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PUMP TRACK ADJACENT TO FOOTBALL PITCHES AT LONGRIDGE RECREATION GROUND

FOOTBALL BALL STRIKE ASSESSMENT

LABOSPORT

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BALL STRIKE ASSESSMENT– PUMP TRACK – LONGRIDGE RECREATION GROUND

CLIENT	Ribble Valley Council
SITE ADDRESS	43 Kestor Ln, Longridge, Preston PR3 3JU
CLIENT CONTACT	Mark Beveridge

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REPORTED BY	[redacted]	[redacted] Special Projects Consultant
APPROVED BY		[redacted] Consultant

INTRODUCTION	To assess the potential risk of footballs surpassing the boundaries of a football pitch at the playing fields at Longridge Recreation Ground, Labosport Ltd has reviewed the site distances and topography to analyse the risk of balls surpassing the site boundaries. The analysis uses a football trajectory model that has been developed by Labosport. 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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LABOSPORT LTD
Unit 3 Aerial Way, Hucknall, Nottinghamshire, NG15 6DW
+44 (0) 115 968 1998
info@labosport.co.uk

Section 1 – Executive Summary of Conclusions

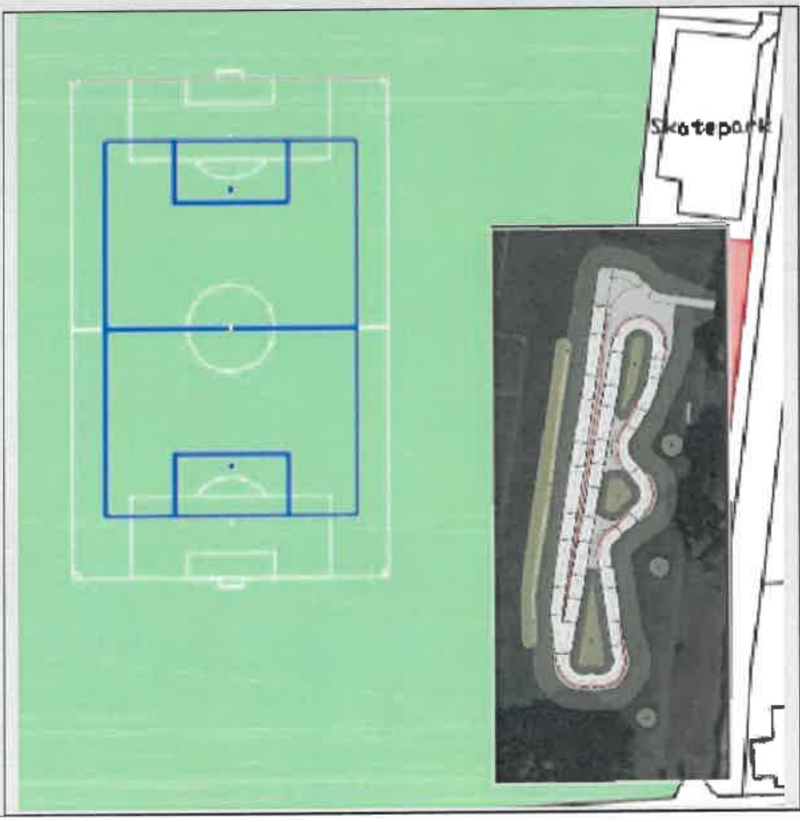
Executive Summary of Conclusions

This report has been prepared to assess the potential risk of footballs surpassing the boundaries of a football pitch at the playing fields at Longridge Recreation Ground and advise on the height and location of mitigation recommended to provide a suitable level of protection.

Orientation	Recommended mitigation height (based on U11s football)
East	0 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 recommended mitigation for this site:



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Section 2 –Football Trajectory Model

Football Trajectory Model Overview

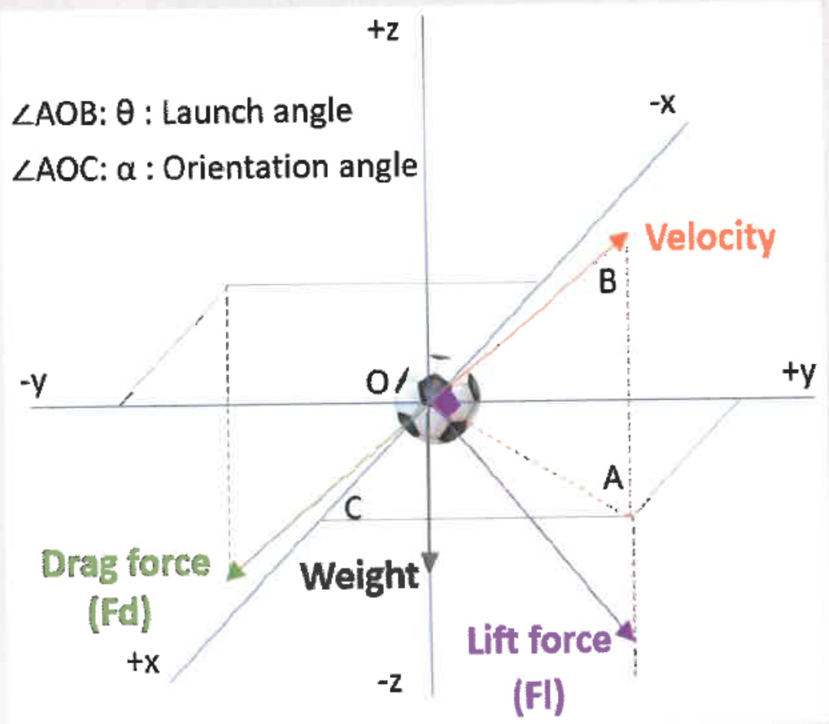
A sophisticated three-dimensional trajectory model was developed to analyse the trajectory of the football ball. The model was built in the numerical programming software 'Matlab' and incorporated aerodynamic drag and lift forces, and the complexities arising from the ball's spin rate.

The model used published aerodynamic coefficients taken from wind tunnel studies on football balls at different kick velocities (Asai, T., Seo, K., Kobayashi, O. *et al.* Fundamental aerodynamics of the soccer ball. Sports Eng 10, 101–109).

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:

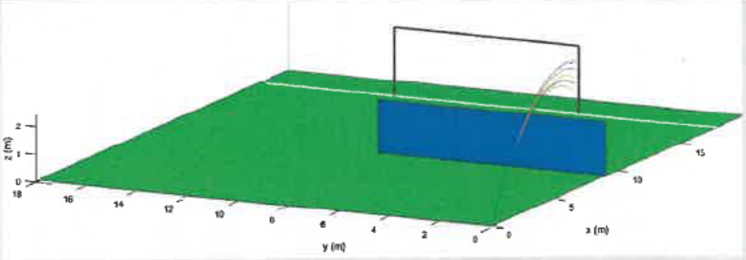
$$F_D = \frac{1}{2} C_D \rho V^2 A$$
$$F_L = \frac{1}{2} C_L \rho V^2 A$$

with C_D and C_L are the non-dimensional drag and lift coefficients, ρ the air density in kg/m³, V the air stream velocity in m/s and A the frontal area of the ball in m².



A free body diagram for the football 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.



An example of a trajectory simulation from the Matlab model.

Trajectory models are known 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.

Football Kick Scenarios

In the game of football, the ball can be kicked in any direction with a wide range of velocities. Nonetheless, some trajectories are far more common than others. This risk 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 football and provides technical support to the world's national governing bodies (e.g. the FA, FFF, KNVB etc) as well as to FIFA. Labosport have drawn on their expertise to define four different in game scenarios where the ball may be kicked on a trajectory that surpasses the site boundary.

For each kick scenario, a reasonable initial speed is determined, and the trajectory is simulated for a range of different launch angles (25 degrees to 35 degrees).

Football Kick Velocities

In the game of football, the ball can be kicked with a wide range of velocities (speeds and angles). Nonetheless, previous researchers have made accurate measurements of ball speeds and spin rates using high speed video and similar technologies. The table below summarises maximal kick velocities from three different studies (taken from; Sterzing, Thorsten, and Ewald M. Hennig. "The influence of soccer shoes on kicking velocity in full-instep kicks." Exercise and Sport Sciences Reviews 36.2 (2008): 91-97).

TABLE 1. Maximum resultant ball velocity achieved with selected kicking techniques.

Study/Authors	Kicking Technique	Maximum Ball Velocity (ms^{-1})	SD (ms^{-1})	Subject Characterization
Levanon and Dapena (1998) (15)	Full-instep	28.6	2.2	Intercollegiate players, n = 6
	Side-foot	22.5	1.8	
Nunome et al. (2002) (18)	Full-instep	28.0	2.1	High school players, n = 5
	Side-foot	23.4	1.7	
Neilson and Jones (2005) (17)	Full-instep	27.1	2.2	Professional club players, n = 25
	Inner-instep	23.5	2.3	
	Outer-instep	20.9	3.1	

Maximum resultant ball velocity achieved with selected kicking techniques overview

We also have to consider the level of play and age when considering velocities. 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]
$D_{support\text{-}ball}$ (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 ± 0.64[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; $D_{support\text{-}ball}$ = 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] $p < .001$. $D_{support\text{-}ball}$ = [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] $p < .001$.

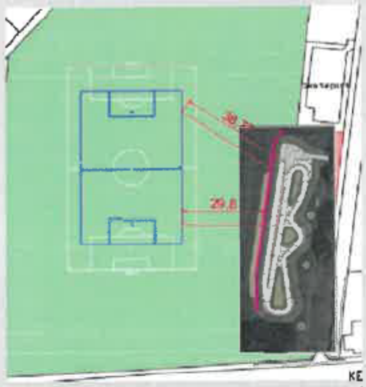
Mean standard deviation for kicking performance variables according to age

We have been informed that the maximum age of play on this site will be U11s football. A worst case scenario of U11s level football was used for this assessment, therefore a maximal kick velocity of 16.08 m/s with a spin rate of 40 rad/s was used.

Section 3 – Trajectory Model Simulations

Trajectory simulation

The diagram below shows a global view of the four different football trajectory scenarios that will be considered for the Football pitches.



A global overview of the site with the different trajectory scenarios identified for the football pitches

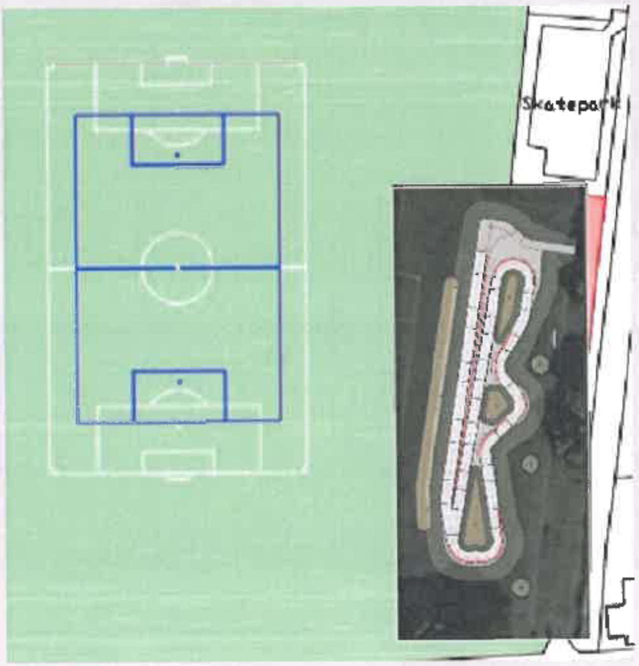
Trajectory 1 – a penalty missing the goal wide – 38.77 metres to proposed mitigation location. (16.08 m/s ball speed)

Kick launch angle (degrees)	20	25	30	35
Predicted trajectory height as ball intersects boundary (m)	*2.73*	*4.39*	*6.01*	*7.51*

Trajectory 2 – a shot across the face of goal – 29.8 metres to proposed mitigation location. (16.8 m/s ball speed)

Kick launch angle (degrees)	20	25	30	35
Predicted trajectory height as ball intersects boundary (m)	*2.81*	*4.46*	*6.07*	*7.60*

Section 4 – Discussions and Conclusions

Discussions and Conclusions
This report has been prepared to assess the potential risk of balls surpassing the boundaries of a the playing fields at Longridge Recreation Ground and to advise on the mitigation recommended to provide a suitable level of protection. The exact frequency of events resulting in a football ball being kicked into the adjacent area 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 these users. In reality, there may be a "freak" kick 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. In consideration of the risks posed by the simulated Football ball trajectories in relation to the context of the location, this report recommends the below mitigation. 

Section 5 - References

References
Asai, T., Seo, K., Kobayashi, O. *et al*. Fundamental aerodynamics of the soccer ball. Sports Eng 10, 101–109 Sterzing, Thorsten, and Ewald M. Hennig. "The influence of soccer shoes on kicking velocity in full-instep kicks." Exercise and Sport Sciences Reviews 36.2 (2008): 91-97 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