Mandurah greyhound track upgrade
Report 4 – Review of track Designs 1 and 2

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For Racing and Wagering Western Australia

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Executive summary

This is the fourth report in a series of reports prepared by UTS for Racing and Wagering Western Australia.

The purpose of this Report was to review two proposed designs for the Mandurah greyhound track[1].

Two different designs were evaluated. These designs were:

- Design 1: 70 m bends, 50 m transitions, 7 m wide; and
- Design 2: 69 m bends, 60 m transitions, 7 m wide.

Both of these designs will reduce the average long-term frequency and severity of injuries at the Mandurah greyhound track.

Notwithstanding, there are a number of potential track designs that could reduce the average long-term frequency and severity of injuries at the Mandurah greyhound track.

Section 5.1, Table 1 of this Report lists several optimum combinations of track radii and transition lengths that Racing and Wagering Western Australia may wish to evaluate in more detail.

For both Designs 1 and 2 drop-on boxes should be considered as an intervention for increasing the turning radius for selected racing distances.

[1]The design beyond the Finish Post will be reviewed after a track design is accepted in principle.

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1 Introduction

1.1 General

This is the fourth report in a series of reports prepared by UTS for Racing and Wagering Western Australia (RWWA).

Mandurah track is located at Kanyana Park, approximately 65 km south of Perth in close proximity to the majority of greyhound trainers. The existing track has four starts, namely: 302 m, 405 m, 490 m and 647 m.

1.2 Design constraints

UTS was instructed to consider the following design constraints:

- The Finish Post (0 m) remains in line with the existing infrastructure;
- The following approximate racing distances: 302 m, 400 m, 487 m and 700 m[2];
- New battery powered lure from Steriline;
- New inside rail to suit battery powered lure;
- New plinths inside and outside;
- New outside fence; and
- New compressed air line for each of the starting boxes.

[2]The 700 m start is necessary so that the Nationals can be conducted at the new racing facility.

2 Existing track

To benchmark the proposed designs a review of the existing track design was initially conducted. This bench-marking allowed the existing track to be used as a control for the two designs being evaluated.

2.1 Existing track: Track shape

Figure 1 is the David Allan Consulting Engineer Pty Ltd *laser grading* plan of the existing Mandurah greyhound track dated 4 February 2021.

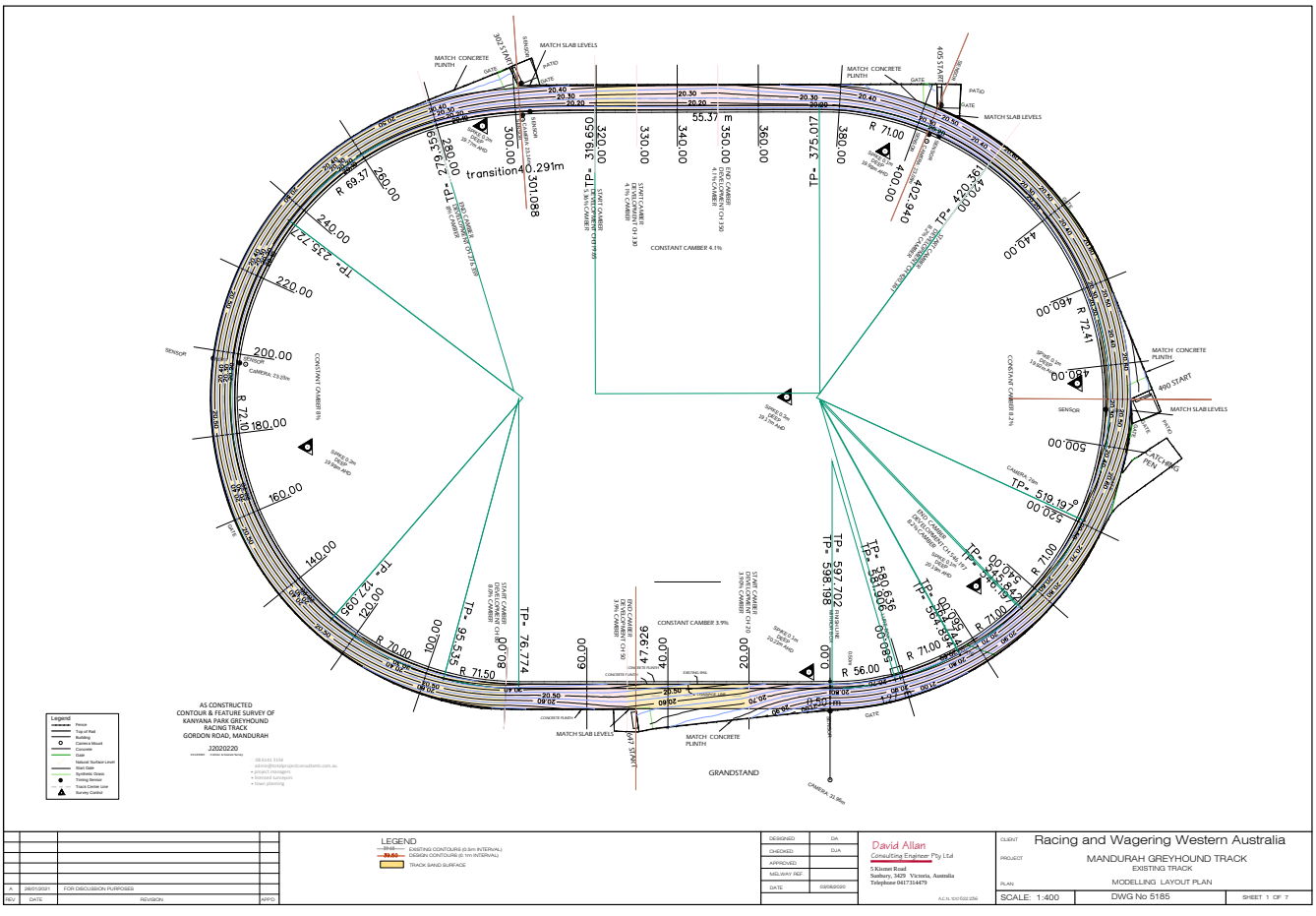

Figure 1: Existing Mandurah greyhound track David Allan Consulting Engineer Pty Ltd *laser grading* plan (4 February 2021).

2.2 Existing track: Curvature for each starting distance

Figure 2 shows a plan view of the Mandurah greyhound track with fundamental track dimensions and the curvature lines. As can be seen from this diagram there is almost no smooth transition from the home straight to the bend after the Finish Post and from this bend and into the Back Straight.

The length of the transition from the Back Straight to the Southern Turn is approximately 40 m as depicted by the red curvature lines in Figure 2.

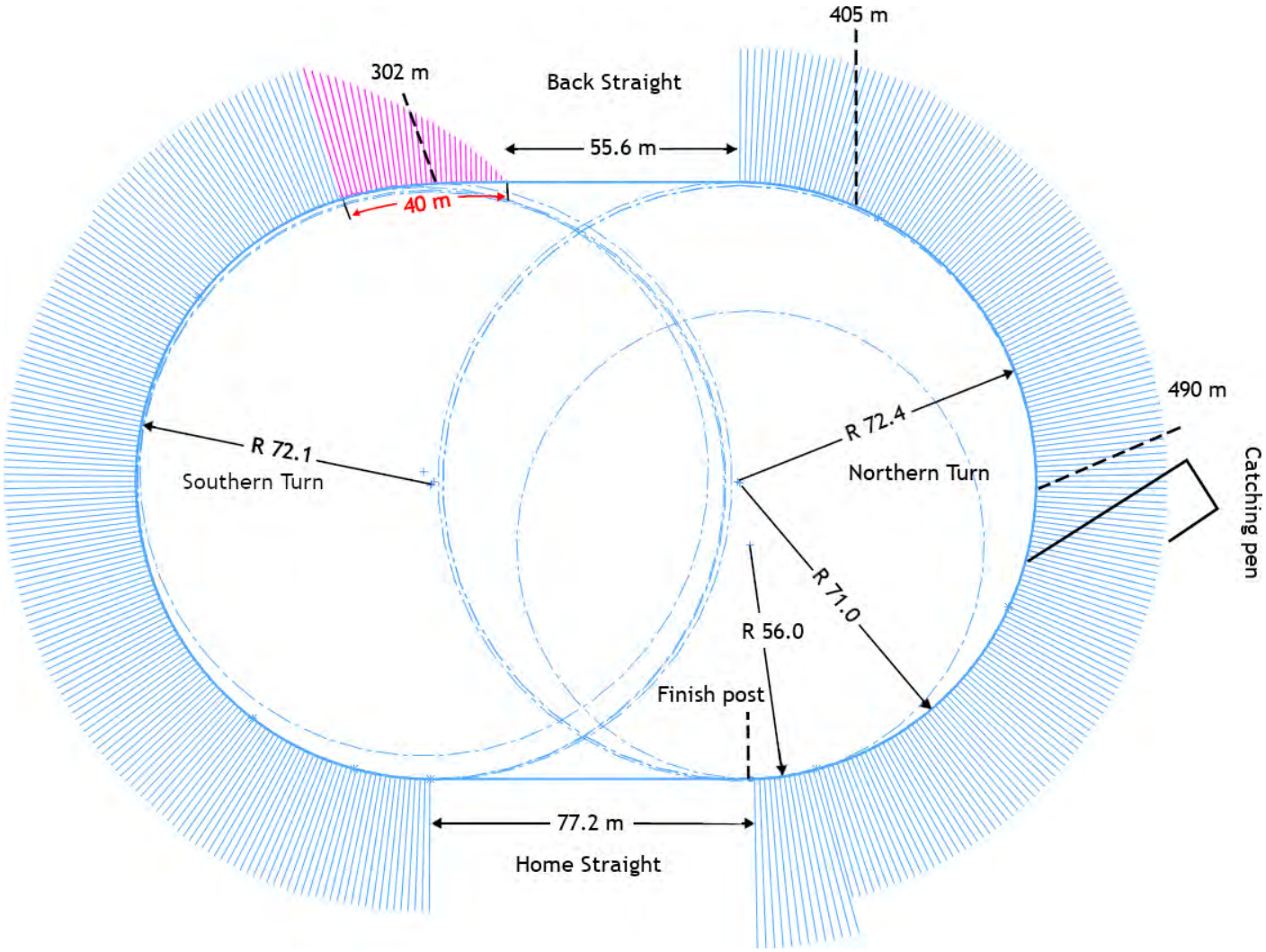

Figure 2: The existing Mandurah greyhound track curvature line plot. The lengths of the perpendicular blue and red lines are inversely proportional to the magnitude of the radius of curvature calculated 1 m perpendicular from the inner rail. This plot also depicts the transition (with red curvature lines) between the Back Straight and the entrance to the Southern Turn. More importantly, it depicts the lack of any meaningful transitions into or out of the Northern Turn and out of the Southern Turn.
Source: David Allan Consulting Engineer Pty Ltd *laser grading* plan (see Figure 1).

The curvature plots for 302 m, 405 m and 490 m starting distances versus track distance measured from the respective starting boxes for the Mandurah track are given in Figure 3. In the curvature plot figure the bends can be seen to have the highest curvature values while straight track segments have zero curvature values. Most importantly, the curvature plots show a non-uniform rate of change of curvature for bend entrance and exit track segments where the duration for bend exit is relatively shorter. The curvature plot data also show smaller turning bend radius from the track bend radius of approximately 72 m at the bend entrance and exit as can be seen from higher curvature values for these track segments. This increase is associated with the average greyhound deviating from the respective running trajectory.

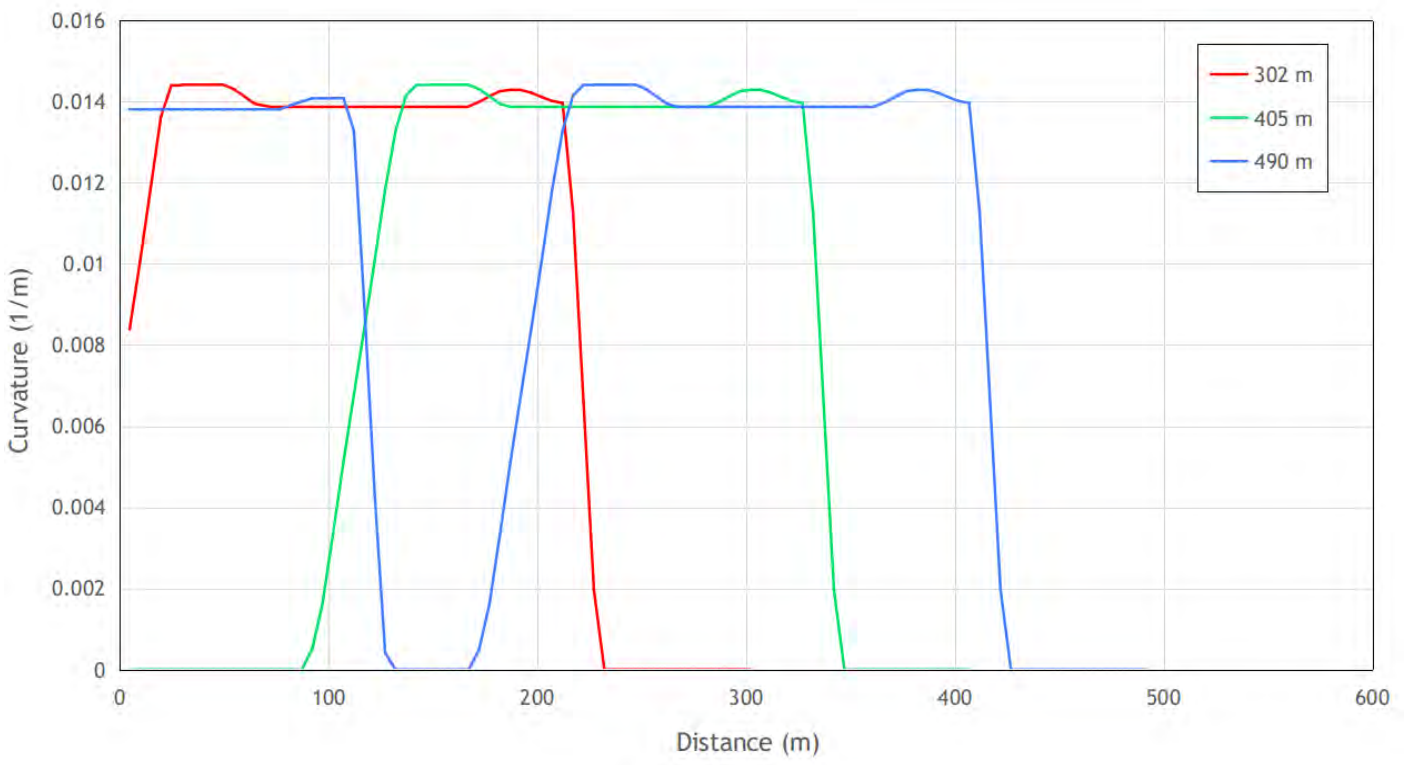

Figure 3: The curvature plots for 302 m, 405 m and 490 m starting distances at Mandurah track. The plots commence at the respective Starting Boxes and end at the Finish Post.

2.3 Existing track: Centrifugal acceleration for each starting distance

The magnitude of centrifugal acceleration for 302 m, 405 m and 490 m starting distances versus track distance measured from the respective starting boxes for the Mandurah track is given in Figure 4.

For the 302 m distance (red plot), the initially low centrifugal acceleration increases rapidly as the greyhounds enter and negotiate their way around the bend where it reaches a peak of 5.3 m/s^2. As they exit the bend the centrifugal acceleration drops rapidly to zero as they enter the home straight.

The initial centrifugal acceleration for 405 m distance (green plot) is effectively zero as the exit the boxes and gallop along the back straight. The centrifugal acceleration increases sharply and reaches a peak of 5.5 m/s^2 as they negotiate their way around the first bend. As they exit the bend the centrifugal acceleration drops rapidly to zero as they enter the home straight.

The 490 m distance (blue plot) rises rapidly to a peak of 5.4 m/s^2 as they exit the boxes. As they exit the bend the centrifugal acceleration drops rapidly to zero as they enter the back straight. By the time the greyhounds reach the second bend they have slowed down a little and this leads to them experiencing a lower maximum and average centrifugal acceleration on the second bend. The centrifugal acceleration drops rapidly as they exit the bend and enter the home straight where the centrifugal acceleration drops to zero.

Finally, it is worth noting that for the 302 m and 490 m starting distances the centrifugal acceleration for the first 100 m of the race is essentially the same.

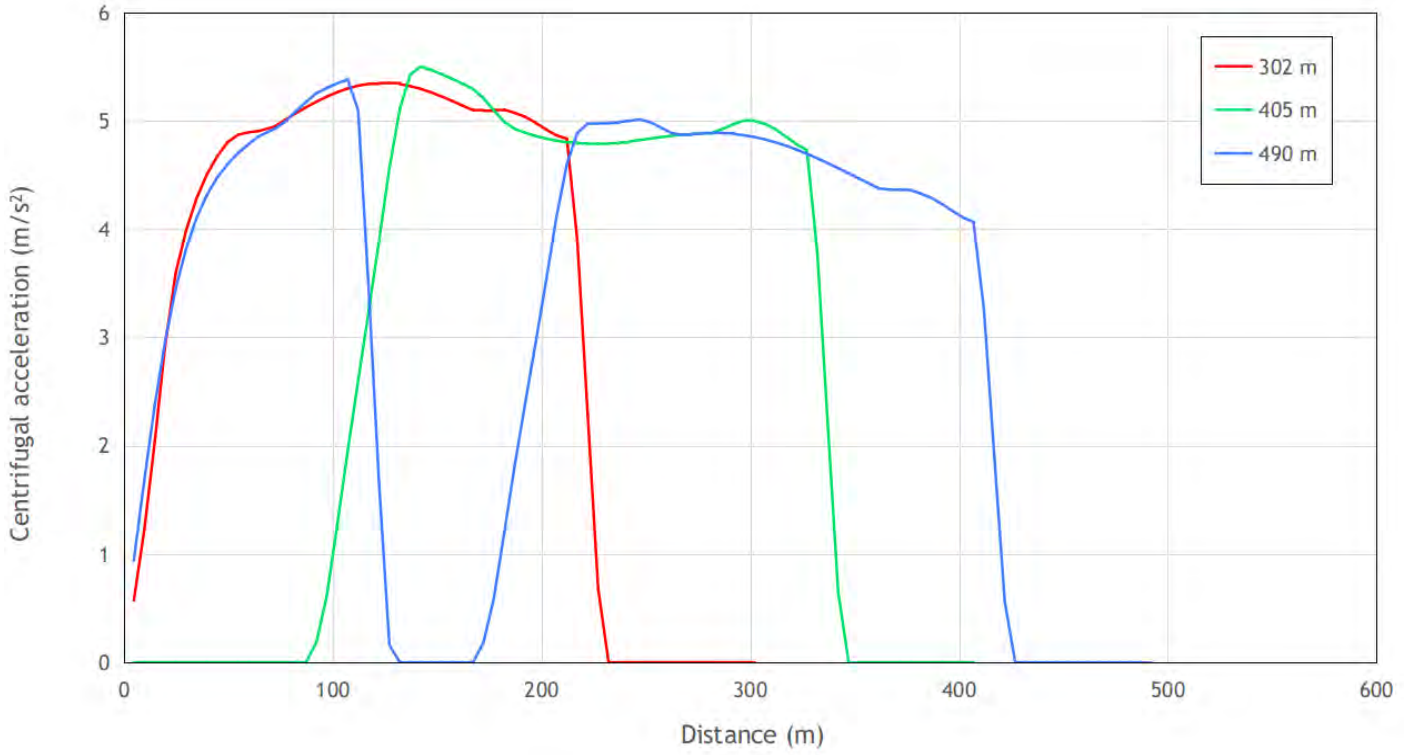

Figure 4: The centrifugal acceleration for 302 m, 405 m and 490 m starting distances at Mandurah track. The plots commence at the respective Starting Boxes and end at the Finish Post.

2.4 Existing track: Jerk for each starting distance

The jerk for 302 m, 405 m and 490 m starting distances versus track distance measured from the respective starting boxes for the Mandurah track is given in Figure 5.

The 302 m distance (red plot) is high at the start as the greyhounds exit the boxes and immediately enter the bend. This is not ideal as they are experiencing their maximum linear acceleration as they accelerate from zero to more than 18 m/s over a very short distance while also experiencing changing high magnitude of centrifugal acceleration. The jerk_{max} of approximately –6 m/s^3 occurs as the greyhounds exit the bend.

The 405 m distance (green plot) has an acceptable jerk as the greyhounds enter the first bend with a peak of under 3 m/s^3. As the greyhounds exit the bend they experience jerk_{max} of approximately –6 m/s^3.

The 490 m distance (blue plot) is high at the start as the greyhounds exit the boxes and immediately enter a bend. They experience a jerk_{max} as they exit this bend of more than –6 m/s^3. Along the back straight the jerk is effectively zero. As they enter the bend at the end of the back straight they experience an extended but nevertheless acceptable jerk of approximately 2 m/s^3. As they exit the second bend they experience another jerk_{max} of approximately –5 m/s^3.

For all racing distances at the Mandurah greyhound track the jerk_{max} is higher than the minimum recommended value of 4 m/s^3 and well short of the preferred 'greenfield' track design value of 2 m/s^3.

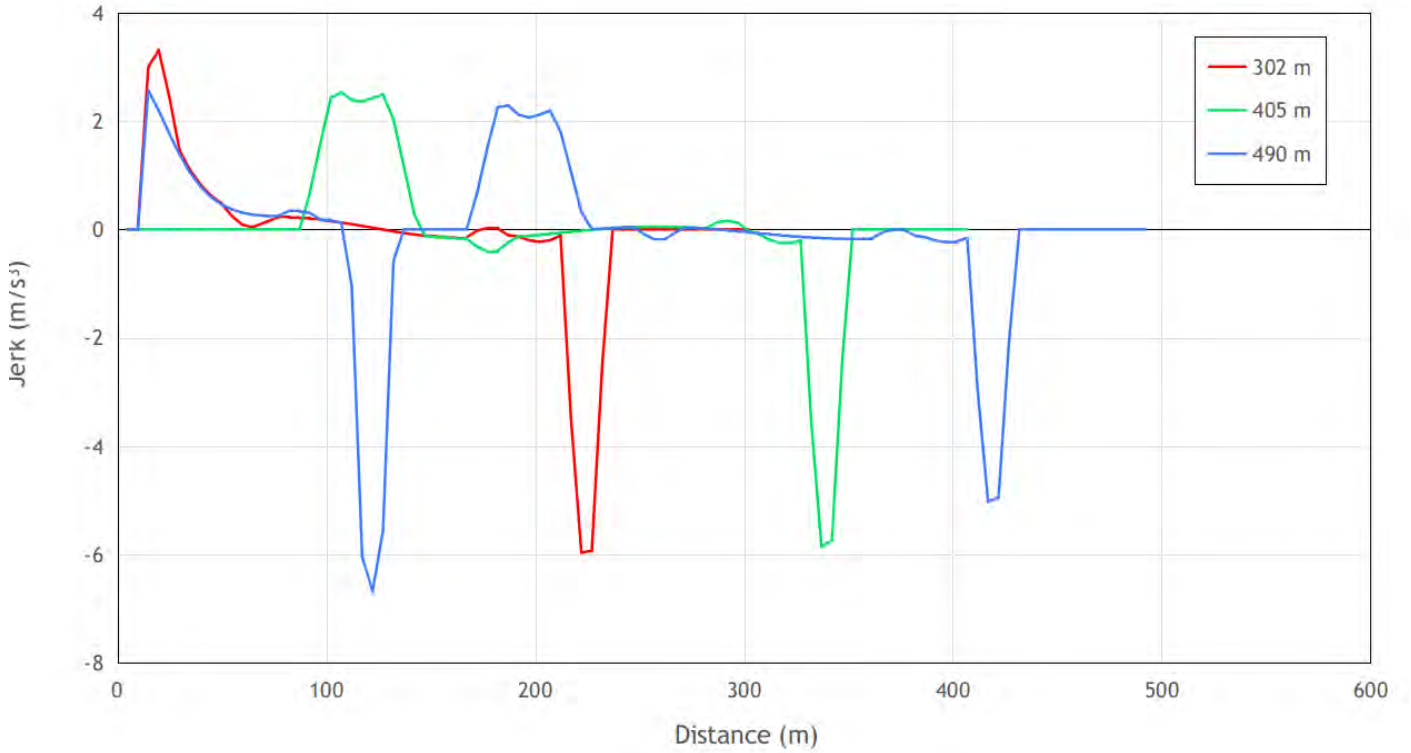

Figure 5: The jerk for 302 m, 405 m and 490 m starting distances at Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

2.5 Existing track: Starting box simulations

Figures 6 to 9 show a simulated greyhound path of a single greyhound and corresponding turning tendency for the 302 m, 405 m, 490 m and 647 m starting box locations and alignments. As can be seen from the turning tendency sequence denoted by the perpendicular arrows, there is no abrupt change in greyhound turning tendency for all race distances and box locations. Furthermore, the most intense turning tendency was observed for 302 m, 490 m and 647 m starting box locations and alignments.

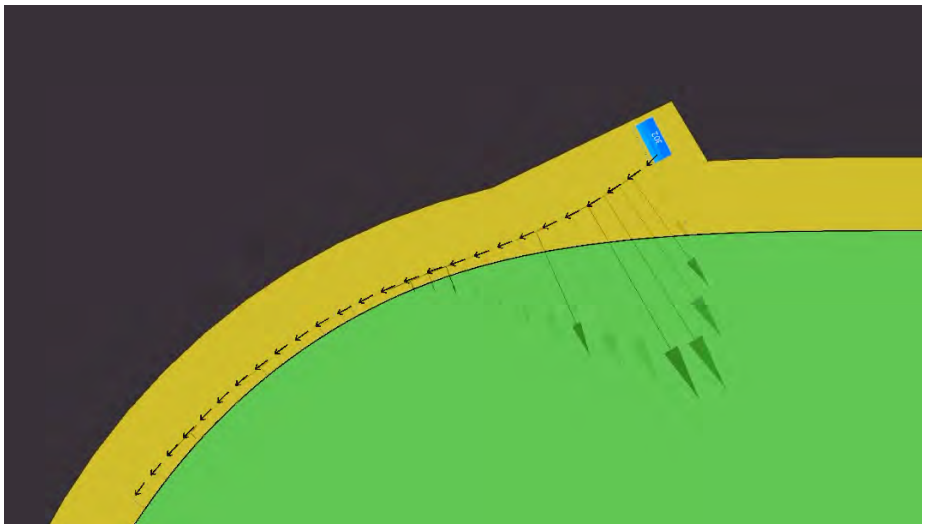

Figure 6: Simulation of greyhound path for the 302 m starting distance at Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

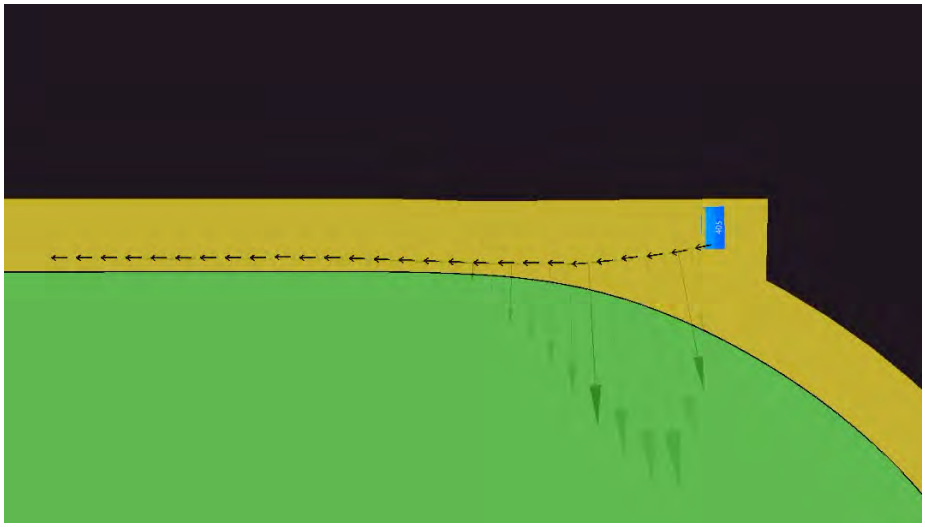

Figure 7: Simulation of greyhound path for the 405 m starting distance at Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

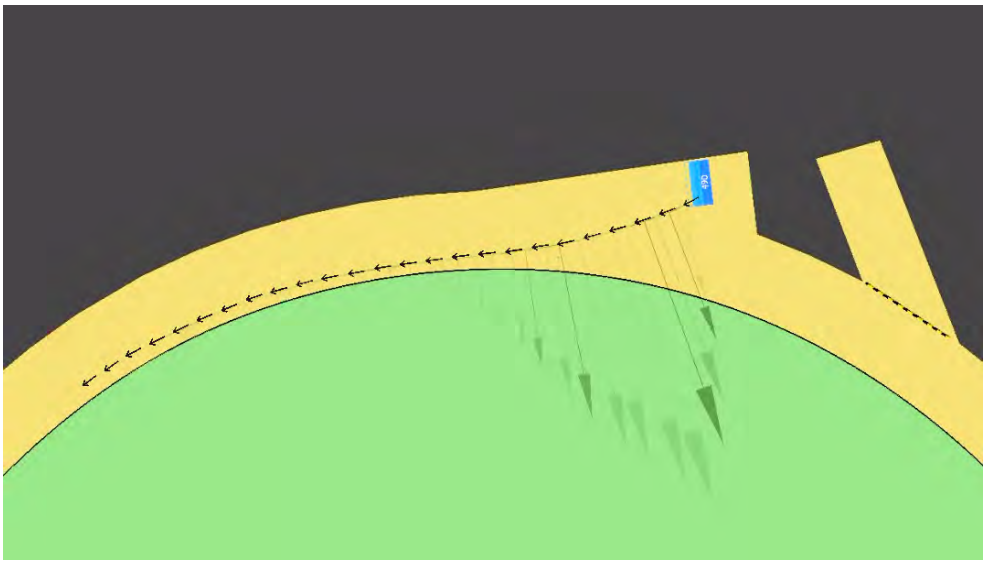

Figure 8: Simulation of greyhound path for the 490 m starting distance at Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

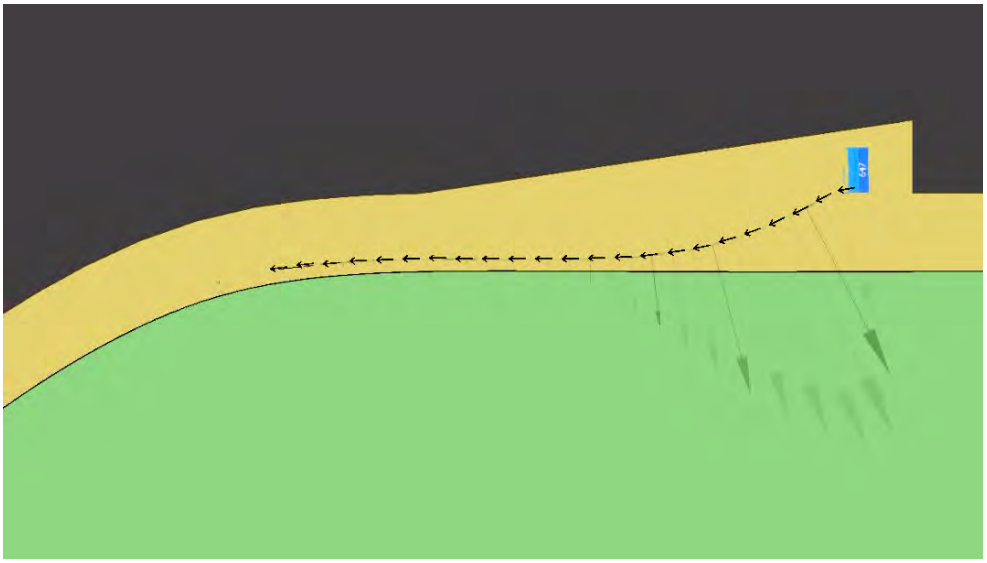

Figure 9: Simulation of greyhound path for the 647 m starting distance at Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

Figure 10 depicts turning radius versus run distance of a greyhound for the 302 m, 405 m, 490 m and 647 m starting box locations and alignments. The plots provide an insight with respect to the small turning radius the racing greyhound has to make when moving from boxes to the track. The 647 m distance starting box location exposes the greyhound to a turning radius which is less than 50 m. This tight radius occurs between 9 m and 19 m with a minimum at approximately 14 m from the box[3]. The 302 m, 405 m and 490 m starting box locations and alignments had similar turning radius performance for up to a distance of around 24 m from the respective boxes where the smallest turning was observed for 302 m box location and alignment of about 50 m radius. As can be seen from the figure, 302 m, 490 m and 647 m race distance alignments currently existing at Mandurah track expose the greyhounds to a much lower turning radius than the track bend radius of approximately 71 m.

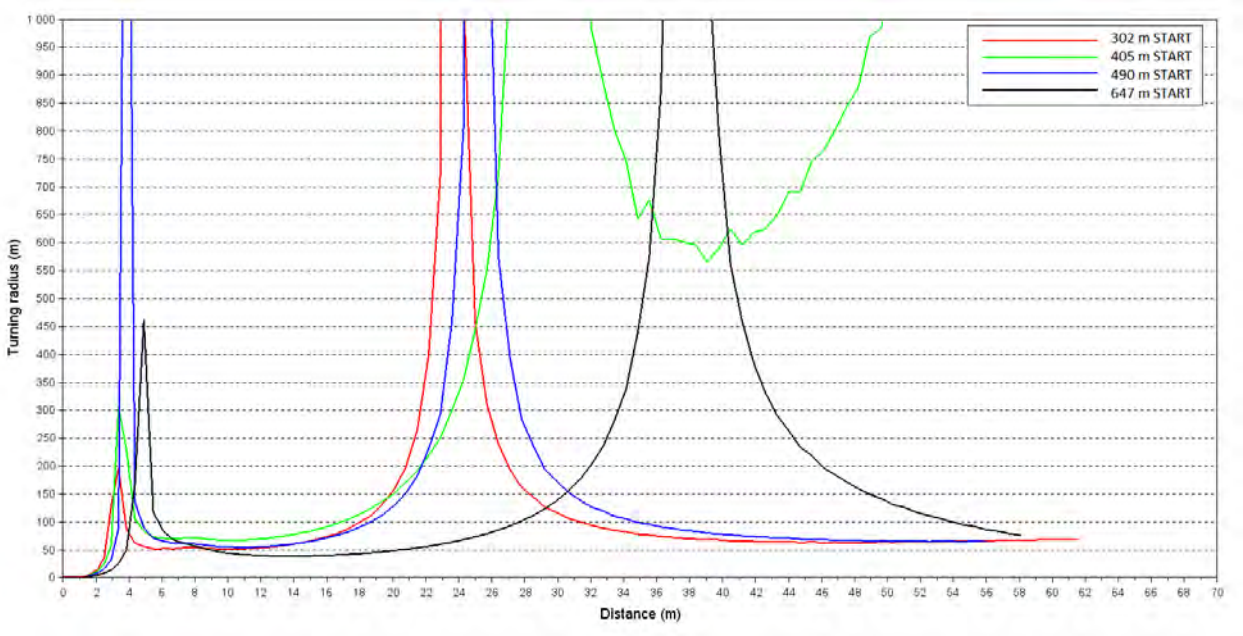

Figure 10: Greyhound turning radius for 302 m, 405 m, 490 m and 647 m starting distances at Mandurah track. The plots commence at the respective Starting Boxes.

[3]The negative effects associated with this centrifugal force on this 10 m long tight radius are moderated by the lower velocity of the greyhounds at the start of of the race.

Figure 11 illustrates yaw rate (rad/s) plotted against the distance out of the box for the 302 m, 405 m, 490 m and 647 m starts. For all race distances starting box locations and alignments showed a continuous turning where the peak turning occurred from around 6 m to 14 m for the 302 m, 405 m, and 490 m start distances, and 9 m to 22 m for the 647 m start distance. The 302 m required minimum initial turning of about 1.76 rad/s and after that, the greyhound yaw rate went through a 0.6 rad/s change over the 44 m run distance. For the 405 m and 490 m distances starting box alignments, the initial yaw rate was considerably more than that of 302 m where after the initial turning phase the greyhound yaw rate went through 0.29 rad/s and 0.58 rad/s changes respectively. The 647 m distance box alignment had the highest instantaneous yaw rate as well as an overall yaw rate change of about 4.1 rad/s and 0.67 rad/s respectively. Finally, among all the distances box alignments 405 m distance was found to be most optimal.

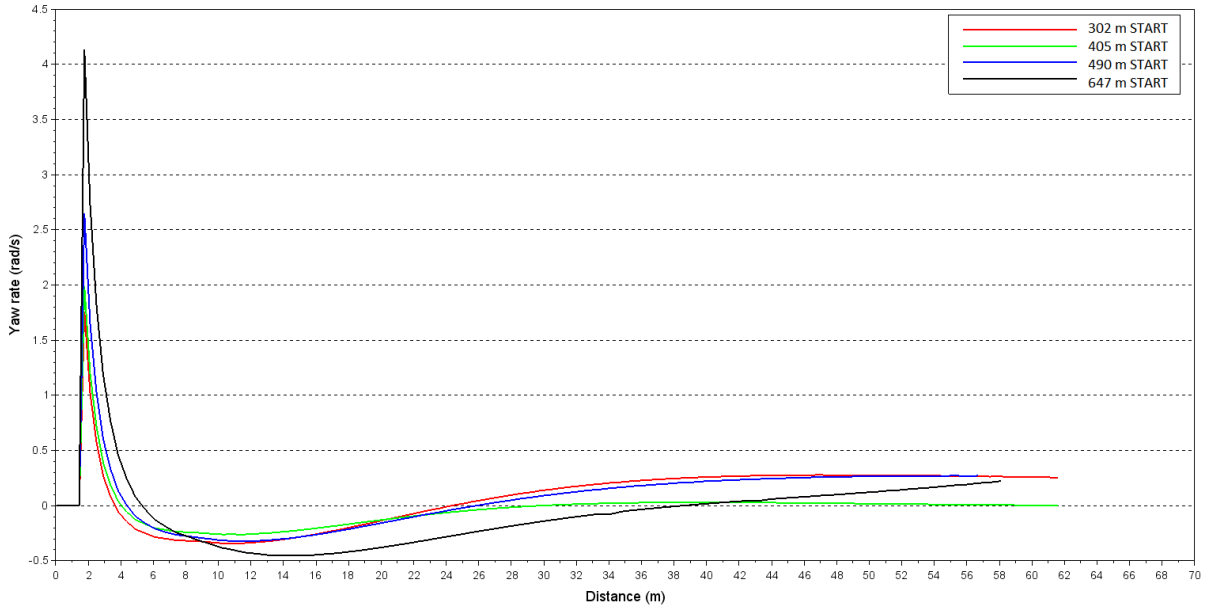

Figure 11: Greyhound yaw rate for the box alignments where a positive value indicates turning anticlockwise and a negative value indicates turning clockwise for 302 m, 405 m, 490 m and 647 m starting distances at Mandurah greyhound track. The plots commence at the respective Starting Boxes.

3 Design 1: 70 m bends, 50 m transitions, 7 m wide

3.1 Design 1: Track shape

The Design 1 proposal is an oval shaped track with two 70.0 m semicircular bends joined to two 27.1 m straights by four 50.0 m transitions. The Design 1 track has four starts, namely: 302 m, 400 m, 487 m and 700 m.

Figure 12 is the David Allan Consulting Engineer Pty Ltd plan for the Design 1 Mandurah greyhound track dated 13 February 2021.

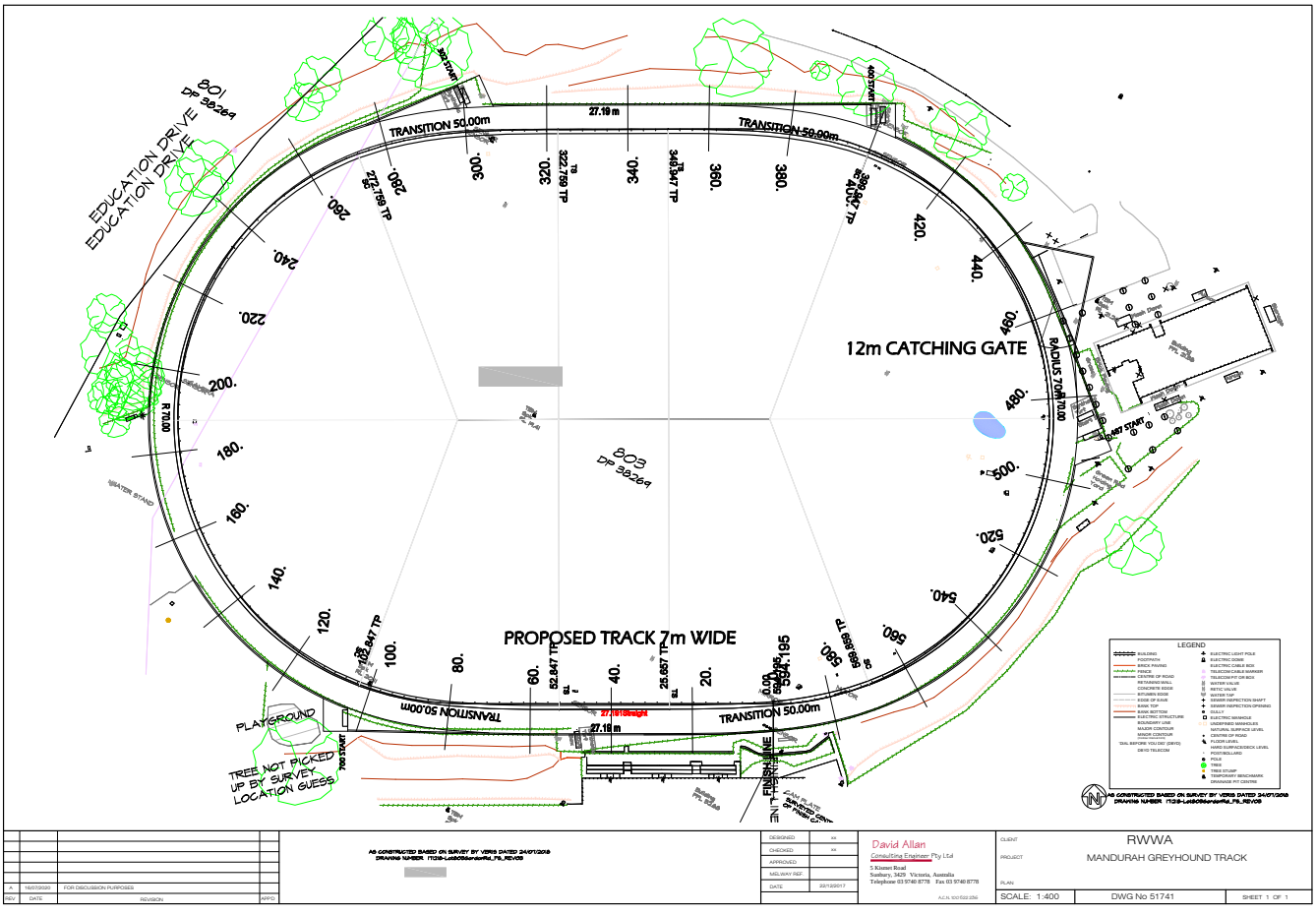

Figure 12: Design 1 Mandurah greyhound track plan David Allan Consulting Engineer Pty Ltd (13 February 2021).

3.2 Design 1: Curvature for each starting distance

Figure 13 shows a plan view of the Mandurah greyhound track with fundamental track dimensions and the curvature lines.

The length of the transition from both straights to both bends is 50 m. This is depicted by the red curvature lines in Figure 13.

Comparing Figure 2 with Figure 13 it can be seen that the curvature for each of the four transitions increases smoothly and gradually and thus provides the greyhounds with a sustainable journey into and out of each bend. Table 1 enumerates different transition lengths and bend radii.

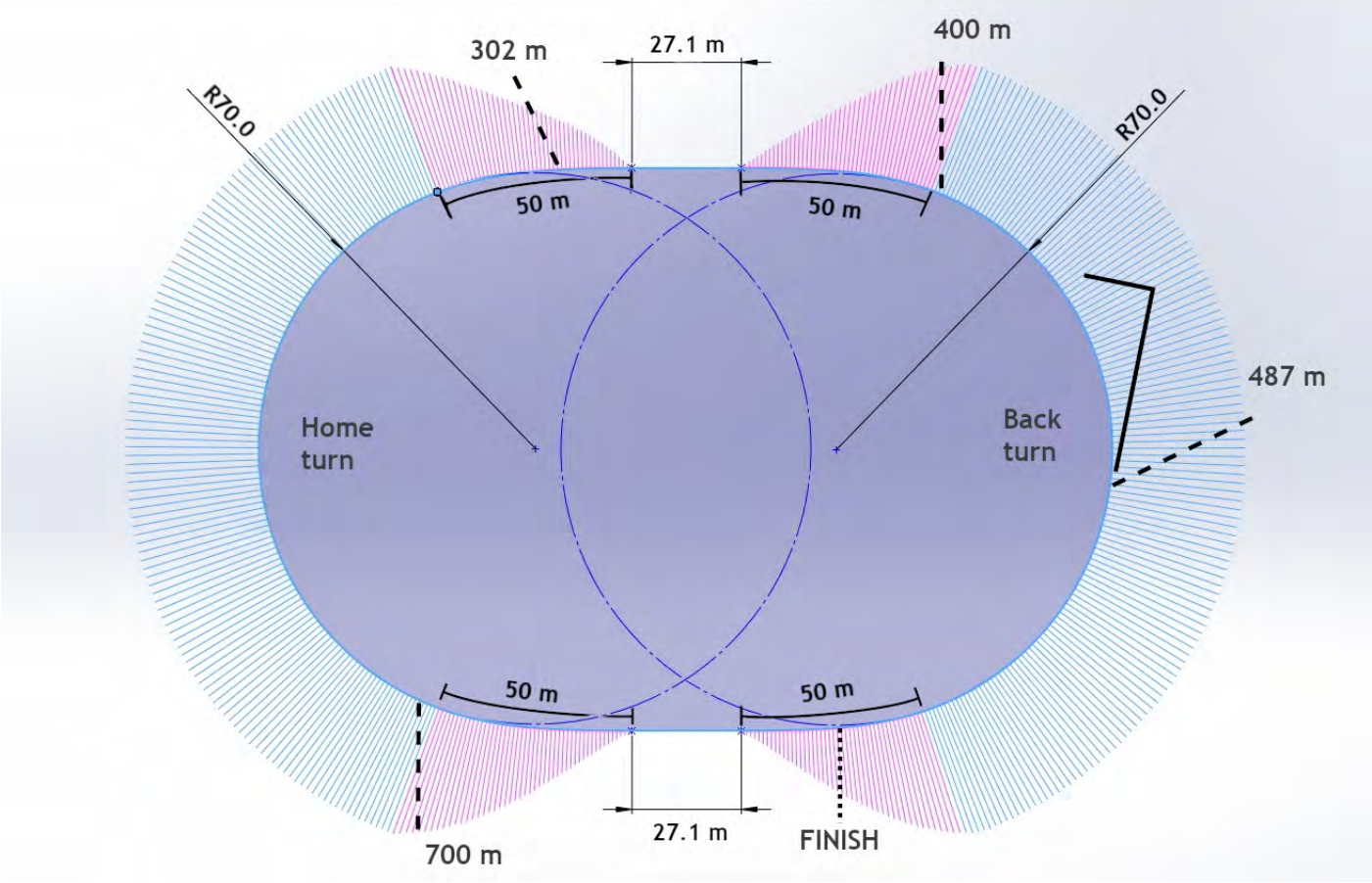

Figure 13: Design 1 Mandurah greyhound track curvature line plot (70.0 m bends, 50.0 m transitions). The lengths of the perpendicular blue lines are inversely proportional to the magnitude of the radius of curvature calculated 1 m perpendicular from the inner rail.
Source: David Allan Consulting Engineer Pty Ltd.

The curvature plots for 302 m, 400 m 487 m and 700 m starting distances versus track distance measured from the respective starting boxes for the proposed Mandurah track are given in Figure 14. In the curvature plot figure the bends can be seen to have the highest curvature values while straight track segments have zero curvature values. Also, there is a linear change in track curvature from straight to bend track segments and vice versa.

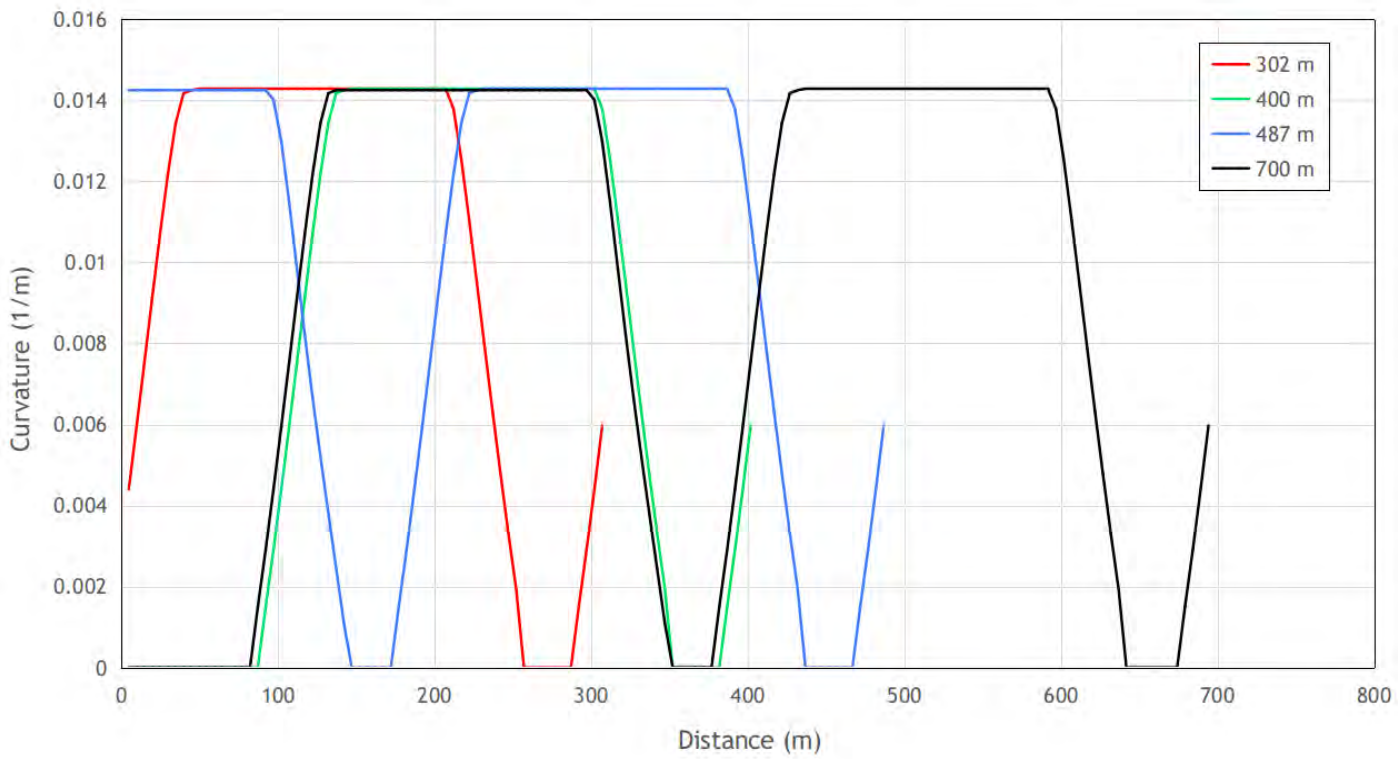

Figure 14: The curvature plots for 302 m, 400 m, 487 m and 700 m starting distances for proposed Design 1 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

3.3 Design 1: Centrifugal acceleration for each starting distance

The magnitude of centrifugal acceleration for 302 m, 400 m, 487 m and 700 m starting distances versus track distance measured from the respective starting boxes for the proposed Mandurah track is given in Figure 15.

The 302 m distance (red plot) has the maximum centrifugal acceleration among all distances and is around 5.6 m/s^2.

The 400 m distance (green plot) maximum centrifugal acceleration is around 5.5 m/s^2.

For the 487 m distance (blue plot), the maximum centrifugal acceleration is around 5.3 m/s^2.

For the 700 m distance (black plot), the maximum centrifugal acceleration is around 5.5 m/s^2.

The change in centrifugal accelerations is more gradual and smooth for the first bend entrance for 302 m and 487 m distances compared to 400 m and 700 m distances because the greyhounds have not reached their maximum velocity.

For all starting distances, the increase in centrifugal acceleration before the Finish Post is because the 50 m transition commences before the Finish Post. The magnitude varies according to the predicted velocity as the greyhounds pass the Finish Post.

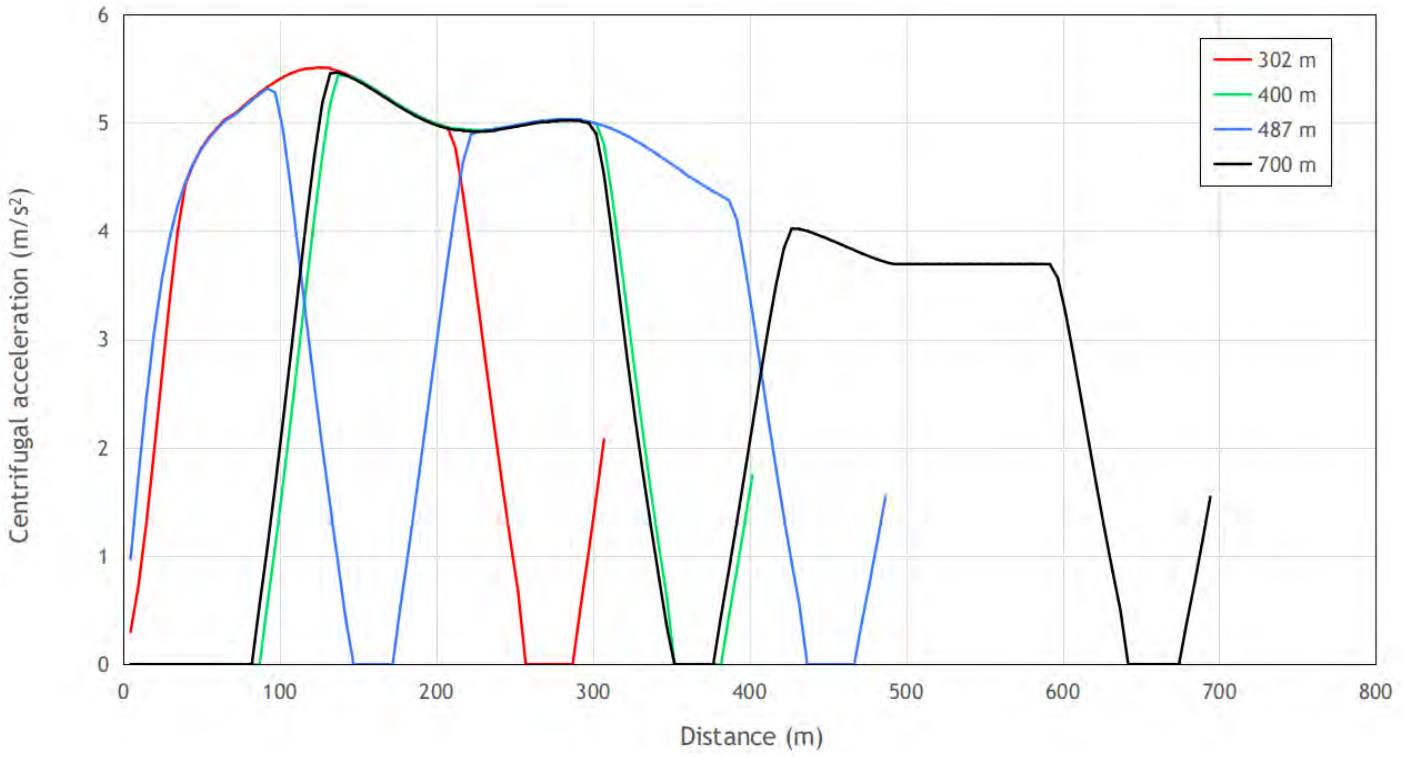

Figure 15: The centrifugal acceleration plots for 302 m, 400 m, 487 m and 700 m starting distances for proposed Design 1 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

3.4 Design 1: Jerk for each starting distance

The jerk for 302 m, 400 m, 487 m and 700 m starting distances versus track distance measured from the respective starting boxes for the proposed Mandurah track is given in Figure 16.

The jerk for the 487 m distance (blue plot) is high at the start as the greyhounds exit the boxes and immediately enter the bend. This is not ideal as they are experiencing their maximum linear acceleration as they accelerate from zero to more than 18 m/s over a very short distance while also experiencing a changing high magnitude of centrifugal acceleration. This combination of circumstances will increase the probability of a race related injury. The jerk_{max} of approximately 2.8 m/s^3 occurs as the greyhound enters the bend.

The 302 m distance has similar jerk to the 487 m distance except it is slightly more favourable to safer racing as the peak is more rounded. Both the 302 m and 487 m starts are less than ideal.

The 400 m distance has identical jerk to the 700 m distance. These are the safest starting distances for this track design.

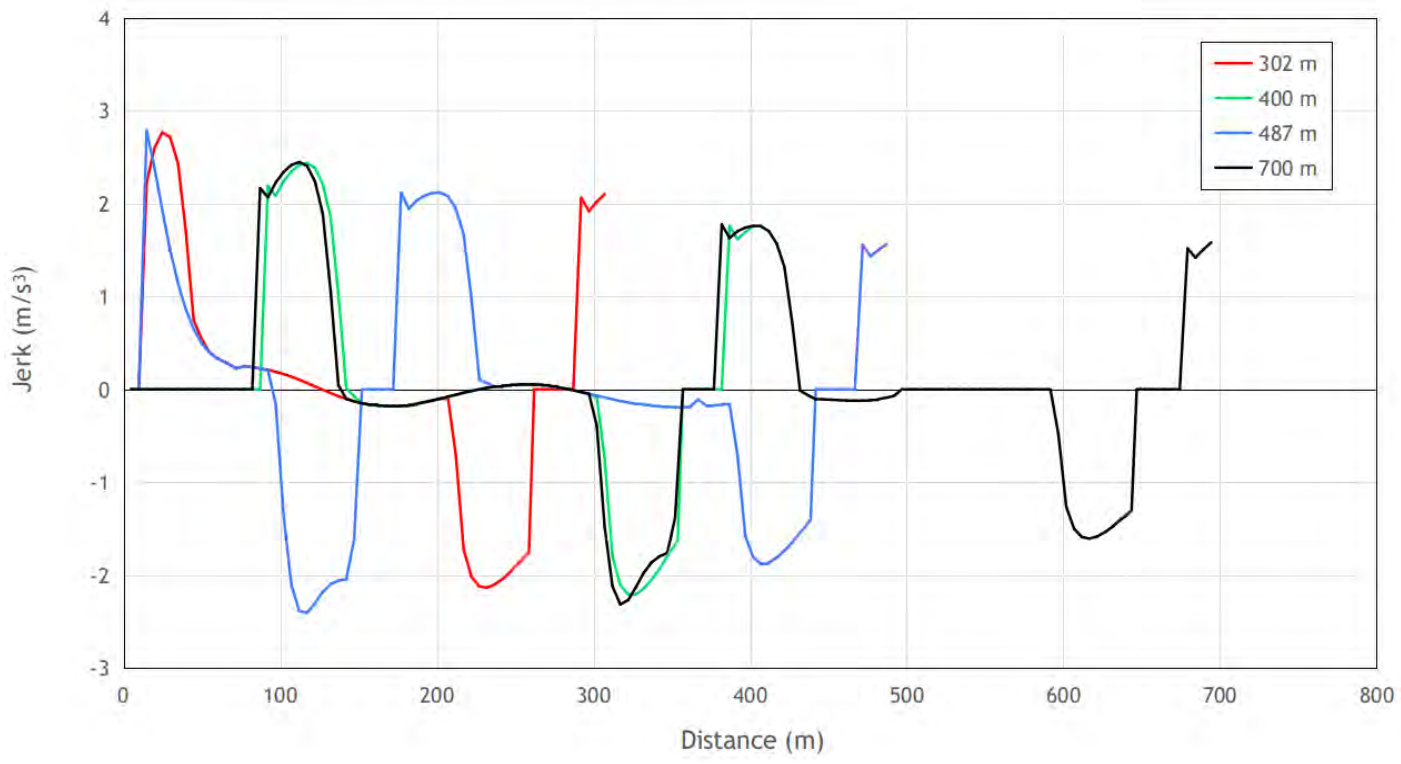

Figure 16: The jerk plots for 302 m, 400 m, 487 m and 700 m starting distances for proposed Design 1 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

3.5 Design 1: Starting box simulations

Figures 17 to 20 show simulated greyhound paths of a single greyhound and corresponding turning tendency for the 302 m, 400 m, 487 m and 700 m starting box locations and alignments.

The turning tendency sequence is denoted by the perpendicular arrows. The highest turning tendency was observed for 700 m distance followed by 487 m, 400 m and 302 m starting box locations and alignments.

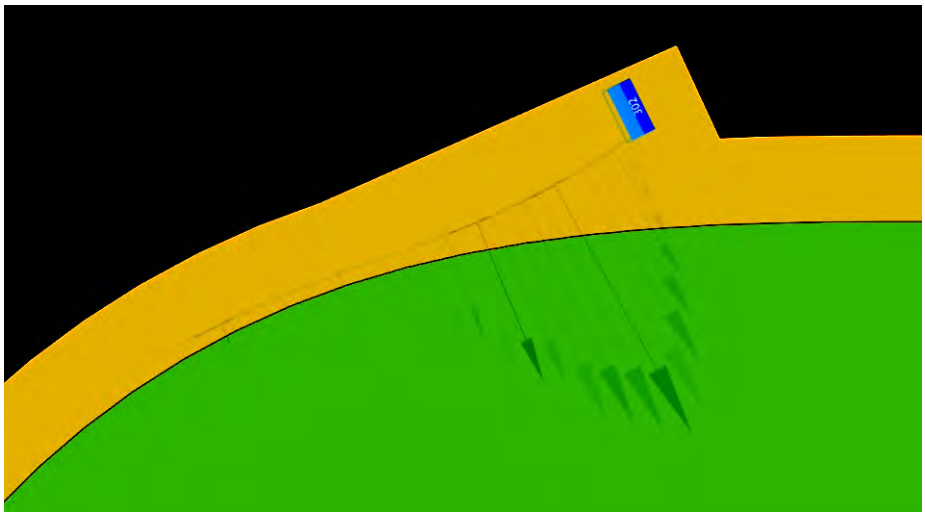

Figure 17: Simulation of greyhound path for the 302 m starting distance at proposed Design 1 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

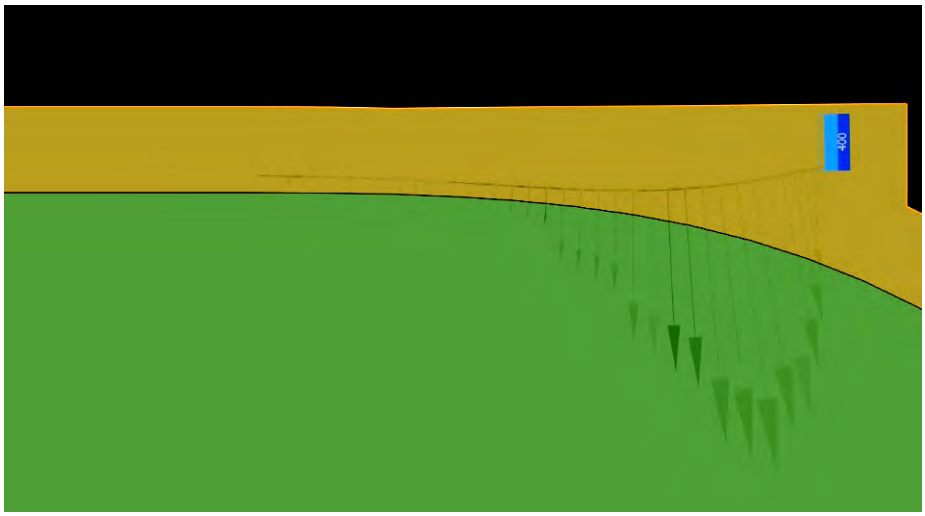

Figure 18: Simulation of greyhound path for the 400 m starting distance at proposed Design 1 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

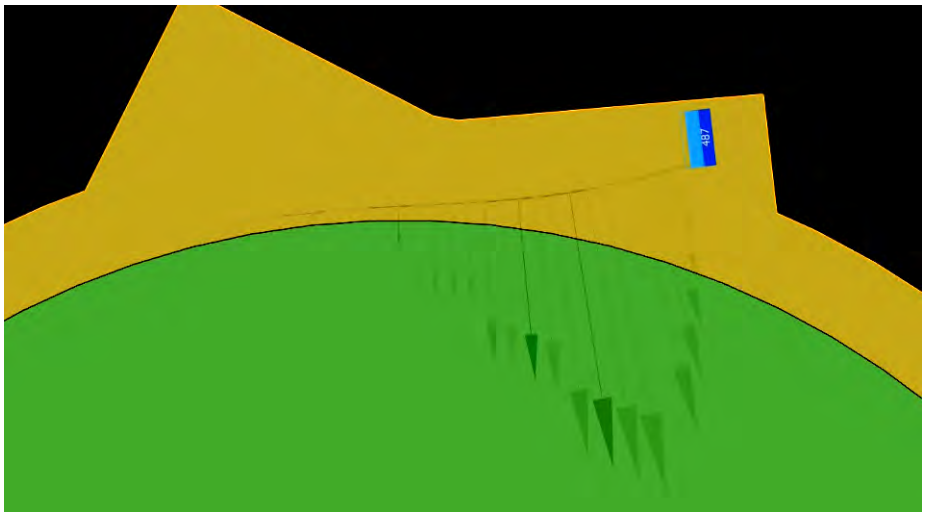

Figure 19: Simulation of greyhound path for the 487 m starting distance at proposed Design 1 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

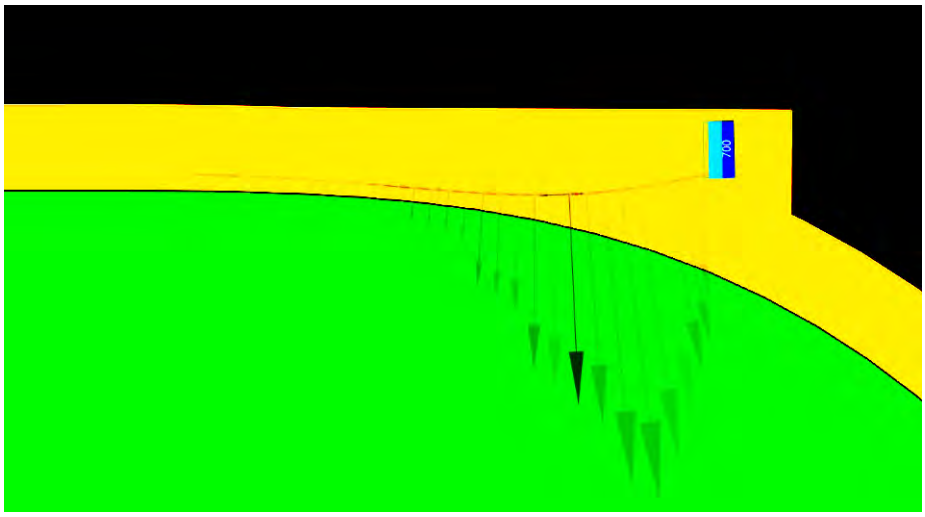

Figure 20: Simulation of greyhound path for the 700 m starting distance at proposed Design 1 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

Figure 21 depicts turning radius versus run distance of a greyhound for the 302 m, 400 m, 487 m and 700 m starting box locations and alignments. The plots provide an insight with respect to the small turning radius the racing greyhound has to make when moving from boxes to the track. The 302 m and 487 m starting box locations and alignments had similar turning radius performance for up to a distance of around 20 m from the respective boxes where the smallest turning was observed for the 302 m box location and alignment of about 59 m radius. The 400 m and 700 m starting box locations

and alignments had similar turning radius performance for up to a distance of around 20 m from the respective boxes where the smallest turning was observed for 700 m box location and alignment of about 52 m radius. Thus, the turning radius immediately after leaving the boxes is much lower than bend radius of approximately 70 m.

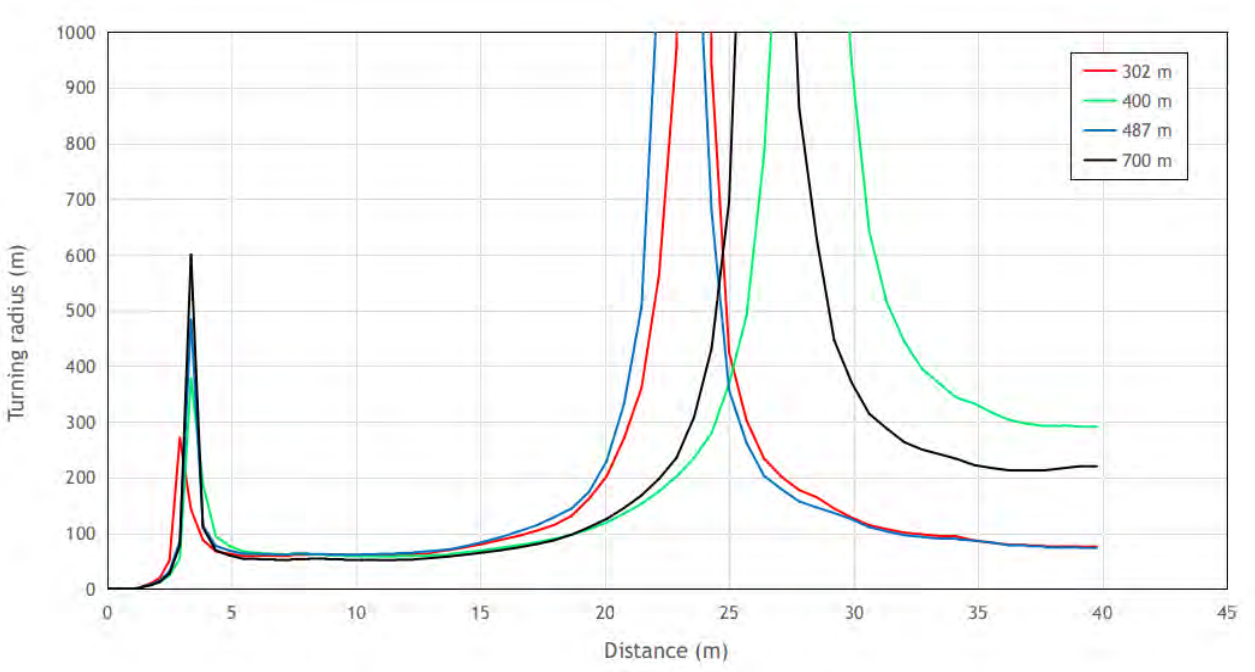

Figure 21: Greyhound turning radius for 302 m, 400 m, 487 m and 700 m starting distances at proposed Design 1 Mandurah greyhound track. The plots commence at the respective Starting Boxes.

Figure 22 illustrates yaw rate (rad/s) plotted against the distance out of the box for the 302 m, 400 m, 487 m and 700 m starts. For all race distances starting box locations and alignments showed a continuous turning where the peak turning occurred from around 7 m to 13 m for all distances. The 302 m required minimum initial turning of about 1.45 rad/s and after that, the greyhound yaw rate went through a 0.52 rad/s change over the 29 m run distance. For the 400 m and 700 m distances starting box alignments, the initial yaw rate was similar and considerably more than that of the 302 m start where after the initial turning phase the greyhound yaw rate went through 0.36 rad/s and 0.42 rad/s changes respectively. The 487 m distance box alignment had a similar yaw rate to the 302 m distance where the required minimum initial turning was higher than the 302 m distance at around 1.8 rad/s. Finally, among all the distances box alignments the 400 m distance was found to be most optimal.

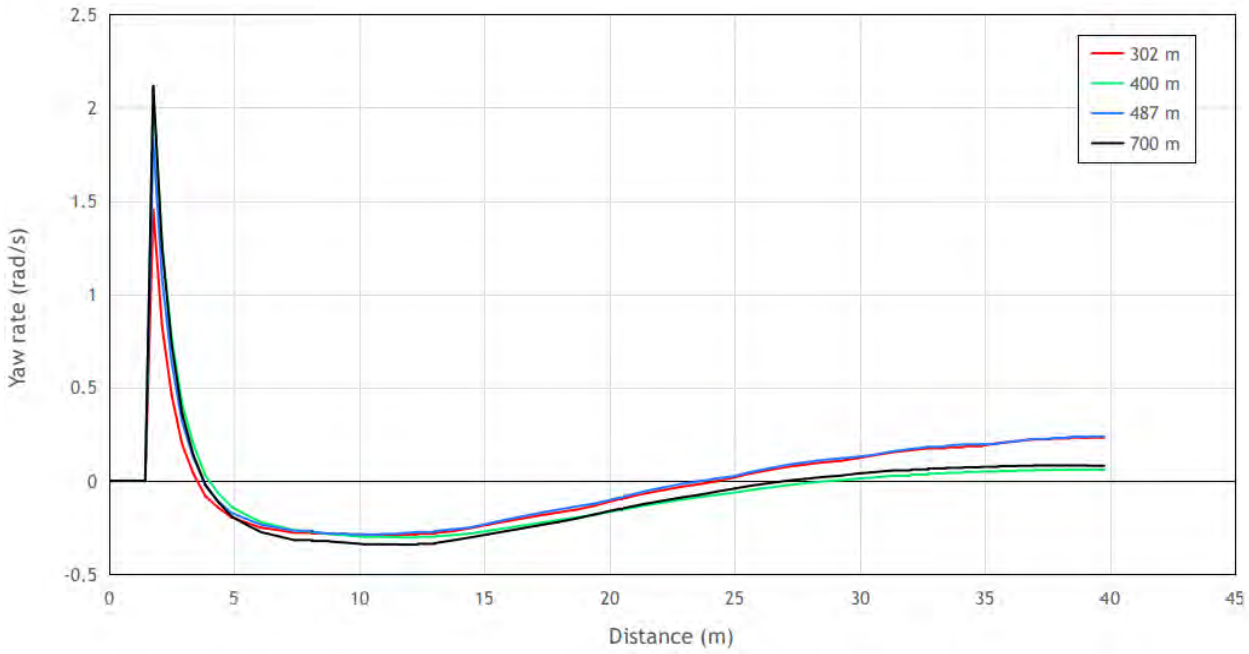

Figure 22: Greyhound yaw rate for the box alignments where a positive value indicates turning anticlockwise and a negative value indicates turning clockwise for 302 m, 400 m, 487 m and 700 m starting distances at proposed Design 1 Mandurah greyhound track. The plots commence at the respective Starting Boxes.

3.6 Design 1: Track width

The width of a track is an important parameter in track safety. A narrow track is more likely to compromise racing greyhound safety. For example, when a track is not sufficiently wide the rate of change of greyhound heading cross-fall is higher on the bend. This situation can cause greyhounds which deviate from the ideal racing line to be injured due to higher vertical force loading. Likewise, race videos confirm that some greyhounds maintain a wider offset from the lure running rail. When these greyhounds enter a bend they are randomly tempted to make sudden changes in their heading which is clearly not desirable.

The Design 1 and 2 track width of 7 m is sufficient to allow the greyhounds adequate room to manoeuvre and self-select a running line that limits their exposure to incidents that may result in a serious injury.

4 Design 2: 69 m bends, 60 m transitions, 7 m wide

4.1 Design 2: Track shape

The Design 2 proposal is an oval shaped track with two 69.2 m semicircular bends joined to two 18.7 m straights by four 60.0 m transitions. The Design 2 track has four starts, namely: 300 m, 400 m, 489 m and 700 m.

Figure 23 is the David Allan Consulting Engineer Pty Ltd plan for the Design 2 Mandurah greyhound track dated 13 February 2021.

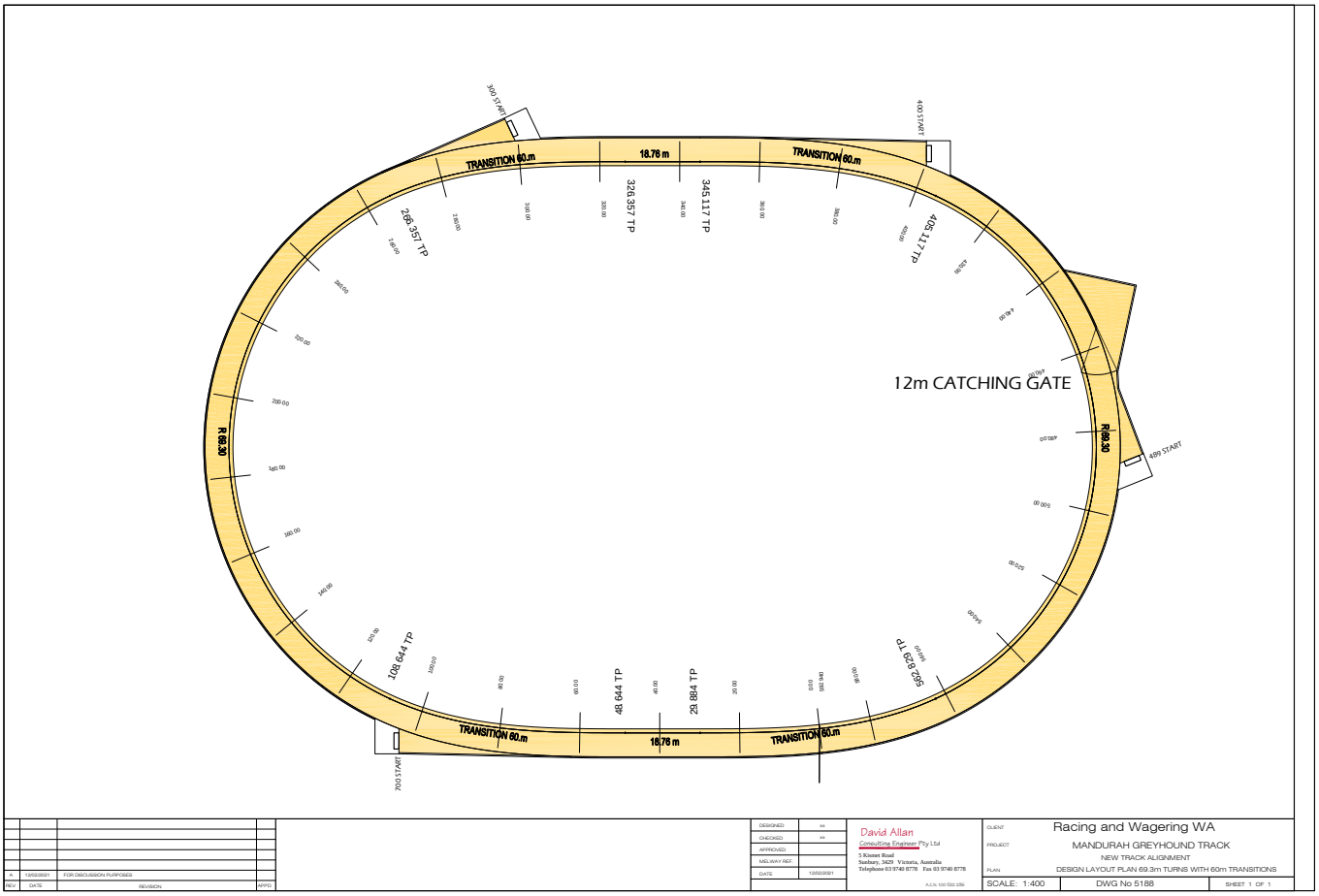

Figure 23: Design 2 Mandurah greyhound track plan David Allan Consulting Engineer Pty Ltd (13 February 2021).

4.2 Design 2: Curvature for each starting distance

Figure 24 shows a plan view of the Mandurah greyhound track with fundamental track dimensions and the curvature lines.

The length of the transition from both straights to both bends is 60 m. This is depicted by the red curvature lines in Figure 24.

Comparing Figure 2 with Figure 24 it can be seen that the curvature for each of the four transitions increases smoothly and gradually and thus provides the greyhounds with an even more sustainable journey into and out of each bend than Design 1.

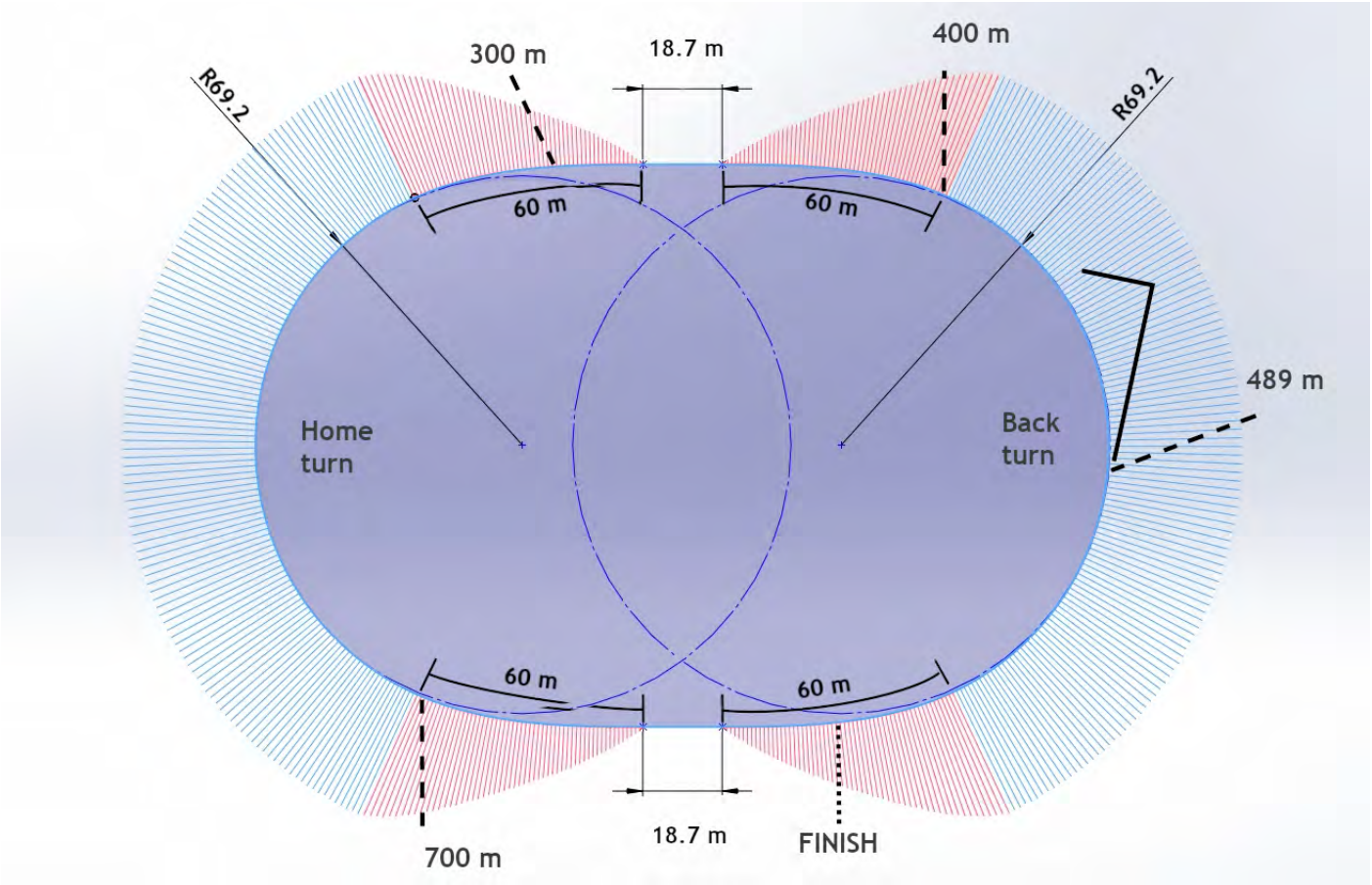

Figure 24: Design 2 Mandurah greyhound track curvature line plot (69.2 m bend, 60.0 m transition). The lengths of the perpendicular blue lines are inversely proportional to the magnitude of the radius of curvature calculated 1 m perpendicular from the inner rail.
Source: David Allan Consulting Engineer Pty Ltd.

The curvature plots for 300 m, 400 m 489 m, and 700 m starting distances versus track distance measured from the respective starting boxes for the proposed Design 2 Mandurah greyhound track are given in Figure 25. In the curvature plot figure the bends can be seen to have the highest curvature

values while straight track segments have zero curvature values. Also, there is a linear change in track curvature from straight to bend track segments and vice versa.

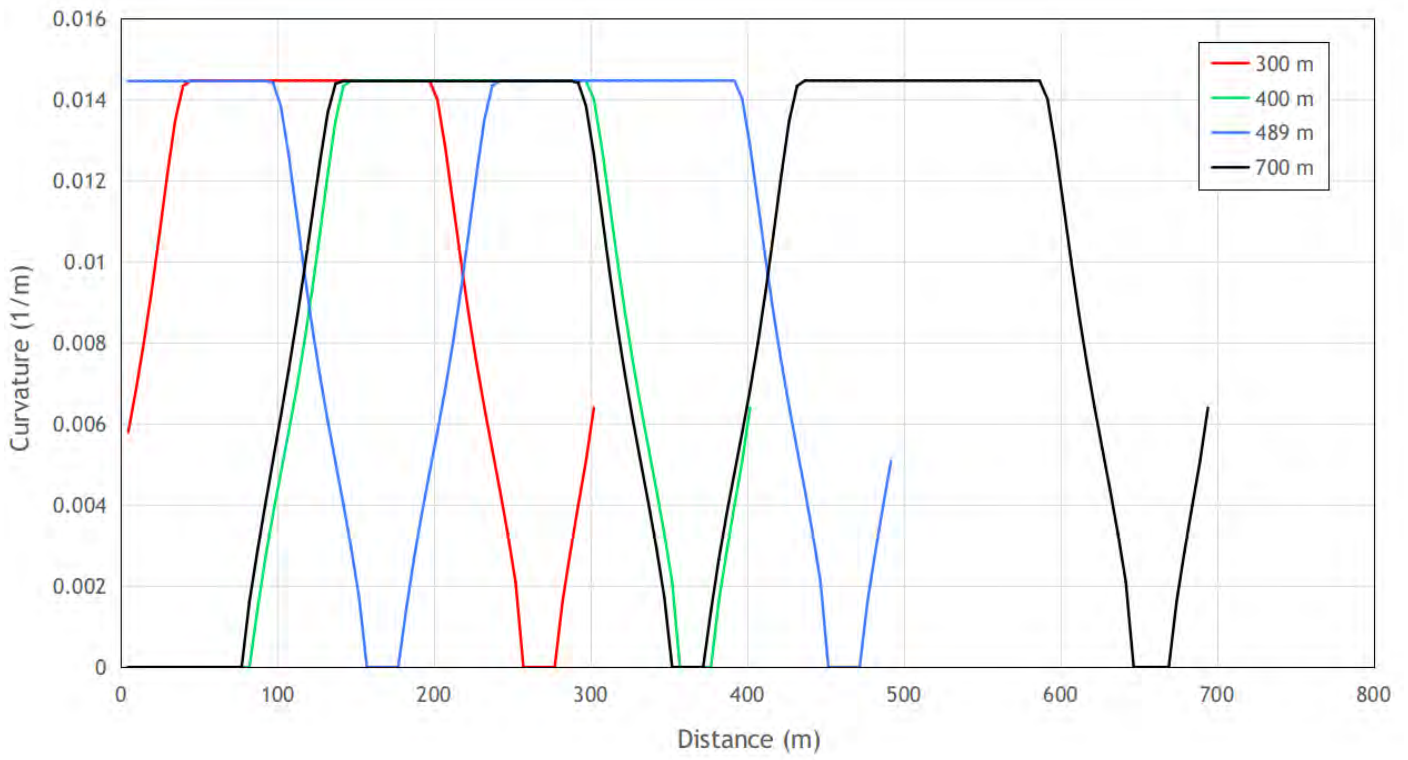

Figure 25: The curvature plots for 300 m, 400 m, 489 m, and 700 m starting distances for proposed Design 2 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

4.3 Design 2: Centrifugal acceleration for each starting distance

The magnitude of centrifugal acceleration for 300 m, 400 m, 489 m and 700 m starting distances versus track distance measured from the respective starting boxes for the proposed Design 2 Mandurah greyhound track is given in Figure 15.

The peak centrifugal acceleration is at 5.6 m/s^2 which occurs for the 300 m distance (red plot).

For all distances the centrifugal acceleration is marginally higher than distances for Design 1.

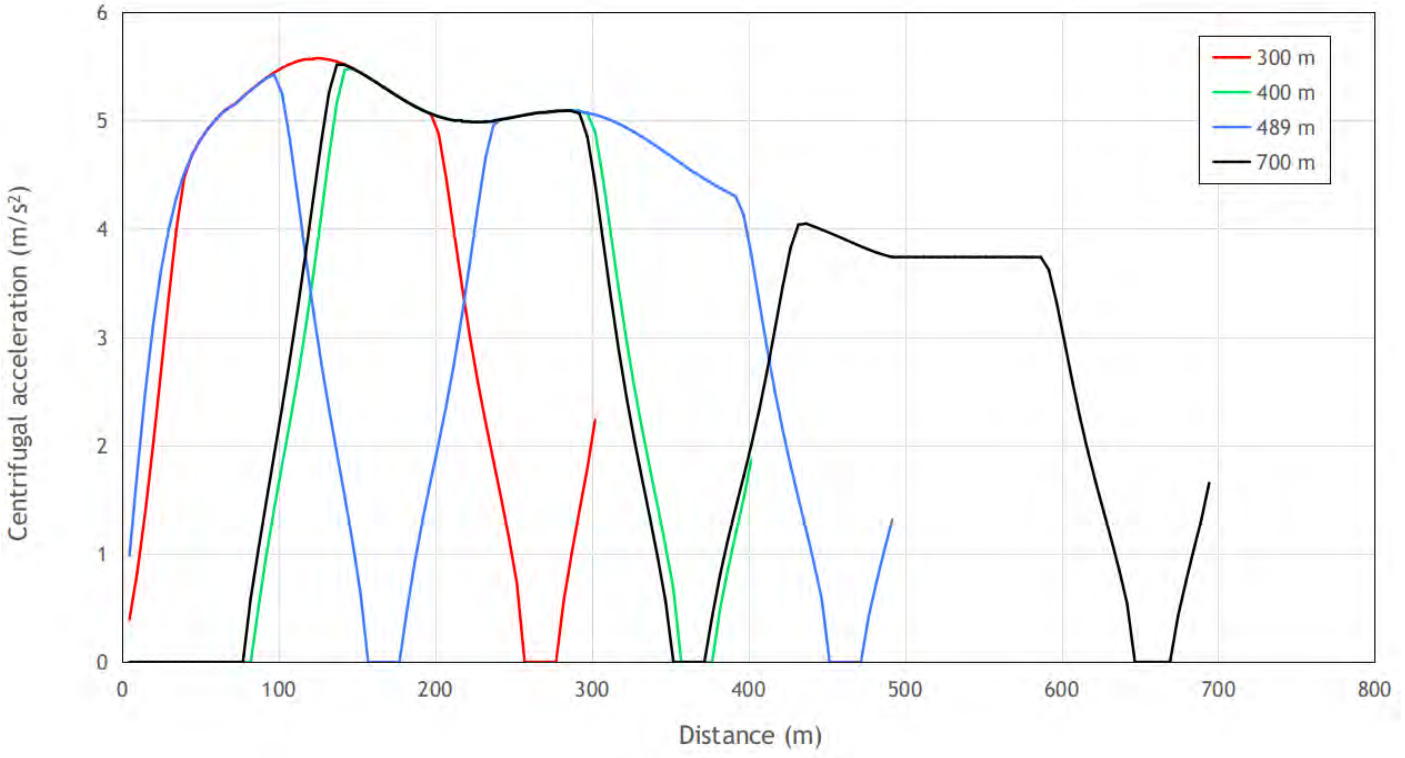

Figure 26: The centrifugal acceleration plots for 300 m, 400 m, 489 m and 700 m starting distances for proposed Design 2 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

4.4 Design 2: Jerk for each starting distance

The jerk for 300 m, 400 m, 489 m and 700 m starting distances versus track distance measured from the respective starting boxes for the proposed Design 2 Mandurah greyhound track is given in Figure 16.

All distances have similar jerk profiles for corresponding distances found in Design 1.

The overall jerk magnitude for all distances is less than corresponding distances of Design 1.

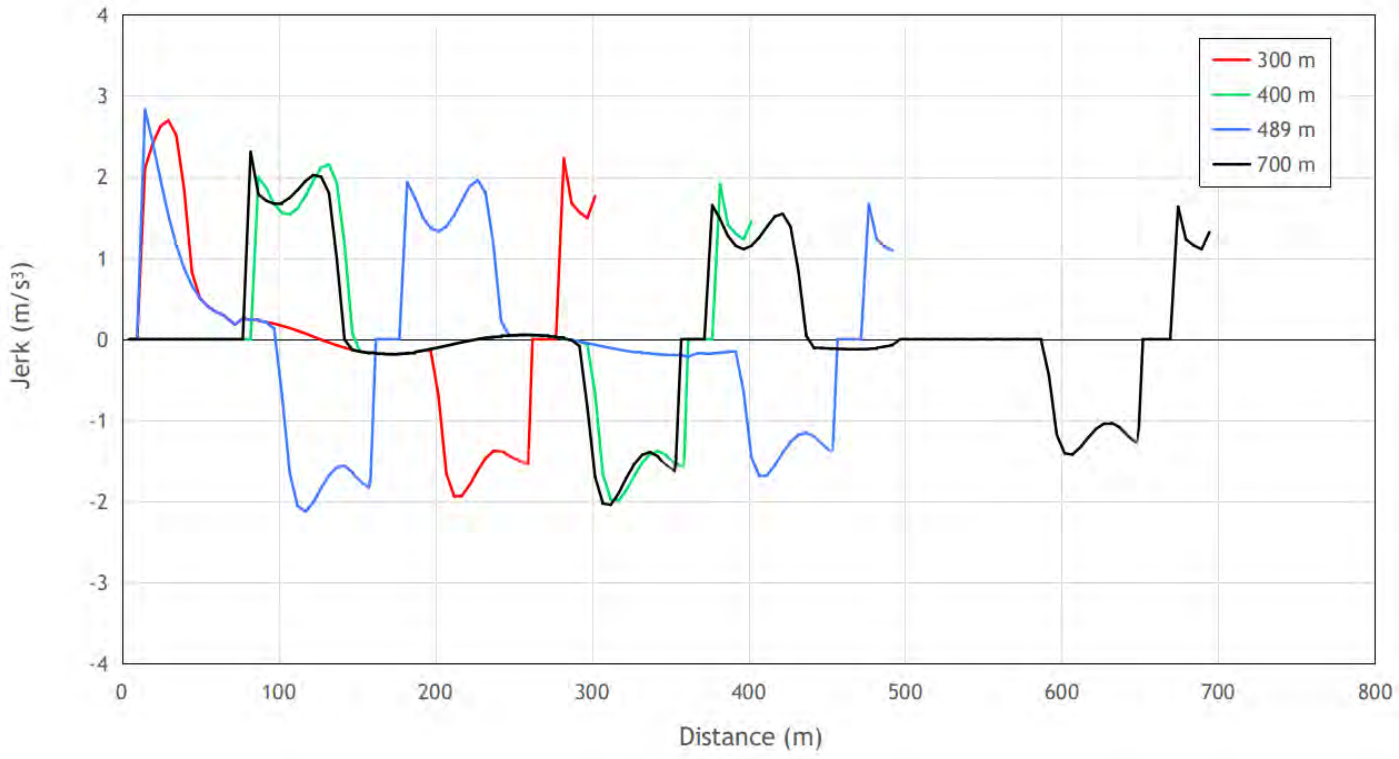

Figure 27: The jerk plots for 300 m, 400 m, 489 m, and 700 m starting distances for proposed Design 2 Mandurah greyhound track. The plots commence at the respective Starting Boxes and end at the Finish Post.

4.5 Design 2: Starting box simulations

Figures 28 to 31 show the simulated path of a single greyhound and corresponding turning tendency for the 300 m, 400 m, 489 m and 700 m starting box locations and alignments.

The turning tendency sequence is denoted by the perpendicular arrows. The highest turning tendency was observed for 489 m, distance followed by 700 m, 300 m and 400 m starting box locations and alignments in the order of magnitude.

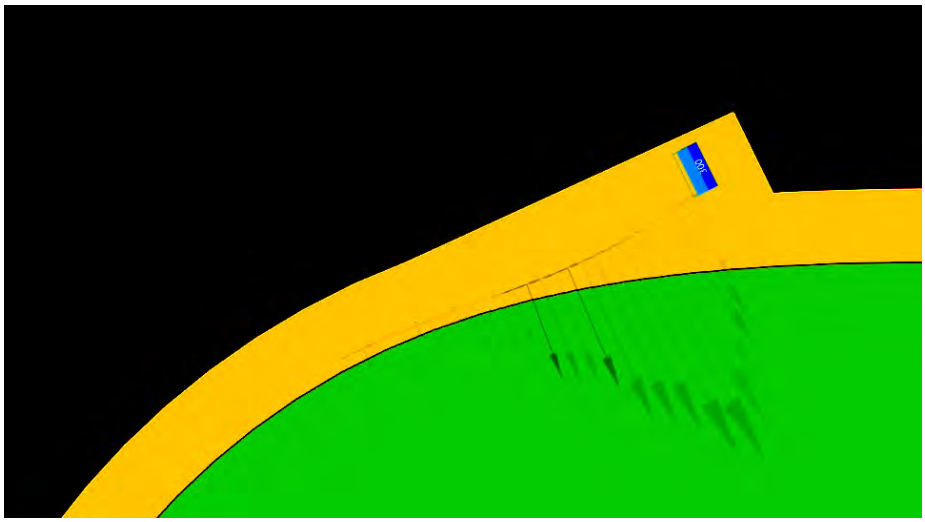

Figure 28: Simulation of greyhound path for the 300 m starting distance at proposed Design 2 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

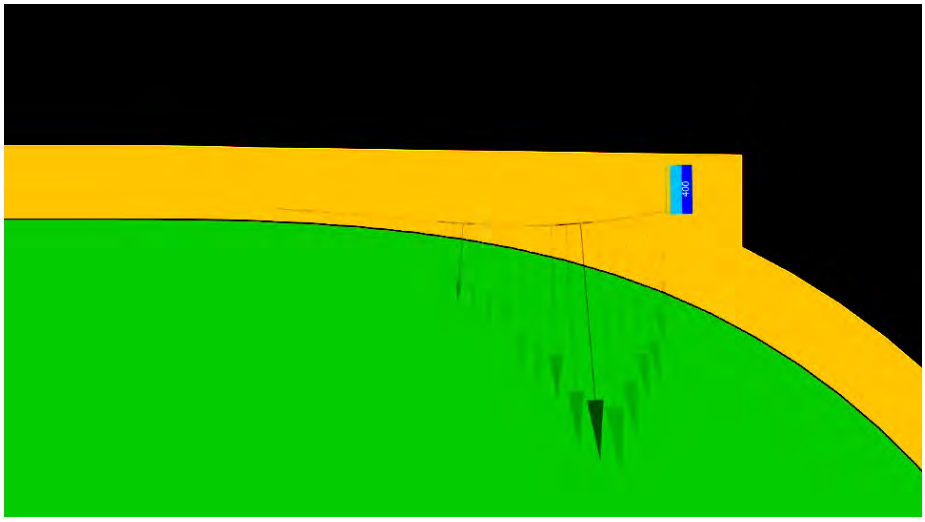

Figure 29: Simulation of greyhound path for the 400 m starting distance at proposed Design 2 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

The overall turning tendency for all distances was observed to be least in magnitude compared to corresponding distances for Design 1.

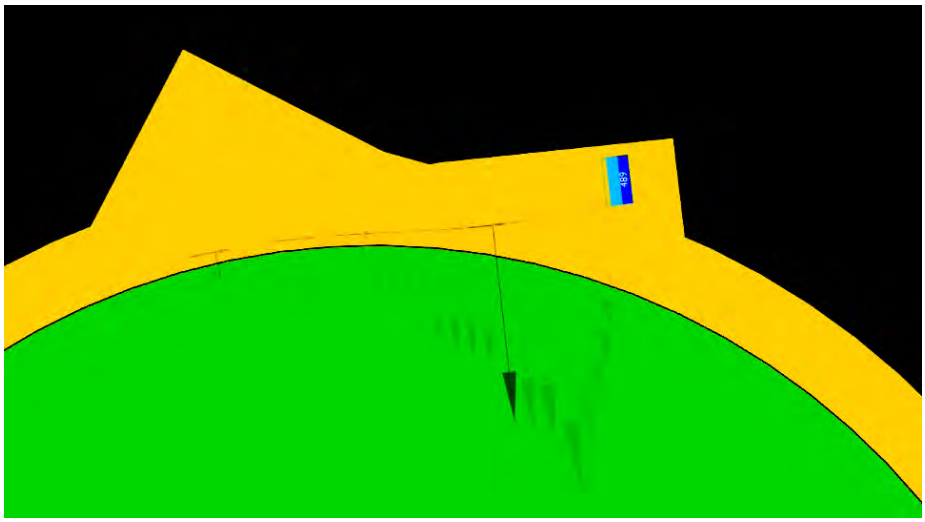

Figure 30: Simulation of greyhound path for the 489 m starting distance at proposed Design 2 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

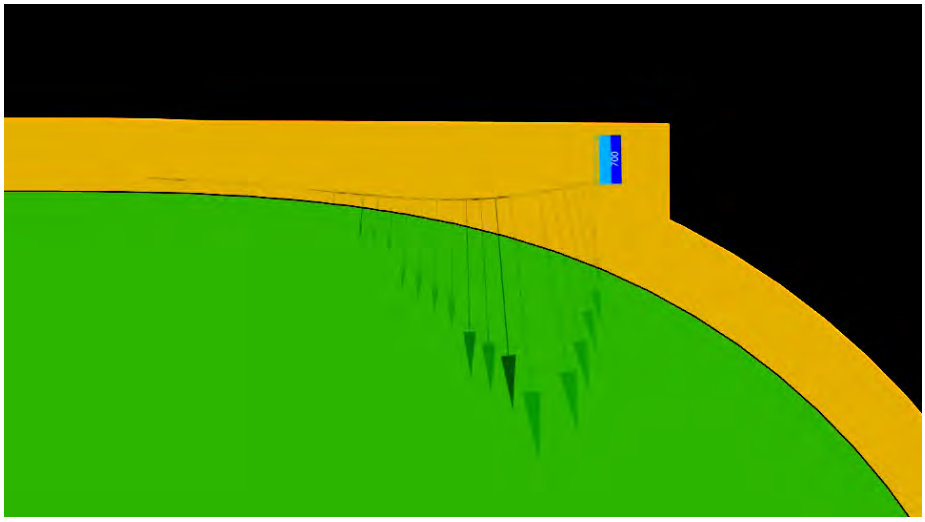

Figure 31: Simulation of greyhound path for the 700 m starting distance at proposed Design 2 Mandurah greyhound track. The length of arrows depicts the magnitude of the Box 1 greyhound's turning tendency as a function of normal velocity component, instantaneous speed and a constant.

Figure 32 depicts turning radius versus run distance of a greyhound for the 300 m, 400 m, 489 m and 700 m starting box locations and alignments. The plots provide an insight with respect to the small turning radius the racing greyhound has to make when moving from the starting boxes to the track. The 400 m and 700 m starting box locations and alignments had similar turning radius performance for up to a distance of around 25 m from the respective boxes where the smallest turning was observed for the 700 m box location and alignment of about 53 m radius. Unlike Design 1, there is no similarity in turning radius between the 300 m and 489 m box locations and alignments. Thus, the turning radius immediately after leaving the boxes is much lower than the bend radius of approximately 69.2 m.

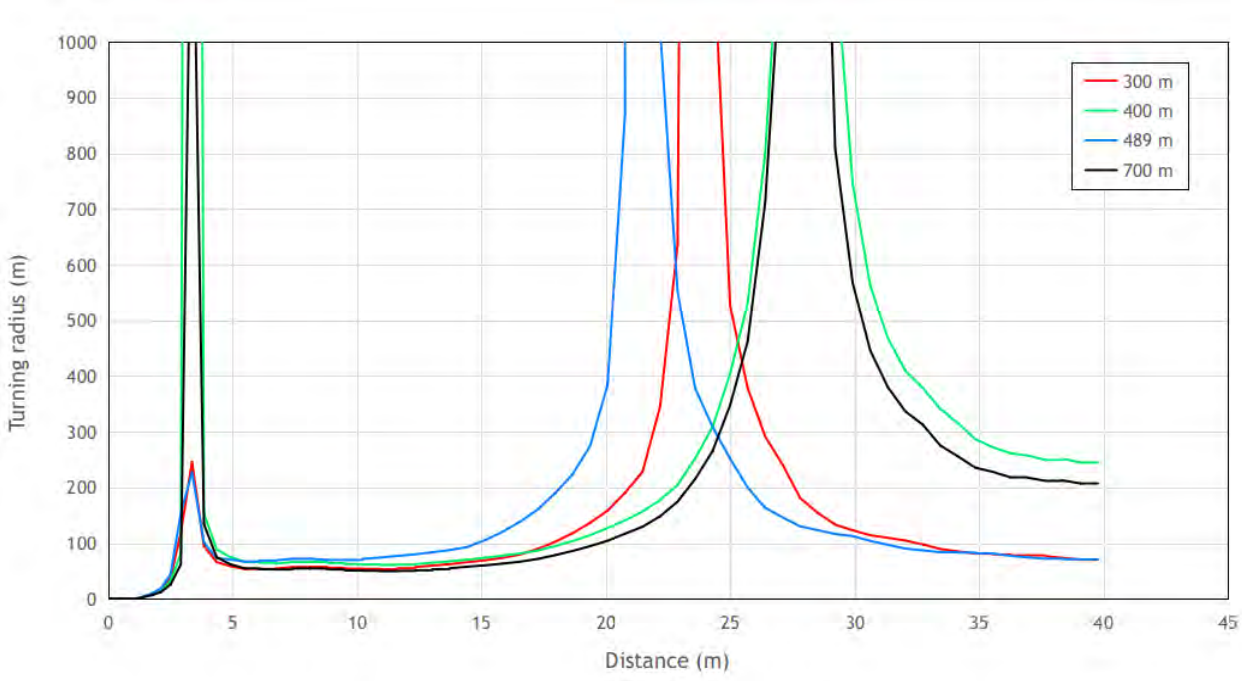

Figure 32: Greyhound turning radius for 300 m, 400 m, 489 m and 700 m starting distances at proposed Design 2 Mandurah greyhound track. The plots commence at the respective Starting Boxes.

Figure 33 illustrates yaw rate (rad/s) plotted against the distance out of the box for the 300 m, 400 m, 489 m and 700 m starts. All race distances starting box locations and alignments showed a continuous turning where the peak turning occurred from around 8 m to 12 m for all distances. The 489 m distance required minimum initial turning of about 1.45 rad/s and after that, the greyhound yaw rate went through a 0.25 rad/s change over the 31 m run distance. For the 300 m and 400 m distances starting box alignments, the initial yaw rate was similar and considerably more than that of the 489 m where after the initial turning phase the greyhound yaw rate went through 0.57 rad/s and 0.35 rad/s changes respectively. Finally, among all the distances box alignments the 489 m distance was found to be most optimal.

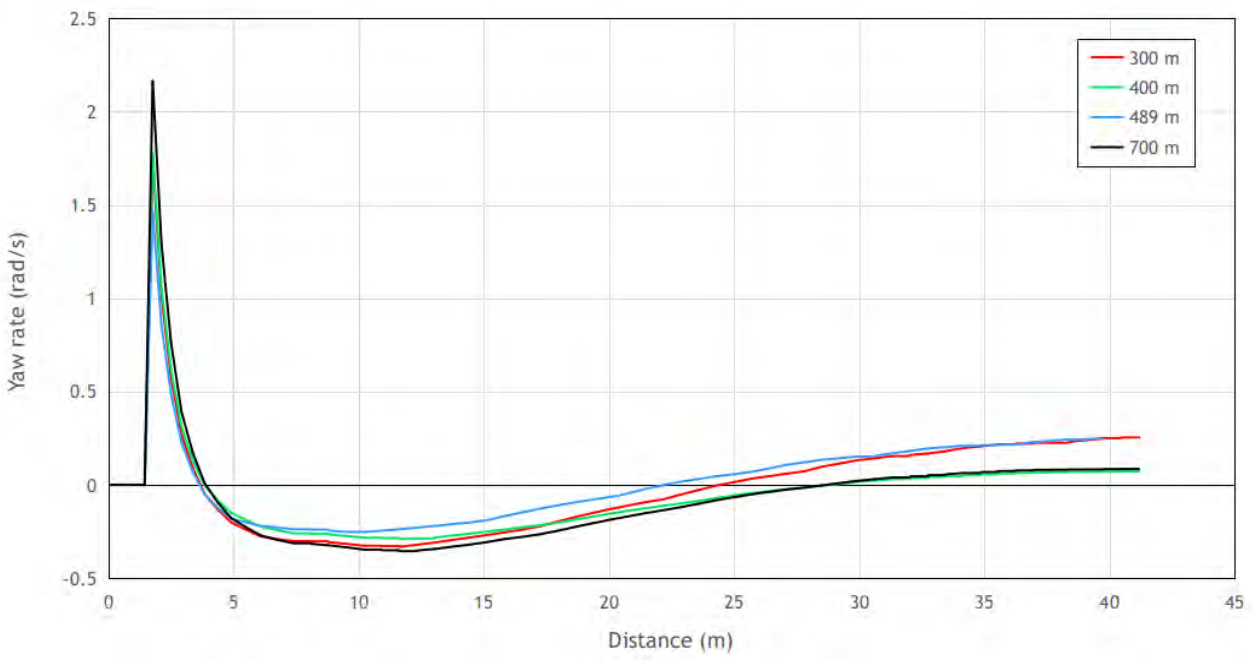

Figure 33: Greyhound yaw rate for the box alignments where a positive value indicates turning anticlockwise and a negative value indicates turning clockwise for 300 m, 400 m, 489 m and 700 m starting distances at proposed Design 2 Mandurah greyhound track. The plots commence at the respective Starting Boxes.

4.6 Design 2: Track width

See Section 3.6 for discussion on the 7 m track width.

5 Suggested track improvements

5.1 Transitions and bend radii

The enumeration of different transition lengths and bend radii shows other design options similar to Designs 1 and 2 with improved theoretical jerk outcomes shown in Table 1.

Table 1: Transition and bend radius (1 m out from the rail) combination of safest jerk with the worst starting distance.
The existing track data are highlighted in purple.
The Design 1 and 2 data are highlighted in red.

Radius (m)	Transition (m)	Jerk (m/s^3)	Jerk improvement (%)
71.0 - 72.4	0.0 - 40.0	6.8	n/a
70.0	50.0	2.8	58.8
69.3	60.0	2.8	58.8
70.9	59.8	2.3	66.0
70.5	55.2	2.5	63.2
69.9	56.4	2.5	63.2
69.5	57.6	2.5	63.2
69.3	57.2	2.8	58.8
69.4	50.6	2.8	58.8
69.6	56.1	2.8	58.8
69.9	55.0	2.8	58.8

5.2 Drop-on boxes

For both Designs 1 and 2 drop-on boxes should be considered as an intervention for increasing the turning radius for selected racing distances.