INITIAL	FINAL
DRY UNIT WEIGHT (pcf)	106.9	108.6
WATER CONTENT (%)	20.2	21.3
DIAMETER (cm)	4.749	4.723
LENGTH (cm)	8.020	7.985

HYDRAULIC GRADIENT (MAXIMUM) 20.4

PERCENT SATURATION 102.2 (Percent saturation calculation is based on final measurements and an estimated specific gravity.)

HYDRAULIC CONDUCTIVITY k (cm/sec) **1.20E-07**

STS Consultants, Ltd.
Laboratory Services Group 750 Corporate Woods Parkway Vernon Hills, Illinois 60061 (847)279-2500 fax(847)279-2550

HYDRAULIC CONDUCTIVITY DETERMINATION
ASTM D 5084, Method C (EM-1110-2-1906 7)
Rising tailwater method in a triaxial permeameter

STS PROJECT NO.: 20850-A

PROJECT: Highland Park Tennis Courts

DATE: 6/16/2003

SUMMARY OF TEST RESULTS

SAMPLE NO. HAR-TRU Green Sand

SAMPLE PREPARATION Remolded to Approx. 90% Mod Proctor Value @ as received

CLASSIFICATION Silty Fine to Coarse Sand little Clay - grayish green SM

	INITIAL	FINAL
DRY UNIT WEIGHT (pcf)	132.4	133.5
WATER CONTENT (%)	10.4	10.4
DIAMETER (cm)	7.135	7.126
LENGTH (cm)	4.785	4.756

HYDRAULIC GRADIENT (MAXIMUM)	19.7	
PERCENT SATURATION	102.2	(Percent saturation calculation is based on final measurements and an estimated specific gravity.)
HYDRAULIC CONDUCTIVITY k (cm/sec)	1.21E-05	

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PERMEABILITY OF GRANULAR SOILS
Constant Head method in rigid wall permeameter
ASTM D 2434

STS PROJECT NO.: 20850-A

PROJECT: Highland Park Tennis Courts

DATE: 6/16/2003

SUMMARY OF TEST RESULTS

SAMPLE NO. Field Base Coarse

SAMPLE PREPARATION Tamped

CLASSIFICATION Silty Fine to Coarse Sand some Fine to Coarse gravel trace clay - greenish gray SM

	INITIAL
DRY UNIT WEIGHT (pcf)	103.5
WATER CONTENT (%)	0.8
DIAMETER (cm)	5.08
LENGTH (cm)	12.00
HYDRAULIC GRADIENT	0.8
HEAD HEIGHT (cm)	10.00
VOID RATIO	0.673
HYDRAULIC CONDUCTIVITY k (cm/sec)	**9.03E-05**