HALLAM LAND, NORTH ST. ALBANS

CRICKET AND RUGBY BALL STRIKE ASSESSMENT

LABOSPORT

BALL STRIKE ASSESSMENT– HALLAM LAND, NORTH ST. ALBANS– CRICKET AND RUGBY PITCHES

CLIENT	Hallam Land
SITE ADDRESS	160 Harpenden Rd, St Albans AL3 6BB
CLIENT CONTACT	David O'Neil

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INTRODUCTION	To assess the potential risk of cricket balls surpassing the boundaries of a cricket pitch and rugby balls surpassing the boundaries of the sports club at land adjacent to Harpenden Road, Labosport Ltd has reviewed the site distances and topography to analyse the risk of balls surpassing the site boundaries. The analysis uses a cricket ball trajectory model that has been developed by Labosport, in collaboration with the ECB. If required, the report will identify the height of any ball trajectory mitigation to minimise the potential risks. **Note:** This is a desk study, Labosport have not visited the site, taken measurements, or carried out a visual inspection. All measurement information has been provided by the client and any error in measurements are not the responsibility of Labosport. This assessment is undertaken on the basis of accurate data.

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Section 1 – Executive Summary of Conclusions

Executive Summary of Conclusions

This report has been prepared to assess the potential risk of cricket balls surpassing the boundaries of a cricket pitch and rugby balls suprassing the boundaries of the playing fields at land adjacent to Harpenden Road, St. Albans and advise on the height and location of mitigation recommended to provide a suitable level of protection.

Orientation	Recommended mitigation height (based on recreational cricket)	Recommended mitigation height (based on adult rugby)
North	0 m	0 m
East	0 m	3 m
Southwest	0 m	4.5 m
West	0 m	4.5 m

For the existing pitches the below mitigation is recommended.

Orientation	Recommended mitigation height (based on mitigation location Pitchside)	Recommended mitigation height (based on mitigation location adjacent to housing development)
South	4.5 m	4 m

Please Note: This may not stop all shots from landing beyond the site boundary, but it is believed from the assessment of the ball trajectory it will significantly reduce their frequency.

The below diagram shows the proposed locations of the recommended mitigation for heights detailed above for adult rugby but there is no recommended mitigation for cricket: Larger Versions of these images can be found in Appendix B.

For New Pitches

Pitchside

Housing Development

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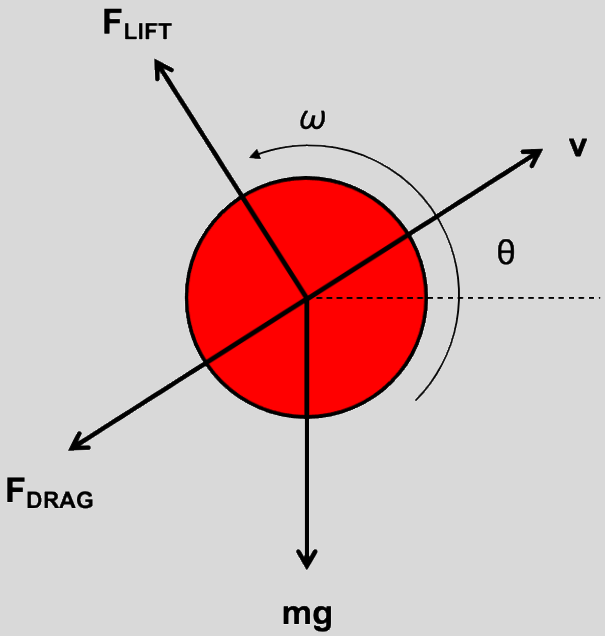
Section 2 – Cricket Ball Trajectory Model

Trajectory Model Overview

Previous work undertaken by Labosport for the England and Wales Cricket Board (ECB) led to the development of a sophisticated trajectory model to estimate the distance a ball would travel, and its trajectory given a specific velocity, angle, spin rate and atmospheric conditions (i.e. altitude).

The trajectory model uses aerodynamic principles and Newtonian physics to predict the ball flight path whilst accounting for the effect of air resistance. The model uses aerodynamic coefficients taken from published wind tunnel studies on cricket balls at different velocities.



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:

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

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

Trajectory models are known to exhibit high accuracy and Labosport have undertaken extensive experimental validation of this trajectory model to refine its accuracy. However, it is not possible to simulate the full complexity of the real world and this model does not account for variations in bat/ball restitution or wind (speed and direction). Due to these limitations, the model is regarded as an indicative prediction tool.

Trajectory Scenarios

The hit angles and velocities are estimated from in-game action to cover a range of 'typical' shots ranging from 20 degrees to 50 degrees and 20 m/s (45 mph) to 50 m/s (112 mph). The exact frequency of shots resulting in a cricket ball being hit into adjacent areas is unknown and impossible to predict with certainty (player skills, type of game and many other factors can influence this) hence a proportionate approach needs to be taken to provide safety to users. In reality, there may be a "freak" shot that will result in a further than expected trajectory; however, the implications of planning for this type of worst-case approach could result in the closure of hundreds of cricket grounds across the country and hence 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.

Trajectories at an angle to the pitch

In scenarios where the direction of the trajectory is perpendicular to the direction of the pitch (or within 45 degrees of perpendicular), the analysis considers one trajectory scenario. This scenario is a ball trajectory played from the closest batting crease in the trajectory direction.

Trajectories parallel to the pitch

Where the direction of the trajectory is parallel to the direction of the pitch (or within 45 degrees), the analysis considers two trajectory scenarios; 1) a trajectory played from the closest batting crease, and 2) a trajectory played from the furthest batting crease. The type of cricket batting shots required to hit the ball from closest stumps are 'late cut' and 'late glance' shots and these do not achieve the same velocity as a 'straight drive' from the furthest batting crease. A greater emphasis is therefore placed on trajectories from the furthest batting crease.

Previous Work

Labosport Ltd have undertaken this type of boundary risk assessment for a great many other cricket grounds over the past 5 years when there have been perceived problems with cricket 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 3 – Site Specifics

Playing Standard of Cricket on the Site
Labosport have investigated the level of cricket that is played on this site. We have been advised that recreational cricket is played on this site. For recreational level cricket the basis of the shot velocity is 40 m/s. For recreational level cricket the basis of the 'late cut' or 'late glance' type shots is 30 m/s It is on this basis that the recommendations in this report have been made.

Existing Mitigation
There is currently no existing mitigation around the facility. This report does not account for any existing, or planned planting (trees, hedges etc). 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.

Site Measurements and Topography

Note that we are now going to measure, report and account for any topographical changes greater than 1 metre.

Orientation of Risk
At the instruction of the client, this boundary risk assessment only evaluate possible ball trajectories in a Northernly, Westernly and Southwesternly direction towards the proposed pavilion annexe. The focus on the analysis is based on the shortest distances from the closest cricket pitches to the potential area of risk.

Section 4 – Site Measurements

Site Measurements

The above diagram illustrates the minimum distances from the cricket square to the site boundaries. Note as this is a risk assessment the worst-case scenarios are considered; consequently, the shortest measured (and calculated) distance is used for the study. The following distances have been used to calculate the projected height of the ball for different shot conditions as specified below:

Measured Distance	Shortest Boundary (m)
North – Closest stump to site boundary	Circa 75.77 m
North** – Furthest stump to site boundary	Circa 96.11 m
Southwest – Closest stump to site boundary	Circa 87.73 m
West – Closest stump to site boundary	Circa 82.8 m

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Section 5 – Estimated Ball Height

Estimated Ball Height (Using the Projection Modelling Tool)

North Orientation

Estimated Ball Height @ 96.1 m		Angle (degrees)						
		20	25	30	35	40	45	50
Velocity (m/s)	20	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	45	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0

Estimated Ball Height @ 75.7 m		Angle (degrees)						
		20	25	30	35	40	45	50
Velocity (m/s)	20	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	45	0	0	0	0	0	0	0
	50	0	0	2.6	4.7	5.1	2.0	0

East Orientation

Estimated Ball Height @ 82.8 m		Angle (degrees)						
		20	25	30	35	40	45	50
Velocity (m/s)	20	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	45	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0

West Orientation

Estimated Ball Height @ 87.7 m		Angle (degrees)						
		20	25	30	35	40	45	50
Velocity (m/s)	20	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0
	30	0	0	0	0	0	0	0
	35	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0
	45	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0

See Appendix A for example trajectories.

Section 6 – Risk Assessment Discussion

Risk Assessment Discussion
This report has been prepared to assess the potential risk of cricket balls surpassing the boundaries of a cricket ground at land adjacent to Harpenden Road, St. Albans and to advise on the height and location of mitigation recommended to provide a suitable level of protection.

Mitigation Recommendations – North Orientation

Distance	Distance to boundary	Mitigation height (majority of risk removed)	Mitigation height (vast majority removed)	Overall mitigation height recommendation
Closest stump to site boundary @30 m/s	75.77 m	0 m high	0 m high	**0 m high**
Furthest stump to site boundary @ 40 m/s	96.11 m	0 m high	0 m high	

Please Note: This may not stop all shots from landing beyond the site boundary, but it is believed from the assessment of ball trajectory it will significantly reduce their frequency.

Mitigation Recommendations – Southwest Orientation

Distance	Distance to boundary	Mitigation height (majority of risk removed)	Mitigation height (vast majority removed)	Overall mitigation height recommendation
Closest stump to site boundary @40 m/s	117.78 m	0 m high	0 m high	**0 m high**

Please Note: This may not stop all shots from landing beyond the site boundary, but it is believed from the assessment of ball trajectory it will significantly reduce their frequency.

Mitigation Recommendations – West Orientation

Distance	Distance to boundary	Mitigation height (majority of risk removed)	Mitigation height (vast majority removed)	Overall mitigation height recommendation
Closest stump to site boundary @ 40 m/s	82.8 m	0 m high	0 m high	**0 m high**

Please Note: This may not stop all shots from landing beyond the site boundary, but it is believed from the assessment of ball trajectory it will significantly reduce their frequency.

Further Notes

This report does not recommend the specific design of a mitigation system, however options could include;

- Ball stop netting
- Rigid panel fencing
- Permanent or temporary fencing structures

It is recommended the client discuss design options with the relevant stakeholders including the LPA, the ECB and the cricket club.

In addition, the client may wish to consider alternative mitigation options such as the location and orientation of the cricket square, controlling the level of cricket played on the site, or defining the location of junior and senior cricket pitches. It is recommended that the client discusses any such plans with the ECB and other relevant organisations along with the club to ensure that plans are suitable in mitigating the risk but also practicable for the cricket club's day to day use.

Section 7 –Rugby Trajectory Model

Rugby Trajectory Model Overview

Labosport have developed a sophisticated trajectory model to analyse the trajectory of the rugby ball. The model was built in the numerical programming software 'Matlab' and incorporated aerodynamic drag and lift forces, and the significant complexities arising from the ball's rotation and its spheroid shape.

Under rotation, the rugby ball's cross-sectional frontal area constantly changes in relation to air flow. The angle of attack between the velocity of the ball and its pitch is also subject to continuous change as the ball rotates. Angle of attack, and cross-sectional area are both important determinants of the ball's aerodynamic coefficients and were accounted for in the model.

A SolidWorks model (size of Gilbert 'Match XV') was used to determine the frontal area by projecting the body onto planes from 0° to 90° relative to the longitudinal axes in interval steps of 10°. The results were imported to Matlab's curve-fitting-tool to create a continuous function to allow the calculation of frontal area at each time step through flight.

The model used published aerodynamic coefficients taken from wind tunnel studies on rugby balls at different angle of attack to the airflow (Seo et al. 2004, plus Djamovski et al. 2012).

The aerodynamic forces of drag (F_D) and lift (F_L) are proportional to the balls 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.

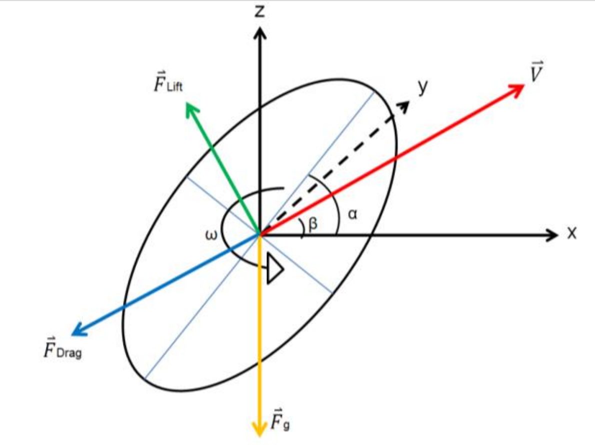

Figure 2. A free body diagram for the rugby ball trajectory model showing the aerodynamic drag and lift forces.

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 are 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.

Rugby Trajectory Model Validation

The model was validated by comparing the computational output to an actual measured rugby ball trajectory. In his PhD thesis, Holmes (2008) created a kicking machine to investigate the flight distance and time of flight for different rugby balls in an indoor aircraft hangar (to avoid the influence of wind). Holmes also accurately measured the launch conditions from his kicking machine using high speed video.

The launch conditions measured by Holmes were used as inputs to the trajectory model and the predicted flight distance and time of flight were calculated. The model calculations were found to be very close to the measured trajectory and the model was deemed to be accurately validated.

	Holmes (2008) measured flight data	Trajectory model calculated flight data
Distance (m)	56.8	58.3
Time of flight (s)	3.70	3.74

Table 1. Validation of the trajectory model by comparison to measured flight data

Rugby Kick Scenarios (relevant to this site)

This report will consider various different reasonable worst case trajectory scenarios for the pitch. In the game of Rugby League, the ball can be kicked in various directions and with a range of velocities. Nonetheless, some trajectories are far more common than others. This trajectory assessment uses a proportionate approach by focusing on the common trajectories to determine the most likely scenarios where a ball may surpass the site boundary.

Labosport has significant experience and expertise in rugby and provides technical support to Rugby Football League, World Rugby, and the RFU. Labosport have drawn on their expertise to define trajectory scenarios where the ball may be kicked on a trajectory that surpasses the site boundary.

Conversion/penalty kicks

Numerous researchers have measured the ball launch dynamics in rugby conversion/penalty kicks using high speed video techniques or Doppler radar speed guns. Table 2 shows a summary of ball launch conditions as reported in six different peer reviewed scientific journal publications. Of these studies, the work of Holmes *et al* (2006) is the most comprehensive for professional players, and the work of Sinclair *et al* (2014) is the most comprehensive for amateur players.

	Participants	2D/3D Data	Ball velocity (m/s)	Launch angle (°)	End-over-end spin (°/s)
Ball (2010) *	7 professionals	2D	25.2 ± 4.0	36 ± 3	
Bezodis et al. (2007)	5 amateurs	3D	24.5 ± 1.0	35	
Holmes et al. (2006)	14 professionals	2D	26.4 ± 3.0	30 ± 4	1440 ± 252
Linthorne & Stokes (2014)	1 amateur	2D	26.2 ± 1.7	31 ± 5	
Sinclair et al. (2014)	20 amateurs	3D	26.6 ± 1.6	34 ± 2	
Zhang et al. (2012)	7 amateurs	3D	17.8 ± 2.5		

* The studied participants were Rugby League players

Figure 3. A summary of ball launch conditions as reported in six peer reviewed scientific journal publications.

A reasonable worst-case scenario has been identified as a player attempting to score a conversion/penalty is 15 metres from the try line, and directly in front of the goal posts. This scenario is a plausible game event and represents the maximum ball trajectory risk. The relevant ball velocity for this site is 26 m/s and a launch angle of 34°.

Note that for this specific site, a conversion/penalty kick on the senior full size rugby league pitch does not present a risk to the site boundaries; however, a risk is apparent on the junior pitch.

Junior conversion/penalty kicks

No peer-reviewed published data is available on youth rugby and ball kick velocities; however, by comparing the difference between youth and adult soccer ball velocities, a reasonable approximation of how ball speed reduces with age can be made. The table below defines the findings collated from the study into 'Kicking Performance in Young U9 to U20 Soccer Players: Assessment of Velocity and Accuracy Simultaneously'. (Luiz H. P. Vieira et al. (2018) Kicking Performance in Young U9 to U20 Soccer Players: Assessment of Velocity and Accuracy Simultaneously, Research Quarterly for Exercise and Sport, 89:2, 210-220).

Table 1. Mean ± standard deviation (95% confidence limits) for kicking performance variables according to age (n = 366).

	U9	U11	U13	U15	U17	U20
V_{ball} (km/hr^{-1})	48.54 ± 8.31[a, b, c, d] [42.96, 54.12]	57.87 ± 10.93[e, f, g, h] [55.32, 60.42]	66.70 ± 13[i, j, k] [63.81, 69.60]	76.92 ± 15.58[l] [73.90, 79.93]	81.35 ± 16.04[m] [77.74, 84.97]	98.74 ± 16.35 [90.55, 106.62]
V_{foot} (km/hr^{-1})	49.08 ± 5.16[a, b, c, d] [45.62, 52.55]	53.79 ± 7.25[e, f, g, h] [52.10, 55.48]	60.54 ± 8.77[i, j, k] [58.58, 62.49]	65.17 ± 10.43[l] [63.15, 67.19]	68.44 ± 11.83[m] [65.77, 71.10]	78.24 ± 9.49 [73.66, 82.81]
V_{ball}/V_{foot} ratio (a.u.)	0.99 ± 0.13[a, b, c, d] [0.90, 1.07]	1.07 ± 0.11[f, g, h] [1.05, 1.10]	1.1 ± 0.11[i, j, k] [1.07, .12]	1.18 ± 0.1[l] [1.16, 1.20]	1.19 ± 0.1 [1.16, 1.21]	1.26 ± 0.11 [1.21, 1.31]
LSL (m)	1.09 ± 0.14[a, b, c, d] [1.00, 1.18]	1.25 ± 0.14[e, f, g, h] [1.21, 1.28]	1.36 ± 0.19[k] [1.32, 1.40]	1.43 ± 0.23[l] [1.38, 1.47]	1.44 ± 0.2[m] [1.39, 1.48]	1.6 ± 0.14 [1.54, 1.67]
$D_{support-ball}$ (m)	0.33 ± 0.07 [0.28, 0.37]	0.3 ± 0.07[e, f, g] [0.29, 0.32]	0.34 ± 0.06 [0.33, 0.35]	0.34 ± 0.09 [0.33, 0.36]	0.34 ± 0.06 [0.33, 0.36]	0.35 ± 0.04 [0.32, 0.37]
MRE (m)	1.4 ± 0.49 [1.07, 1.73]	1.65 ± 0.6[f, g, h] [1.52, 1.79]	1.59 ± 0.59[i, j, k] [1.46, 1.72]	1.34 ± 0.48 [1.24, 1.43]	1.29 ± 0.5 [1.18, 1.40]	1.14 ± 0.35 [0.98, 1.31]
BVE (m)	1.26 ± 0.58 [0.87, 1.65]	1.47 ± 0.73[f, g, h] [1.31, 1.64]	1.30 ± 0.57 [1.17, 1.43]	1.18 ± 0.51 [1.08, 1.27]	1.17 ± 0.5 [1.06, 1.28]	1.05 ± 0.32 [0.90, 1.21]
ACUR (m)	1.93 ± 0.64 [1.50, 2.36]	2.25 ± 0.84[f, g, h] [2.06, 2.45]	2.09 ± 0.72 [1.93, 2.25]	1.81 ± 0.62 [1.69, 1.93]	1.77 ± 0.5 [1.63, 1.92]	1.57 ± 0.4 [1.38, 1.76]

Note. a = U9 × U13; b = U9 × U15; c = U9 × U17; d = U9 × U20; e = U11 × U13; f = U11 × U15; g = U11 × U17; h = U11 × U20; i = U13 × U15; j = U13 × U17; k = U13 × U20; l = U15 × U20; m = U17 × U20. Confidence limits = (lower, upper bound). V_{ball} = ball velocity; V_{foot} = foot velocity; V_{ball}/V_{foot} = ball velocity-to-foot velocity ratio; LSL = last stride length; $D_{support-ball}$ = distance between support foot and ball; MRE = mean radial error; BVE = bivariate variable error; ACUR = accuracy. Significance level of post-hoc comparisons: **V_{ball}** = [a, e] $p < .01$. [b, c, d, f, g, h, i, j, k, l, m] $p < .001$. **V_{foot}** = [i] $p < .05$. [a, m] $p < .01$. [b, c, d, e, f, g, h, j, k, l] $p < .001$. **V_{ball}/V_{foot} ratio** = [a, l] $p < .05$. [b, c, d, f, g, h, i, j, k] $p < .001$. **LSL** = [e, l, m] $p < .01$. [a, b, b, d, f, g, h, k] $p < .001$. **$D_{support-ball}$** = [e, f, g] $p < .01$. **MRE** = [i, k] $p < .05$. [f, h, j] $p < .01$. [g] $p < .001$. **BVE** = [g, h] $p < .05$. [f] $p < .01$. **ACUR** = [j, k] $p < .05$. [h] $p < .01$. [f, g] $p < .001$.

Figure 4 - Mean standard deviation for kicking performance variables according to age

<u>Kicking the ball into touch</u>

Within the game of rugby league, a ball may surpass a boundary when a player 'kicks the ball into touch' to achieve an attacking line out after a penalty. In this scenario, the ball is launched via a punt kick out of the hands.

A reasonable worst-case scenario has been identified as a player attempting to punt kick the ball into touch at a location of 10 metres inside the touch line, and at an angle of 45 degrees towards the opponent's goal. This scenario is a plausible game event and represents the maximum ball trajectory risk to the site boundary which can occur at any point on the boundary.

Pavely, Stuart et al (2010) analysed maximal punt kicks out of the hands from 10 professional rugby players. The mean measured distance of the kicks was 42 metres, and the mean launch angle was 18 degrees. This study determined a punt kick velocity of 28 m/s.

Section 8 – Trajectory Model Simulations

Trajectory simulation

The diagrams below shows a global view of the five different rugby ball trajectory scenarios that will be considered for the three pitches.

Figure 5. A global overview of the site with the five different trajectory scenarios identified for the Rugby pitches

Shot 1 – Rugby kick into touch – 21.87 metres to proposed mitigation location

The distance to the site boundary is **21.87 metres**. The trajectory model predicts that the rugby ball will have height **4.22** as it surpasses this boundary. Note this trajectory can take place anywhere along the touchline and the worst-case scenario will be chosen for mitigation.

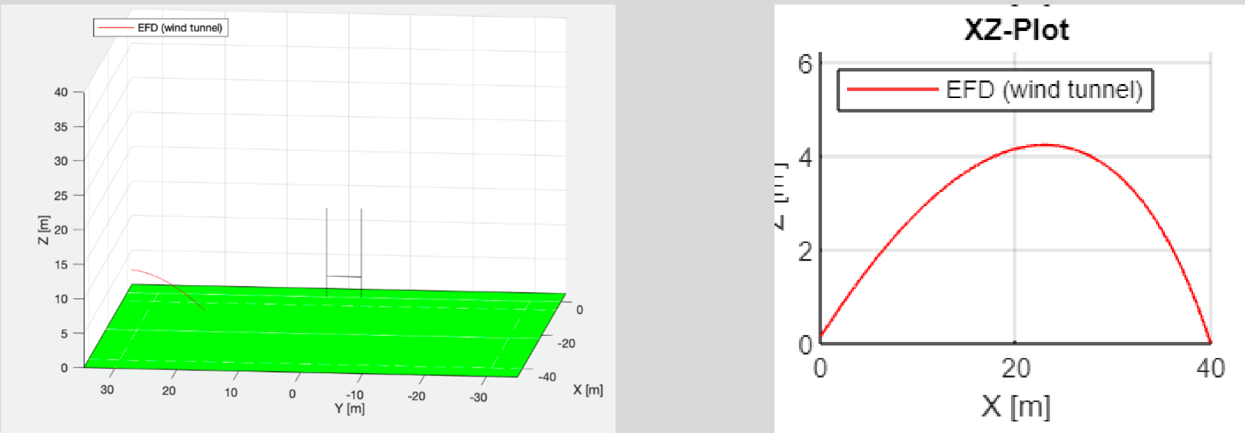

Figure 6 – Trajectory visualisation of a punt into the corner

Shot 2 – Rugby kick into touch – 42.77 metres to proposed mitigation location
The distance to the site boundary is **42.77 metres**. The trajectory model predicts that the rugby ball will have returned to the ground before it surpasses this boundary. Note this trajectory can take place anywhere along the touchline and the worst-case scenario will be chosen for mitigation.

Shot 3 –Conversion missing wide– 82.65 metres to proposed mitigation location.
The distance to the site boundary is **82.65 metres**. The trajectory model predicts that the rugby ball will have returned to the ground before it reaches the boundary.

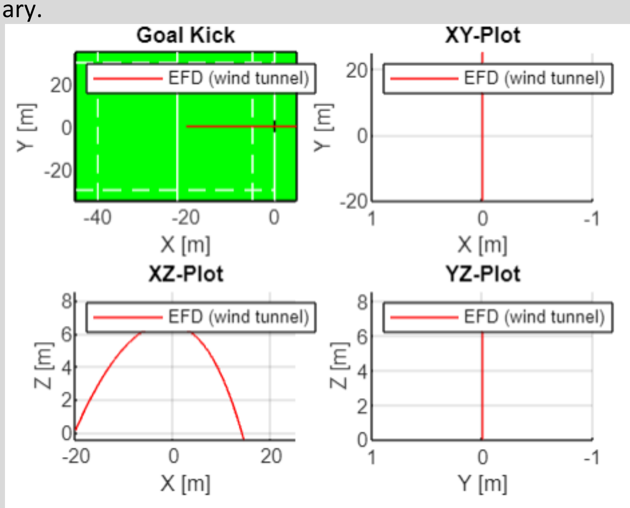

Figure 8 - Trajectory visualisation for an U18 Conversion kick.

Shot 4 - Rugby kick into touch – 33.6 metres to proposed mitigation location
The distance to the site boundary is **33.6 metres**. The trajectory model predicts that the rugby ball will have height **2.82 m** as it surpasses this boundary. Note this trajectory can take place anywhere along the touchline and the worst-case scenario will be chosen for mitigation.
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Shot 5 – Rugby kick into touch – 38.72 metres to proposed mitigation location
The distance to the site boundary is **38.72 metres**. The trajectory model predicts that the rugby ball will have a height of **0.685m** as it surpasses this boundary. Note this trajectory can take place anywhere along the touchline and the worst-case scenario will be chosen for mitigation.

Figure 9 – three extra trajectories were identified to have potential for ball strike issues on the existing pitches

Shot 6 - Rugby conversion Kick, Missing Wide – 71.43 metres to proposed mitigation location
The distance to the site boundary is **71.43 metres**. The trajectory model predicts that the rugby ball will have retuned to the ground before it surpasses this boundary.

Shot 7 – Rugby Conversion Kick – 67.16 metres to proposed mitigation location
The distance to the site boundary is **67.16 metres**. The trajectory model predicts that the rugby ball will have returned to the ground before it surpasses this boundary.

Shot 8 – Rugby kick into touch – 34.37 metres to proposed mitigation location against development or 8m to proposed mitigation location pitchside.
The distance to the site boundary is **34.37 metres**. The trajectory model predicts that the rugby ball will have a height of **2.64m** as it surpasses the housing development boundary with a **1m** change in elvation from the pitch to the housing development boundary. Note this trajectory can take place anywhere along the touchline and at any point on the field and the worst-case scenario will be chosen for mitigation. For the pitchside mitigation at **8 m** distance the trajectory of the ball is still rising and it can be assumed that shots from further away would surpass the mitigation recommendation for this distance therefore it is recommended that the maximum height mitigation be applied which is **5 m.**

Section 9 – Conclusions

Conclusions

This report has been prepared to assess the potential risk of cricket balls surpassing the boundaries of a cricket pitch and rugby balls suprassing the boundaries of the playing fields at land adjacent to Harpenden Road, St. Albans and advise on the height and location of mitigation recommended to provide a suitable level of protection.

Orientation	Recommended mitigation height (based on recreational cricket)	Recommended mitigation height (based on adult rugby)
North	0 m	0 m
East	0 m	3 m
Southwest	0 m	4.5 m
West	0 m	4.5 m

For the existing pitches the below mitigation is recommended.

Orientation	Recommended mitigation height (based on mitigation location Pitchside)	Recommended mitigation height (based on mitigation location adjacent to housing development)
South	4.5 m	4 m

Please Note: This may not stop all shots from landing beyond the site boundary, but it is believed from the assessment of the ball trajectory it will significantly reduce their frequency.

The below diagram shows the proposed locations of the recommended mitigation for heights detailed above for adult rugby but there is no recommended mitigation for cricket:

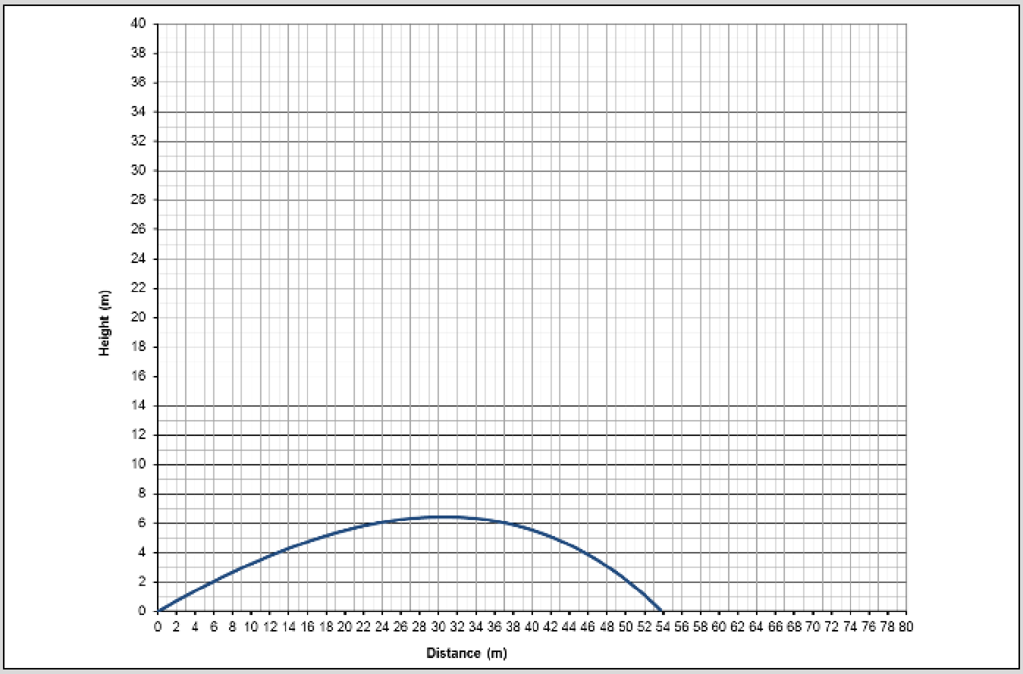
For New Pitches

Pitchside

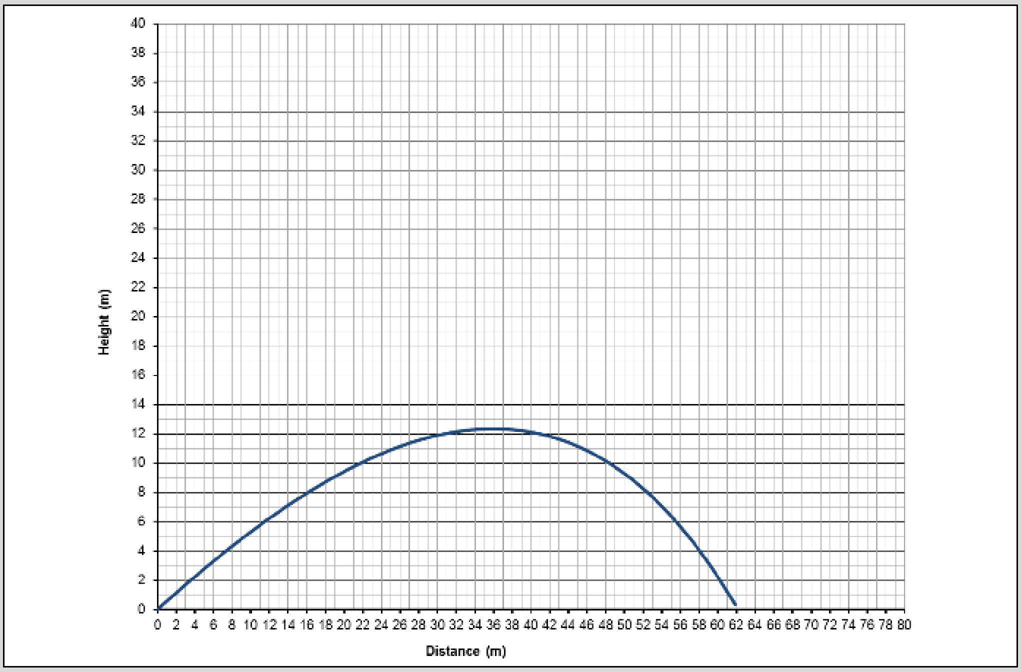
Housing Development

Appendix A – Typical Example Trajectories

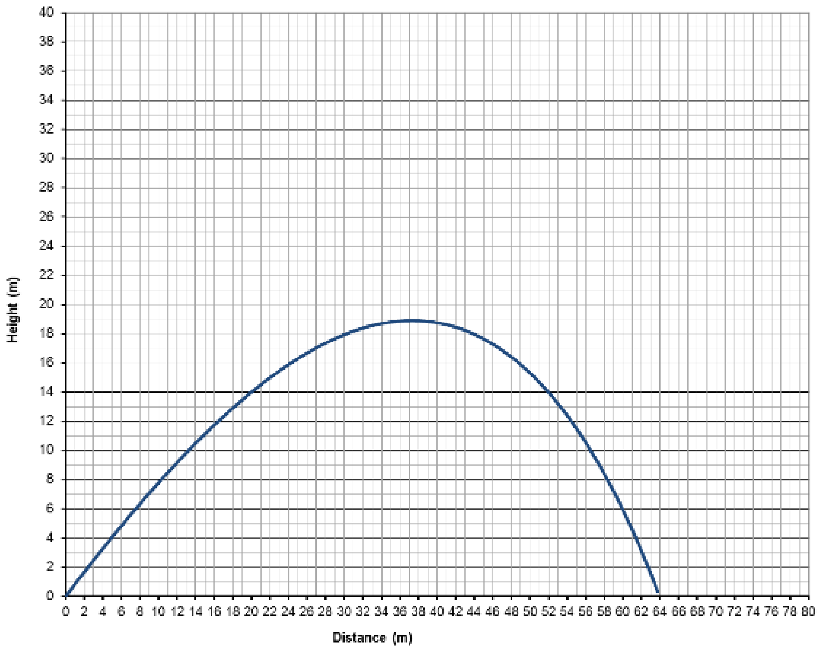
20 ° @ 40 m/s



30 ° @ 40 m/s



40 ° @ 40 m/s


Height (m)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 68 70 72 74 76 78 80
Distance (m)

Appendix B – Larger Mititgation Diagrams


110m @ 4m High