A Future FOR THE Sport

LANE CERTIFICATION STUDY REPORT

2017

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LANE CERTIFICATION STUDY REPORT

SUMMARY

A study into the certification process has been ongoing for well over two years. The existing process has many flaws including:

- Inaccurate lane certification reports with an average of 53% data accuracy
- Lack of correct documentation of center certification data

The idea of Professional Lane Inspectors to conduct lane inspections was considered but proved to be cost-prohibitive.

Data has been collected to determine:

- The extent of the lanes that are out of specification
- How lane topography shifts over time
- How lane topography affects the ball path
- Which pin deck measurements affect scoring the most

We examined 64 centers across the country to determine how well the lanes complied with certification specifications. After measuring more than 1,000 lanes in the centers, the results showed:

	Pct. results out of spec	Pct. lanes out of spec
• Crowns and depressions	9.8%	74.2%
• Cross tilts	14.6%	69.5%
• Flat gutter depth	14.4%	22.6%
• Crosswise tilt on pin deck	11.9%	11.9%
• Lengthwise tilt on pin deck	3.2%	4.2%
• Kickback-to-kickback measurement	21.5%	21.5%
• All pit measurements together	46.9%	46.9%

Lanes at USBC headquarters and in the Dallas area were measured over time to determine how they moved and we found lanes change seasonally but tend to return to approximately the same flatness on a yearly basis. But the topography does change throughout the year.

The pin deck scoring study determined the kickback-to-kickback measurement has the greatest influence on scoring, compared with other specifications in the pin deck area, including the gutter depth.

A math model was developed to predict how lane topography affects a straight ball path. The math model was evaluated and determined to be accurate. Then, the model was used to analyze the data from the 1,000 lanes that were mapped at the being of the study. The analysis from lanes in 64 centers concluded that if lanes are within our existing spec of .040” for crowns and depressions, plus crosswise tilt, the straight ball path will drift less than ± 3 boards in 87% of the lanes. The other 13% of the lanes will drift from 3-5 boards. The flatter the lane, the less drifting from the straight ball path.

CONCLUSIONS:

- The lane topography will move throughout the year because of changes in environmental conditions (temperature and humidity)
    - The measurements seem to move in a cycle and return to approximately the same topography every year at the same time
    - 95% of crowns and depressions will move less than .030”
- The most important pin deck measurement that affects the percentage of strikes is the width between the kickback to kickback at the back of the pin deck

    - The flat gutter depth, pin deck crosswise tilt, and pin deck lengthwise tilt within the existing spec range had a small effect on strike percentage
- 87% of lanes within .040" crowns and depressions will cause a straight ball path to drift less than three inches in either direction
    - Even with 10% measurements exceeding .040" this same amount of drifting holds true
        - This leaves 13% of the lanes drifting more than three inches even if the existing .040" spec is maintained
- When we leveled a 60-lane center to within .020" or less, the drifting was calculated to be ±3 boards for 95% of the lanes
- Lanes leveled to .020" or less tend to stay within the existing spec of .040" for many years

From the study, the following changes are being implemented for the 2019-2020 season:

- Change the specification for new installations, including overlay installations, to ±.030" (30/1000") over a 42-inch span for crosswise tilts and crowns/depressions starting Aug. 1, 2019

- For all new installations, including overlay installations, the lane surface shall be a limit to .040" (40/1000 of an inch) over a 42-inch span for lengthwise tilt.

- For all installations older than 12 months, the lane surface shall have a limit of ± 0.040" (40/1000 of an inch) over a 42-inch span for crosswise tilt and crowns/depressions

- New installations must be inspected within 14 days of completion

- The following changes will be made to the lane certification form starting with the 2018-2019 season:

    - Requires taking crowns/depressions and crosswise tilt measurements at five locations on every lane (one on each synthetic panel). Presently, only three measurements are required
    - Change the kickback-to-kickback (wood to wood) specification in the pin deck to kickback plate to kickback plate, since that is what is measured
    - The lane certification form must be signed by three people to ensure accuracy:
        - The local association manager
        - The lane inspector
        - A representative from the center (proprietor or manager)

- USBC Headquarters will gather and analyze "good" certification data starting with lane certifications for the 2018-2019 season:
    - The lane certification form will require five measurements per lane to start collecting lane certification data
    - USBC will require a copy of all certification forms be sent to USBC Headquarters so data can be analyzed
    - All centers with a properly completed lane certification form, including all measurements sent to USBC Headquarters, will be certified for the 2018-2019 season
    - The data will be used to determine future lane certification specification changes
    - Correcting measurements that are out of specification will start Aug. 1, 2019, along with implementing the new installation specification and overlay specification of +/-.030".

The USBC is taking lane certification seriously. This is a beginning to the new certification requirements.

REPORT DETAILS

During 2015 and 2016, the Equipment Specs Department gathered data for the Lane Inspection Process Project.

The initial goal of the project was to determine the accuracy of the Lane Inspection Process in the field. Are the certification reports accurate? Are lanes meeting specifications?

Eventually, the project extended into gathering data to determine, scientifically, the effect from the various certification specifications. This second phase of the project was divided into three research areas:

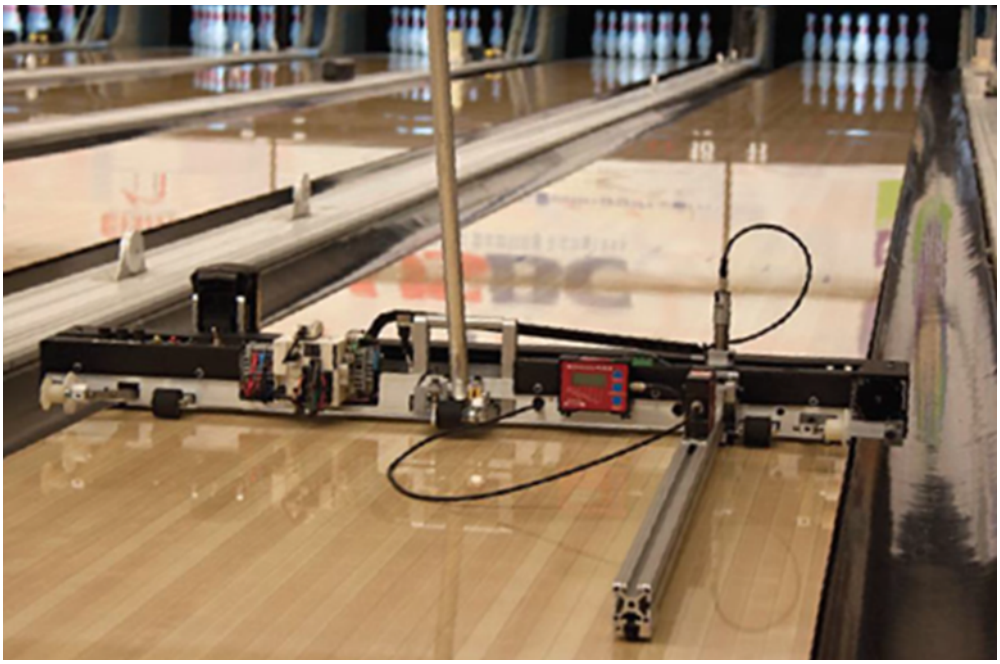
1. Determine how lane topography fluctuates over time
2. Determine the effect of lane topography on the ball path
3. Determine the effect of pin deck specifications on pinfall

INITIAL RESULTS

The Lane Inspection Project started out by gathering data from the local associations to determine what was truly being measured and reported. Presently, local associations are required to inspect all lanes in their association, fill out the certification form, and then fill out an online form that asks if all measurements pass all certification specifications; and if not, then enter the measurements that were out of specifications.

Copies of the actual applications for Certified Bowling Center Certificates were gathered from 223 local associations. It was determined that 80% of these applications were completed with less than 75% of the required measurements. In fact, the average certification form had 53% correct lane certification data. Many applications had incorrect information on them; such as, the same measurements on all the lanes, instances of incomplete applications with measurements for only a few lanes in the center, or the same measurements as the prior year.

Next, the Equipment Specification Department went to 64 centers in 20 states across America and took the certification measurements on just over 1,000 lanes. The lanes were measured using a lane mapper, which takes a measurement on every board or 39 readings across the lane, and every three feet down the lane, or 18 locations per lane. This was more than 700 readings per lane, not including any pin deck measurements.



The results in the tables below show most lanes had some measurements that did not pass specifications.

All Measurements	**Pct. Measurements Out of Spec**		
	All Measurements	Synthetic	Wood
Crown & Depressions	9.8%	10.5%	1.7%
Crosswise tilts	14.6%	15.2%	7.3%
All lane measurements combined (not pin deck measurements)	9.9%	10.6%	1.8%
Pin deck measurements (not including pin spotting)	46.9%		

Percentage of all lanes with some measurements out of spec:

Measurement	**Pct. Lanes Out of Spec**
Crown & Depressions	74.2%
Crosswise tilts	69.5%
Pin deck	46.9%

Scientific Study – How Lane Specifications Affect Bowling

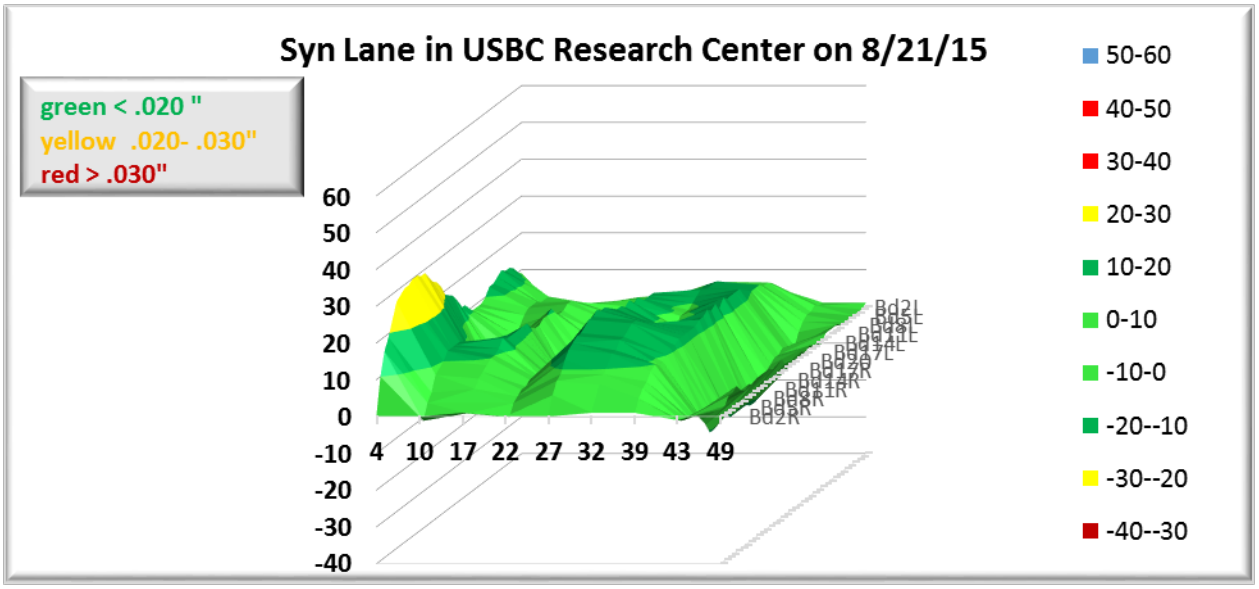
The second phase of the Lane Inspection Project was a scientific analysis to determine how the lane certification specifications influence the ball path and scoring.

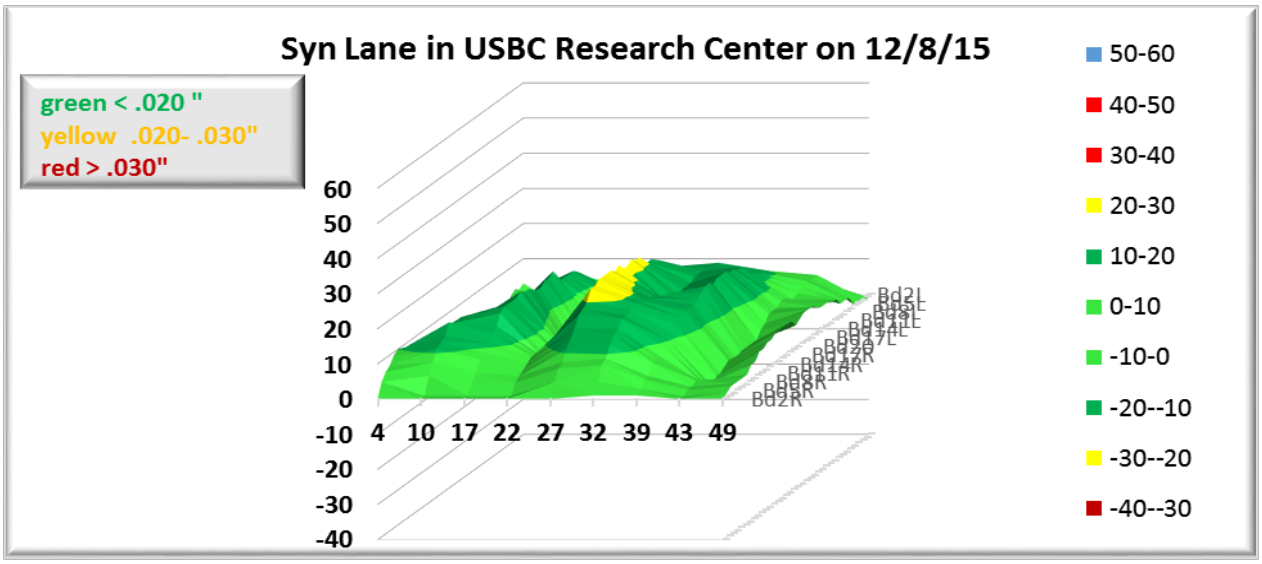
1. Determine how lanes topography fluctuates over time

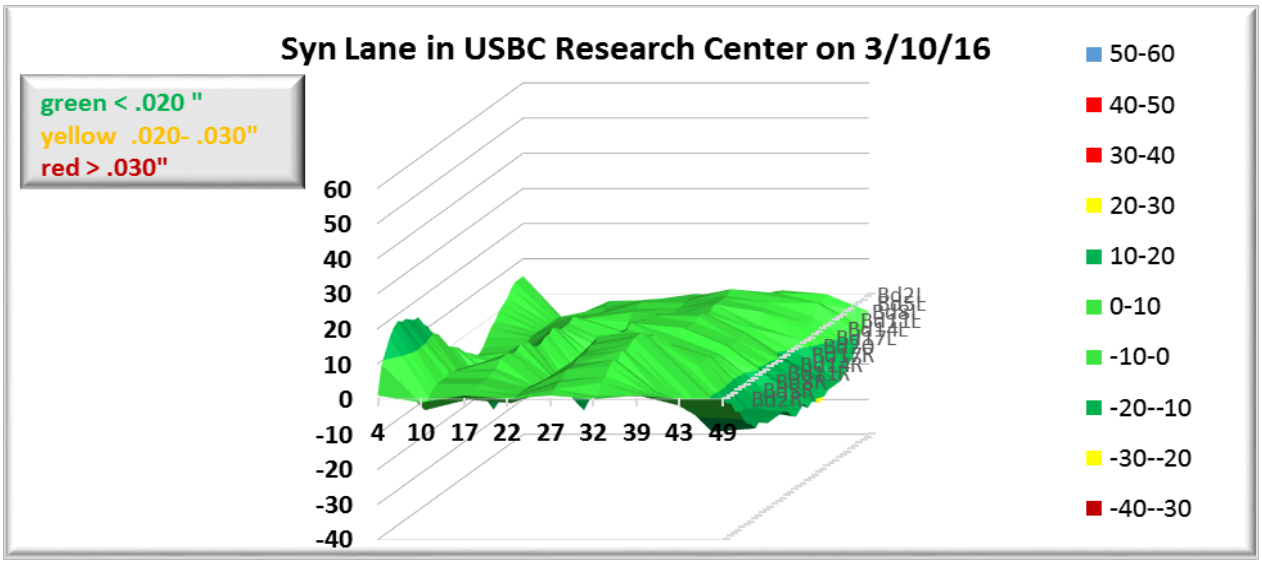
Certification specs require lanes to be flat within ±.040" for crowns and depressions, plus crosswise tilts. Lanes are made from wood or synthetic material comprised of kraft paper and phenolic resin. All these products can expand and contract due to environmental factors, such as temperature and humidity, which will alter the topography. Therefore, a study was conducted to determine how lanes move over a year's timeframe.

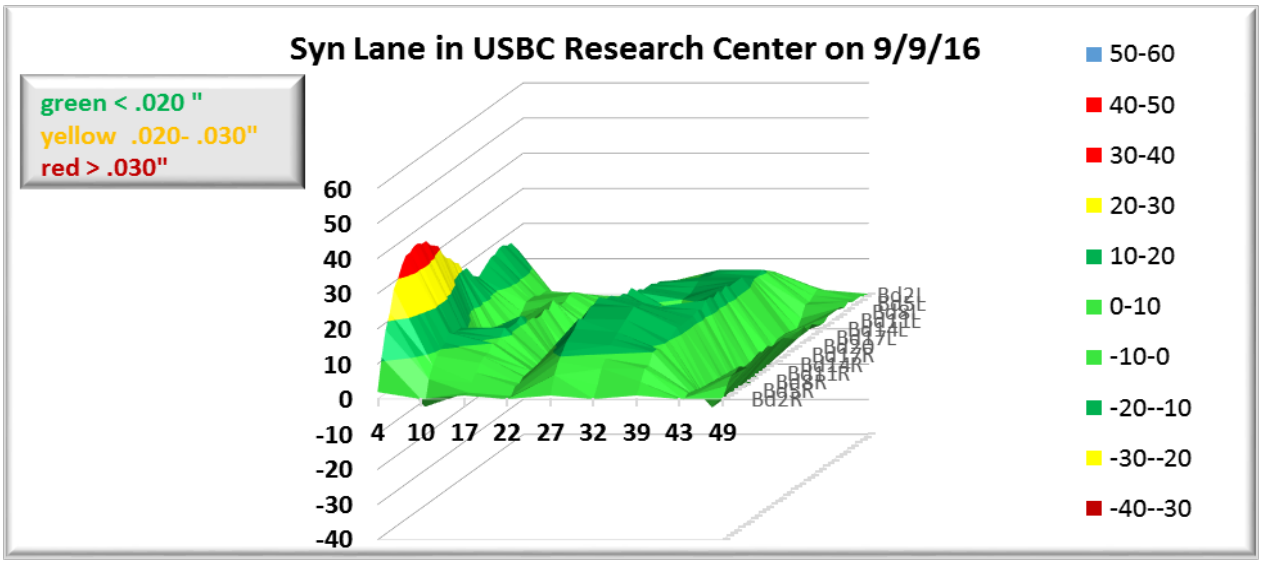
Lanes were measured at USBC headquarters and at a commercial center that was leveled just before starting the test.

Below are contour graphs of the same synthetic lane measured over the course of a year, which show the lane moving, but returning to approximately the same topography after one year.

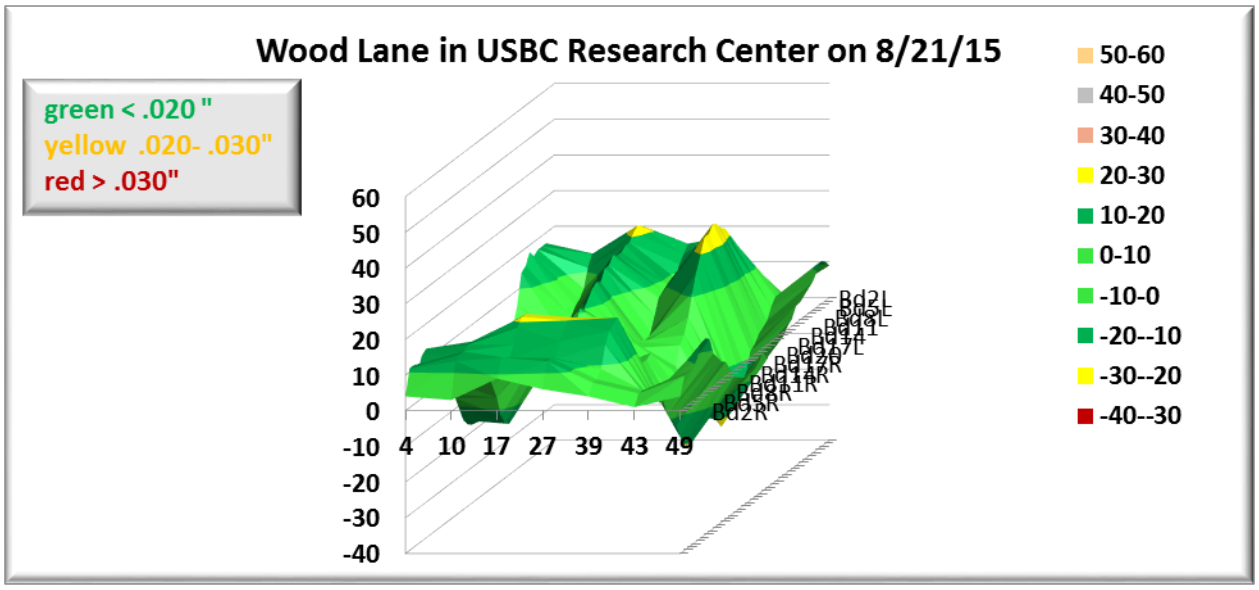

Syn Lane in USBC Research Center on 8/21/15
green < .020 "
yellow .020- .030"
red > .030"
60
50
40
30
20
10
0
-10
-20
-30
-40
4 10 17 22 27 32 39 43 49
Bd2L
Bd2R
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30

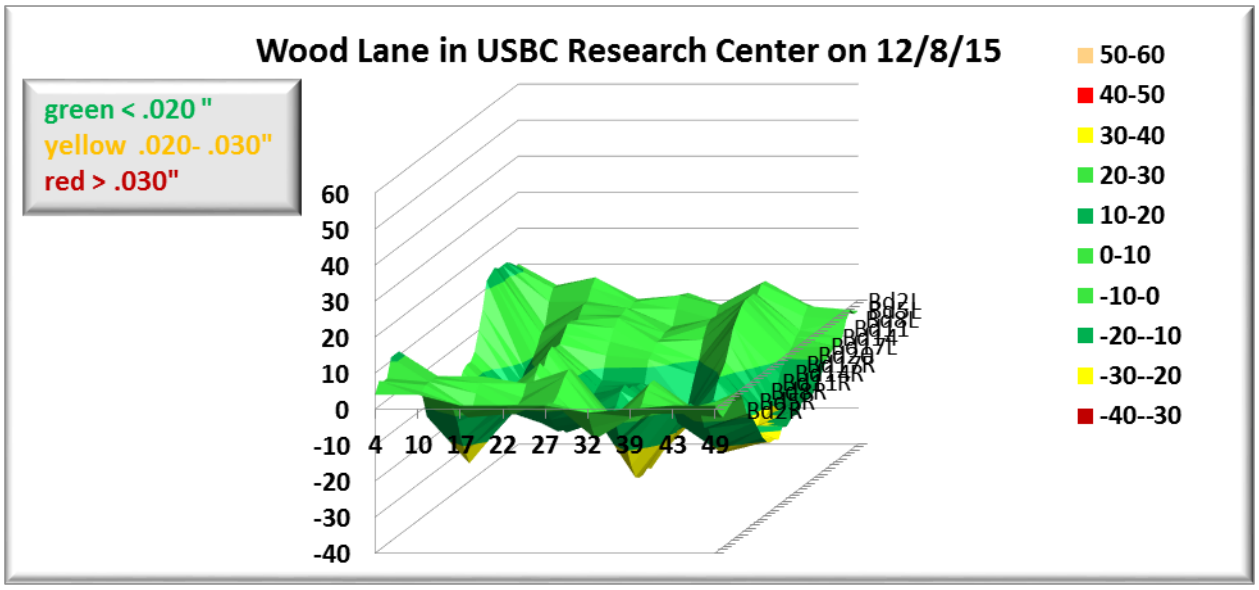

Syn Lane in USBC Research Center on 12/8/15
green < .020 "
yellow .020- .030"
red > .030"
60
50
40
30
20
10
0
-10
-20
-30
-40
4 10 17 22 27 32 39 43 49
Bd2L
Bd2R
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30

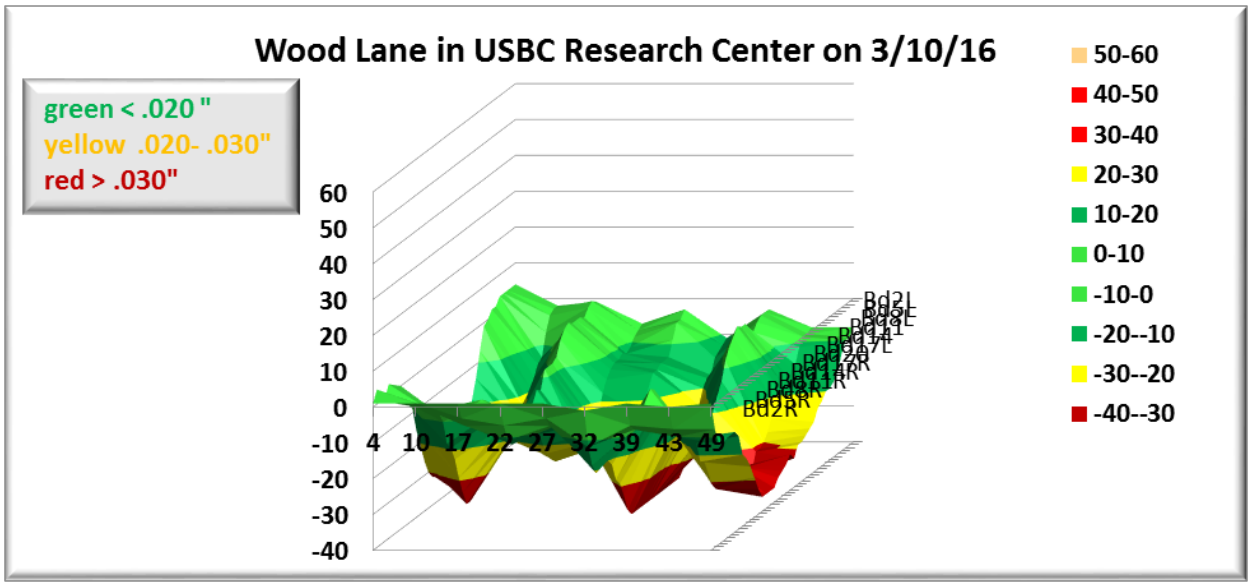

Syn Lane in USBC Research Center on 3/10/16
green < .020 "
yellow .020- .030"
red > .030"
60
50
40
30
20
10
0
-10
-20
-30
-40
4 10 17 22 27 32 39 43 49
Bd2L
Bd2R
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30

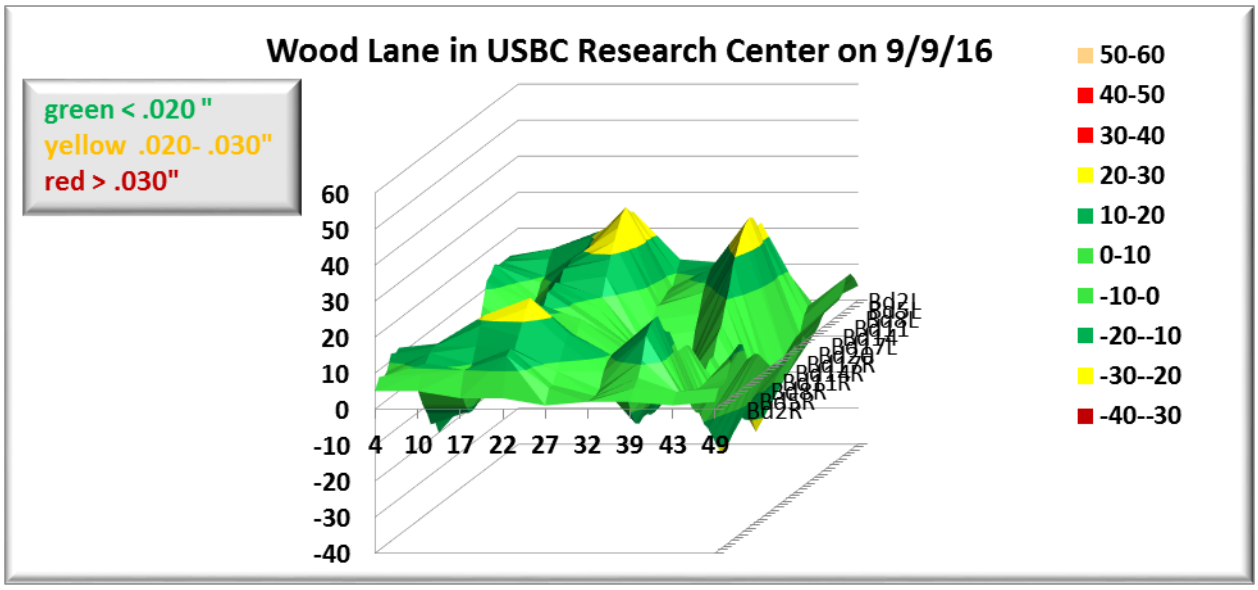


Below are contour graphs for a wood lane over the same one-year timeframe, which shows movement throughout the year but returning to approximately the same topography after a year.

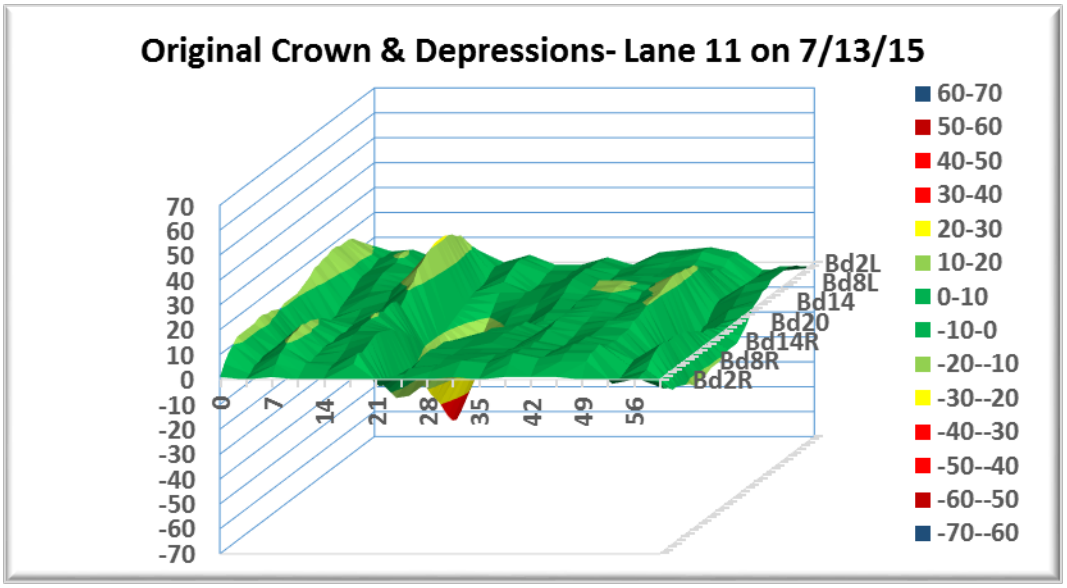


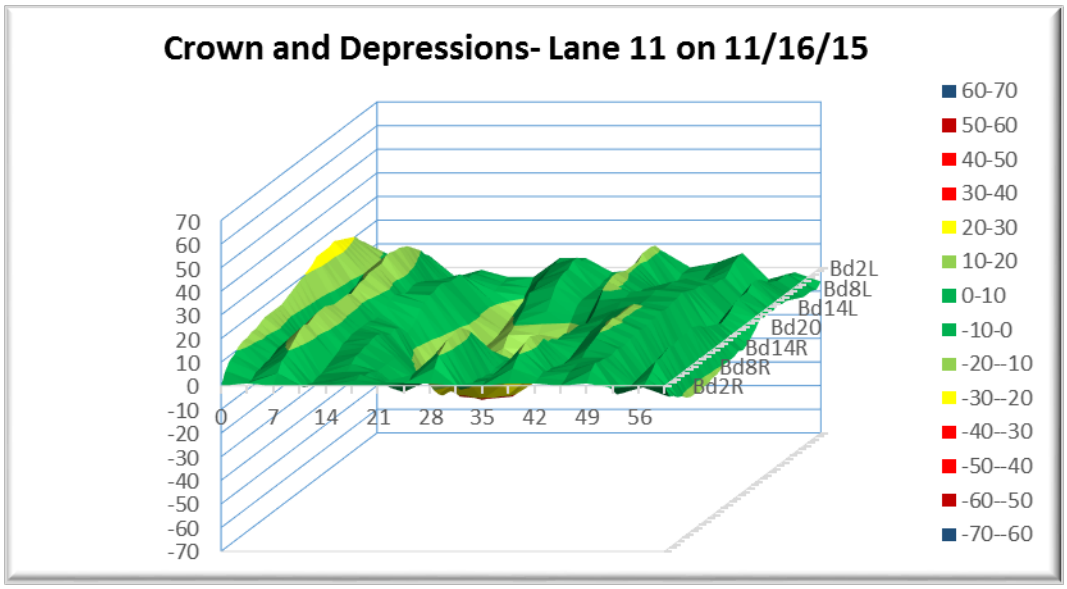

Wood Lane in USBC Research Center on 12/8/15
green < .020 "
yellow .020- .030"
red > .030"
60
50
40
30
20
10
0
-10
-20
-30
-40
4 10 17 22 27 32 39 43 49
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30

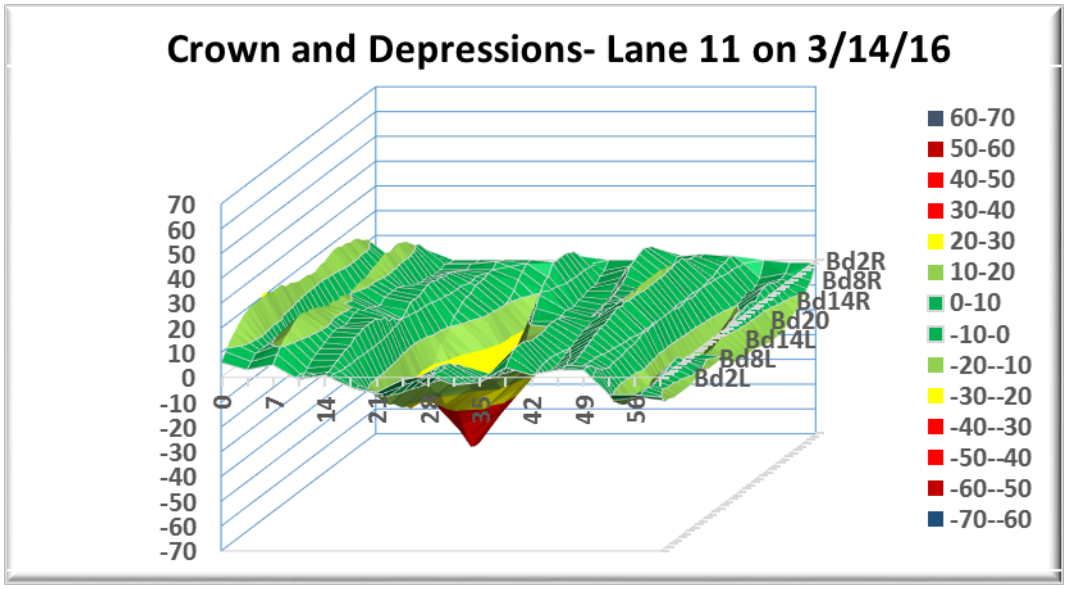

Wood Lane in USBC Research Center on 3/10/16
green < .020 "
yellow .020- .030"
red > .030"
60
50
40
30
20
10
0
-10
-20
-30
-40
4 10 17 22 27 32 39 43 49
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30

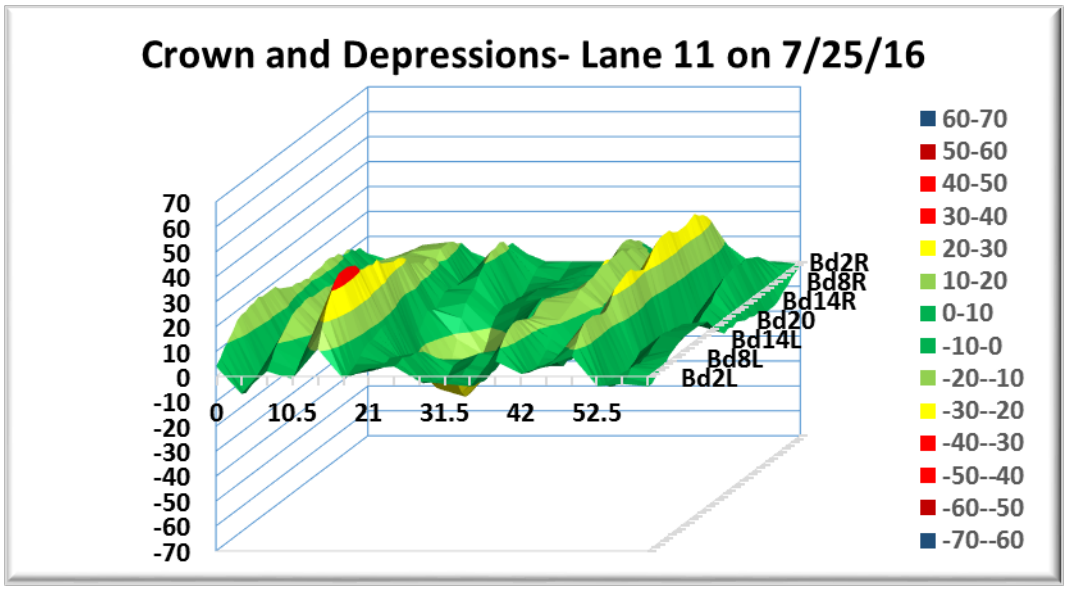

Wood Lane in USBC Research Center on 9/9/16
green < .020 "
yellow .020- .030"
red > .030"
60
50
40
30
20
10
0
-10
-20
-30
-40
4
10
17
22
27
32
39
43
49
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30

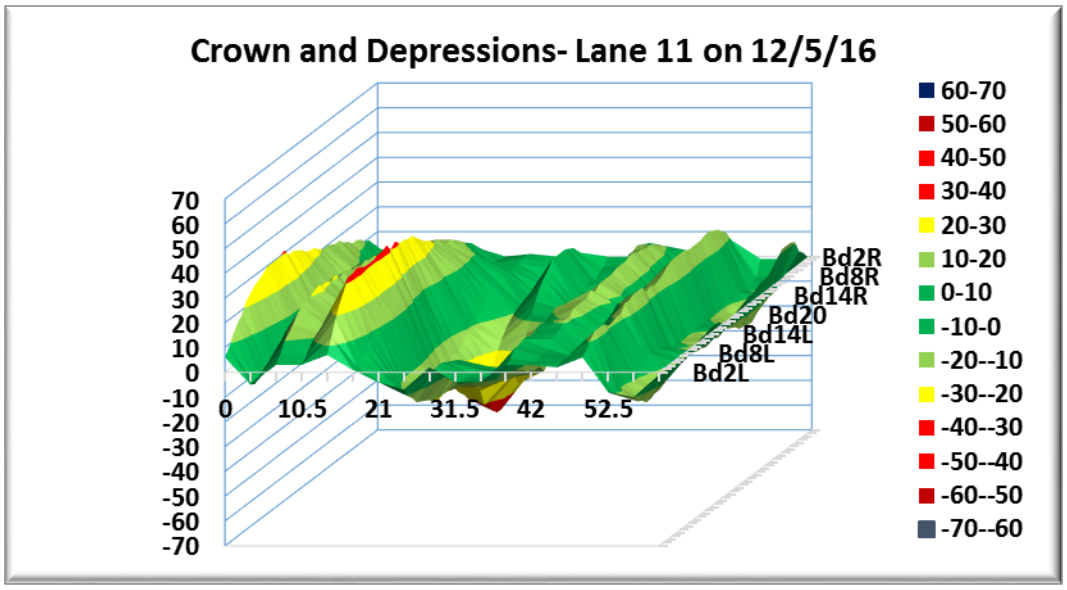
Below are contour maps from a commercial synthetic lane center that was leveled to within ±.0.020” just prior to conducting this study.






Crown and Depressions- Lane 11 on 3/14/16
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0
7
14
21
28
35
42
49
56
Bd2R
Bd8R
Bd14R
Bd20
Bd14L
Bd8L
Bd2L
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30
-50--40
-60--50
-70--60

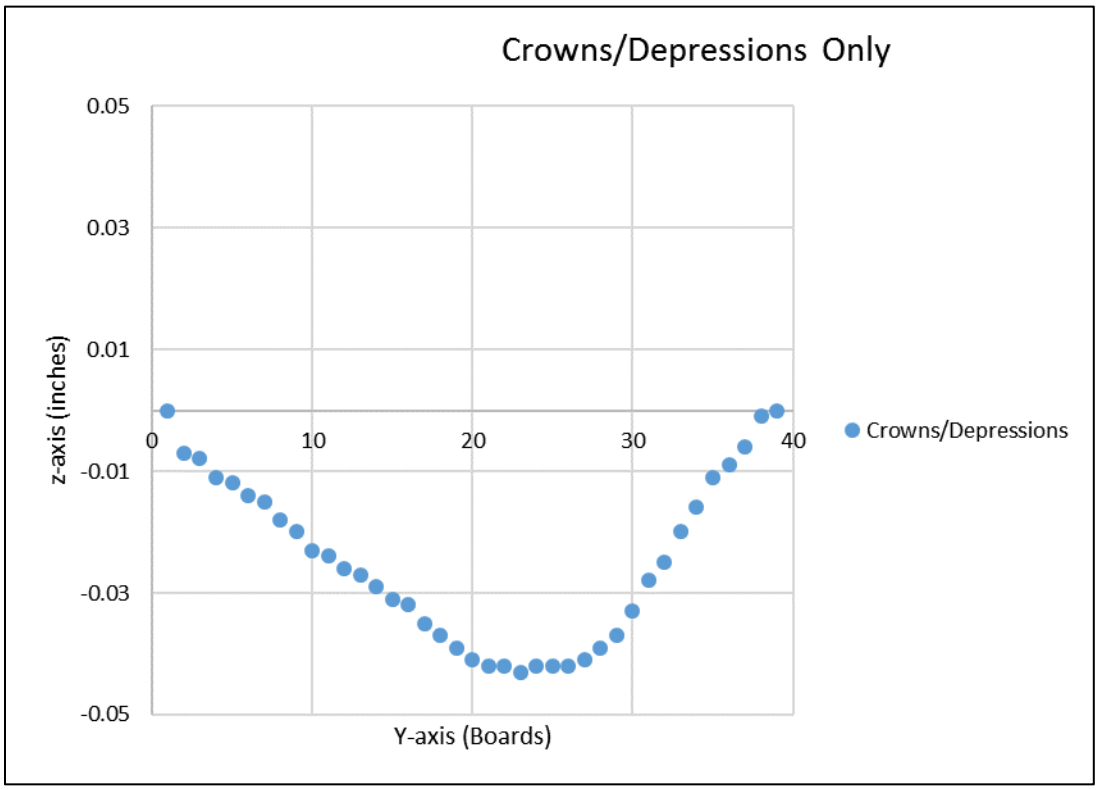

Crown and Depressions- Lane 11 on 7/25/16
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
0
10.5
21
31.5
42
52.5
Bd2R
Bd8R
Bd14R
Bd20
Bd14L
Bd8L
Bd2L
60-70
50-60
40-50
30-40
20-30
10-20
0-10
-10-0
-20--10
-30--20
-40--30
-50--40
-60--50
-70--60

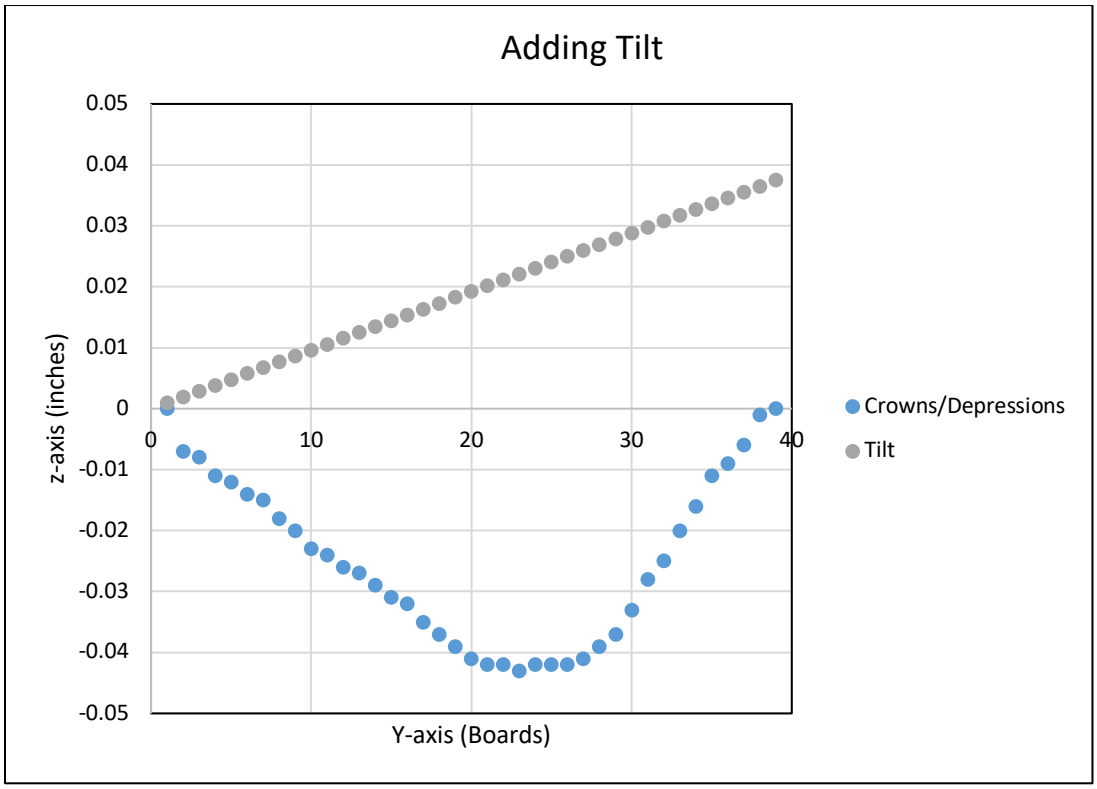


Lane surface topography fluctuates over time due to environmental conditions. Crowns and depressions moved up to .034" over one year, but on average, the commercial center moved back to within .008" of the original measurements after a year. So, individual measurements can have a large variance but overall the average fluctuation is less than .010".

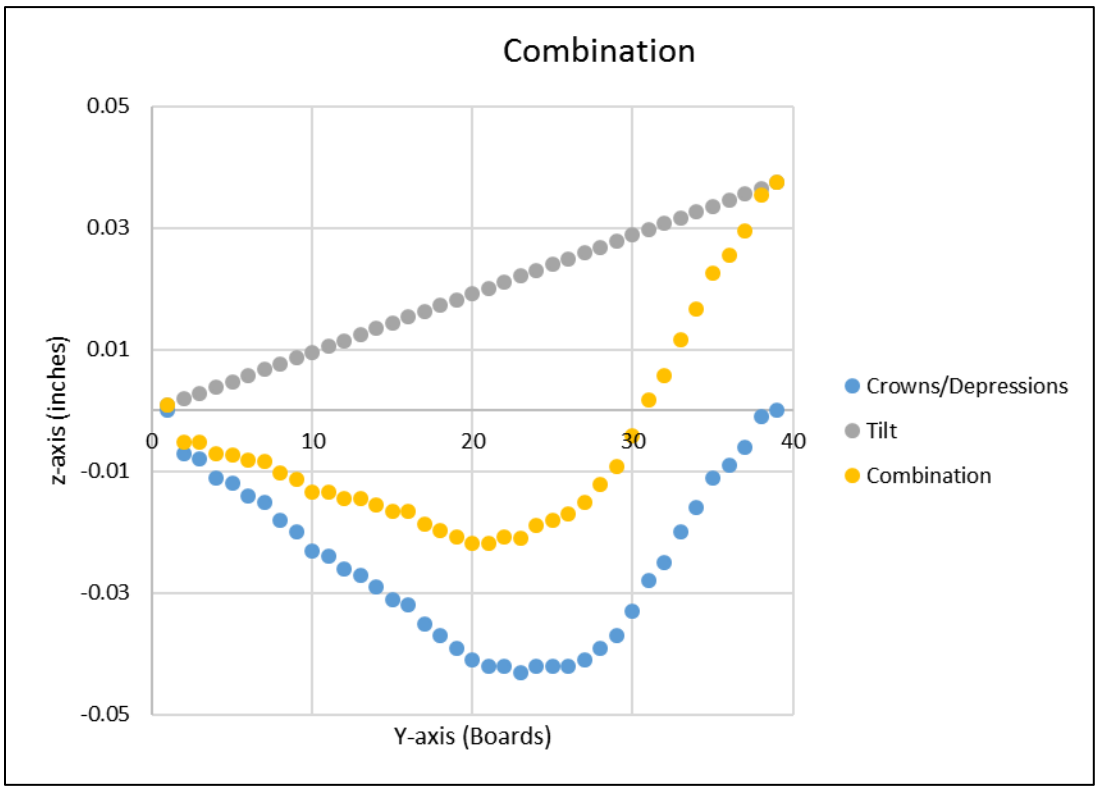
2. Determine how lane topography effects the ball path

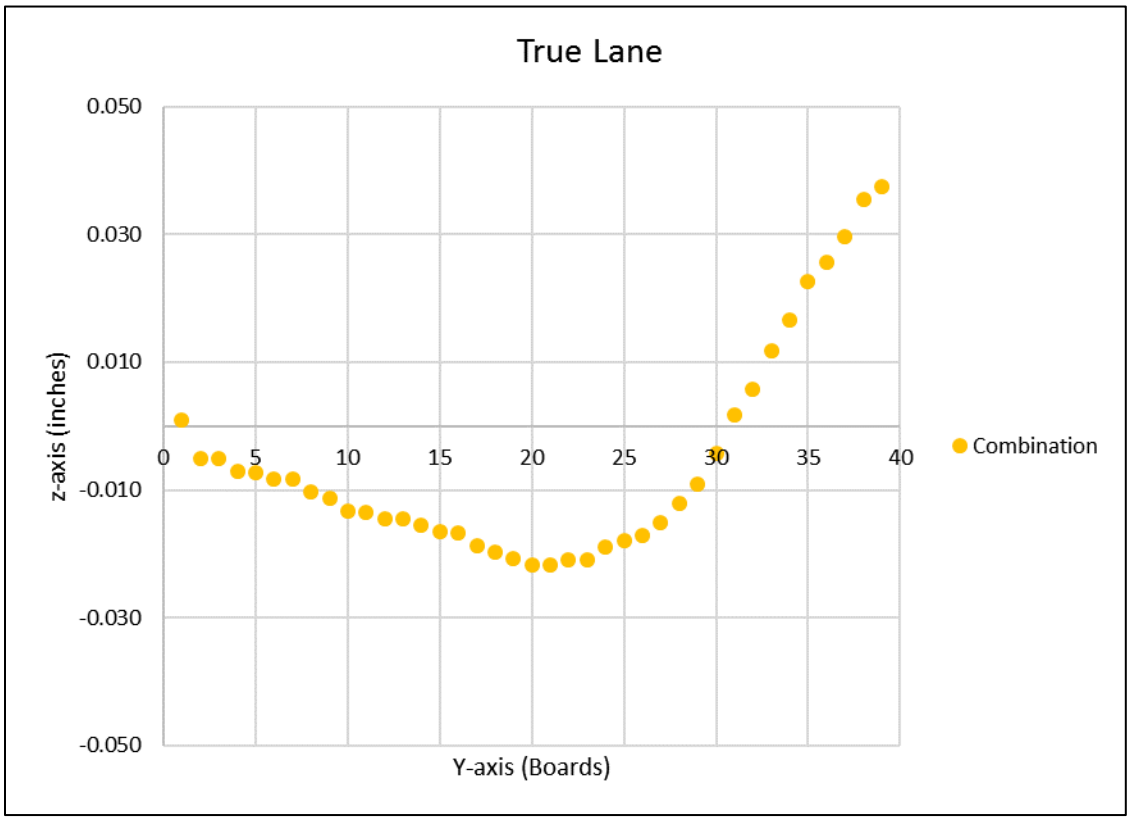
Another phase of the scientific study was to determine the effect topography has on the ball path. The present specification requires crowns/depressions plus crosswise tilts not to exceed ±.040". The goal was to determine how this specification affected a straight ball path. A mathematical analysis determined the theoretical deviation from the straight ball path due to the contour of the lane surface. The true lane contour requires combining the crosswise tilts with the crowns and depressions.


Crowns/Depressions Only
0.05
0.03
0.01
-0.01
-0.03
-0.05
z-axis (inches)
0
10
20
30
40
Y-axis (Boards)
Crowns/Depressions

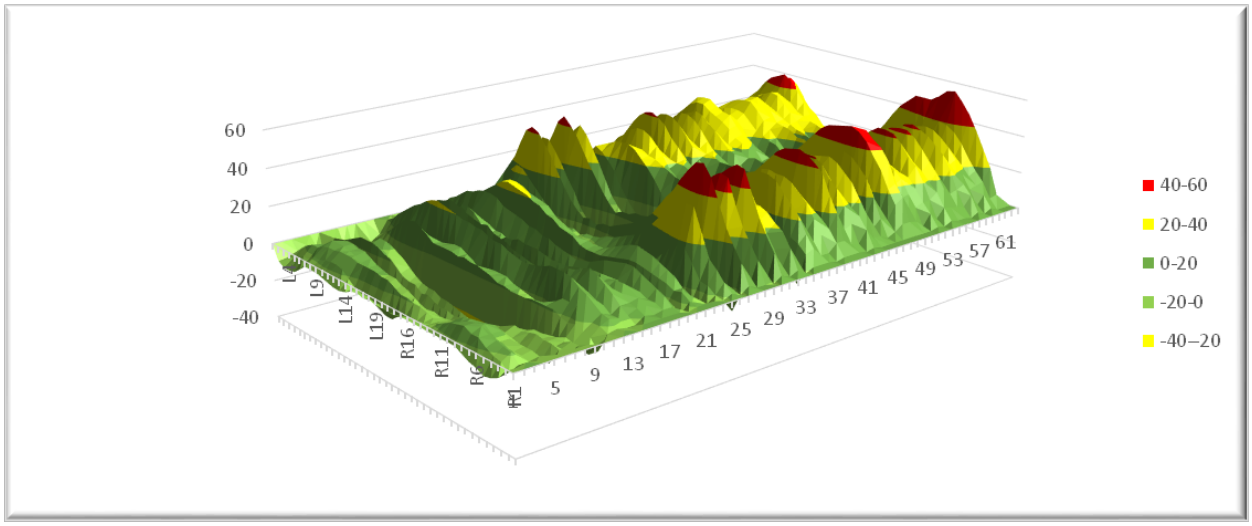

Adding Tilt
0.05
0.04
0.03
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
-0.05
z-axis (inches)
0
10
20
30
40
Y-axis (Boards)
Crowns/Depressions
Tilt

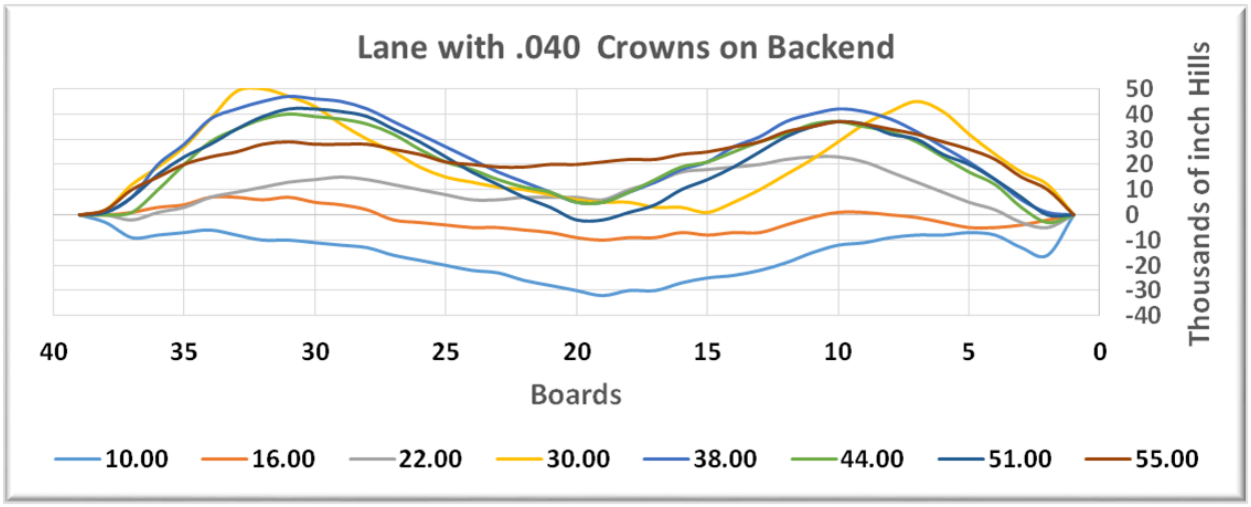
The yellow ball path below is the combined lane contour:



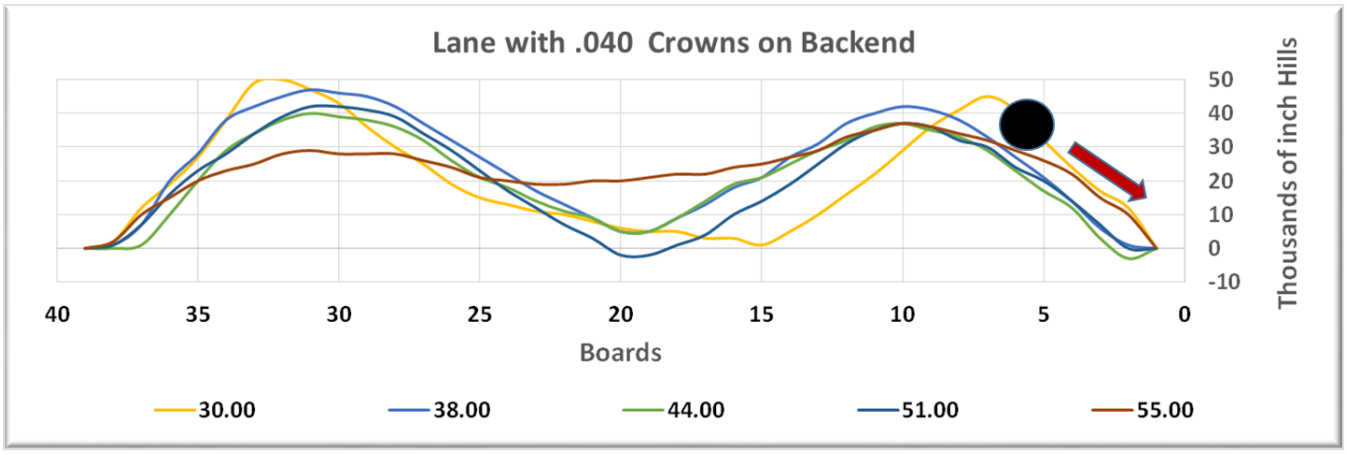


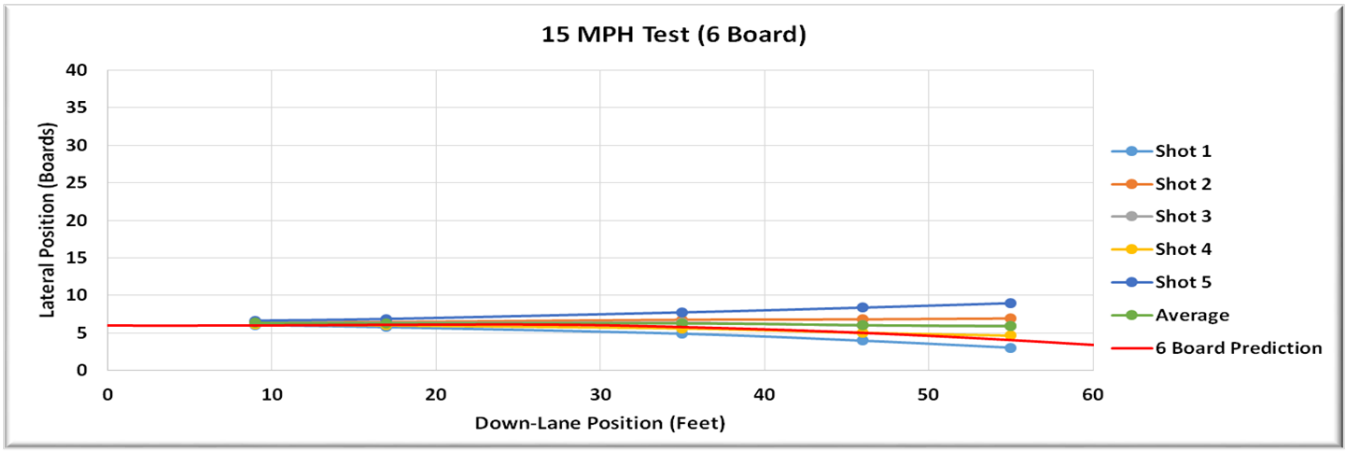
Then, once the true contour was determined, a mathematical model was used to determine the effect on the ball path by this non-flat surface. The math model was verified by setting up a lane with two crowns that were .040" high, from 20 to 60 feet down the lane. (Note: USBC specifications state "the surface must be free of all continuous grooves or ridge", which would make this illegal.)

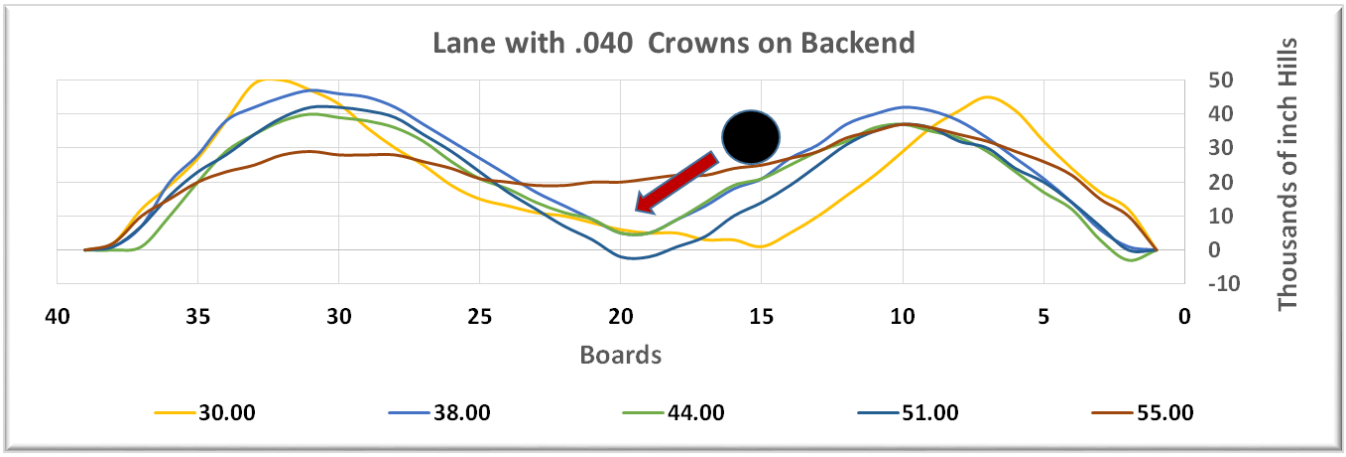


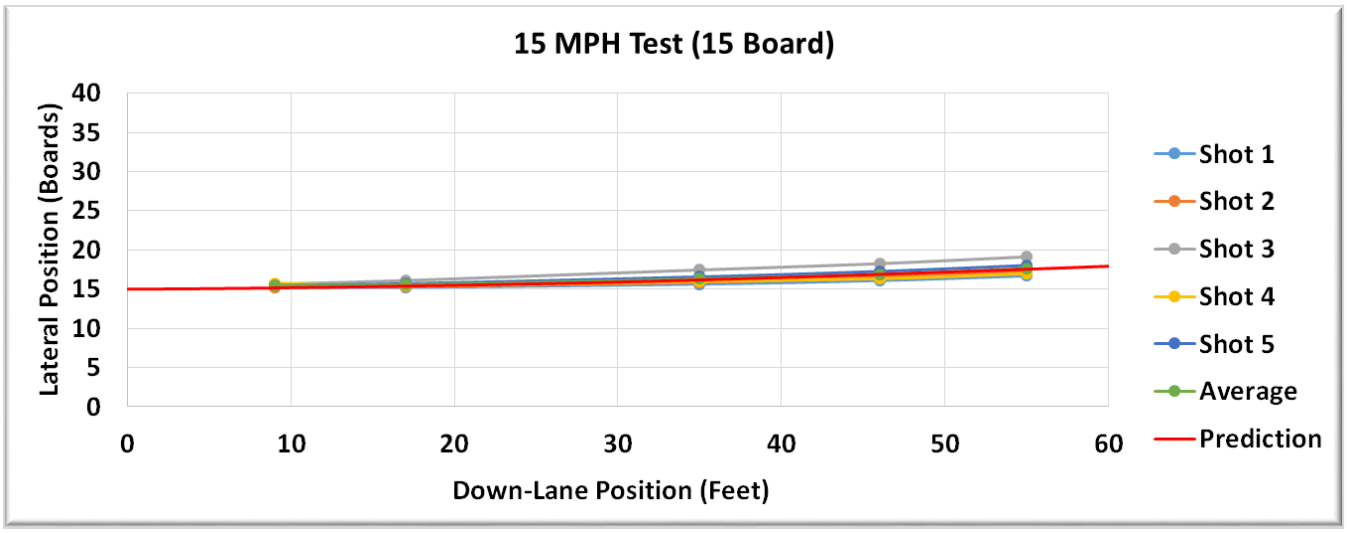


A ball was thrown straight down the lane at various locations to allow the crowns to steer the ball left or right, and the deviation from the straight ball path was compared to the math prediction.


Lane with .040 Crowns on Backend
50
40
30
20
10
0
-10
Thousands of inch Hills
40
35
30
25
20
15
10
5
0
Boards
30.00
38.00
44.00
51.00
55.00

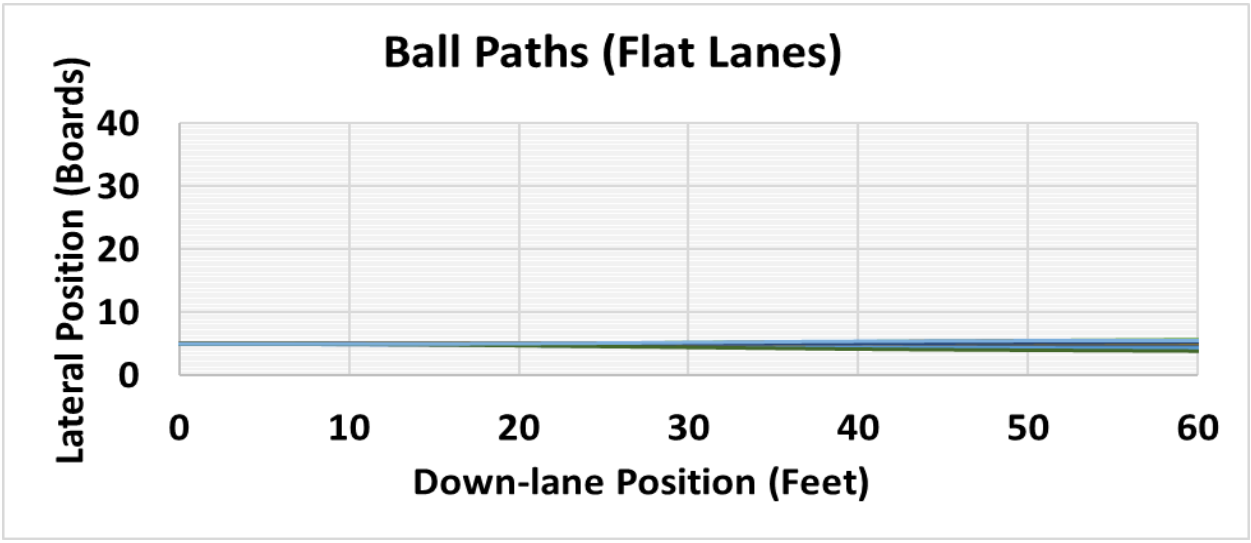

15 MPH Test (6 Board)
Lateral Position (Boards)
40
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
Down-Lane Position (Feet)
Shot 1
Shot 2
Shot 3
Shot 4
Shot 5
Average
6 Board Prediction

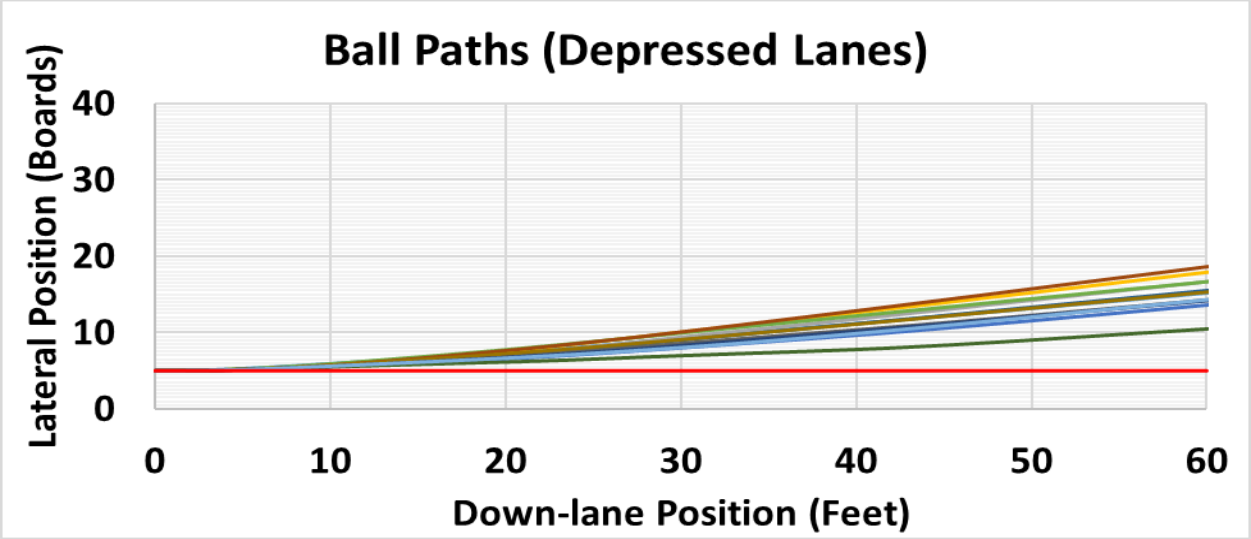


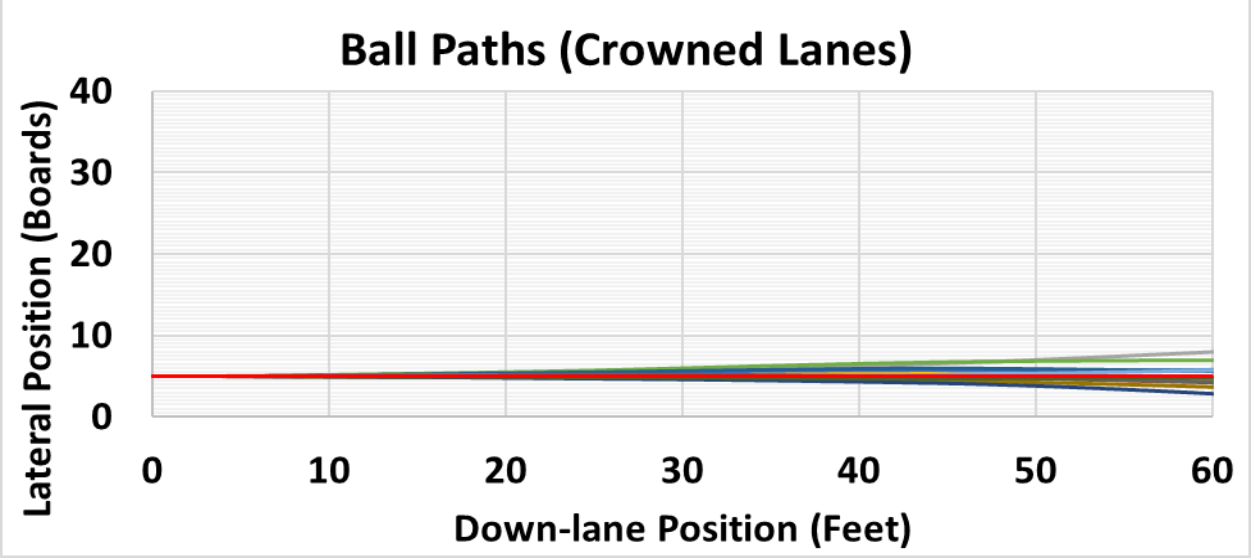


The calculated math model matched the test results; therefore, the math model was accurate.

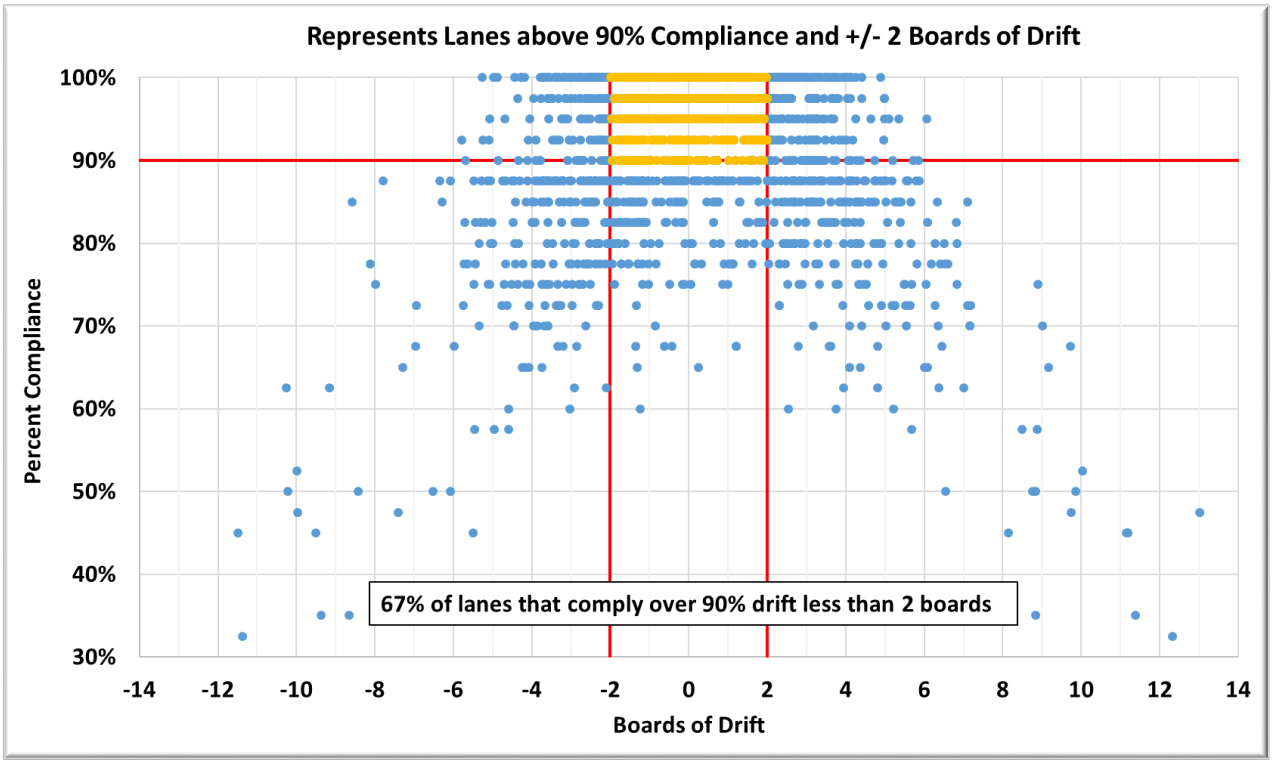
The math model was used to evaluate the certification data of the 1,000-plus lanes collected in the 64 centers. The math model was used to predict what would happen if a ball was thrown down the fifth and 35th boards on every lane.




Ball Paths (Depressed Lanes)
Lateral Position (Boards)
40
30
20
10
0
0
10
20
30
40
50
60
Down-lane Position (Feet)


Ball Paths (Crowned Lanes)
Lateral Position (Boards)
40
30
20
10
0
0
10
20
30
40
50
60
Down-lane Position (Feet)

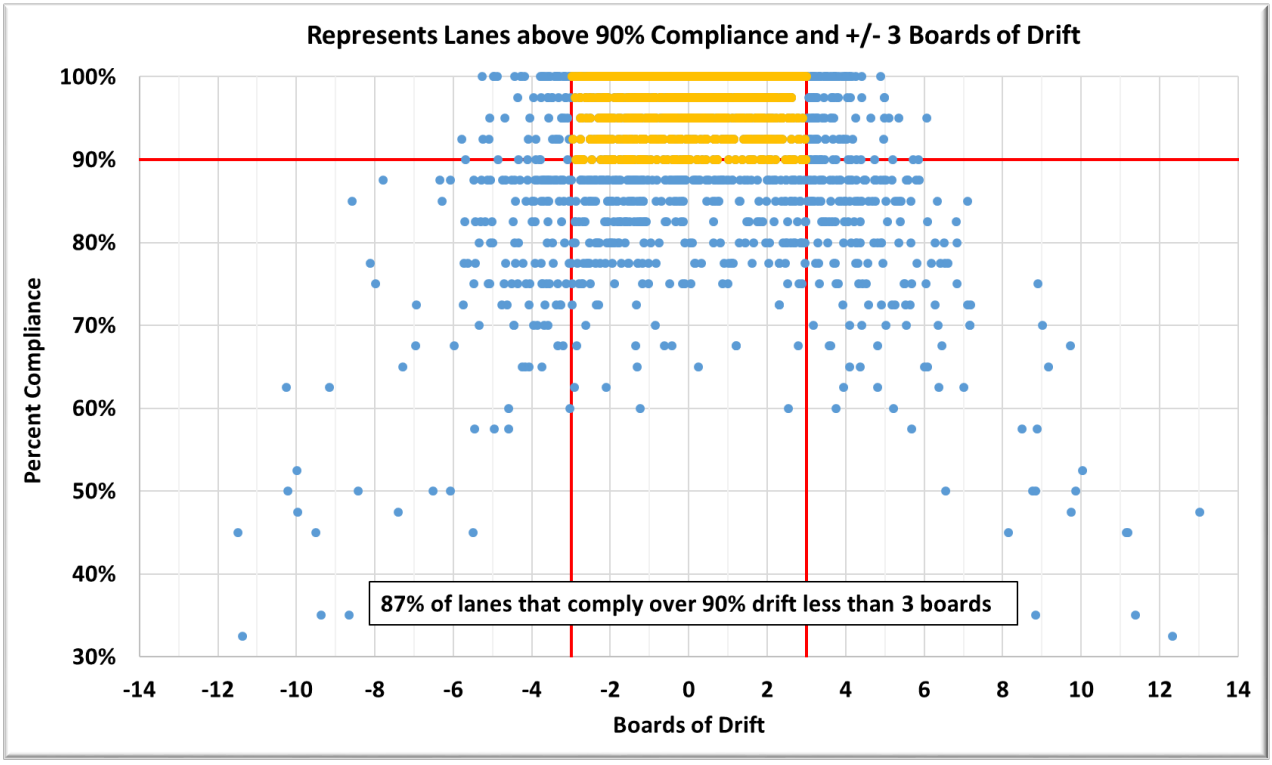
The chart below shows how much the ball would drift from the straight ball path due to the topography if the ball was thrown down the 5th and 35th boards on all 1,000-plus lanes.



The percent compliance axis refers to the percent of the lane measurements complying with the ±.040" crowns/depression and crosswise tilt spec. For example, 90% means 90% of the lane measurements pass specifications. The boards of drift axis refer to the movement off the straight ball path at the pins. Drift of minus-2 is two boards to the left on the lane and plus+2 is two boards to the right. Overall, if the lane drops below 60% compliance, all ball paths drift more than two boards left or right (no data points are between the vertical red lines at -2 and +2 below 60% compliance).

Therefore, the topography greatly affects the ball path when the lane topography gets bad. The good thing is there were not many lanes that had less than 60% compliance based on the number of data points in this area of the chart. If the compliance is 75-80%, there are more data points outside the two red vertical lines, indicating there is a good chance for these lanes to be inconsistent from lane to lane. The yellow data points are lanes that drift less than ±2 boards and have 90% compliance or better. This represents 67% of all the data points over 90% compliance within the lane specification. This indicates consistency from lane to lane across a center with less than ±2 boards of drifting. The bad news is the overall chart has more data points outside this "good" yellow zone then inside (more blue data point then yellow). This means the ball paths will drift differently when moving from lane to lane.

The chart below is the same chart but the yellow data points show 87% of the lanes with at least 90% lane measurement compliance will drift less than ±3 boards. There is a heavy concentration of data points within this yellow box, which means centers with all lane measurements within the ±.040" spec, or up to 10% outside of spec, are fairly consistent from lane to lane.



2. Determine the effect of pin deck specifications on pinfall

Next, the pin deck specifications were evaluated for their impact on pinfall. Bowlscore, an automated ramp, was used for this evaluation. Each pin deck specification measurement was adjusted to cover more than the spec range and Bowlscore was used to evaluate the effect on pinfall.

The following properties were adjusted beyond their spec limits and tested to measure their effect on pinfall:

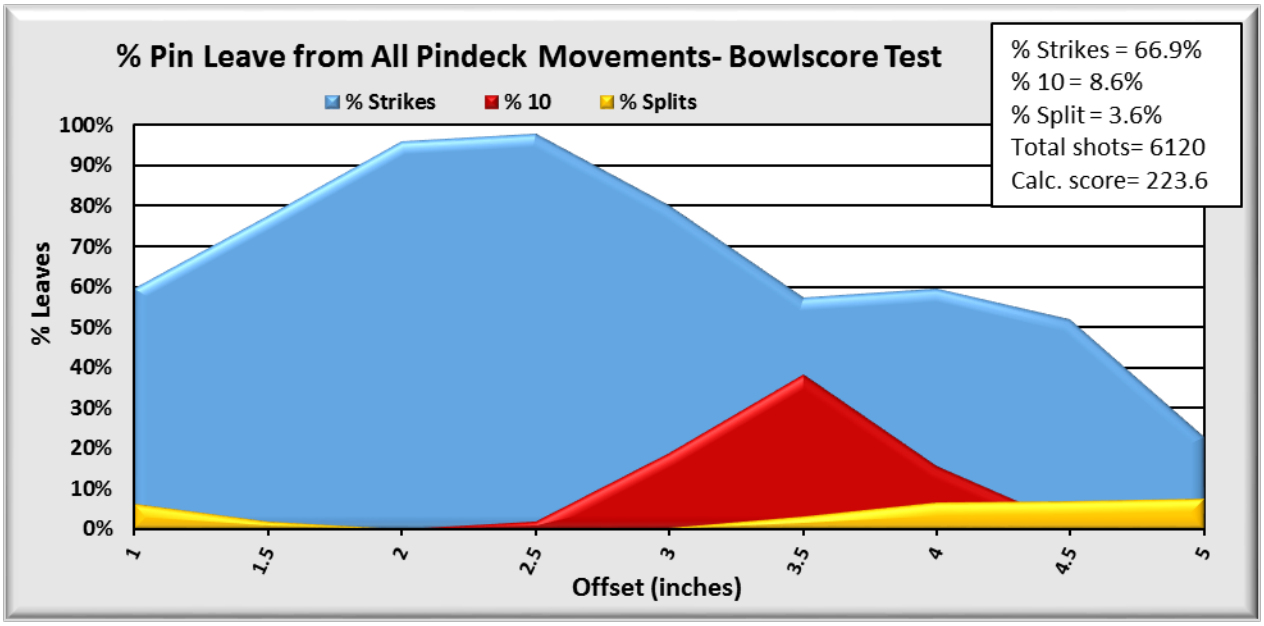
- Width between Kickbacks in the front and rear of pin deck
- Flat gutter depth
- Pin deck crosswise tilt
- Pin deck lengthwise tilt from front to back

Bowlscore was adjusted to throw different weight balls at different entry angles and offsets to hit the head pin everywhere from a very light hit to a very high hit in the pocket. Below is a chart where the pinfall was converted into a potential score. The average score for all the different pin deck specification settings was 223.6.

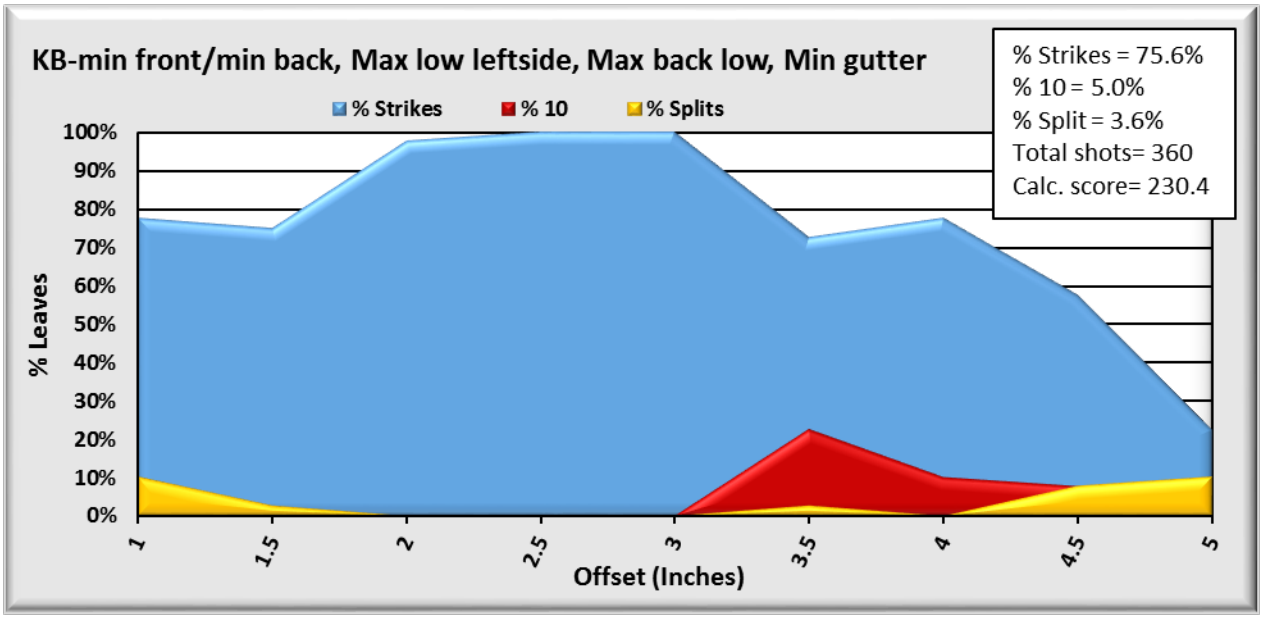
Property	min value	max value	Score @min value	Score @max value
Width between kickbacks @ front	59.25"	61.25"	223.8	223.1
Width between kickbacks @ back	59.25	61.25"	227.8	219.1
Cross tilt	-0.080	0.080"	222.8	224.1
Lengthwise tilt	-0.250	0.250"	224.2	222.7
Gutter depth	2.75"	4"	223.9	223.0
Overall test average-all settings			223.6	

The above chart shows the width between the kickbacks at the rear of the pindeck (along the 7-10 pin line) had the largest range in scoring; therefore, it is the most important property affecting the scoring potential.

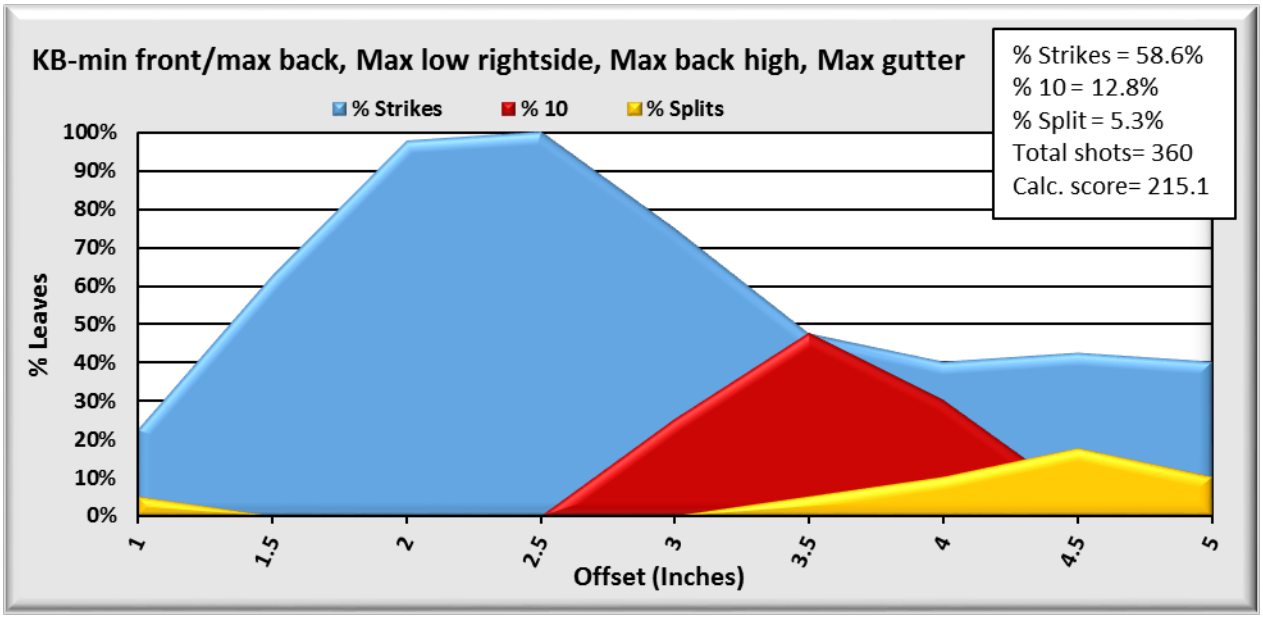
The graph below shows the overall percentage strikes, percentage 10 pins, and percentage splits at different offsets for all combinations of the pin deck specification that were tested using a 16-pound ball:



The graph below was the highest-scoring combination of properties.

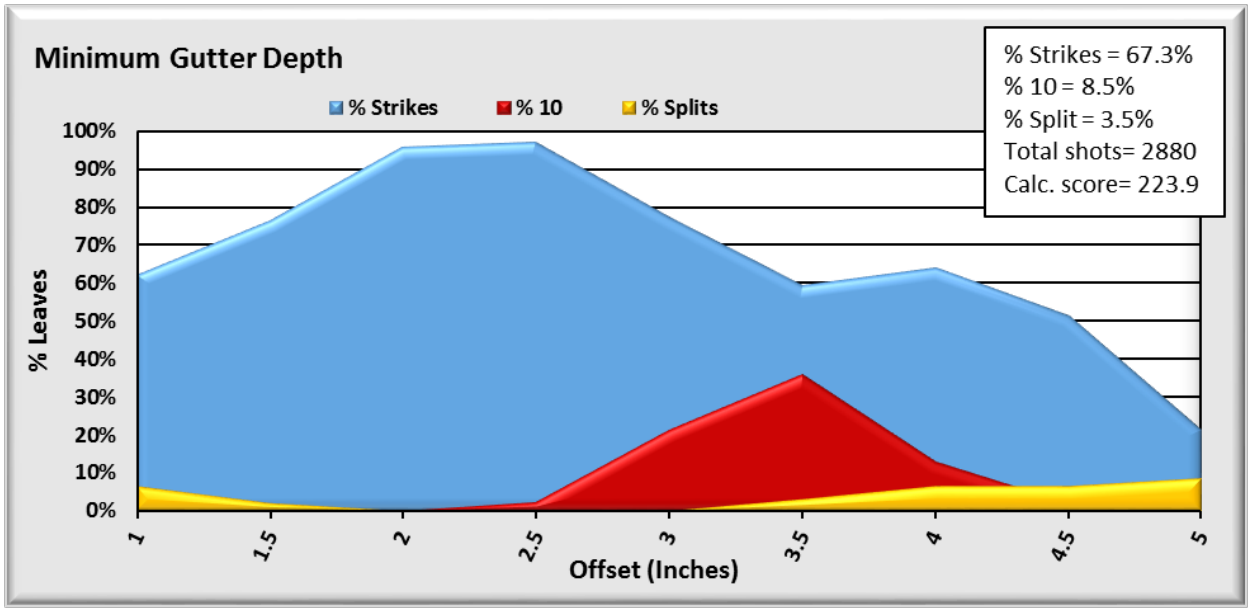


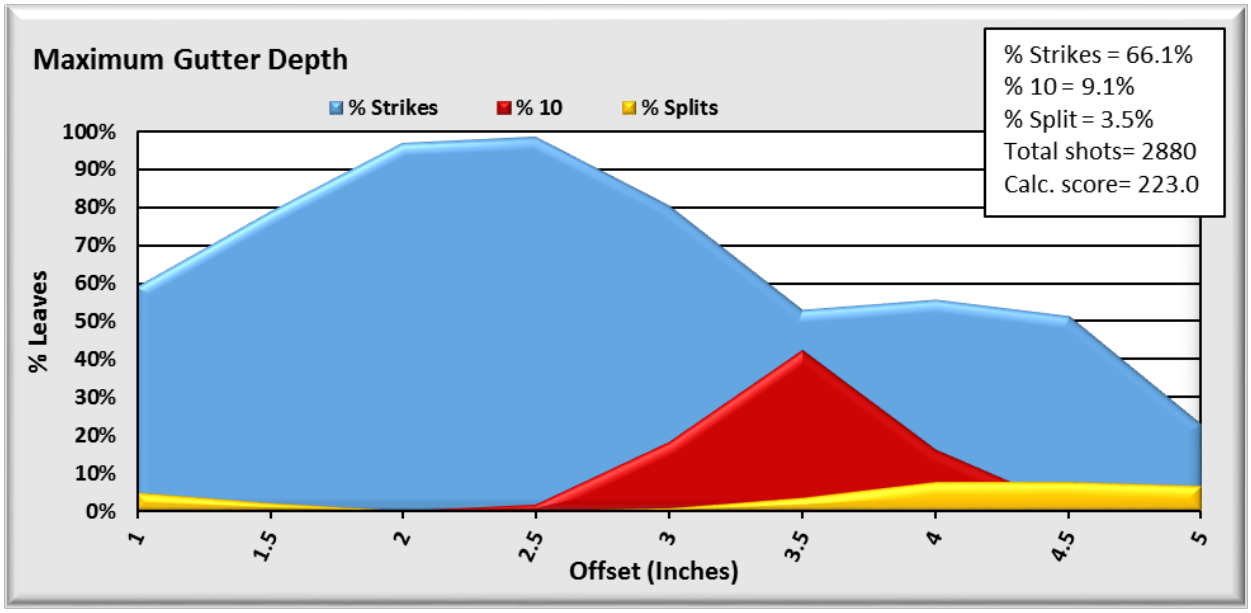
The graph below was the lowest-scoring combination of properties.



These graphs show if the ball hits the “ideal” strike pocket location at 2- to 2.5-inch offset, then strikes are a result from the pins knocking each other over with the gutters and kickback never coming into play. But, when the ball hits high or light in the pocket, then the pins must ricochet off the kickbacks to strike. On these light and high hits, the strike percentage can be altered with the various pin deck properties, especially the kickback-to-kickback dimension.

Gutter depth has always been thought to be an important property in scoring. For this test the gutter depth was varied from 2-3/4" to 4" (spec is 3-3/8" to 3-5/8") and the results showed less than 1 pin difference in scoring:





Shallower gutter depth did reduce 10-pin leaves as might be expected from pins being more likely to bounce out of the gutter; but it was by less than 1% difference (8.5% for shallow gutter vs. 9.1% for deep gutters), which had minimum impact on scoring.