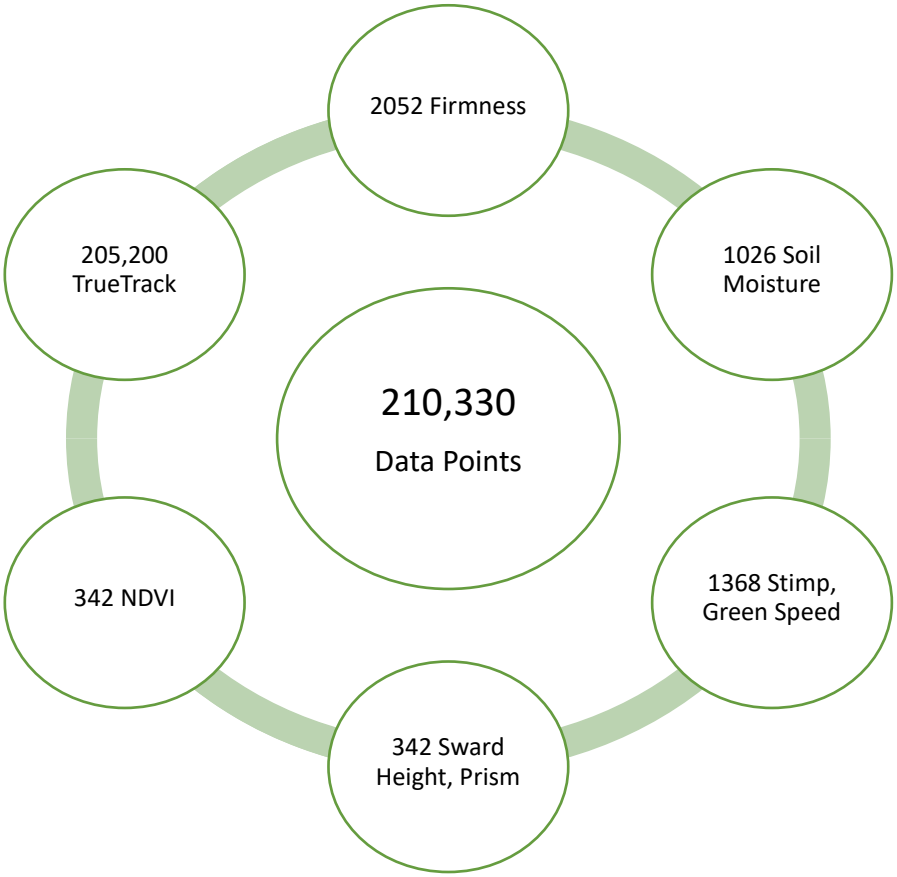
PROPITCH

JULY 2022

HILLSIDE GOLF CLUB

DP WORLD TOUR TOURNAMMENT

Contents



Executive Summary

In this report we summarise the programme of testing, and scoring for Hillside Golf Club greens pre, during and post play of the **DP World Tour Cazoo Classic** in July 2022**.** This included the practice day, Pro Am and all four competitive rounds of the tournament.

Over the 6 days we recorded over **210,000 data points** to support our analytics and used the ProPitch APP and portal to data log, and present trends.

The data, provides **objective evidence** of elite course performance with some of the most **sustainable practices** used by Link Course Manager Chris Ball and his greenkeeping team.

Within this report we will detail the following outcomes.

1. During a period of extreme temperatures and no rainfall, an elite golf course can still be delivered with low water consumption and sustainable nutritional inputs, proven by objective testing data. The greens performed consistently well throughout the tournament even when under climatic stress, as this has been one of the most challenging dry periods leading up to a tournament.

2. Electric mowers can still deliver the quality and consistency required for elite greens proven by objective testing data.

3. Morning preparation: Maintenance plans tailored green to green based on live testing. With more on-site objective data, localised maintenance could be identified to stop a 'one-size-fits-all' approach, unnecessary maintenance, irrigation, and thus encourage more sustainable practices.

4. Evening post play maintenance: Objective testing was used to make better informed decisions on maintenance and recovery practices every day as well as tracking any changes in surface performance in response to the day's play.

5. Green performance should also consider consistency across all greens.

6. 'Live' Player reports can be produced in the morning before play. These are more specific to playing quality test methods that would support shot selection.

7. A new method 'TrueTrack' has supported in assessing ball roll characteristics, for vertical and horizontal deviation also referred to in industry as Trueness and Smoothness. This transparent, accurate and camera based technology allows ball roll performance to be measured with more accessible tools and software, tested during the stimp meter test of a free rolling golf ball.

8. Green speed and consistency of green speed on all greens has been recorded and can be accurately managed by the European Tour throughout the tournament, starting at the Putting Green every day.

9. Low moisture readings in the upper rootzone can be negated by deep rooted turf and adequate soil moisture at lower levels through the soil profile. This investigation was carried out when analyses the moisture readings throughout the tournament.

10. Extremely high firmness readings can be managed throughout the tournament and not have an adverse effect on plant health should the root have access to adequate moisture.

11. Firmness increases on high trafficked areas around the pins and then shown to relieve itself within 24hrs.

12. NDVI versus 'TrueTrack' (Brown / green) confirmed even when sacrificing aesthetics of the course, ball roll performance is still high.

This model of data collection can be used for tournament delivery and provide new, innovative, and transparent information for educated decision making, not only by the Course Manager but also by players and other stakeholders.

The vision and open nature of Hillside Golf Club is ground-breaking in allowing others to be well informed on benchmarking and sharing sensitive information. This will support golf clubs around the world embrace sustainability and manage courses with the challenging climatic conditions considered.

Introduction

ProPitch Ltd is an independent testing institute and consultancy practice for natural and hybrid sports surfaces. ProPitch agronomists harness the power of objective testing data to support decision making and recommendations. The key to this is using practices and equipment that are transparent, accurate and repeatable.

For the last 12 months ProPitch, Hillside Golf Club & Advance Grass Solutions have been preparing to undertake this research on the greens at Hillside golf club during the DP World tour Cazoo Classic tournament.

This research has been carried out in conjunction with BASIS [1](The British Association for Sustainable sport) as the cultivar practices, machinery, and application of fertilisers by Hillside Golf club has heavily considered its environmental footprint and drive towards more sustainable practices.

The objective of this project was to prove that using sustainable practices can still retain elite performing golf greens. Leading up to and during the tournament there was a period of high climatic stress and low rain fall.

Data was collected each tournament day after the maintenance team had carried out the preparation of the greens for the tournament and input to the DP World Tour assessment on the ProPitch System. This was used as knowledge to shape the next phase of maintenance practices during tournament delivery.

In addition to the greenkeeping team and test team, Eugene Hennessy from the European tour was on hand working in conjunction with the greens team.

Testing Team

The core testing team of six each day comprised of ProPitch Consultants and Advance Grass Solutions representatives so that all 18 greens could be covered before the first players started their round. Each team had an independent ProPitch Consultant.

- Ian Craig | ProPitch Consultant & Lead Agronomist
- Dean Tingley | ProPitch Consultant

[1] BASIS | The British Association for Sustainable Sport

- Andrew Culbert | ProPitch Consultant
- Kerr Lambert | ProPitch
- Niall MacPhee | ProPitch & Basis Technical Working Group Chair
- Matt Le Brun | Advance Grass Solutions & Basis Natural Working Group Lead
- Becky Hallsworth | Advance Grass Solutions
- Phil Logan | Advance Grass Solutions

Testing Schedule

Testing was carried out 3 months prior to the tournament and through out the tournament. This allows a full course passport for the season of testing results. During the tournament no surface compromising tests were carried out such as water infiltration, mass root depth or organic matter analysis due to the probability of leaving surface damage that would affect play and be visible. That being said during the tournament approval was provided by the European Tour and Chris Ball (Links Manager) to take a soil core from one green, where soil moisture and mass root depth were analysed.

Pre Tournament	Pre tournament & invasive testing

- 16/05/2022, 11/04/2022, 06/04/2022, 17/03/2022

Practice Round	Tuesday 19th July 2022

- TrueTrack
- Stimp meter testing

Pro Am	Wednesday 20th July 2022

- Full DP World Tour ProPitch Assessment

Round 1	Thursday 21st July 2022

- Full DP World Tour ProPitch Assessment
- Players Report

Round 2	Friday 22nd July 2022

- Full DP World Tour ProPitch Assessment
- Players Report

Round 3	Saturday 23rd July 2022

- Full DP World Tour ProPitch Assessment
- Players Report

Round 4	Sunday 24th July 2022

- Full DP World Tour ProPitch Assessment
- Players Report

Equipment & Tests

From the 3 months prior to the tournament and during the tournament the onsite tests and equipment are detailed below.

Test Equipment (Overview)

Test | TrueTrack

TrueTrack measures the vertical and horizontal ball movement on the green, what a player may experience during a putt. This is displayed as a % from the true horizontal and vertical line path.

Test | Firmness

The Clegg Impact Hammer measures surface firmness by obtaining a measurement of the peak deceleration of a free falling mass (0.5 kg hammer) from a set height. (G)

Test | Soil Moisture	Test | NDVI
	
Volumetric water content or moisture content is the quantity of water contained in the soil. (%)	The normalized difference vegetation index (NDVI) is a simple graphical indicator assessing whether or not the target being observed contains live green vegetation. (Index value)

Test | Green Speed	Test | Green Speed Consistency
	
The "**stimp**" or "stimp rating" of a putting green is a numerical value that represents how fast the golf ball rolls on the putting surface. Golfers call this rating the green speed. That value is based on a measurement taken with a simple instrument called a Stimpmeter (hence the terms stimp and stimp rating) (ft or m)	In addition to the green speed we assess the **consistency** across all greens. All 18 greens were tested each day. (%)

Test | Field Marshall	Test | Sward Height
 **FIELD MARSHALL**	
Energy Restitution, the returned energy after surface impact. (%) **Shock Absorption,** the surface hardness versus calibrated concrete. (%) **Vertical Deformation,** the deformation of the surface on impact. (mm) **GMax**, A GMAX test measures impact attenuation – the ability of the playing surface to absorb the "shock", or kinetic energy (g)	The sward height, measured with equipment called the Prism. (mm)

Test | Mass Root Depth & Thatch 'Organic' Layer	
	
The depth (mm) of the roots measured after a core sample has been removed. The organic matter is measured as well from the same core sample removed.	

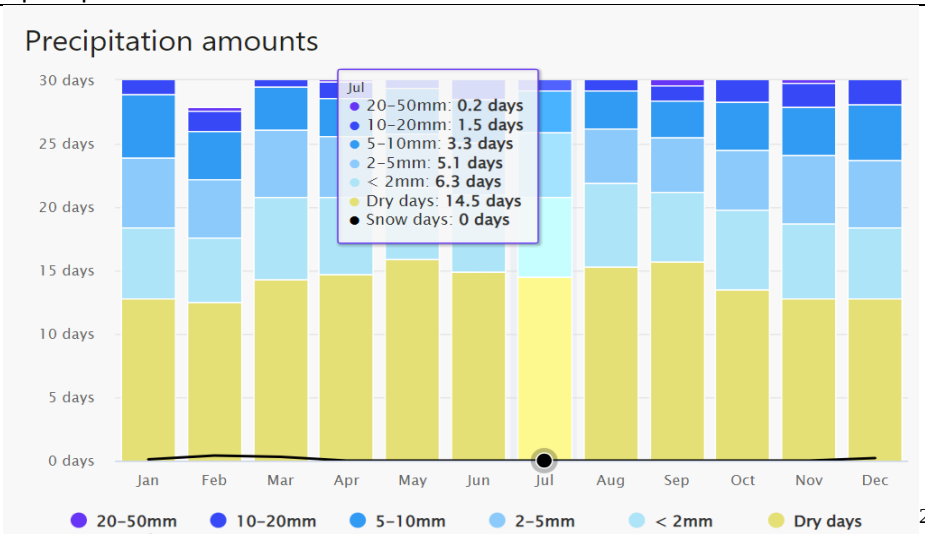
Test | Water Infiltration	Test | Botanical Assessment
	
Measuring the ability of the surface to vertically percolate the water through the profile. (mm/hr).	An assessment of the grass species composition present on the greens.

Weather Tracking

The weather conditions has a direct impact on the playing conditions and presented is the weather data pre and during the tournament.

- There was 12 precipitation days out of 31 for the month of July, of which 8 were less than 2mm. Usually there are 18 days of precipitation at Hillside Golf Club in July of which 11 are over 2mm.
- There was only 1mm of precipitation in the previous 20 days before round 1. This is an unprecedented low precipitation period.
- In addition the week leading up to the tournament the temperature peaked at 39°C representing some of the hottest temperatures experienced at Hillside Golf Course.

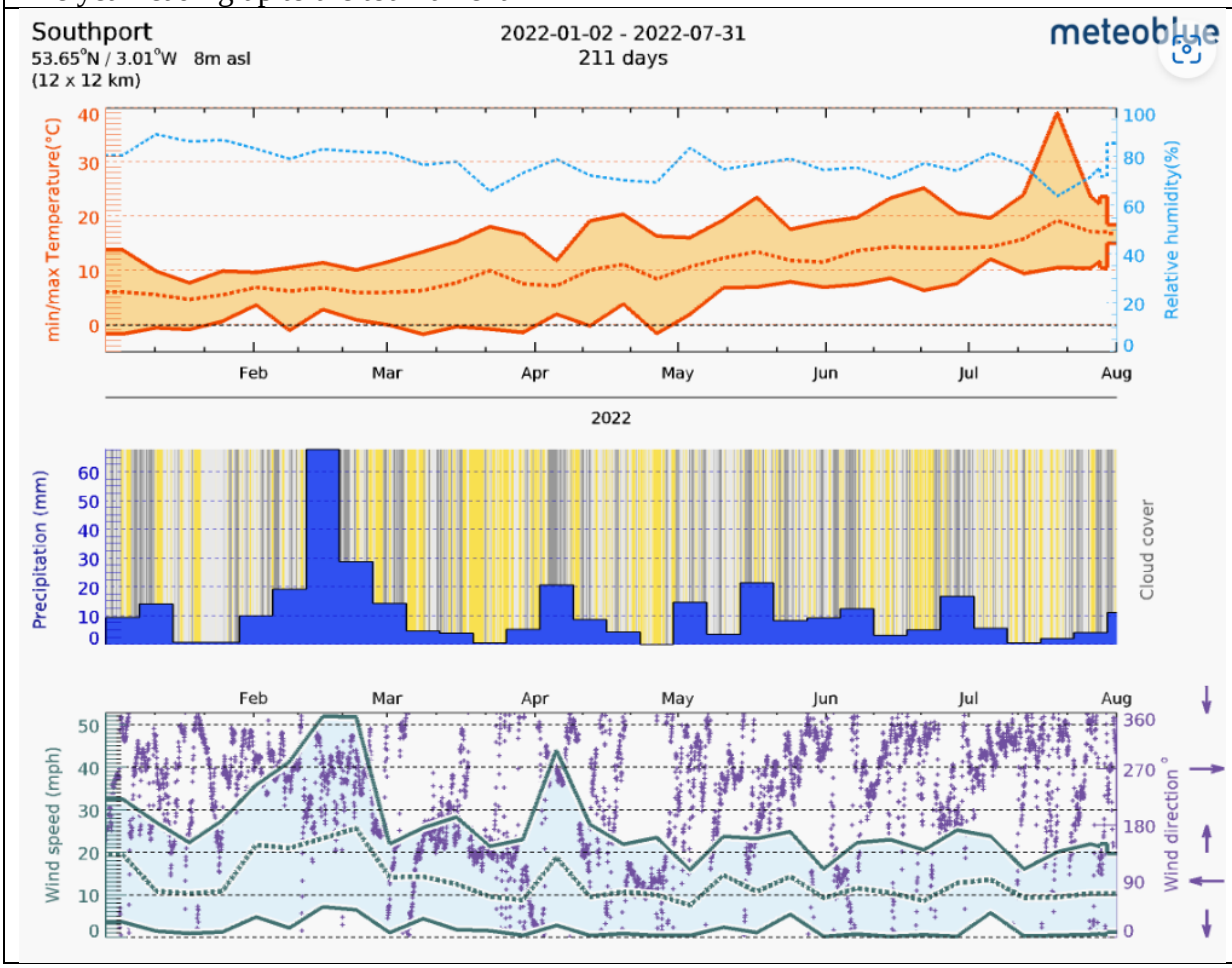
Average annual precipitation



[2]

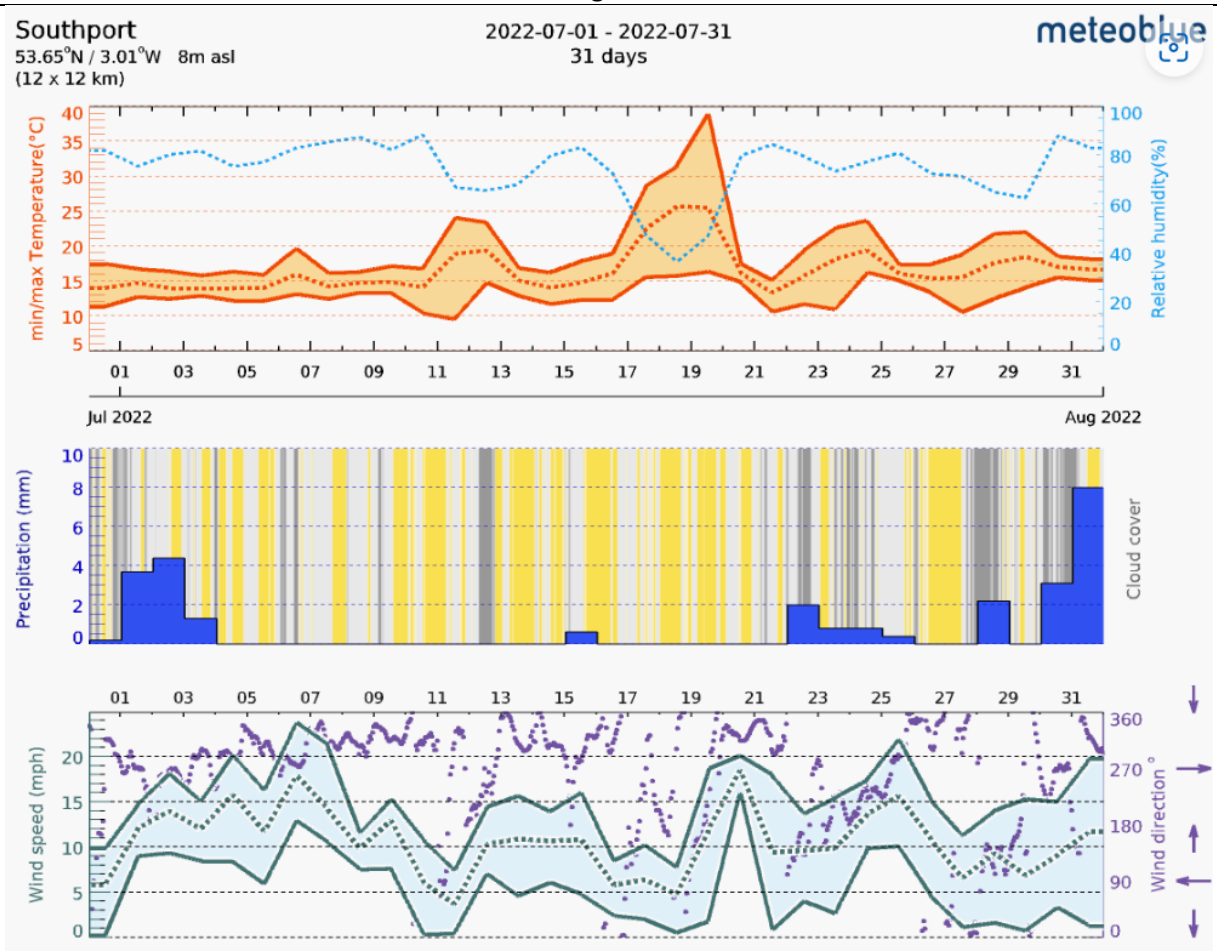
[2] https://www.meteoblue.com/en/weather/historyclimate/climatemodelled/southport_united-kingdom_2637343

The year leading up to the tournament



The climatic conditions were extreme and posed challenges in terms of tournament preparation and delivery where precipitation was very low with high ambient air temperatures. This is not a normal weather pattern but would demonstrate the potential future challenges posed for golf courses.

Weather in the month of the tournament and through the tournament.



Data collection

The data presented is a summary of all the points collected.

Green speed (ft) & consistency (%)

Stimp Speed / Consistency DP World Tour Hillside GC																			
Green	Morning 20.07.22 Pro AM			Morning 21.07.22 Round 1			Morning 22.07.22 Round 2			Before Round 3, Morning preparation			Before Round 4, Morning preparation		
	Avg (cm)	Ft	Variation from course average	Avg (cm)	Ft	Variation from course average	Avg (cm)	Ft	Variation from course average	Avg (cm)	Ft	Variation from course average	Avg (cm)	Ft	Variation from course average
Putting	306	**10' 0"**	-1.2	308	**10' 1"**	-0.7	316	**10' 4"**	-0.6	319	**10' 5"**	-0.2%	309	**10' 1"**	-4.1%
1	313	**10' 3"**	1.1	309	**10' 2"**	-0.4	328	**10' 9"**	3.3	336	**11' 0"**	5.3%	342	**11' 3"**	6.3%
2	314	**10' 4"**	1.4	295	**9' 8"**	-4.9	323	**10' 7"**	1.6	306	**10' 0"**	-4.1%	317	**10' 5"**	-1.4%
3	302	**9' 11"**	-2.5	314	**10' 4"**	1.3	314	**10' 4"**	-1.1	331	**10' 10"**	3.7%	323	**10' 7"**	0.4%
4	309	**10' 2"**	-0.2	319	**10' 6"**	2.9	339	**11' 1"**	6.8	346	**11' 4"**	8.4%	348	**11' 5"**	8.2%
5	292	**9' 7"**	-5.7	313	**10' 3"**	0.9	317	**10' 5"**	-0.3	333	**10' 11"**	4.3%	343	**11' 3"**	6.5%
6	279	**9' 2"**	-9.9	303	**9' 11"**	-2.3	308	**10' 1"**	-3.0	317	**10' 5"**	-0.9%	311	**10' 2"**	-3.5%
7	344	**11' 3"**	11.1	346	**11' 4"**	11.6	359	**11' 9"**	12.9	310	**10' 2"**	-2.9%	319	**10' 5"**	-1.0%
8	313	**10' 3"**	1.1	304	**9' 12"**	-2.0	317	**10' 5"**	-0.1	309	**10' 1"**	-3.4%	320	**10' 6"**	-0.7%
9	318	**10' 5"**	2.7	283	**9' 3"**	-8.7	302	**9' 11"**	-5.0	315	**10' 4"**	-1.5%	321	**10' 6"**	-0.3%
10	320	**10' 6"**	3.3	310	**10' 2"**	0.0	302	**9' 11"**	-4.9	299	**9' 10"**	-6.5%	326	**10' 8"**	1.4%
11	356	**11' 8"**	14.9	300	**9' 10"**	-3.3	313	**10' 3"**	-1.6	329	**10' 9"**	2.9%	318	**10' 5"**	-1.1%
12	288	**9' 5"**	-7.0	295	**9' 8"**	-4.9	315	**10' 4"**	-0.8	318	**10' 5"**	-0.4%	321	**10' 6"**	-0.3%
13	291	**9' 7"**	-6.0	310	**10' 2"**	0.0	305	**10' 0"**	-3.9	305	**10' 0"**	-4.5%	316	**10' 4"**	-1.9%
14	305	**10' 0"**	-1.5	318	**10' 5"**	2.5	310	**10' 2"**	-2.4	326	**10' 8"**	2.0%	302	**9' 11"**	-6.1%
15	294	**9' 8"**	-5.1	309	**10' 2"**	-0.4	293	**9' 7"**	-7.9	316	**10' 4"**	-1.0%	337	**11' 1"**	4.8%
16	315	**10' 4"**	1.7	316	**10' 4"**	1.9	317	**10' 5"**	-0.3	323	**10' 7"**	1.0%	314	**10' 4"**	-2.4%
17	316	**10' 4"**	2.0	312	**10' 3"**	0.6	313	**10' 3"**	-1.4	316	**10' 4"**	-1.2%	314	**10' 4"**	-2.4%
18	306	**10' 0"**	-1.2	328	**10' 9"**	5.8	345	**11' 4"**	8.7	316	**10' 4"**	-1.0%	314	**10' 3"**	-2.5%
AVG	310	**10' 2"**		310	**10' 2"**		317	10' 5"		319	10' 5"		322	10' 7"	

Green Firmness (G)

Locations highlighted in orange sit above the recommended maximum of 130 Gravities in previous studies.[5]

	Day	Putting Green	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average (g)
Firmness (g)	Pro AM	135	132	115	130	131	126	127	131	130	134	127	128	137	127	140	138	125	132	132	130
	R1	135	139	136	138	134	134	124	132	132	146	143	150	145	127	148	136	131	136	133	137
	R2	141	139	139	144	141	140	126	138	141	125	142	147	138	129	140	132	136	129	150	138
	R3	127	122	124	125	124	124	117	119	126	123	130	133	129	119	124	130	125	125	125	125
	R4	123	117	116	123	124	113	115	124	121	120	124	124	121	114	118	119	118	115	119	119
	Avg	132	130	126	132	131	128	122	129	130	130	133	136	134	123	134	131	127	128	132	130

Soil Moisture (% at 40mm), same area as Green Firmness

	Day	Putting Green	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average (%)
Moisture (%)	Pro AM	9.7	13.8	13.8	9.4	13.4	15.2	16.6	20.1	10.4	12.2	17.7	13.0	12.0	15.3	9.7	10.9	13.0	12.7	11.7	13.4
	R1	9.0	12.4	14.2	8.1	12.1	14.0	16.7	16.9	12.6	7.1	12.8	10.1	9.1	13.6	7.6	7.8	6.8	8.9	9.1	11.1
	R2	9.0	9.6	11.3	8.3	12.6	12.7	15.5	15.7	9.7	11.7	12.7	9.9	12.0	11.7	9.3	7.8	9.4	8.9	6.0	10.8
	R3	15.8	15.6	16.3	17.3	15.9	15.6	18.0	19.2	20.0	14.8	18.1	13.2	15.5	21.6	15.3	14.9	12.9	12.9	12.1	16.1
	R4	21.5	22.1	22.7	16.8	19.5	23.7	23.5	24.3	19.2	23.2	23.3	21.0	22.1	22.2	19.0	22.8	18.0	19.9	19.6	21.3
	Avg	13.0	14.7	15.7	12.0	14.7	16.2	18.1	19.2	14.4	13.8	16.9	13.5	14.1	16.9	12.2	12.8	12.0	12.7	11.7	14.5

[5] FIRMNESS FIRST, Richard Windows & Henry Bechelet, With a little help from Dr Christian Spring & Jay Dobson

Approach Firmness (G)

Locations highlighted in orange sit above the recommended maximum of 130 Gravities.

	Day	Putting Green	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Average (g)
Approach Firmness (g)	Pro AM	-	142	133	155	147	167	123	136	148	140	136	122	147	151	152	152	144	136	137	143
	R1	-	146	119	136	151	159	116	146	145	165	149	133	140	147	148	164	153	147	143	145
	R2	-	153	128	158	154	172	124	140	164	146	142	133	138	152	154	165	150	142	141	148
	R3	-	129	121	131	135	137	115	133	133	135	134	126	127	133	134	135	129	127	133	131
	R4	-	120	113	128	137	130	115	128	127	125	132	121	120	131	134	132	126	125	128	126
	Avg		138	123	142	145	153	119	137	143	142	139	127	134	143	144	150	141	135	136	138

Botanical Composition

During the course of the testing, all stimp and TrueTrack readings were measured in the same locations on each green, while consciously avoiding the impact of ball tracking where it follows the same path created by the previous ball. We estimated the sward species composition of these locations and assigned a score to each based on the perceived 'desirability' of the grass species. The scores were calculated based on the estimated proportions of each within the locations and an average score was assigned. As Fescue is the 'most desirable' species, a 100% Fescue sward would be awarded a score of 5. Our findings are summarised in the table below.

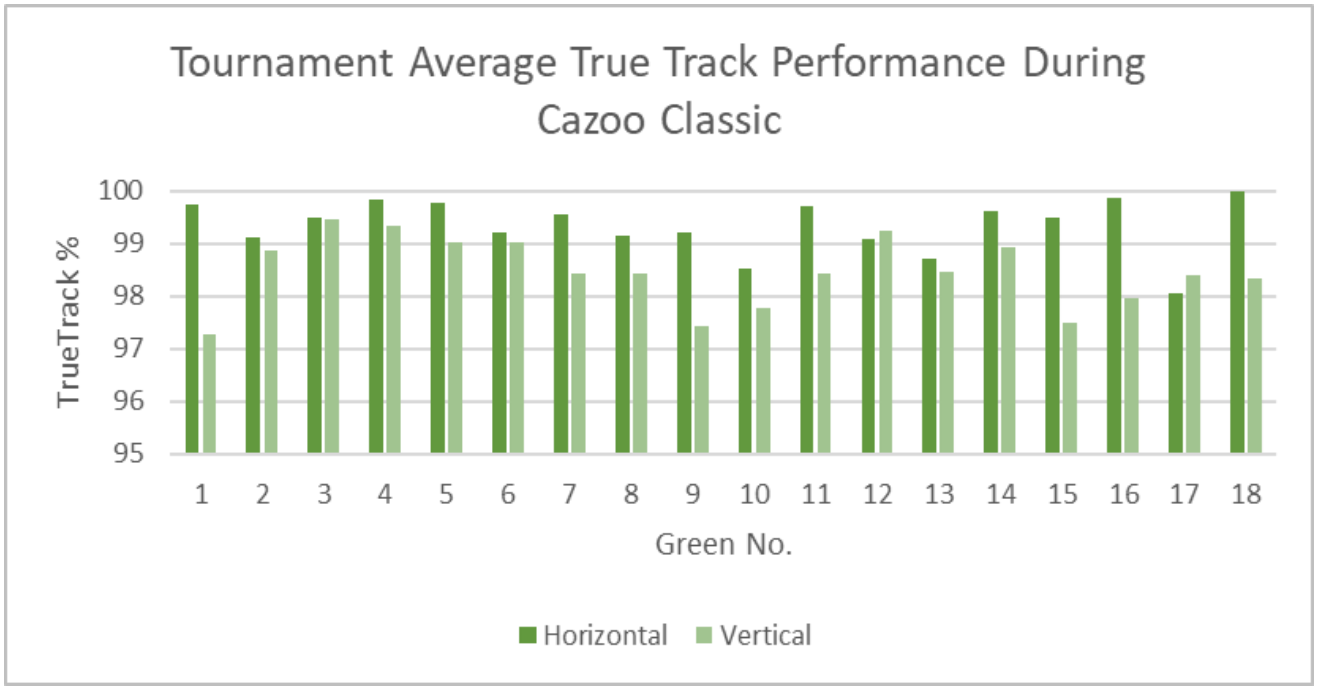
		Green no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Grass Species	Score																			
Fescue	5	%	10	10	20	15	10	50	10	0	20	0	10	5	20	20	10	20	5	30
Bentgrass	4		45	60	40	60	70	40	40	60	45	50	45	60	70	60	40	30	70	30
Meadowgrass	2		45	30	40	25	20	5	50	40	25	50	45	35	10	15	25	50	25	40
Yorkshire Fog	1		0	0	0	0	0	5	0	0	10	0	0	0	0	5	25	0	0	0
	Avg		3.2	3.5	3.4	3.7	3.7	4.3	3.1	3.2	3.4	3	3.2	3.4	4	3.8	2.9	3.2	3.6	3.5

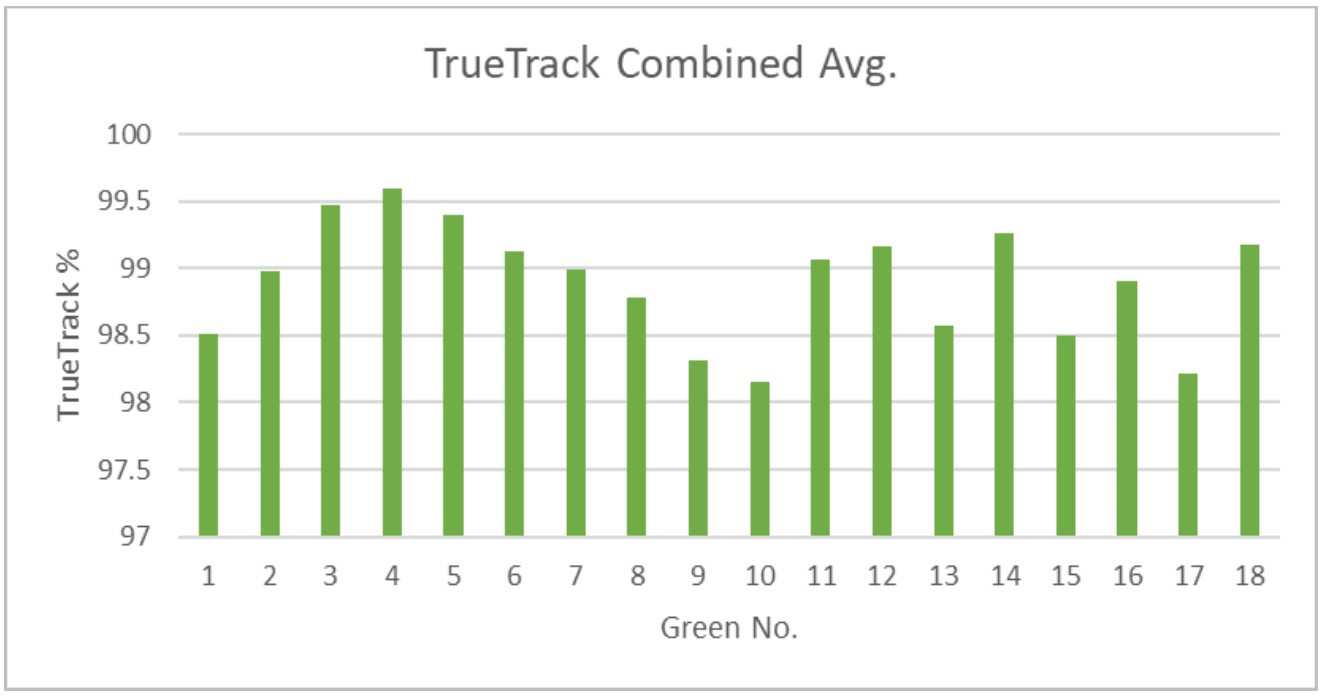
TrueTrack

TrueTrack measures the vertical and horizontal ball movement on the green, what a player may experience during a putt. This is displayed as a % from the true horizontal and vertical line path.

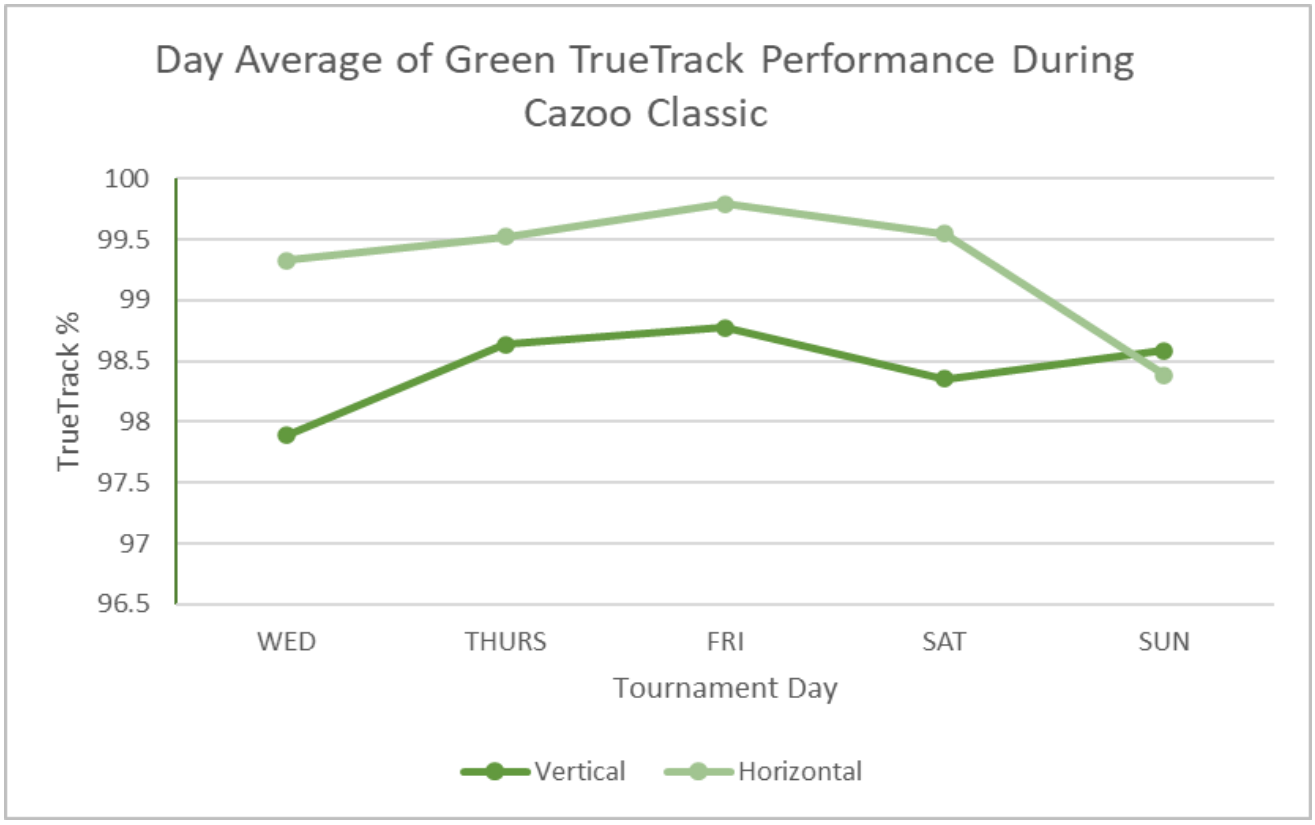
Greens experiencing results above 95% would be categorised as excellent, 5 star in the ProPitch system. **At no point after daily preparations did the greens drop below 95%,** even in the challenging climatic conditions under intense round numbers and exposure to traffic.

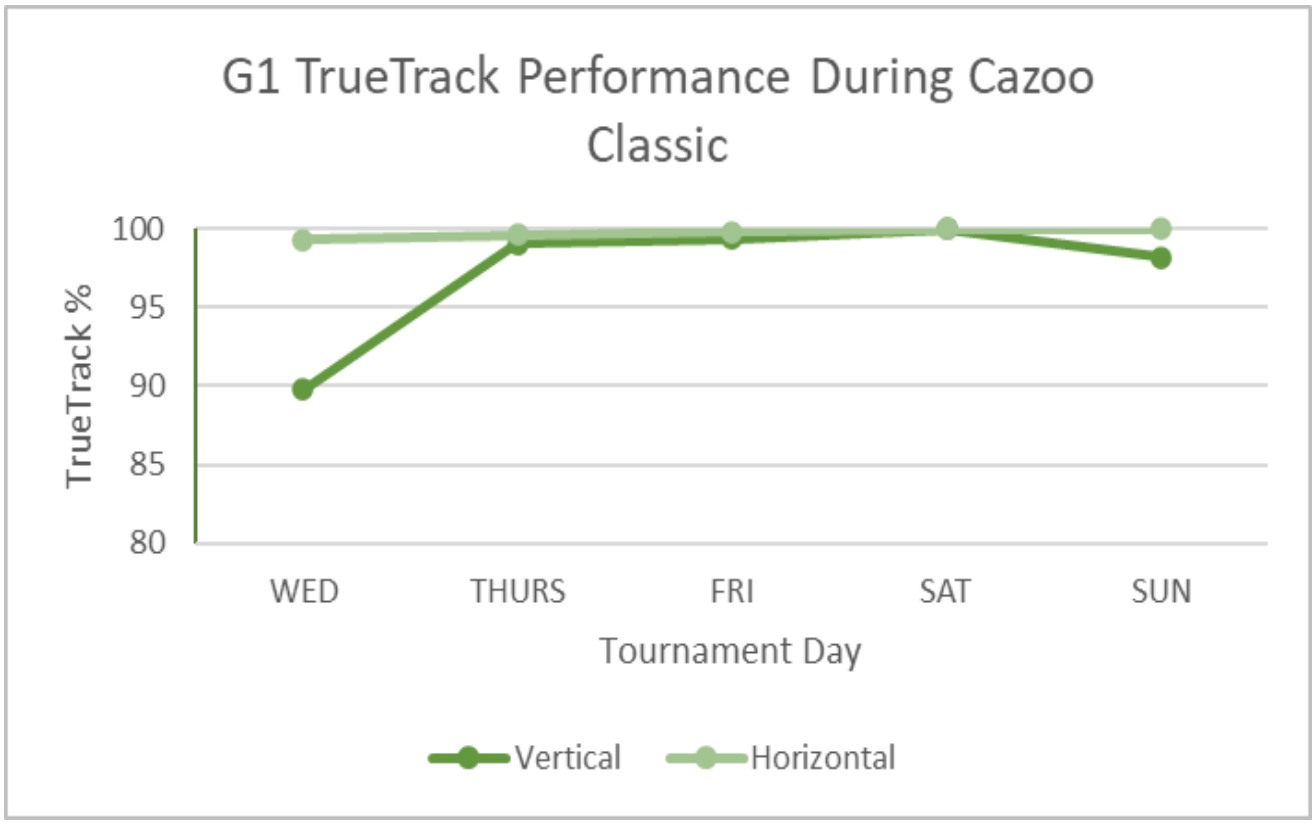
- All greens performed at an elite level with respect to TrueTrack throughout the whole duration of the tournament.
- Avg. Vertical performance remained above 97%.
- Avg. Horizontal performance remained above 98%.
- Green 3 had the best average vertical performance.
- Green 18 had the best average horizontal performance.
- Green 4 averaged the best combined TrueTrack Avg. performance.
- Green 10 averaged the weakest combined TrueTrack Avg. performance.



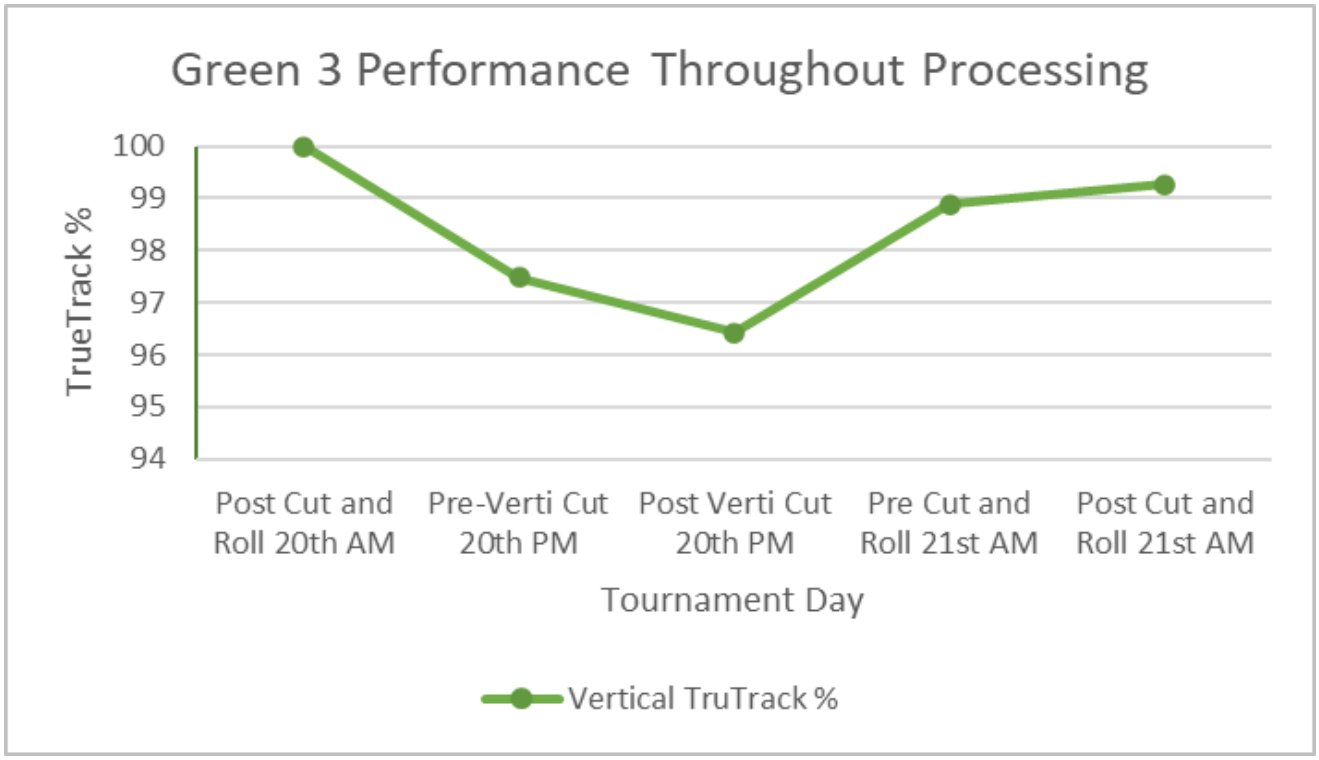


- Day average green performance was best on Friday for horizontal and vertical TrueTrack.
- Day by day monitoring of performance across the whole tournament is possible.
- Possible to track the influence of cutting/maintenance on results throughout.



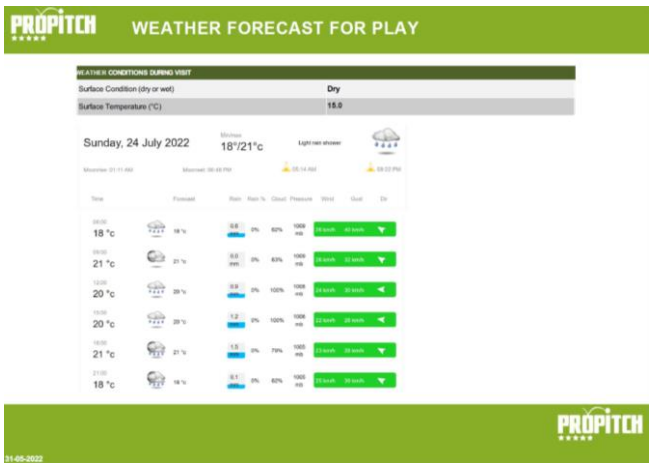


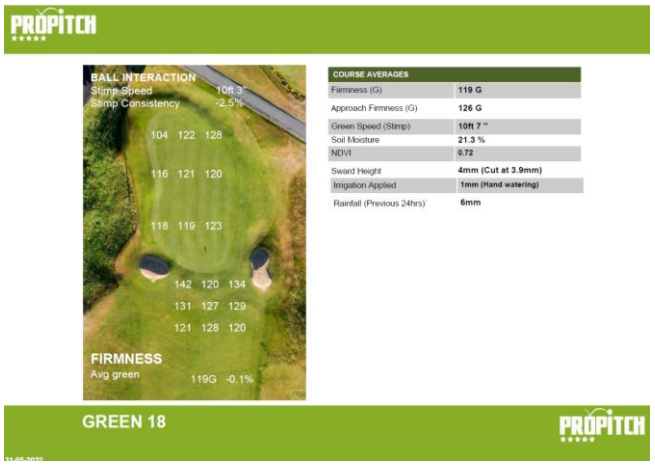
During the tournament additional testing was undertaken to present the relationship between specific maintenance practices and greens performance.

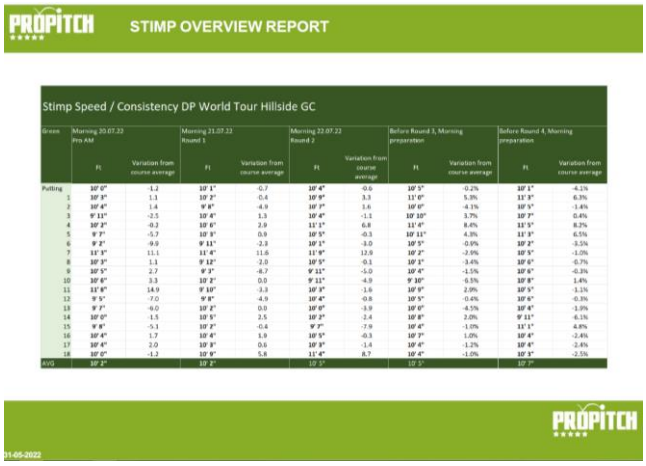


Players Report

During the tournament it was proven that a Players/Caddie Report could be presented each day before play to support informed decision making. The key highlights are the forthcoming weather that day, variation in firmness, and green speed versus the course average while also presenting the results on a plan view of the green and approach.

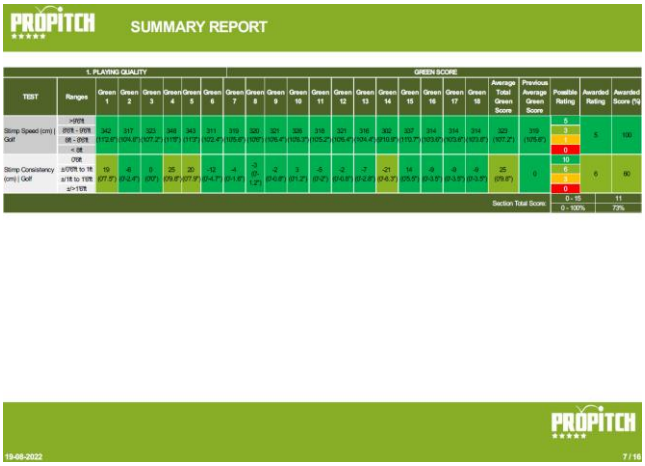


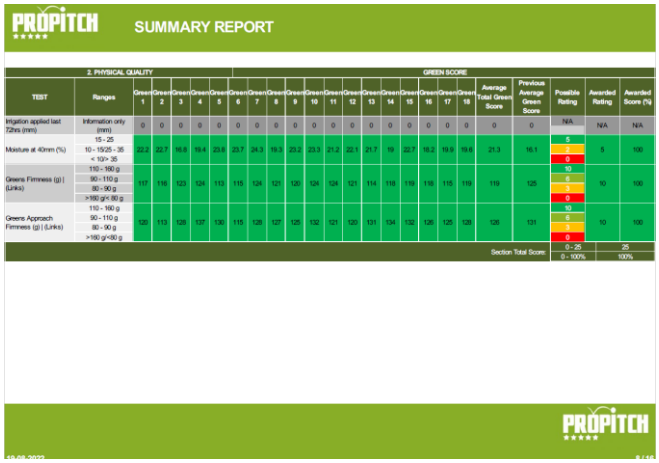




DP World Tour Assessment Report

A full results report was produced each day, this formed the key metrics for informed decision on maintenance type and frequency before the next day's play. The ProPitch scoring system and DP World Tour Assessment created included the stimp speed, stimp consistency, moisture, firmness and approach firmness.





Additional Testing and Investigations

Throughout the tournament additional testing was carried outside of the basic scope of works.

1. NDVI versus TrueTrack (brown vs green) sacrificing aesthetics of the course. We used the NDVI meter to assess the smoothness and trueness of areas of the greens affected by drought or heat stress versus those considered to be 'green'. The vertical ball roll deviation was better on the 'Brown'.

Hillside Green 3 Green Colour TrueTrack Analysis												
Green					Brown				Difference Between Colours			
NDVI	75				63							
Test	Horz. TrueTrack %	Vert. TrueTrack %	H Decel.	V. Decel	Horz. TrueTrack %	Vert. TrueTrack %	H Decel.	V Decel.	Horz. TrueTrack %	Vert. TrueTrack %	H Decel.	V. Decel
AVG. 6 Rolls	**100.00**	**96.95**	0.54	0.45	**99.68**	**99.17**	0.57	0.74	**-0.32**	**2.23**	0.03	0.29

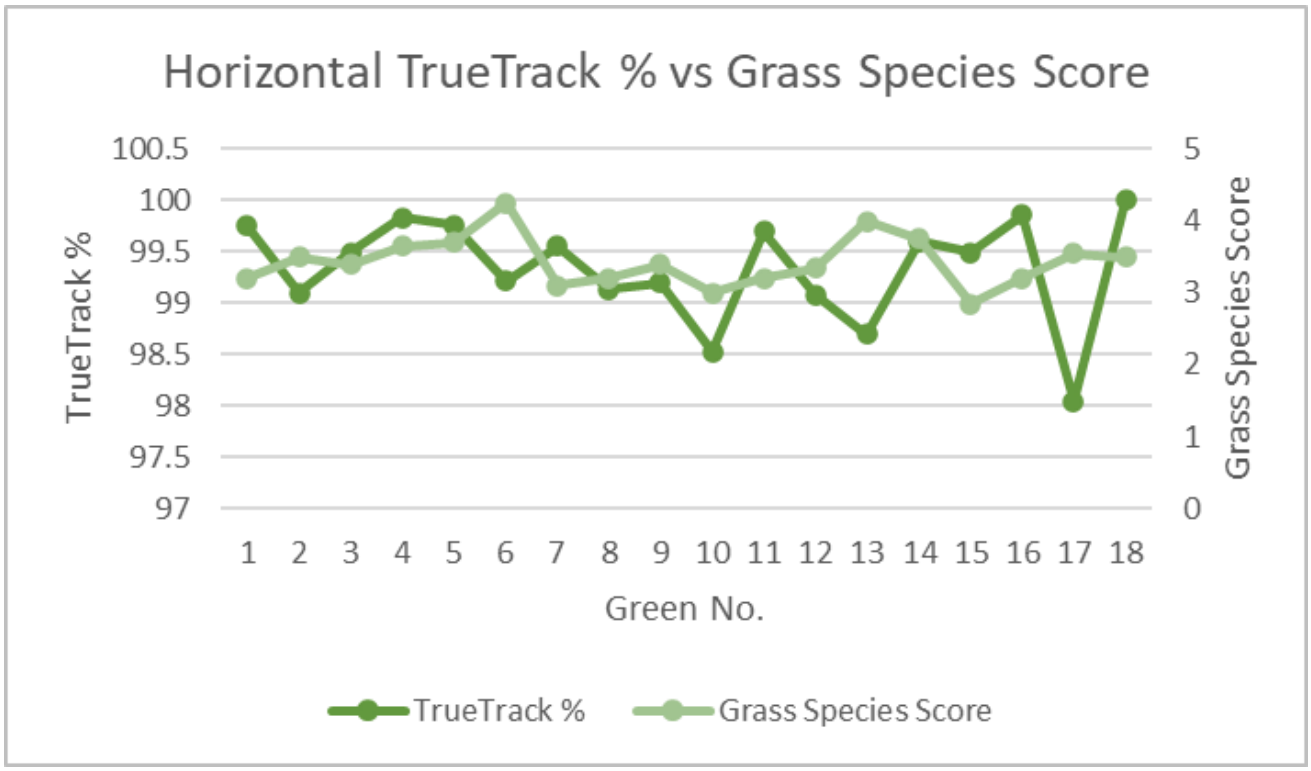
2. Soil Moisture was measured at varying depths across the profile in order to determine any layers that were holding moisture. This would allow us to further investigate the relationship between root length and water availability.

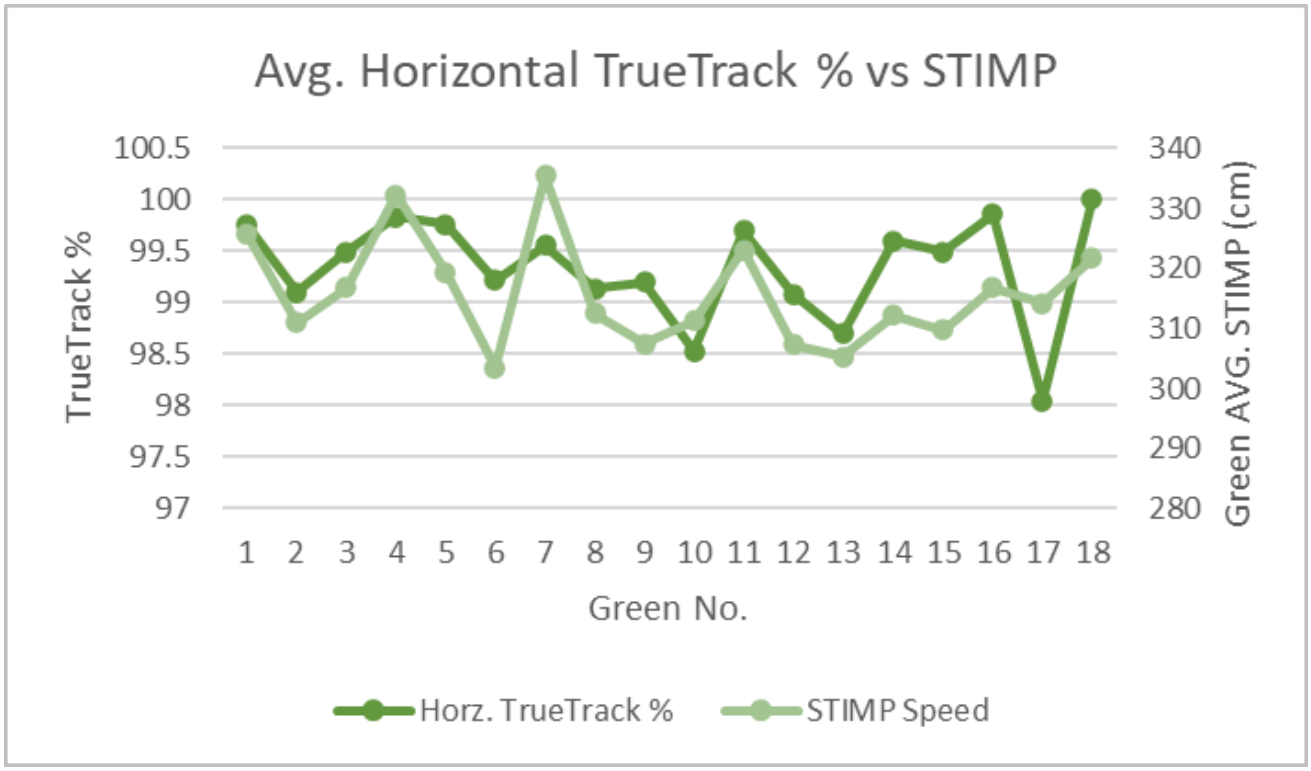
3. The effect of verti-cutting on Trueness. We look further into the effect vert-cutting has on green speed and trueness, does verti-cutting really improve the trueness of your surface in the way we'd expect it to?

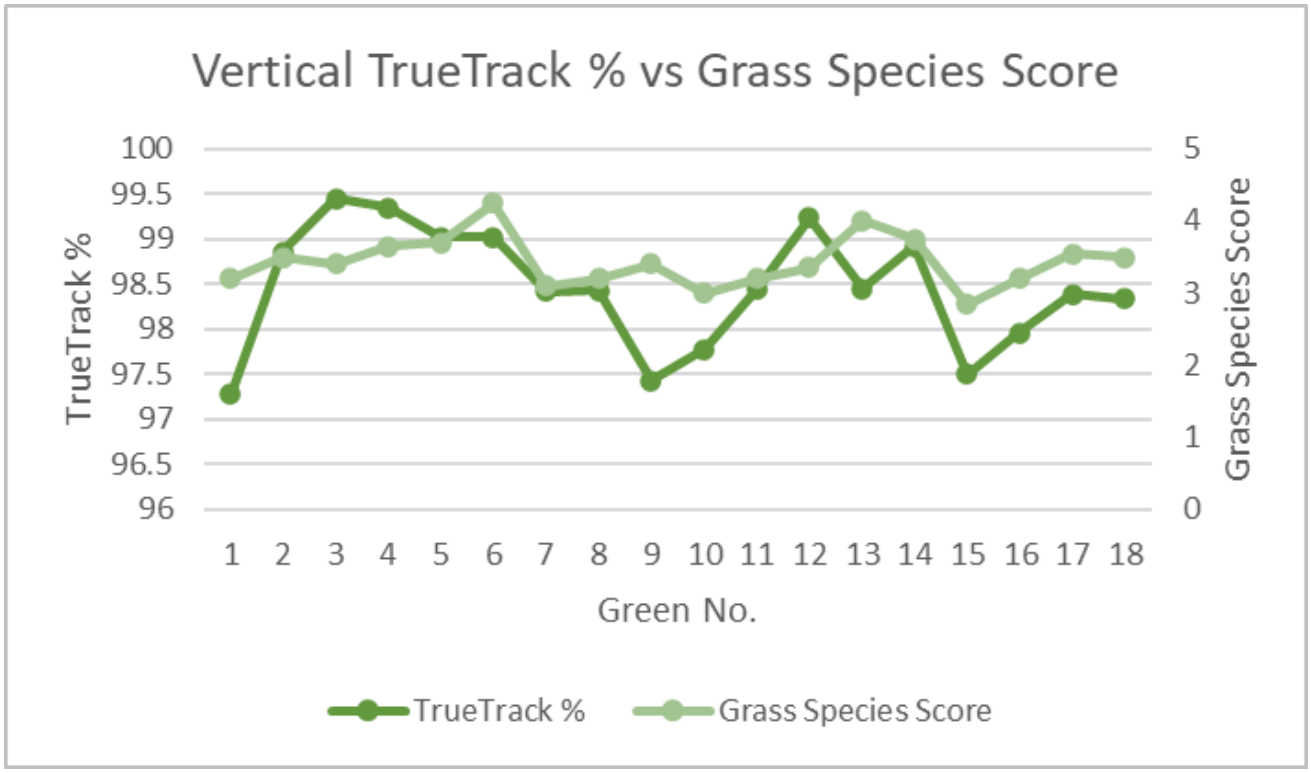
4. Can data collection save you time and effort in the long run? We explore how testing the greens can lead to informed decisions on maintenance and how treating each green differently can make you more efficient.

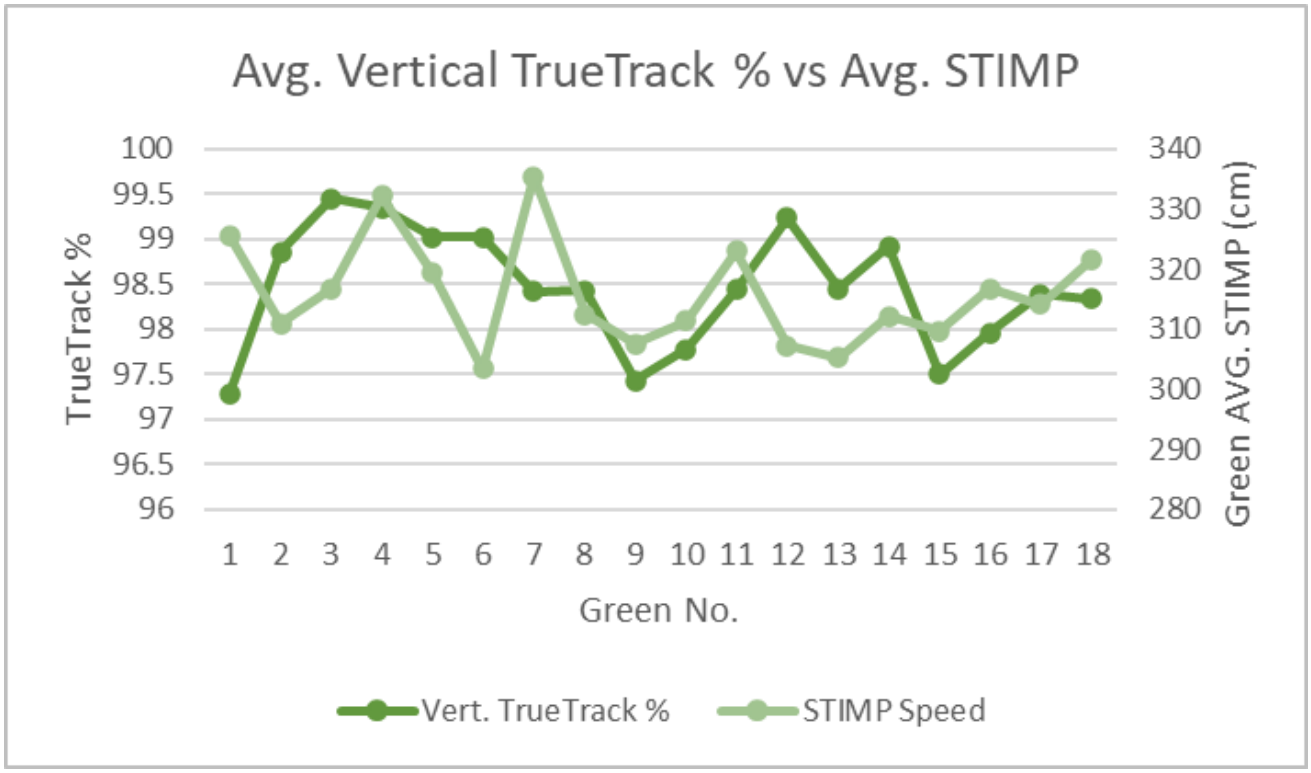
5. Truetrack was measured before and after rolling to assess the improvement in ball roll performance. The greens were already performing in an 'elite' capacity however post rolling there is an improvement in vertical ball roll deviation.

Hillside Putting Green Pre/Post Roll TrueTrack Assessment											
22.07.22						23.07.22					
Pre-Rolling			Post Rolling			Pre-Rolling			Post Rolling		
	Horz TrueTrack %	Vert TruTrack %	Roll No.	Horz TrueTrack %	Vert TruTrack %	Roll No.	Horz TrueTrack %	Vert TruTrack %	Roll No.	Horz TrueTrack %	Vert TruTrack %
AVG. 6 Rolls	99.93	96.23	AVG.	100	99.36	AVG.	98.48	97.30	AVG.	99.935	98.66
		Improvement		0.07	3.13			Improvement		1.46	1.35




Avg. Horizontal TrueTrack % vs STIMP
TrueTrack %
100.5
100
99.5
99
98.5
98
97.5
97
340
330
320
310
300
290
280
Green AVG. STIMP (cm)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Green No.
Horz. TrueTrack %
STIMP Speed


Vertical TrueTrack % vs Grass Species Score
TrueTrack %
100
99.5
99
98.5
98
97.5
97
96.5
96
5
4
3
2
1
0
Grass Species Score
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
Green No.
TrueTrack %
Grass Species Score



Discussion

During a period of dry summer weather and low rainfall an elite golf course can still be delivered with low water consumption and sustainable use of fertiliser and feed, proven by objective testing data. The greens perform consistently well throughout the tournament even when under climatic stress. This has been one of the most challenging dry periods leading up to a tournament.

Measuring the moisture content across 9 locations on the greens allowed for more accurate watering of surfaces post play. Certain areas on greens were found to be drying out at a higher rate than the surrounding areas of the greens. From this data, specific areas on greens could be pinpointed for additional hand watering or spot treatment through the automated irrigation system. In addition to specific spot treatments, watering of individual greens on a whole could be tailored to their own requirements. Using this data resulted in **reduced water usage** and **greater time efficiency** when it came to man hours used for hand watering.

On the **morning of Round 2, the average moisture content in the top 40mm across all greens averaged 10.8%, with certain greens showing soil moisture as low as 7%.** This figure would be considered to be alarmingly low, to the point that the plant would have been expected to start showing visible signs of stress. Despite the low moisture content, greens continued to perform well and very few signs of stress were present. Upon investigation, it was found that the lower rootzone was holding moisture deeper in the profile, with moisture varying between 15-20% within the depth section of 180-250mm. This moisture had become available to the plant due to its extended root network – something that was promoted during the period leading up to the tournament through detailed nutrition and periods of intense moisture management. Root mass length on this specific green was measured at 100mm, with longer independent roots visible, having penetrated what were suggested to be deep tine aeration holes.
The data suggests that promoting a deep and extensive root system can help to reduce irrigation and water usage, ultimately, becoming more environmentally aware.

The collection of objective data allows us to move away from a 'one fits all' approach. Identifying localised issues or differentiating between individual greens allows for informed decisions to be made when it comes to maintenance, mechanical procedures and inputs.

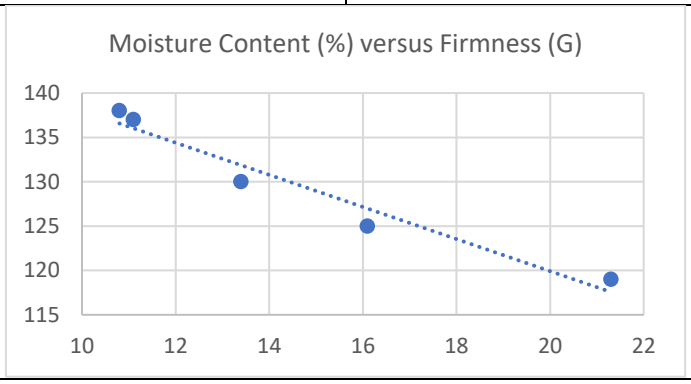
Live testing was carried out on each morning of play. This allowed for up to date decisions to be made by Chris Ball (Course Manager) and Eugene Hennessy (European Tour) as they move from green to green, instructing the maintenance team on specifics changes to be made to the maintenance programme. Data collected on green speed and firmness would have a direct impact on the frequency of mowing and rolling of the greens in order to create consistency across the whole course.

All of the **data** was accumulated using the **ProPitch APP** in order to present it in an appropriate manner. The easy to understand layout allowed for identification of outlying greens. Specific greens with outlying results to the others could be identified in order to introduce certain practices post play – bringing the outlying greens up to standard with the others. Green 6 was identified as the slowest green after testing on the morning of the Pro AM, with a speed of 9'2", 12 inches slower than the course average of 10'2". This prompted the decision to introduce **verti-cutting practices** to the maintenance plan for green 6 alongside the cut and roll that was being carried out on all other greens. The aim was to increase the green speed in accordance with the other greens to provide consistency across the course. This was achieved with results showing green 6 increased in speed on day 1 to 9'11", only 3 inches off the course average of 10'2". By day 3, green speed of green 6 increased to 10'5", matching the course average on that day of 10'5".

'Live' player reports were formed using the ProPitch app and the data that was collected. This information was more specific to playing quality, looking at firmness of greens and approaches, coupled with green speed. These parameters can have a direct impact on how the **ball interacts with the surface**, and therefore can **influence a player's** mind-set and shot selection.

Firmness readings were found to be high across many greens with testing on the morning of Round 2 showing average firmness across the course sitting at 138G having been measured with the Clegg hammer. Green 11 provided an average of 147G on the morning of Round 2 which is 17G over the suggested maximum of 130G. As seen before with extremely low moisture levels, it was found that what were thought to be alarmingly firm greens still managed to perform throughout the tournament with no visible signs of stress. It is thought this is achievable due to the extended root system which aids overall plant health.
As firmness increased, moisture decreased. This correlation was seen again as moisture increased after rainfall, firmness was seen to decrease.

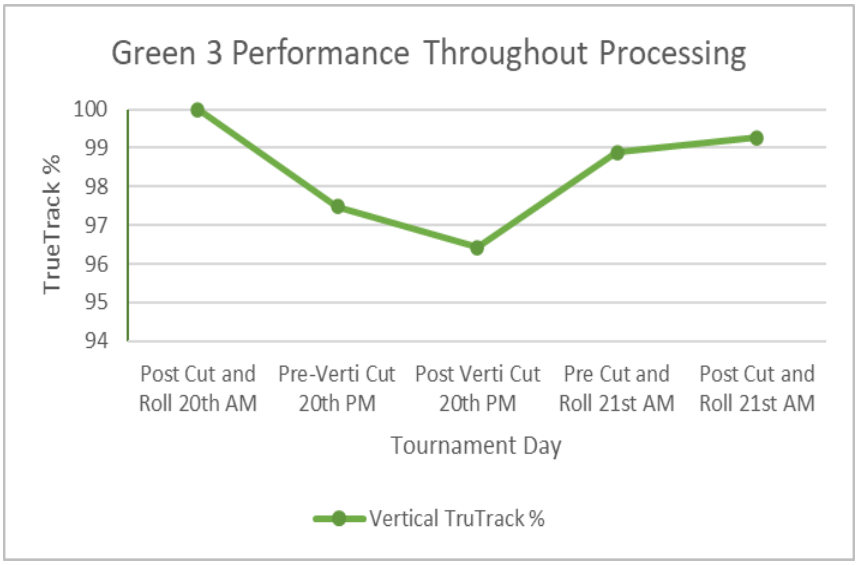
	Course Average Moisture %	Course Average Firmness(G)
Pro AM	13.4	130
R1	11.1	137
R2	10.8	138
R3	16.1	125
R4	21.3	119



Firmness was also seen to increase in the location of the previous days pin position, showing that foot traffic has an affect on green firmness. These areas however where seen to reduce in firmness the following day back to what would have been expected, showing foot traffic firmness can be relieved within 24 hours.

TrueTrack has supported in assessing ball roll characteristics, for vertical and horizontal deviation. This gave the opportunity to measure trueness of greens before and after certain cultural practices to assess their effect on trueness, with some interesting findings. Verti-cutting is widely carried out within greenkeeping with the aim of increasing green speed and increasing trueness by removing coarse grasses and soft decaying organic matter which has the tendency to decompose which can lead to decompressions within the surface thus having a negative effect on trueness. In this instance, verti-cutting was introduced with the main aim of increasing green speed whilst maintaining trueness.

It was found that, post vert-cutting (followed directly by a mow), green speed would further increase as desired however trueness would be negatively effected and actually decrease immediately after the verti-cutting and mow process was carried out. The theory was that disturbance to the canopy from the vertical action of the blades forced the plant to stand upright in an inconsistent manner, having a negative effect on trueness. However, further cutting and rolling would even further increase green speed again as trueness would also begin to improve and recover to the same level as it where before the invasive nature of the verti-cutting process. This leads to the belief that verti-cutting can be used in order to improve surfaces in terms of green speed and trueness, so long as the process is followed up with increased frequency of mowing and rolling in order to return the canopy to its more flattened growth habit.



Acknowledgements

We would like to show our gratitude and thanks to Chris ball and his green staff at Hillside Golf Club. Transparency and access provided throughout the whole event made this data collection possible.

In addition Eugene Hennessy from the European tour for his support shown to this project.

This is extremely important development of sport surfaces, particularly golf greens, where we get new learnings and insights during elite tournaments in the climatic challenges we face.

Appendix 1| Site Photographs

Image 1 'Toro Electric Mower'

Image 2 '2nd Green

Image 3 '17th Green 'Field Marshall' Innovation

Image 4 'Pretournament'

Image 5 '17th Green

Image 6 'The Test Team'

Image 7 ‘Greenkeeper morning call’	Image 8 ‘Practice putting green’
	

Image 9 ‘18th Green’	Image 10 ‘Equipment’
	

End of Report

PROPITCH