



BOUNDARY RISK ASSESSMENT STAND GOLF CLUB, WHITEFIELD

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BOUNDARY RISK ASSESSMENT – STAND GOLF CLUB

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REPORT NUMBER	LSUK.26-0355_GBRA	
VERSION NUMBER & DATE	1.0	22/05/2026
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SUMMARY	A new development is being planned for land adjacent to Stand Golf Club. There is a possibility that balls may surpass the boundaries of the golf course and present a risk to the new development. Labosport Ltd has reviewed the site to ascertain the risk of balls landing in areas past the boundaries; and to advise on the type and level of mitigation recommended to provide a suitable level of protection.
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Section 1 – Introduction**Introduction**

To assess the potential risk of golf balls surpassing the boundaries of Stand Golf Club and entering the proposed development, Labosport Ltd has reviewed the site to ascertain the risk of balls landing in areas past the boundaries; and to advise on the type and level of mitigation recommended to provide a suitable level of protection.

A sophisticated trajectory model was developed using data from published studies on golf ball aerodynamics and measured data on golf ball launch dynamics. The model was used to simulate ball trajectories for relevant shots at specific locations at the golf course where potential risks were identified. The height of the ball as it surpassed the site boundary was calculated for each scenario. This report forms the basis of a risk assessment and a recommended mitigation strategy to minimise potential risks.

Note: This is a desk-based study. Labosport have not visited Stand Golf Club to survey the site. All measurements have been provided by the client or taken from satellite imagery, and Labosport cannot be held accountable for any errors that may arise from this information.

Previous Work

Labosport Ltd have undertaken this type of sports boundary risk assessment for over 5 years when there have been perceived problems with balls exceeding the boundary, or the potential influence of a new adjacent development to an existing club. Through this work, Labosport Ltd have developed significant expertise that supports our judgements in these matters.

Section 2 – Golf Ball Trajectory Model

Trajectory Model Overview

A sophisticated three-dimensional trajectory model was developed to analyse the trajectory of the golf ball. The model was built in the numerical programming software 'Matlab' and incorporated aerodynamic drag and lift forces, and the complexities arising from the ball's spin rate.

The model used published aerodynamic coefficients taken from wind tunnel studies on golf balls at different velocities and spin rates (Bearman, P. W. & Harvey, J. K. (1976) – *Golf Ball Aerodynamics - Aeronautical Quarterly*, Volume 27, Issue 2, May 1976, pp. 112-122).

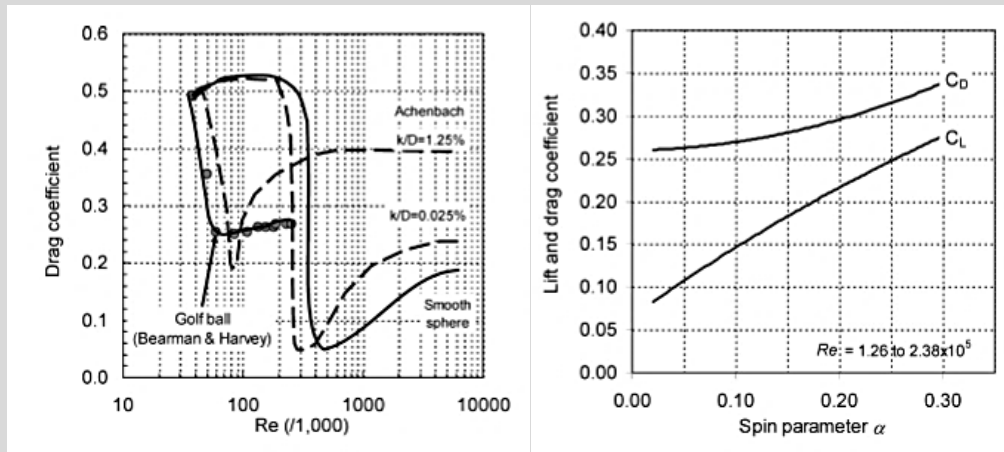


Figure 1 (a) Drag coefficient for a golf ball compared to rough and smooth spheres; (b) Lift and drag coefficients for a spinning golf ball with spin parameter $\alpha = \omega r / U_\infty$ (Bearman & Harvey, 1976).

The aerodynamic forces of drag (F_D) and lift (F_L) are proportional to the ball's velocity relative to the air flow, frontal area, air density and the drag coefficient respectively lift coefficient. The forces are defined as:

$$F_D = \frac{1}{2} C_D \rho V^2 A$$

$$F_L = \frac{1}{2} C_L \rho V^2 A$$

with C_D and C_L are the non-dimensional drag and lift coefficients, ρ the air density in kg/m^3 , V the air stream velocity in m/s and A the frontal area of the ball in m^2 .

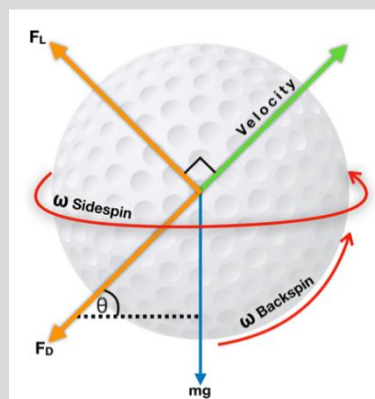


Figure 2. A free body diagram for the golf ball trajectory model showing the aerodynamic drag and lift forces.

Due to the complexity of the flight dynamics, the trajectory can only be resolved by using a numerical time step approach whereby the ball conditions are calculated at small timesteps throughout the trajectory. The conditions at time step 1 are used to calculate the conditions at time step 2; the conditions at timestep 2 are used to calculate the conditions at time step 3 and henceforth. A timestep of 0.001 seconds was used to generate high-resolution trajectory data.

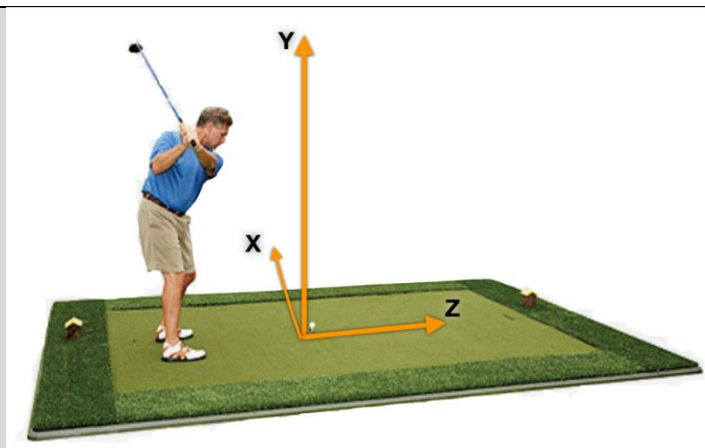


Figure 3. The coordinate system used in the trajectory model.

The trajectory model uses a standard Cartesian coordinate system to define the location of the ball throughout flight. Examples of the trajectory model simulations can be seen in Figure 4.

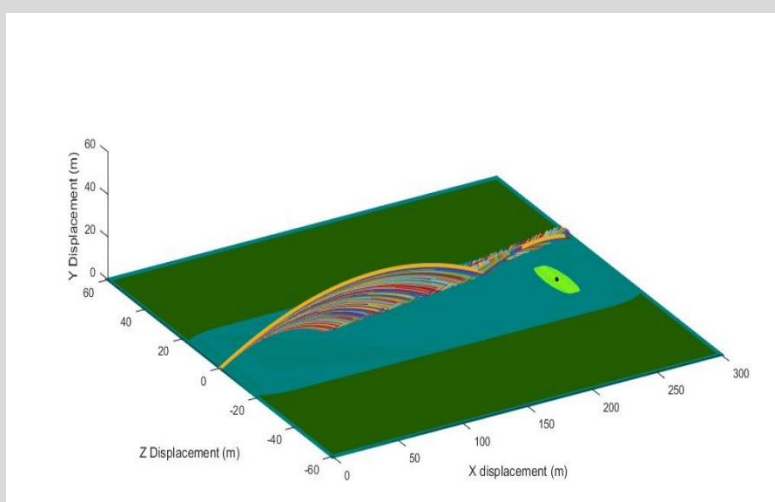


Figure 4. Examples of the trajectory model visualisations in Matlab.

Model Validation

The trajectory model was validated by comparing the TrackMan measured flight distance for an average male amateur with predictions from the trajectory simulations. The trajectory was found to exhibit high accuracy; however, it is not possible to model the full complexity of the real world and the model developed for this project is best regarded as an indicative predictive tool.

TrackMan measured flight distance	Trajectory model prediction (based on initial launch conditions)	Trajectory model accuracy
186.5 metres	187.0 metres	< 0.3%

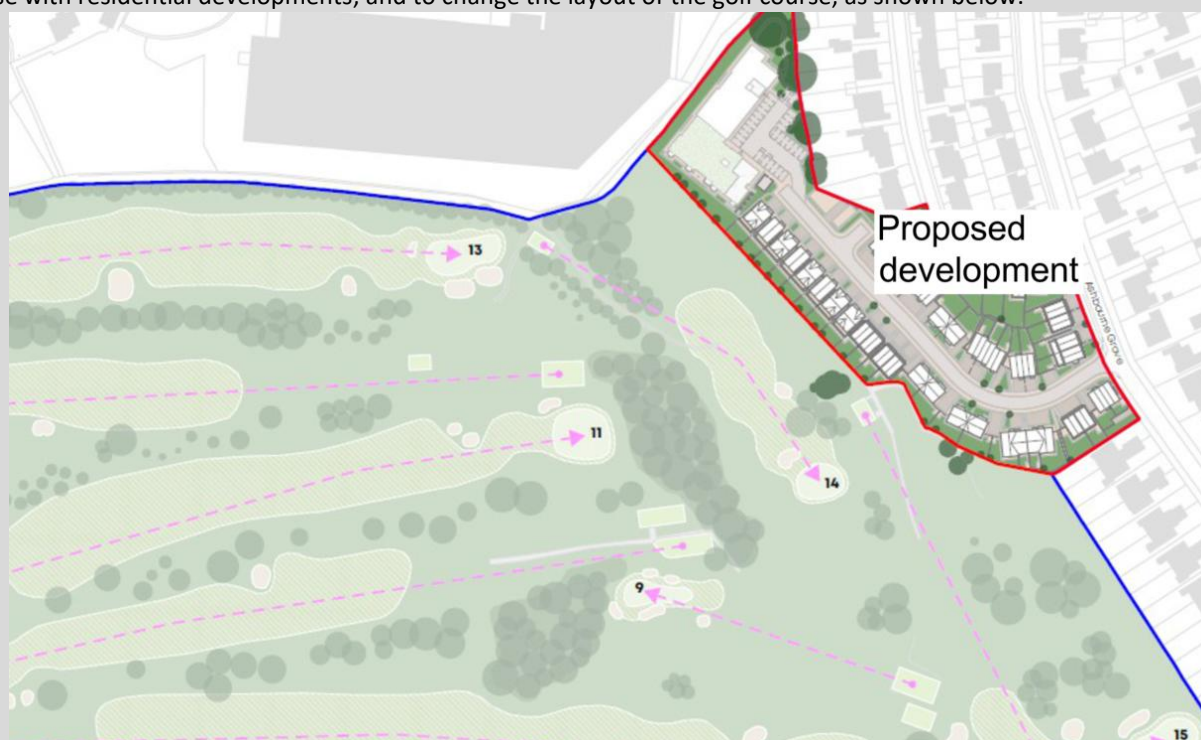
Section 3 – Site Specifics

Course Layout

Labosport have been provided with plans that show how the layout of Stand Golf Course is to be amended to enable the proposed development. The current layout of the golf course has the 18th hole finishing in an easterly direction towards the clubhouse, as shown below.



The plan for the proposed development is to relocate the clubhouse to the western side of the golf course, to replace the existing clubhouse with residential developments, and to change the layout of the golf course, as shown below.



In this new course layout, the potential ball strike risks are associated with the new par 3, 14th hole. The below image shows the orientation of this new course layout hole in relation to the proposed development boundary. Due to the proximity of the new development to the proposed 14th hole, an assessment of the potential ball strike risk is warranted.



An overview of the proposed new 14th hole in relation to the proposed development boundary

Existing Ball Stop Mitigation

This report does not account for any existing, or planned planting (trees, hedges etc). This trajectory assessment is based on reasonable worst-case scenarios, and it is our informed opinion that planting cannot be relied upon to provide protection against ball trajectories. The planting may not be sufficiently dense to stop the ball, nor homogeneous across the length. The planting may change during the seasons, or indeed be cut back or removed.

Section 4 – Ball Trajectory Scenarios

Site Measurements and Topography

In the game of golf, a tee shot presents the highest risk to site boundaries as it is the golf shot with the longest and highest trajectory; however, depending on the length of the hole, different clubs with different ball launch characteristics will be chosen. For this hole, a representative trajectory would be a shot hit with an iron (e.g. 8 iron) from the tee towards the green. Players will aim to launch the ball down the fairway in the direction of the hole, but it is understood that variations in targeting accuracy can result in a range of possible trajectories. In this scenario, a reasonable assumption is that variations in targeting accuracy will be considered with a maximum likely 'error' of ± 20 degrees for Driver shots and ± 15 degrees for Iron shots.

As shown in the image below, the proposed 14th hole layout will include both a water hazard and trees along the left-hand side of the fairway to help discourage players hitting in the direction of the new development. Though the trees are not considered as a form of ball stop mitigation, they will act as a method of directing golf ball trajectories away from the proposed new development.



The potential effects of targeting errors at the proposed development adjacent to Stand Golf Club

Golf Shot Launch Conditions

Golf balls can be launched with a wide range of initial conditions (speeds, angles and spin rates). Nonetheless, previous researchers have made accurate measurements of ball speeds and spin rates using high speed video, Doppler radar and similar technologies. Stand Golf Club attracts golfers of all levels, with players of different standard able to hit the ball with a wide range of distance and accuracy. In addition, due to advances in golfing equipment, coaching and playing style, even amateur level golfers are able to hit the ball significantly further than in the past. As a result, mis-hit shots have the potential to divert further away from the intended direction of the fairway and therefore pose an increased level of risk to adjacent areas. TrackMan provide gold standard ball launch monitoring systems and have collected expansive datasets of launch characteristics from both professional and recreational players. The table below presents the ball launch conditions that will be used in the trajectory model simulations.

Tee Shot Scenario – Driver

Characteristic	Imperial unit	Metric unit
Ball Speed	167 mph	75.99 m/s
Launch Angle	10.9 degrees	0.19 radians
Spin rate	2686 rpm	281.28 rad/s

Approach Shot Scenario – Fairway wood

	Imperial	Metric
Ball Speed	158 mph	70.63 m/s
Launch Angle	9.2 degrees	0.161 radians
Spin rate	3655 rpm	382.8 rad/s

Approach Shot Scenario – 4-iron

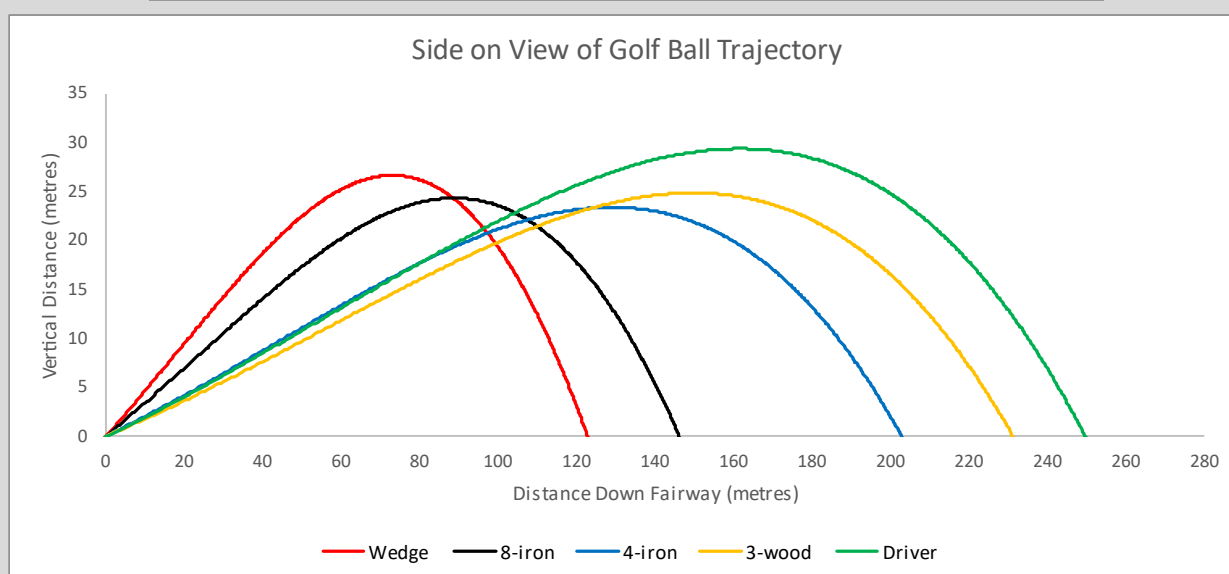
	Imperial	Metric
Ball Speed	137 mph	61.24 m/s
Launch Angle	11.0 degrees	0.192 radians
Spin rate	4836 rpm	506.4 rad/s

Approach Shot Scenario – 8-iron

	Imperial	Metric
Ball Speed	115 mph	51.41 m/s
Launch Angle	18.1 degrees	0.316 radians
Spin rate	7998 rpm	837.5 rad/s

Approach Shot Scenario – Pitching wedge

	Imperial	Metric
Ball Speed	102 mph	45.60 m/s
Launch Angle	24.2 degrees	0.422 radians
Spin rate	9304 rpm	974.3 rad/s



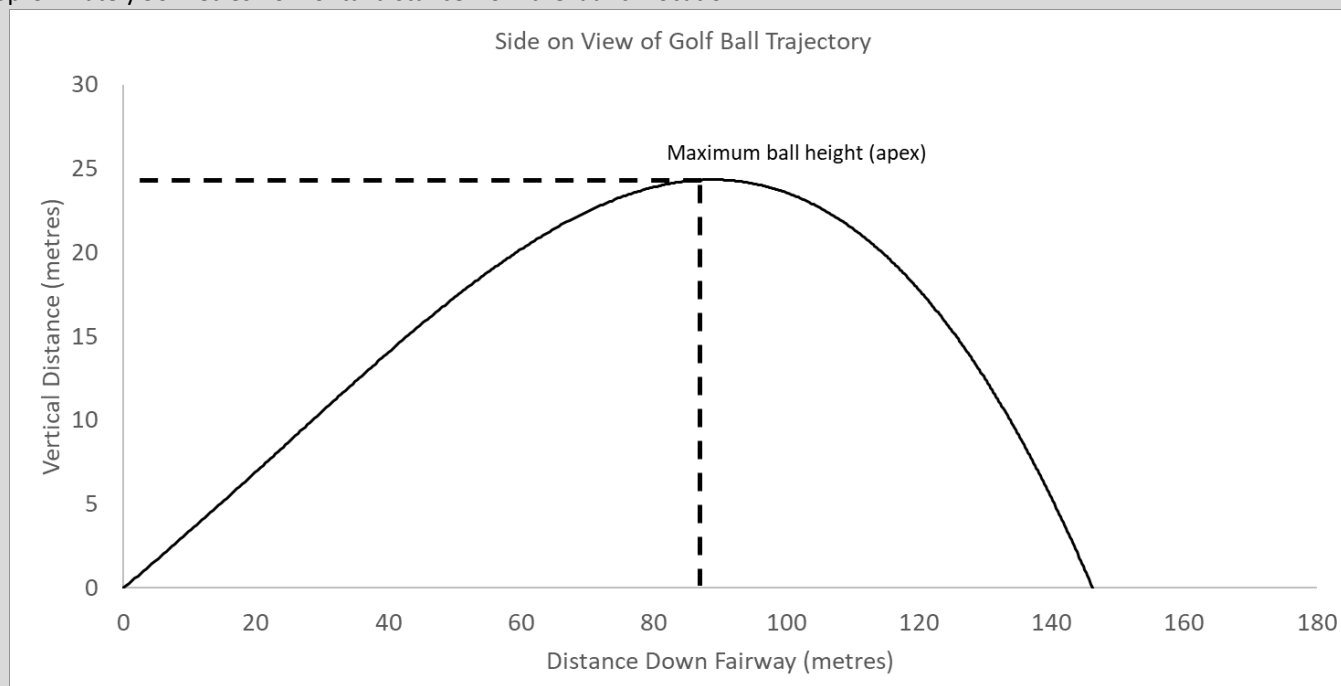
Simulated golf ball trajectories for the trajectory model simulations.

Section 5 – Estimated Ball Height

Estimated Ball Heights (Using the Projection Modelling Tool)

Hole 14 – Tee shot with 8 iron

Trajectory scenarios for the tee shot on the proposed 14th hole with an 8 iron are considered. Based on the assessment of simulated golf ball trajectories on the proposed 14th hole, the estimated maximum ball height will be approximately 25 m, occurring at approximately 90 metres horizontal distance from the launch location.



Estimated ball flight for tee shot on 14th hole.

Section 6 – Risk Assessment Discussion

Ball Stop Netting Recommendations

This report has been prepared to assess the potential risk of golf balls surpassing the boundaries of Stand Golf Club and to advise on the type and level of mitigation recommended to provide a suitable level of protection.

The exact frequency of events resulting in a golf ball being hit into the adjacent area is unknown and impossible to predict with certainty (player skills and many other factors can influence this) hence a proportionate approach needs to be taken to provide safety to these users. In reality, there may be a “freak” shot that will result in a further than expected trajectory, but a balanced risk mitigation strategy needs to be implemented that is proportionate. Indeed, there are risks associated with many everyday activities, but plans need to be developed to reduce risk following good practical health and safety principles including a combination of likelihood and severity.

Recommendations

The trajectory analysis shows that the proposed layout of the new 14th hole in relation to the new development, in terms of the direction of the hole, the distance to the site boundary, as well as the addition of water hazards and trees along the left-hand side of the fairway to help discourage players hitting in the direction of the development, provides sufficient mitigation without the need for additional ball stop fencing or netting.