Thomas Turf Services
SOIL ANALYSIS AND TURF MANAGEMENT

ACCREDITED
Testing Certificate Number: 0743.01

February 15, 2016

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Mr. Hagy:

The 3/8" Gravel was subjected to the standard ASTM C-136 testing procedure used to determine acceptable materials for golf course construction. The results were compared to the *USGA Recommendations for a Method of Putting Green Construction* (2004).

Gravel Recommendations

Selection of Gravel For USGA 2-Layer System of Construction:

> The USGA criteria are based on engineering principles which rely on the largest 15% of the sand particles "bridging" with the smallest 15% of the gravel particles. Smaller voids are produced, and they prevent migration of sand particles into the gravel yet maintain adequate permeability. The $D_{85(sand)}$ is defined as the particle diameter below which 85% of the sand particles (by weight) are smaller. The $D_{15\ (gravel)}$ is defined as the particle diameter below which 15% of the gravel particles (by weight) are smaller.
>
> For bridging to occur, the $D_{15\ (gravel)}$ must be less than or equal to eight times the $D_{85\ (sand)}$.
>
> To maintain adequate permeability across the sand/gravel interface, the $D_{15\ (gravel)}$ shall be greater than or equal to five times the $D_{15\ (sand)}$.

Furthermore, any gravel selected shall have 100% passing a 1/2" (12 mm) sieve and not more than 10% passing a No. 10 (2 mm) sieve, including not more than 5% passing a No. 18 (1 mm) sieve.

Discussion of Lab Results

The results of the tests performed on the 3/8" Gravel sample proposed for use in bunker construction at the Tribute Golf Course are summarized in the enclosed tables. The results of the quality control sample run simultaneously with this sample indicate the data are accurate.

The 3/8" Gravel was checked for compatibility with the #55 Bunker Sand and #32 Bunker Sand previously tested and reported as Lab ID: G9750 on 22-Dec-15. For ease in comparison, the Particle Size Analysis Report is included with this report.

3/8" Gravel

The 3/8" Gravel was free of particles greater than 12.5 mm in size. The gravel contained 2.6% of the particles in the 9.5-12.5 mm range, 24.7% in the 6.3-9.5 mm range, 46.3% in the 4.0-6.3 mm range and 24.5% in the 2.0-4.0 mm range. The gravel contained an acceptable total of 1.9% of the particles in the less than 2.0 mm ranges which is within the recommended maximum of 10%. Based on these results, the 3/8" Gravel does meet the USGA's particle size recommendations for use in the 2-layer system of construction.

The 3/8" Gravel had an acceptable coefficient of uniformity of 2.9 which is within the recommended maximum of 3.0. This indicates the gravel has a narrow spread in particle sizes which is ideal.

3/8" Gravel / #55 Bunker Sand - Compatibility

To determine if the 3/8" Gravel and the #55 Bunker Sand could be used in the 2-layer system of construction, the bridging and permeability factors were calculated and are shown in the enclosed compatibility table.. The gravel and bunker sand combination had an acceptable bridging factor of 3.5 which is within the recommended maximum of 8.0. This indicates the bunker sand will not migrate into the gravel. The gravel and bunker sand combination had an acceptable permeability factor of 12.4 which indicates the gravel can transmit the needed amount of water to the drains.

3/8" Gravel / #32 Bunker Sand - Compatibility

To determine if the 3/8" Gravel and the #32 Bunker Sand could be used in the 2-layer system of construction, the bridging and permeability factors were calculated and are shown in the enclosed compatibility table. The gravel and bunker sand combination had an acceptable bridging factor of 3.6 which is within the recommended maximum of 8.0. This indicates the bunker sand will not migrate into the gravel. The gravel and bunker sand combination had an acceptable permeability factor of 14.1 which indicates the gravel can transmit the needed amount of water to the drains.

Summary

The 3/8" Gravel did meet the USGA's gravel size recommendations for use in the 2-layer system of construction. The 3/8" Gravel had an acceptable coefficient of uniformity which indicates a narrow spread in particle sizes.

The 3/8" Gravel had acceptable bridging and permeability factors with the #55 Bunker Sand sample.

The 3/8" Gravel also had acceptable bridging and permeability factors with #32 Bunker Sand sample.

Based on the above results, the 3/8" Gravel is acceptable for use below either the #55 Bunker Sand or #32 Bunker Sand in the 2-layer system of construction and these materials should work well together in the Better Billy Bunker construction method at the Tribute Golf Course.

If you have any questions concerning these recommendations or are in need of further assistance, please feel free to phone me directly at 979-575-5107. You may also send E-Mail to: <soiltest@thomasturf.com>. Thank you for using Thomas Turf Services, Inc.

Sincerely,

James C. Thomas, C.P.Ag.
Pres., Thomas Turf Services

JCT:rgy

Enclosures: Tables (3)
Invoice

File: 98568, G9796

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Soil Analysis & Turf Management
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Testing Certificate Number: 0743.01
Geotechnical Putting Green Materials

Texas Sport Sands	Facility: Tribute Golf Course
Paul Hagy	Account No.: 98568
1919 South Shiloh, Suite 312-LB2	Lab ID: G9796
Garland, TX 75042	Date Rec'd: 11-Feb-16
Phone: 972-278-1585 Cell: 469-450-3257	Test Date: 12-Feb-16
E-mail: plhagy@yahoo.com	Report Date: 15-Feb-16

Gravel Distribution Report - ASTM Test Method C136-01

Diameter	>12.5 mm	9.5 - 12.5 mm	6.3 - 9.5 mm	4.0 - 6.3 mm	2.0 - 4.0 mm	1.0 - 2.0 mm	<1.0 mm
U.S. Sieve	1/2 inch	3/8 inch	1/4 inch	No. 5	No. 10	No. 18	< No. 18
Units	Percent Retained on Sieve						
2004 USGA Recommendations*	0					< 10**	
Sample ID							
3/8" Gravel	0.0	2.6	24.7	46.3	24.5	1.1	0.8

*** For use in the 2-layer system**
****<10% passing 2 mm including <5% passing 1 mm**

Reviewed by: _____
James C. Thomas, C.P.Ag.
Pres., Thomas Turf Services, Inc.

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Gravel / Rootzone - Compatibility Report*

	D_{15}		D_{85}	D_{90}	Coefficient of Uniformity	Bridging Factor	Permeability Factor
	Gravel	RZ	RZ	Gravel	D 90g/D 15g	D15g/D85 rz	D15g/D15 rz
2004 USGA Recommendations					**≤3**	**≤8**	**≥5**
Sample ID							
3/8" Gravel	2.88			8.44	2.9		
#55 Bunker Sand (G9750, 12/22/15)		0.23	0.82			3.5	12.4
3/8" Gravel	2.88			8.44	2.9		
#32 Bunker Sand (G9750, 12/22/15)		0.20	0.79			3.6	14.1

* Based on test data from ASTM Methods F1632 and C136-01

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Facility: Tribute Golf Course
Account No.: 98568
Lab ID: G9796
Date Rec'd: 11-Feb-16
Test Dates: As Noted
Report Date: 14-Feb-16

Particle Size Analysis Report - ASTM F1632 - Method A

	Textural Analysis				Particle Size Distribution					
	Sand	**Silt**	**Clay**	**Gravel**	**Very Coarse**	**Coarse**	**Medium**	**Med-Fine**	**Fine**	**Very Fine**
Particle Diameter (mm)	**.05 - 2.0**	**.002 to .05**	**<.002**	**>2.00**	**1.0-2.0**	**0.50-1.0**	**0.25-0.50**	**0.15-0.25**	**0.10-0.15**	**< .10**
U.S. Sieve (mesh)				**10**	**18**	**35**	**60**	**100**	**140**	**< 140**
Units	%	%	%	%	**Values Represent Percent Retained on Sieve**					
Bunker Recommendation (%)	**94 - 100**	**3 Max**		**3 Max**	**15 Max**	**65 Minimum**		**25 Maximum**		
Sample ID										
#55 Bunker Sand	98.6	1.0	0.3	0.1	2.9	42.8	37.2	12.7	1.6	1.4
Duplicate (G9750, 12/22/15)	98.5	1.3	0.1	0.1	3.5	42.1	37.5	13.1	1.9	0.4
#32 Bunker Sand	98.0	1.4	0.3	0.3	2.5	35.6	41.0	15.0	2.0	1.9
Duplicate (G9750, 12/22/15)	98.6	1.0	0.3	0.1	3.0	36.3	40.2	15.3	2.8	1.0

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