Louisiana Transportation Research Center

Final Report 555

Field Evaluation of Roller Integrated Intelligent Compaction Monitoring

by

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DOTD conducted a demonstration project evaluating intelligent compaction (IC) technology. The project selected a project site and developed specifications, which allowed and incorporated the IC rollers on the project. The research shadowed the normal acceptance process, collecting RICM data from each pavement layer as measurement passes (soil) and compaction passes for HMA. Standard specifications and quality assurance acceptance testing governed the project. Research testing supplemented the standard acceptance testing conducted by District 03.

The DOTD IC specification went through the competitive bidding process and produced a wide range of cost numbers. The item for the soil roller had a range of bids from $15,000 to $95,000. The item for the asphalt roller had a range in bids from $7,000 to $100,000. The range may be attributed to the knowledge and familiarity (or lack of) within Louisiana regarding the intelligent compaction technology. This project sought to increase the knowledge base in Louisiana. LTRC therefore hosted a Showcase on the pilot project, which provided presentations from researchers, FHWA, and manufacturers. The project was well attended and well received.

Manufacturer equipment and software training/support are critical to the success of an IC project, which includes good communication throughout. In this case, the contractor had relationships with each roller manufacturer, and LTRC was able to interact with roller and manufacturer. Initial setup of roller and GPS connections was a challenge with both project rollers, as LTRC local roller representatives and the contractor were generally learning about the details of the technology for the first time. National roller representatives were helpful, but could not be on site at all times. The contractor’s survey staff became proficient in the two systems; and needed GPS knowledge; capable, accurate, and reliable GPS equipment; as well as the ability to connect properly and effectively with the rollers’ on-board software.

Contractor roller operators can adjust patterns and time based on real-time reactions, and the roller display can show and track coverage, passes, and compaction effort (measurement values) hopefully speeding production and assisting with quality control. Weak areas can be identified for rework. Departments of Transportation benefit from continuous coverage records (vs. point tests at roughly 1000-ft. spacing), and accelerated construction through the contractor’s IC use (appropriate passes/energy). The technology promotes consistent and uniform pavement layers that can be visually verified.

The recommendations include (1) recommend that the contracting community examine and evaluate the benefits of each IC roller system, and hopefully utilize a system to increase confidence, consistency, quality, and efficiency in production; (2) continue to promote the technology to the contracting community will help spread knowledge regarding these systems and the potential benefits they offer; (3) reevaluate the specification in the future as the technology becomes more mainstream; and (4) delay implementing quality assurance and acceptance standards via DOTD through the use of these rollers in Louisiana, but consider additional projects and presentations to increase knowledge within the contracting community.

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Project Review Committee

Each research project will have an advisory committee appointed by the LTRC Director. The Project Review Committee is responsible for assisting the LTRC Administrator or Manager in the development of acceptable research problem statements, requests for proposals, review of research proposals, oversight of approved research projects, and implementation of findings.

LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

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ABSTRACT

DOTD conducted a demonstration project to evaluate intelligent compaction (IC). The project developed specifications, which allowed and incorporated the IC rollers on the project. The specification went through the competitive bidding process and produced a wide range of cost numbers. The item for the soil roller had a range of bids from $15,000 to $95,000. The item for the asphalt roller had a range in bids from $7,000 to $100,000. The range may be attributed to the lack of knowledge and familiarity within Louisiana regarding the intelligent compaction technology. This project sought to increase the knowledge base of IC in Louisiana.

DOTD/LTRC hosted a showcase on the pilot project, which provided presentations from researchers, FHWA, and manufacturers. The showcase highlighted the US 90 Frontage Roads project, which collected both soil and asphalt data with two different rollers. The project was well attended and well received.

Manufacturer equipment and software training/support are critical to the success of an IC project, which includes good communication throughout. In this case, the contractor had relationships with each roller manufacturer, and LTRC was able to interact with roller and manufacturer. Initial setup of roller and GPS connections was a challenge with both project rollers, as LTRC local roller representatives and the contractor were generally learning about the details of the technology for the first time. National roller representatives were helpful, but could not be on site at all times. The contractor's survey staff became proficient in the two systems; and needed GPS knowledge; capable, accurate, and reliable GPS equipment; as well as the ability to connect properly and effectively with the rollers' on-board software.

The contractor can realize some advantages through the utilization of the rollers. Operators can adjust patterns and time based on real-time reactions/display, and the roller display can show and track coverage, passes, and compaction effort (measurement values) hopefully speeding production and assisting with quality control. Weak areas can be visually identified on the roller's real-time screen through installed software for rework.

Through the use of the IC technology, by the contractor, the Department can also realize some advantages. The rollers continuous coverage records (vs. point tests at roughly 1000-ft. spacing) can speed construction with contractor's use (appropriate passes/energy). The technology promotes consistent and uniform pavement layers, which can be visually verified by the roller real-time screen. With further research study, this technology could possibly

provide a quality assurance tool, and an alternative/replacement for the nuclear density gauge.

The new IC technology will hopefully benefit the contracting community the most. The rollers can speed up the compaction process by focusing efforts where needed to control uniformity. The technology is still new and not mainstream yet, though its advantages are many, including consistency of coverage, digital documentation of efforts, visual representation of roller movements, possible alternative to nuclear density gauges, and provide stiffness measurements with GPS location position.

The recommendations include (1) recommend that the contracting community examine and evaluate the benefits of each IC roller system, and hopefully utilize a system to increase confidence, consistency, quality, and efficiency in production; (2) continue to promote the technology to the contracting community will help spread knowledge regarding these systems and the potential benefits they offer; (3) reevaluate the specification in the future as the technology becomes more mainstream; and (4) delay implementing quality assurance and acceptance standards via DOTD through the use of these rollers in Louisiana, but consider additional projects and presentations to increase knowledge within the contracting community.

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IMPLEMENTATION STATEMENT

One goal of this research was to examine the technology and its utilization within the DOTD. Proper, uniform, and consistent compaction, while reducing project delays are key benefits of this technology. Another goal in this project was to utilize the rollers to shadow the normal data collection process throughout a test section. National involvement and research results (collected on soil and asphalt) were used to help develop draft specifications and proposal to demonstrate the IC technology on a Louisiana highway test site. Two specifications were created (soil measurement pass and asphalt construction pass) and used for a demonstration project on US 90 frontage roads (New Iberia).

An Intelligent Compaction Showcase was held in 06/04/13, at the research project demonstration site to promote the research and technology. PowerPoint and field presentations were conducted as part of the showcase. The research is also being shared with SHRP2 partners for use in their study: “Performance Specifications for Rapid Renewal (R07).”

An Every Day Counts (EDC) Exchange for Local and Tribal Agencies on Intelligent Compaction was held on April 3, 2014, and attended by the Project Review Committee and local contractors. The IC technology was discussed via national presentations, the demo project reviewed by the researcher, and the next steps reviewed and evaluated by all.

Developed over recent years, IC technology has made great strides in combining old and new technologies. Instrumentation, computer technology, and GPS have transformed the slow roller into one of the smartest devices on a jobsite.

Roller Integrated Compaction Monitoring (RICM) systems are not presumed to be a silver bullet or magic wand, but they can serve contractors and state departments of transportation as a valuable tool in the toolbox. Desired densities or stiffness moduli will still be difficult to achieve if the soil is too wet or dry, regardless of the compaction effort. Similarly, HMA densities and moduli will be affected if the material is outside of the temperature requirements. Moisture for soils and temperature for HMA must be at appropriate levels for compaction to occur. The RICM systems do not adjust these parameters. Contractor means and methods in these areas are still needed to sculpt a successful project.

The new technology will hopefully benefit contractors by speeding the compaction process by focusing efforts where needed to control compaction uniformity. The IC technology is still new and not mainstream yet, though its potential advantages are many, including consistency of coverage, digital documentation of efforts, visual representation of roller movements, possible alternative to nuclear density gauges, and provide stiffness measurements with location position.

The research recommendations are to promote the technology to the contracting community to help them realize the potential benefits of adopting RICM and IC technology. The recommendation to DOTD is not to implement the technology for acceptance criteria at this time, though pursue future projects recommending the use of smart rollers by contractors to help push and advance knowledge about the IC technology and its potential benefits.

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INTRODUCTION

Roller Integrated Compaction Monitoring (RICM) [i.e., intelligent compaction (lC) or continuous compaction control (CCC)] refers to the compaction of road materials, including subgrade soils, aggregate bases, stabilized materials, and asphalt-paving materials, using modern rollers equipped with an integrated IC or CCC measuring system.

The technology continuously records the roller's GPS location and reaction to layer stiffness, and plots the result during compaction operations, so the roller operator can adjust (rolling pattern, settings, etc.) to ensure appropriate compaction effort. The recorded stiffness measurements can be correlated to conventional physical and engineering properties of compacted materials, such as dry density, strength, and modulus. The field-generated data and plots also provide a good means for quality control/quality assurance (QC/QA) of compaction operations as well as uniformity of compaction.

Current departmental standards require contractors to build uniform pavement structure layers to meet density and moisture criteria, but with little means to check and quantify it. Compaction with standard rollers is typically through a trial-and-error process and its quality control is based on the experience and judgment of individual contractors. The minimum spacing of 1000 ft. for quality assurance tests at selected point locations is expected to represent the entire section. In reality, many factors such as variations in soil gradation, soil composition, moisture contents, and subgrade condition affect the homogeneity of the compacted material, resulting in non-uniformity of compaction and hence stiffness. There is a need for more uniform compaction and stiffness of pavement layers to optimize their performance.

RICM is a technology that can assist contractors and state departments of transportation to improve the compaction process in a way to verify consistency throughout constructed pavement layers. The technology, developed in Europe, has the potential to provide real-time continuous measurements of in-situ stiffness and performance characteristics of the pavement section using highly instrumented rollers to compact soil and asphalt in highway construction projects. Advantages over normal rollers include the use of Global Positioning Systems (GPS), instrumentation (accelerometer and drive-power based), and onboard computers for calculations and data collection with graphical displays for the roller's operator. The RICM measurements include roller specific measurement values (IC-MVs) and roller operation parameters (speed, vibration frequency and amplitude, gear, etc.).

In comparison to normal rollers, RICM can help real-time monitor and quantify the uniformity (or variability) of pavement layers across a continuous section, aid in controlling consistency, and help speed up the compaction process.

There is a need to demonstrate and evaluate the emerging technology in a real construction project and its potential implementation logistics (specification, etc.) within Louisiana.

Background

During the construction of highways and embankments, the subgrade soils, base course materials, treated geomaterials, asphalt layer, embankment soils, and other geo-materials are compacted to obtain optimum performance during their service life. Most state agencies utilize a density-based quality acceptance criteria for controlling the construction of pavement systems and other earth materials. This is mainly based on achieving adequate field density (or compaction) relative to a laboratory maximum dry density from a standard or modified Proctor tests. This practice anticipates producing a dense and durable material that can perform satisfactory throughout its expected design life.

Compaction generally increases the density of the material, and hence improves the engineering properties of the material, such as strength and stiffness. However the densest state of a material may not necessarily provide adequate strength/stiffness criteria needed in the design, and hence (may not) ensure acceptable performance. Over the years, the realization that field performance of highway material is primarily dependent on their strength and stiffness, rather than their density progressed. The gap between the design process, field performance, and field quality control makes it difficult to implement a performance-based specifications or warranty-based construction criteria. In addition, there is a national interest toward moving from an empirical to a mechanistic-empirical design for pavement systems. With the current desire to adapt performance-based specification, it becomes essential to change the QC/QA procedures during the construction of compacted earth and/or geomaterials from a density-based criterion to a stiffness/strength-based criterion that is closely correlated to the parameters used in the design to ensure that the required performance levels are achieved. Therefore, the determination of the in-situ stiffness modulus is considered essential in characterizing the different pavement materials.

The nuclear moisture-density gauge is a common tool for measuring moisture and density in the field. Unfortunately, the nuclear moisture density gauge poses certain risks on a job. Though a small and relatively safe source of radiation, risks exist and special safety precautions, training, and documentation must occur in conjunction with the device. A need to reduce potential risks from this nuclear device is also desired. Several non-nuclear in-situ testing devices, like the dynamic cone penetrometer (DCP), falling weight deflectometer (FWD), light falling weight deflectometer (LFWD), plate load test (PLT), and soil stiffness gauge (GeoGauge), were introduced in the last two decades to measure the in-situ stiffness of the compacted geomaterials.

Regardless of the testing device, in-situ tests are generally performed at selected spots/locations along the pavement section (e.g., every 1000 ft.) assuming material homogeneity, and that the tests represent the entire section. Based on those point test results, the stiffness of the entire section length is evaluated. In addition, in-situ spot tests are generally time consuming and can take time for results to be available for field engineers. To achieve an efficient compaction, there is a need for a continuous measurement of the in-situ stiffness of the constructed layer after each pass of the compaction device.

In conventional compaction, compaction generally occurs by repeatedly running a roller (static drum, vibrating drum, or rubber tired) a fixed number of passes at a constant speed, and at a constant vibrating frequency and amplitude (when vibratory roller is used). This standardized tactic can lead to non-homogeneity compaction of the material due to variation in the material properties of compacted material (gradation, soil composition, and moisture contents), and stiffness/condition of the underlying layer. While some areas will be sufficiently compacted, constant passes can leave other local areas either insufficiently compacted or over-compacted. Selected point density/stiffness measurements may not be able to capture weak, insufficiently compacted areas.

When operator capabilities and distractions are added, a consistent number of passes on adjoining parallel strips may not occur as planned, and the desired/target density may not necessarily be achieved. How do roller operators know when to stop rolling the material – trial and error, or more nuclear tests? Contractor’s means and methods must ensure that the job specifications, including compaction (moisture and density), are achieved, and current Departmental standards require the minimum spacing of quality assurance tests; but what confidence do we have on the points in-between? In addition, how can we be assured that the roller operator consistently rolled all points of the jobsite, i.e., consistent coverage and passes?

Literature Review

GPS systems, including the use of Real-Time Kinematic (RTK) systems, have become more mainstream in construction, road measurements, levee construction, etc. These GPS systems enable quick measurements with high levels of accuracy and precision. Roller passes can be tracked with these GPS systems and plotted on a project map (with aerial photo background, GIS software, Google maps, etc.) in a display visible to the roller operator. In this, the operator can see areas that are not properly compacted, areas that need additional passes, etc., and take corrective action as necessary to achieve the target compaction.

Like standard rollers, some smart rollers can vibrate the roller mass, which then bounces along the material surface, and these rollers instrumented with accelerometers that can measure this "bounce" reaction and interpret whether the roller is on weak or stiff material. At the same time, the roller can collect and link GPS information to these stiffness measurements.

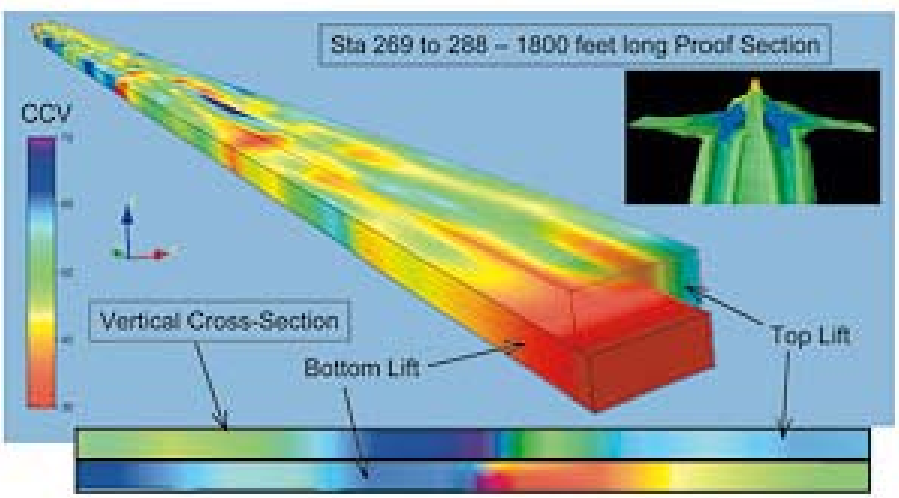


Figure 1
3-D illustration of roller compaction measurements and project alignment
http://www.engineering.iastate.edu/facultystaff/featured-faculty-david-white/dwhite3.html

These stiffness measurements can be calibrated to a stiffness index, and compared against target values. So as the roller progresses, a data file is created and displayed to the operator, showing the material stiffness results as different colors (Figure 1). Roller results can therefore be used to influence subsequent passes for coverage (more or less), and to improve/address weak areas as identified by the stiffness data. The on-board computer helps the operator avoid over and under compaction, aiming to ensure proper compaction is achieved while reducing delays and "pumping" problems.

Some compaction rollers use relative compaction testing method to control the construction of compacted materials. The concept of this method is based on calculating a relative value by comparing certain compaction meter values (dimensionless) obtained by the compaction equipment for two successive passes. An example of relative compaction testing method is the CCC system, which has a compaction meter that continuously measures the acceleration of the roller drum and calculates a compaction meter value from the acceleration signal. The roller operator can continuously monitor the compaction meter value. This will enable the operator to judge the areas with sufficient compaction, areas needing additional passes, and areas where sufficient compaction cannot be achieved with the present roller. GPS instrumented rollers benefit the contractor by allowing the roller operator an onscreen guide to ensure entire job coverage and compaction with optimum effort (not under or over compacted). To the department, complete consistent coverage is more likely achieved, and documented by creating a data record showing the track and coverage of the roller. Examples of these systems are the Omegameter and Terrameter from BOMAG (Figure 2), and Compactometer from Geodynamik (Figure 3).

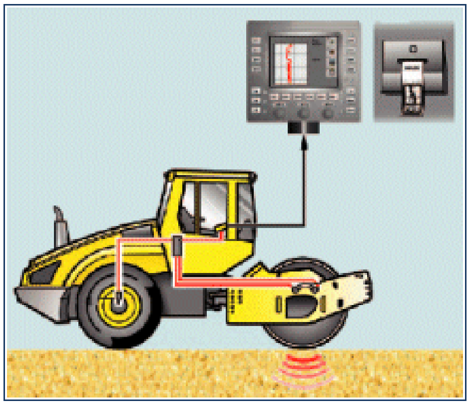


Figure 2
Terrameter from BOMAG *[1]*

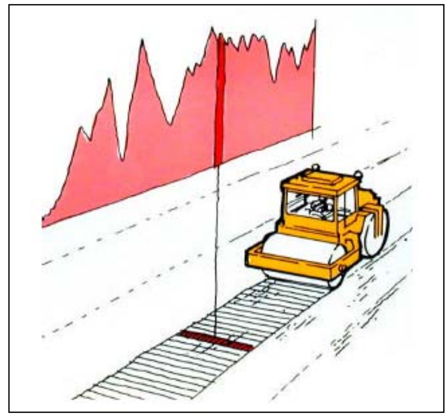


Figure 3
Compactometer Value in CCC *[2]*

Absolute compaction testing methods were incorporated in some compaction rollers. In these rollers, the manufacturer attached an equipment system to the compaction roller that can continuously measure the absolute values of stiffness, which is monitored by the roller operator. These roller systems can give the operator and the contractor real-time proof that the proper compaction has been reached. An example of this type is the rolling equipment manufactured AMMANN that measure the stiffness modulus *[3, 4, 5, 6]*.

The IC technology has been introduced and used for the last ten years in some European and Asia countries. The concept of IC started in the late 1970s with the work of three European companies (AMMANN in Switzerland, BOMAG in Germany, and GEODYNAMIK in Sweden) *[3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]*. The basic concepts in addition to some initial experience were reported by Forssblad and Thurner and Sandstorm *[15, 16]*.

According to FHWA "IC is a compaction technology used for materials including soils, aggregates, and asphalt mixtures, by using vibratory rollers equipped with the real-time kinematic (RTK) Global Positioning System (GPS), roller-integrated measurement system (normally accelerometer-based), feedback controls, and onboard real-time display of all IC measurements."*[17]*. The feature of varying the response of the roller is also known as automatic feedback control (AFC).

IC rollers, in contrast to continuous compaction control (CCC) rollers, are capable of AFC, where the onboard computer not only records the stiffness measurements, but also adjusts the roller's vibration frequency and/or amplitude to adapt to weak or stiff material encountered.

The roller receives feedback from the in-place material based on the resistance encountered; and the IC roller then automatically and "instantaneously" modifies its settings (force amplitude, frequency) to meet the target modulus. NCHRP report 676 did not recommend the use of AFC during measurement passes and quality assurance (QA) due to the effect of roller operating parameters on measurement values (MVs); however, AFC could be utilized by the contractor during normal compaction operations *[18]*.

The IC method is based on the concept of absolute measurement of the stiffness by certain instruments in the roller itself with a control system that is capable of continuously adjusting the performance of the compaction equipment to meet the required conditions based on compaction meter's input (Figure 4). The performance of the compaction equipment is adjusted by changing the different compaction parameters of the roller: amplitude, frequency, and working speed *[19]*.

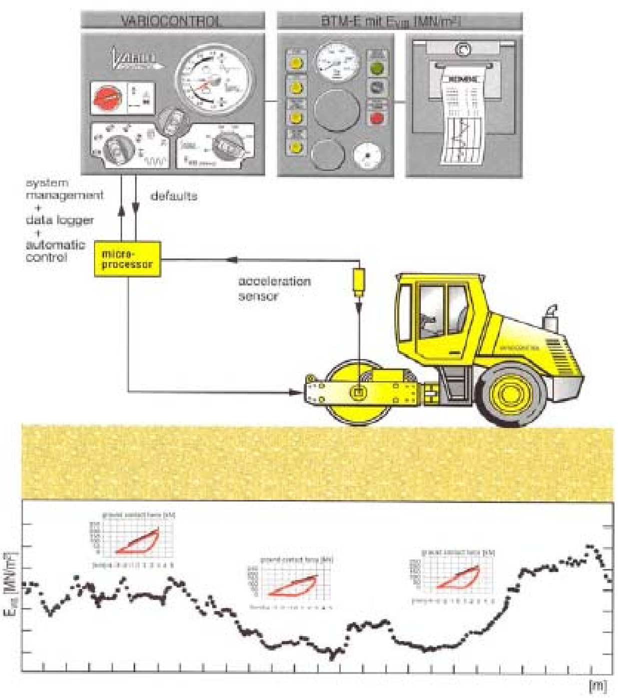


Figure 4
Intelligent Compaction System (from BOMAG) *[19]*

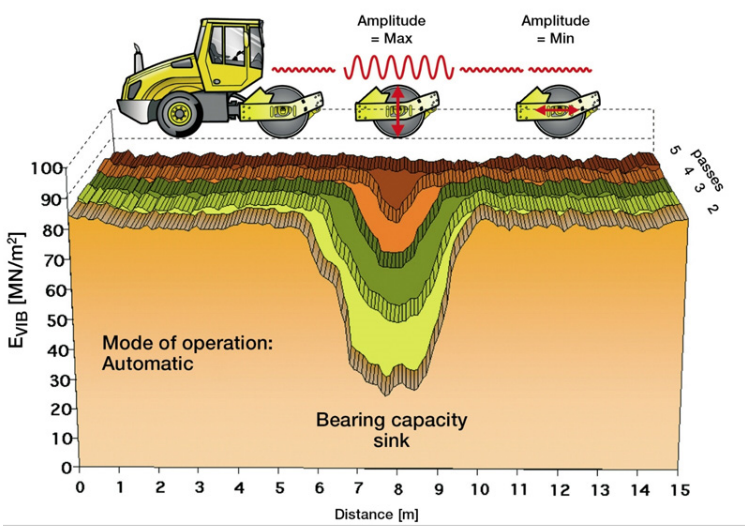


Figure 5
Varying amplitude and frequency to optimize compaction (from BOMAG) ***[1]***

For efficient construction control, the equipment system is provided with a pre-specified acceptance, or target stiffness value for the compacted job site. During compaction, the roller changes the vibration amplitude and frequency depending on soil type and measured stiffness (optimum operation). For example, high amplitude and low frequency are used to compact soft soils while low amplitudes and high frequencies are used to compact stiff soils (Figure 5); high amplitude and low frequency can be used for first passes while low amplitude and high frequency can be used for further passes *[19]*. Once the targeted stiffness value is achieved at a certain spot, the roller will pass that spot without vibration. This will ensure that the material will not be over-compacted.

The most important challenge in adopting the stiffness criteria as the compaction control procedure for the RICM is to identify the target stiffness values for the different soil types and layer thicknesses. The roller gives a stiffness value that is calculated from the measured drum acceleration, which depends on many factors including the stress level, strain level, rate of loading, number of cycles, and moisture content, and soil layering and thickness. Therefore, proper correlation is needed between the soil stiffness modulus obtained by IC roller and the soil modulus measured by a well-established test. In European countries, the roller stiffness (E_{roller}) modulus was compared with the modulus obtained from the standard plate load test (PLT), since in these countries the PLT moduli (E_{v1} and E_{v2}) have been used for design for a long time. Based on this comparison, Briaud concluded that E_{roller} = 45 MPa can be used as a control criteria for low traffic, and E_{roller} = 120 MPa can be used for freeways *[19]*. In addition, the IC measured stiffness represents "composite" value within the roller's influence zone.

The recent Report 676 from the National Cooperative Highway Research Program (NCHRP) entitled *Intelligent Soil Compaction Systems* outlines the current state of practice, fundamentals, analysis, case studies, and many other facets of this technology.

Theoretical Background

In roller integrated compaction, the roller has a dual role during the compaction process: compact the pavement material and measure the soil stiffness. The stiffness is calculated from the measurement of the drum acceleration, and the corresponding theory is clear and well established based on the equilibrium equation and the solution of a drum on an elastic half space foundation. The force applied to the ground (F_B) by a vibratory roller during a compaction operation is given as follows *[20, 21, 22, 23]*:

$$F_B \cong -m_d \ddot{x}_d + m_u r_u \Omega^2 \cdot \cos(\Omega_t) + \left(m_f + m_d\right) \cdot g \tag{1}$$

where, m_d is the mass of the drum (kg), x_d is the vertical displacement of drum (m), $\ddot{x}_d$ is the acceleration of drum (m/s^2), m_f is the mass of the frame (kg), m_u is the unbalanced mass (kg), r_u is the radial distance at which m_u is attached (m), $m_u r_u$ representing the static moment of the rotating shaft (kg.m), $\Omega = 2\pi f$, t = time elapsed (sec), g is the acceleration due to gravity (m/sec^2), f is the frequency of the rotating shaft (Hz)

If the subsoil is described as a spring and dashpot system, the reaction force (F_B') to the roller provided by the ground is given by:

$$F'_B \cong k_B x_d + d_B \cdot \dot{x}_d \tag{2}$$

where, k_B is the stiffness of soil (kN/m), d_B is the damping coefficient (kN.s/m), and $\dot{x}_d$ is the velocity of the drum (m/s).

The acceleration of the drum and the phase angle between excitation and oscillation can be measured and all quantities are known on the right hand side of equation (1). These two forces must be equal to maintain equilibrium (i.e., $F_B = F'_B$). The damping coefficient in equation (2) is usually assumed by using a damping ratio equal to 20% *[19]*. The soil stiffness (k_B) can then be obtained since all other parameters are known. Another approach can be used by calculating the dynamic stiffness of the material being compacted from the slope of the loading portion of the force settlement curve as described in Figure 6.

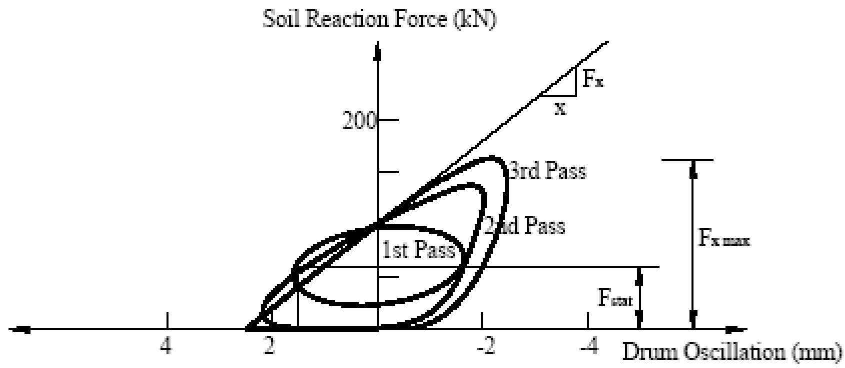


Figure 6
Soil reaction versus amplitudes for different passes *[24]*

The soil stiffness (k_B) calculated from equations (1) and (2) is different from the elastic soil modulus (E) needed in the analysis and design for compacted soils. The k_B represents the ratio of applied load divided by the surface deformation, which depends on the size of the loaded area. Therefore, it is necessary to derive a relationship between E from k_B. This problem was solved by Hertz and Lundberg *[25, 26]*. The relationship between the stiffness (k_B) and the elastic soil modulus (E) is given in the following Equation *[25, 26]*:

$$k_B = \frac{E \cdot L \cdot \pi}{2 \cdot \left(1 - \nu^2\right) \cdot \left(2.14 + \frac{1}{2} \cdot \ln\left[\frac{\pi \cdot L^3 \cdot E}{\left(1 - \nu^2\right) \cdot 16 \cdot \left(m_f + m_d\right) \cdot R \cdot g}\right]\right)} \quad [MN/m] \qquad (3)$$

where, L is the drum width, υ is Poisson's ratio, m_f is the mass of the roller frame, m_d is the masses of the roller drum, R is the radius of the drum, and g is the acceleration due to gravity.

Once k_B is known, the E value can be solved using equation (3) by iteration method. The relationship between k_B and E can also be established experimentally by comparing the measured roller k_B value with reference elastic moduli obtained from other standard field tests such as the plate load tests. AMMANN reported a study from ETH Zurich in Switzerland that was conducted to establish a relationship between k_B and E *[27]*. The results showed reasonable relationship with some scatter.

IC Roller Manufacturers

BOMAG-America, AMMANN-America, and GEODYNAMIK are three compaction equipment manufacturers that are able to supply IC technology into the USA *[3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14]*.

BOMAG-America, Inc. is the United States branch of BOMAG in Germany *[7, 8, 9, 10, 11, 12]*. As an innovation developed by BOMAG, BOMAG VARIOCONTROL (BVC) single drum rollers for soil/base compaction have the capability of automatically changing the direction of amplitude based on inputted criterion and soils response to result in optimized compaction energy (Figure 7). BTM-E is a modified version of the BOMAG Terrameter, a computerized display of many important compaction parameters with display of dynamic modulus Evib in MN/m2 (Figure 8). A tandem roller and VARIOMATIC system is used for hot asphalt mix. BOMAG also has sophisticated documentation systems: BOMAG Compaction Management (BCM) for soils compaction and Asphalt Manager for asphalt compaction that record compaction information continuously.

AMMANN is the United States branch of Amman Compaction, Ltd. in Switzerland *[3, 4, 5, 6]*. AMMANN compaction Expert-ACE is the compaction metering and measurement system for soils, granular bases, and asphalt. When ACE is being used, the materials stiffness data and its attributed location are continuously stored in the Continuous Compaction Control (CCC) computerized system (Figure 9). The ACE system will eliminate the problem of overcompaction through automatic compaction energy control and allow project personnel to identify weak areas and to take corrective action immediately.

GEODYNAMIK in Sweden manufactures the Compactometer for use in CCC with its Compaction Documentation System (CDS-012J™) displaying the compaction results (CMV) while the roller is actually at work (Figure 10) *[13, 14]*. The Continuous Asphalt Compaction (CAC) and Asphalt Documentation System (ACD) are used for hot mix.

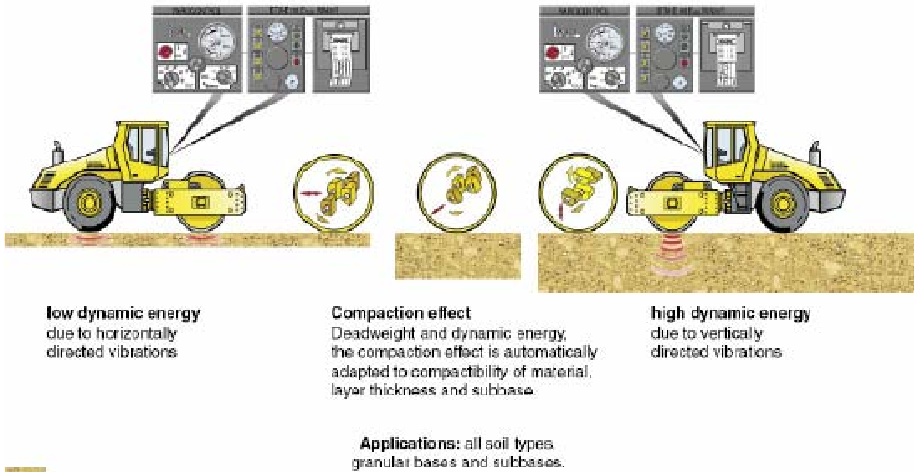


Figure 7
VARIOCONTROL single drum rollers *[7, 8, 9, 10, 11, 12]*

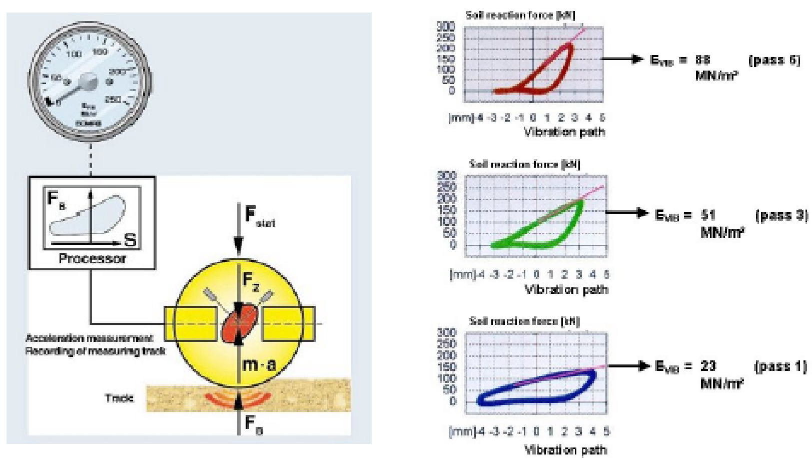


Figure 8
Principle of the Evib measurement system – BTM-E *[7, 8, 9, 10, 11, 12]*

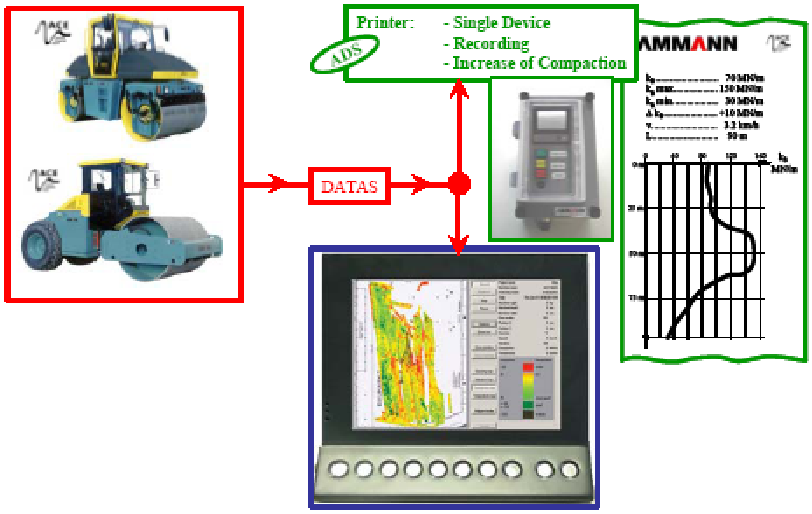


Figure 9
Continuous Compaction Control, CCC-Concept *[4]*

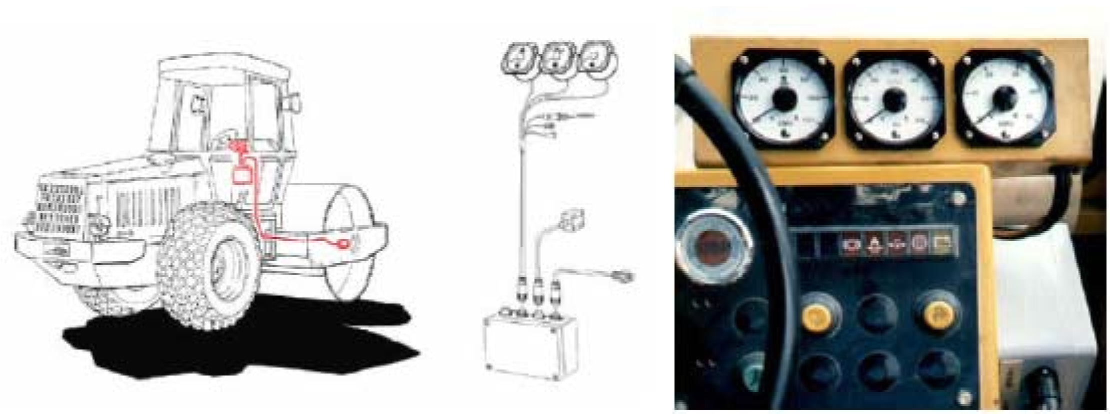


Figure 10
Compactometer *[13, 14]*

CATERPILLAR (CAT) has both a vibratory system, and a unique system termed Machine Drive Power (MDP) *[28]*. MDP rollers utilize a technology based on the energy necessary to advance the roller. For example: if the roller is bogging down and must exert more energy to advance over the soil ahead, the roller would document that effort as soft or less compacted soil. In contrast, if the material is hard and compacted flat, the roller requires relatively less energy to advance. An illustration simplifying the MDP concept is included as Figure 11.

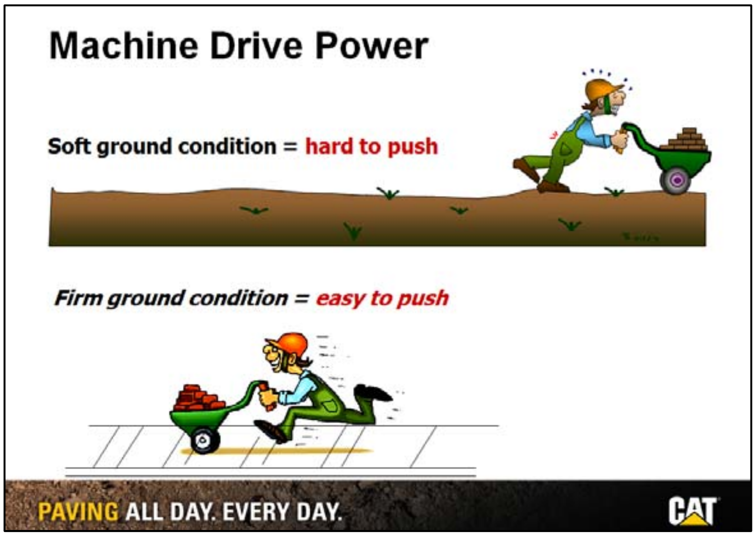


Figure 11
MDP illustration (from CAT) ***[28]***

Caterpillar's roller brochure states, *Machine Drive Power (MDP) is a new, innovative, compaction measurement technology only available from Caterpillar. MDP utilizes a completely different principle, measuring the amount of energy required to propel through the soil, which provides a more direct indication of soil stiffness. Because it does not rely upon vibration energy on the soil, MDP can make measurements whether the vibe system is on or off, and is not subject to the restrictions that affect accelerometer-based technologies. MDP produces a more reliable measurement on more soil types, at a depth that is comparable to the typical lift thickness, and it works on smooth-drum or padfoot machines*. The brochure also states that the MDP roller has a measurement depth of 12 to 24 in *[28]*.

The NCHRP report # 676 also provides insight on the roller technology including the following, Figure 12 and equation (4), which explains stress theory of the system *[18]*.

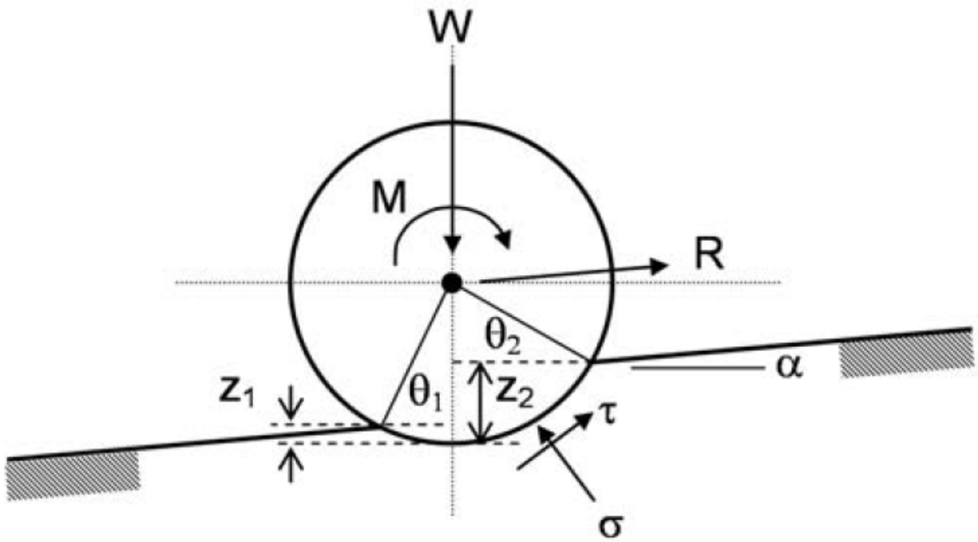


Figure 12
MDP Simplified two-dimensional free body diagram of stresses acting on a rigid compaction drum *[18, 29]*

$$MDP = Pg - WV(\sin\theta = \frac{a}{g}) - (mV + b) \quad (4)$$

where:
Pg= gross power of roller
W = roller weight
a = machine acceleration
g = gravity
θ = slope angle (roller pitch)
V= roller velocity
m, b = machine loss coefficients (machine specific)

Significance of Research/Implementation Potential

RICM systems are not presumed to be a silver bullet or magic wand, but can serve both contractors and the state's departments of transportation as a valuable compaction tool in their toolbox. Desired densities or stiffness moduli may still be difficult to achieve, especially if soil is too wet or dry, regardless of the compactive effort. Similarly, for HMA, densities and moduli will be affected if the material is outside of temperature requirements. Contractor means and methods in these areas help sculpt a successful project. Moisture for soils and temperature for HMA must be within appropriate levels for compaction to occur – RICM systems do not adjust these parameters.

Developed over recent years, intelligent compaction technology has made great strides in combining old and new compaction technologies. The instrumentation, computer technology, and global positioning systems (GPS) have transformed the slow roller into one of the smartest compaction devices on a jobsite.

The technology is still new and not mainstream yet, though its potential advantages are many, including consistency of coverage, uniformity of compaction, detecting weak spots, digital documentation of efforts, visual representation of roller movements, possible alternative to nuclear gauges, and stiffness measurements with location position.

OBJECTIVE

The objectives of the research study were to:

1. Demonstrate the value of RICM and CCC to accelerate construction, reduce re-work, and improve uniformity of pavement layers.

2. Evaluate the reliability and potential use of RICM data for acceptance and measurements of in-situ stiff ness of the constructed earth materials, linking to properties that relate more directly to design (e.g., modulus), and in-service performance.

3. Establish field monitoring sections and monitoring protocols/assessments for LTRC to document the impact of implementing these technologies and specification approaches.

4. Demonstrate Strategic Highway Research Program (SHRP) 2 R-07 performance specifications for rapid renewal using nondestructive RICM technology and mechanistic-based in-situ point measurements on a new pavement section including subgrade, stabilized subgrade, base course, and HMA layers.

SCOPE

This research focused on the use of roller integrated compaction monitoring (RICM) on the specific DOTD project, 424-04-0053 (H.002890), located southeast of New Iberia, Louisiana, and consisting of new, two lane, frontage roads connecting the existing intersections and frontage roads from Darnall Road to LA 85 along US 90. The research did will not cover the existing intersection areas and frontage roads, only the new, straight lengths of connecting frontage roads.

RICM rollers were used on the embankment, base, and HMA in a shadowing process, which does not affect the current acceptance specifications. LTRC and Strategic Highway Research Program (SHRP2) personnel will share the collected testing data (see SHRP2 R07 Project Objectives, Appendix B).

This research was primarily focused on Continuous Compaction Control (CCC), specifically, the gathering of data from self-propelled roller integrated compaction systems including the measurement and recording of roller position, date/time, speed, vibration frequency, vibration amplitude, surface temperature (for HMA rollers), pass count, travel direction, and roller stiffness measurement value (IC-MV).

METHODOLOGY

This section presents a description of our research work plan. The research approach divided the project into tasks to accomplish the objectives of the research. LTRC personnel coordinated activities with the District 03 office, the contractor, and the researcher's SHRP2 R-07 partners as best possible.

Site Selection

Researchers and the project review committee (PRC) worked to find a suitable site that met the needs of the demonstration project. Ideally, the project would be close to Baton Rouge to facilitate research and testing. The project would have multiple layers of construction and be of a reasonable length. The project will also serve as a Louisiana Demonstration Project for intelligent compaction technology and will be part of the Every Day Counts Initiative.

Roller and Project Specifications

The research team developed specifications for the demonstration project. These specifications allowed the use of smart rollers to be incorporated into the project from the on-set versus a change order. The specifications were set to detail the desired roller capabilities and their utilization on the project. The specification clearly stated that the project is only a demonstration project, only shadowing the normal acceptance process.

Roller Selection

Since the roller specification was part of the project plans, the roller selection was determined by the lowest bidder according to Louisiana State Bid Law. The lowest bidder was required to provide the equipment according to the specifications to meet the RICM project needs. This creates some uncertainty in that the specific roller manufacturer is not known before the contract is awarded.

Data Collection Plan

The research study consisted of extensive field activities with laboratory support. Details of the plan were refined after the contractor was selected and the specific roller(s) was chosen. The specification outlined the roller activity, measurement passes, and roller data collection.

Roller type and manufacture could, and did, vary between layers (soil vs. HMA); therefore, the plan depended upon the winning bidder's choices.

Layers for RICM

The research is aimed at the implementation and performance of the specifications into a real DOTD project. The selected section provided adequate lengths and sufficient layers for testing.

Soil. The goal of the research is to see how RICM will compare to current acceptance testing performed by the department. The developed specifications outlines how and when measurements will be collected. The roller measurements provided an adequate characterization of the consistency of the compaction between the point-tests currently conducted for acceptance by the district.

Asphalt. The goal of the research is to see how the RICM measurements will compare to the current acceptance methods, but also serve as documentation for the creation and construction of the layer by documenting the passes, IC-MVs, and temperature.

Coordination Activities

The project required extensive coordination for the specification approval with interactions and approval through the district, project review committee, contracts and specification section, and the NCHRP and SHRP2 partners.

Once begun, execution of the field and laboratory activities were coordinated with district, construction, and research personnel to schedule field operations for the training, collection, and analysis of intelligent and traditional compaction data on the demo project.

The project was also designed to also evaluate the effectiveness of the drafted specification in the field and through the construction side of the project. The project provided an opportunity to discover any implementation issues or hurdles that need to be addressed with the specification, should the technology prove to warrant full implementation.

Laboratory and Field Testing

Extensive laboratory and field testing were conducted on each pavement layer. Testing conducted by the LTRC research team and the District laboratory. LTRC testing was focused on research purposes, and the district testing for quality assurance and pay.

Within LTRC, geotechnical and asphalt units worked in conjunction to test each layer of the pavement cross-section to collect data from various devices for comparison of results against the on-site roller. The roller results were also compared against the District 03 acceptance testing. Collected instrumentation and in-situ testing data from this project served to shadow and not affect the normal quality control/ assurance process conducted by the district.
The roller data were utilized to compare against future and long-term monitoring of the sections.

Soil Tests

Standard laboratory soil tests included material properties, Proctor compaction tests, unconfined compression, and some resilient modulus testing. Field-testing included: Dynamic Cone Penetrometers (DCP), GeoGauge, nuclear moisture-density gauge, plate load tests, falling weight deflectometer (FWD), and Dynaflect.

DCP Tests. The Dynamic Cone Penetrometer (DCP) is a simple and effective tool for the assessment of in-situ strength of pavement layers and subgrades. Figure 13 shows the DCP device used in this investigation. It consists of an upper fixed 22.7-in. travel rod with 17.6-lb. falling weight hammer, a lower rod containing an anvil, and a replaceable 60° cone of ¾ in. diameter.

The test involves lifting and dropping the hammer to strike the anvil, which then penetrates the ¾ in. diameter cylindrical cone from the surface down, providing continuous measurements of in-situ strength and stiffness without sampling. During the test, the penetration for each hammer blow is recorded and later plotted. Flatter plots represent stiffer layers and steeper plots represent weaker layers. Very stiff layers reduce penetration rates so much (< 1 mm/blow) that the test is ceased to prevent damage to the equipment.

Figure 13
Dynamic cone penetrometer (DCP)

Nuclear Density Gauge Tests. The Troxler nuclear moisture-density gauge was utilized throughout the project by the research staff via shadow testing and by the district for normal acceptance testing. The device is common in earthwork operations and was also be utilized by the district.

GeoGauge Tests. The Humboldt Soil Stiffness Gauge (GeoGauge) has been utilized by LTRC for several years as a forensic tool, and an additional tool in the toolbox to see trends. It vibrates and imparts a very small dynamic forces to produce small deflections, which are measured via an internal geophone over the course of the minute or so test. The GeoGauge data was not emphasized in this report, but utilized as a reference device when available, and as time permitted.

Figure 14 shows the influence depth of several field testing devices, including the GeoGauge, DCP, nuclear moisture density gauge, and a roller compactor. Note that the Machine Drive Power (MDP) roller is not a vibratory impact roller and is stated to have an influence depth of one to two feet from Caterpillar (CAT) *[28]*.

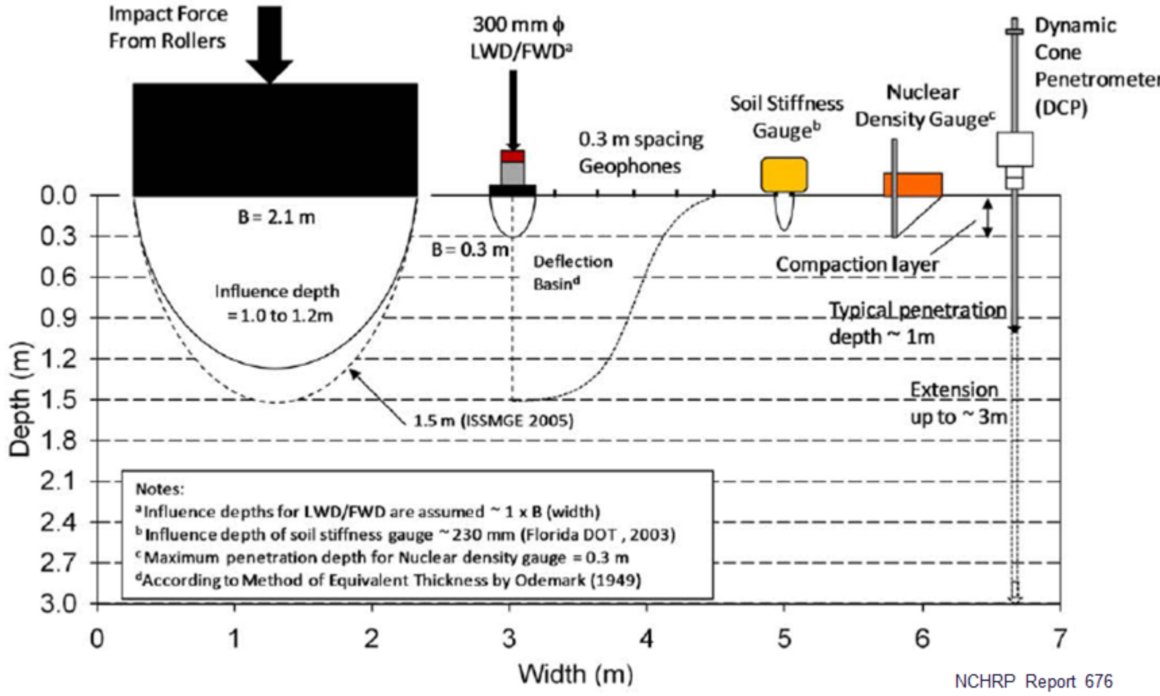


Figure 14
Device influence depths *[18]*

Resilient Modulus Tests. Resilient modulus is a parameter to characterize stiffness of pavement materials under repeated loading, with the consideration of the influence of stress levels (both confining pressure and deviatoric stress) and the nonlinearity induced by traffic loading. Resilient modulus is an essential input parameter in Pavement ME Design. Repeated load triaxial (RLT) tests for resilient modulus were performed in accordance with AASHTO procedure T 307-09 for each base course material evaluated as related to the scope of this study. A typical RLT test result is depicted in Figure 15, with marked recoverable axial strain (ε_a) and cumulative permanent axial strain (ε_{pe}) at a certain loading cycle. Resilient modulus is defined as:

$$M_r = \frac{\sigma_d}{\varepsilon_r} \tag{5}$$

where, σ_d = deviatoric stress; and ε_r = recoverable axial strain.

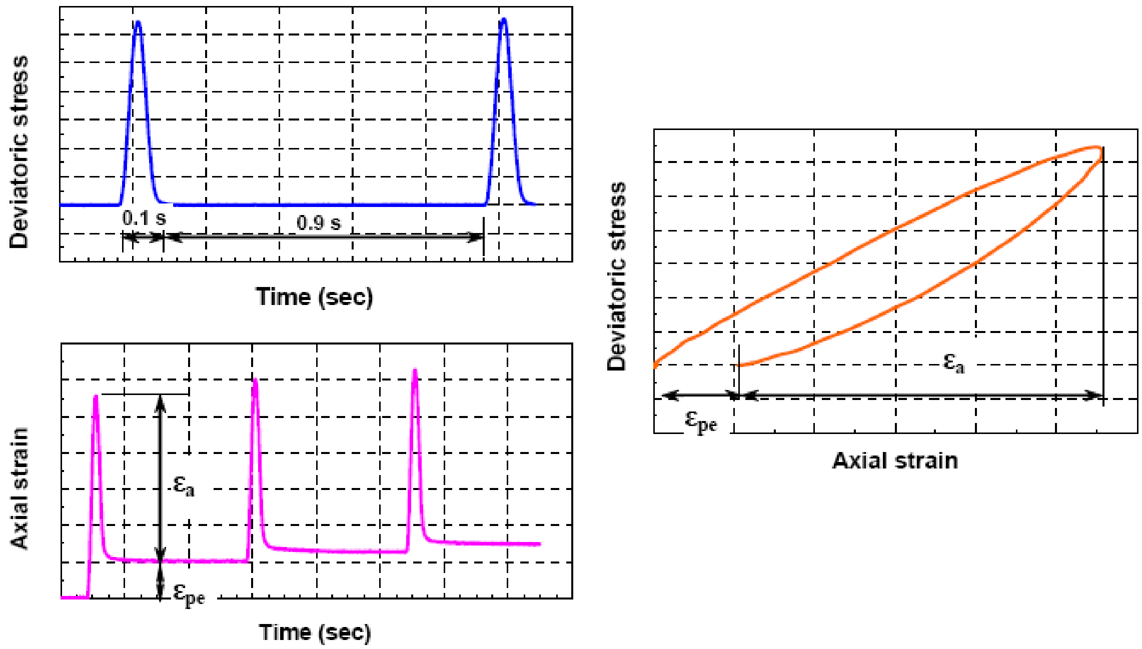


Figure 15
Typical results from a RLT test

Dynaflect Tests. The "Dynamic Deflection Determination System" (DYNAFLECT) is a trailer-mounted electro-mechanical device. A dynamic load is induced on the pavement and the resulting deflections are measured with five geophones spaced at 1-ft. intervals from point of load application. The pavement is subjected to a 1,000-lb. dynamic load at a frequency of eight cycles per second produced by the counter rotation of two unbalanced flywheels. The load is transmitted vertically to the pavement through two steel wheels spaced 20 in. center-to-center. The deflection measurements are expressed in terms of milli-inches (thousandths of an inch). The Dynaflect was used to determine a structural number and modulus for the pavement layers.

Falling Weight Deflectometer (FWD) Tests. The FWD is a trailer-mounted device, which delivers an impulse load to the pavement. The equipment uses a weight lifted to a given height and dropped onto a 300-mm circular load plate. The plate is mounted with a thin rubber pad underneath. A load cell measures the force caused by the applied load to the pavement under the plate. The deflections caused by the impulse load are measured by seven sensors and can be displayed by the computer in either mils or microns. The peak load magnitude can be measured as both force and pressure in metric units: kPa and kN/m², or

English units: lbf and psi. The first sensor is always mounted in the center of the load plate, while sensors 2-7 are spaced at various distances up to 10 ft. from the load center. The impulse load can be varied by changing the mass of the falling weight, the drop height, or both. The FWD was used to back-calculate a correlated subgrade modulus. Both the Dynaflect and the FWD collected measurements over several time periods to show any gains in pavement layer strength.

Plate Load Tests. The static plate load test (PLT) has been a useful site investigation tool for many years and has been used for proof testing of pavement structure layers in many European countries. Currently, it is used for testing both rigid and flexible pavements. The test consists of applying a static load in increments on a circular plate resting on the surface of the layer to be tested and measuring the corresponding deflections. The plates used for runways are usually 30 in. diameter, while for roads they are usually smaller, with a diameter of 12 in. In order to prevent bending of the plate, other plates with decreasing diameters are usually placed on top of it. The load is transmitted to the plates by a hydraulic jack, acting against heavy mobile equipment as a reaction frame. The corresponding deflection is usually measured at four points on the plate surface, and at right angles to one another (or two points on the plate surface, and at diagonally opposite two locations), by means of dial gages attached to a horizontal beam, with its supports placed far enough away from the plate, such that it will not be affected by any applied load. Figure 16 depicts a typical set-up of PLT in this study.

Figure 16
Plate load test set-up

Plate load tests can be conducted using variable procedures, depending on the information desired. In all cases, the magnitude of each load increment shall be small enough to permit the recording of a sufficient number of load-deflection points to produce an accurate load-deflection curve, as shown in Figure 17. From this figure, one can calculate the initial elastic modulus (E_i), reloading elastic modulus (E_R), modulus of subgrade reaction (k), and bearing capacity (q_u) of the test section. In this research study, the testing procedure was performed according to the ASTM D 1196-12, where the load increments were applied and maintained until the rate of settlement was less than 0.03 mm/min for three consecutive minutes. The load and the corresponding footing settlement were measured using a pressure gauge and two dial gauges, respectively. The initial tangent modulus ($E_{\mathrm{PLT(i)}}$) and the reloading elastic modulus for second load cycle ($E_{\mathrm{PLT(R)}}$) were determined from the plate load tests using the following equation:

$$E_{PLT} = \frac{p\pi R(1-\nu^2)}{2\delta} \tag{6}$$

where, p is the applied pressure; R it the radius of plate; δ is the deflection of plate at load, P; and ν is the Poisson ratio, = 0.15 for cement stabilized base, 0.25 for cement treated subgrade soil, and 0.45 for subgrade soil in this study.

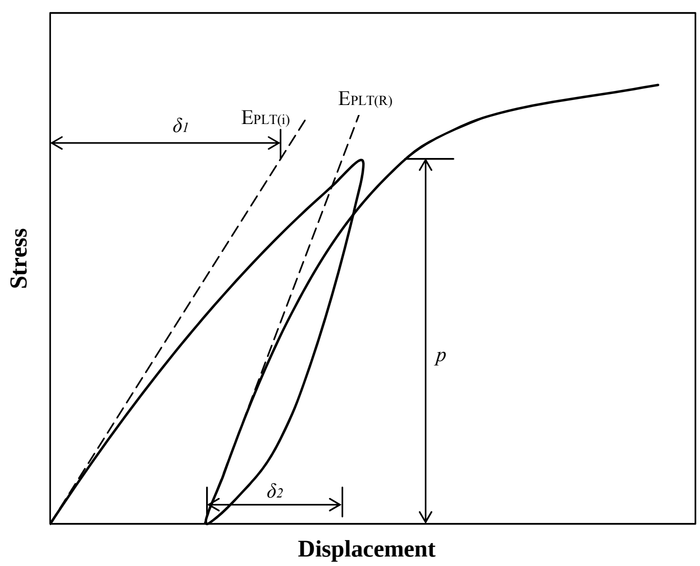


Figure 17
Definition of elastic modulus from PLT

Asphalt Tests. LTRC will coordinate with District 03 regarding the asphaltic materials in the asphalt layers, asphalt cores, and tests. The research project shadowed the normal design, construction, and acceptance processes. The binder and wearing courses were accepted based on departmental specifications, mixture design, asphalt binder content, aggregate gradation, and asphalt binder testing.

The asphalt mixtures were evaluated to compliment the demonstration project.
The mixtures evaluated in this study were designed according to AASHTO PP 28 "Standard Practice for Designing Superpave HMA" and Section 502 of the 2006 Louisiana Standard Specifications for Roads and Bridges. The optimum asphalt cement content was determined based on volumetric (VTM = 2.5 - 4.5 percent, VMA ≥ 12%, VFA = 68% -78%) and densification (%Gmm at Ninitial ≤ 89, %Gmm at Nfinal ≤ 98) requirements.

In addition, aggregate testing was conducted to verify their aggregate consensus properties. Consensus properties included coarse aggregate angularity (CAA), fine aggregate angularity (FAA), flat and elongated particles (F&E), and sand equivalency (SE). The different job mix formulas (JMF) of each of the mixtures were evaluated in this study.

The asphalt binder content of each mixture were determined in accordance with AASHTO T 308, *Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method*. This method determined the amount of asphalt binder by elevating the temperature of a mixture in a furnace above the flashpoint of the binder and recording the mass loss. The mass lost is then corrected for the aggregates utilized and the asphalt content as a percentage of the total mixture is computed. The computed asphalt content was compared to that of the submitted JMF for the respective mixture.

The aggregate particle size distribution was determined for each mixture after the asphalt binder was removed in accordance with AASHTO T 30 *Standard Method of Test for Mechanical Analysis of Extracted Aggregate*. The particle size distribution was determined by a method of mechanical sieve analysis in accordance with DOTD specification. The results of the particle distribution were compared to that of the submitted JMF.

Asphalt binders were collected during the production of each of the mixtures. The binders were evaluated in accordance with AASHTO R 29 *Standard Practice for Grading or Verifying the Performance Grade of an Asphalt Binder*. This testing was conducted to ensure the asphalt met the requirements of DOTD specifications.

The asphalt breakdown roller was instrumented with RICM technology as per the specifications. Field cores were collected to measure density. The samples were collected with a 4-in. core barrel. The core densities were compared to the required densities.

Data Analysis

The data from the roller was transferred to LTRC for analysis. The analysis examined the completeness of coverage, data transfer, the effectiveness of real-time data collected from a moving roller, and the timeliness of how the data can be used to in quality assurance tests, and determining quality control/quality acceptance factors.

VEDA Software. From IntelligentCompaction.com *[30]*, "Veda (pronounced as 'Vehda,' meaning 'knowledge') is a powerful software for viewing and analyzing geospatial data. It was developed by The Transtec Group and is sponsored by Minnesota Department of Transportation (MnDOT) *[30]*. Veda can import data from various IC machines and MOBA PAVE-IR thermal bars/scanners to perform editing, data layering, point testing, and analysis. Veda displays compaction information in easy-to-read formats, including graphs and maps."

DISCUSSION OF RESULTS

Specifications

The research team at LTRC developed the Roller Integrated Compaction Monitoring (RICM) specification for the State of Louisiana, attached in Appendix A, for use in the research project by working with the Project Review Committee (PRC), District 03 Project Engineers, George Chang, Ph.D., P.E. of the Transtec Group Inc. (IntelligentCompaction.com), Strategic Highway Research Program (SHRP2) researchers, and NCHRP researcher, David White, Ph.D., from Iowa State University.

The specification identifies both the roller requirements and the testing requirements for the demo project. Dr. White and Dr. Chang were helpful due to their familiarity with the rollers (ability, manufacturers, etc.) and the emerging IC technology.

Because the IC technology is still in its early implementation stages across the country, the DOTD objective of the demo project was to evaluate the implementation elements of the technology and specifications within the normal/current DOTD process. The PRC therefore sought to shadow the current (normal) acceptance process during this demonstration project, collecting intelligent roller data from each pavement layer as measurement passes for soil and compaction passes for HMA, rather than allow the IC technology to control acceptance (and pay to the contractor). A secondary benefit would be to keep control of the project within the District, rather than in the hands of research to reduce the potential for delays associated with this technology, which is new to DOTD.

As part of the specifications for this project, the automatic feedback control (AFC) was not allowed during measurement passes on the soil or construction passes on the asphalt. The technology adds another variable that can cloud the results and induce double jumping due to the automatic adjustments to the amplitude of the roller during compaction. This study stayed with continuous compaction control (CCC) of measurement passes for soil and HMA layers, which kept constant operating settings for roller speed, vibration amplitude, and frequency.

The specification utilized for the demo project contained lump sum bid items for the subgrade and base course roller compaction monitoring, and for the asphalt roller compaction monitoring. The resulting bids will be discussed in a later section of this report.

Site Selection

DOTD project no. 424-04-0053 (H.002890) was selected as a demonstration site in this research study to provide an evaluation of the IC technology. The site is located southeast of New Iberia, Louisiana, and consists of the extension of frontage roads from Darnall Road to LA 85 along US 90. The site is about 86 miles from LTRC in Baton Rouge. Figure 18 shows a vicinity map of the selected demo project location.

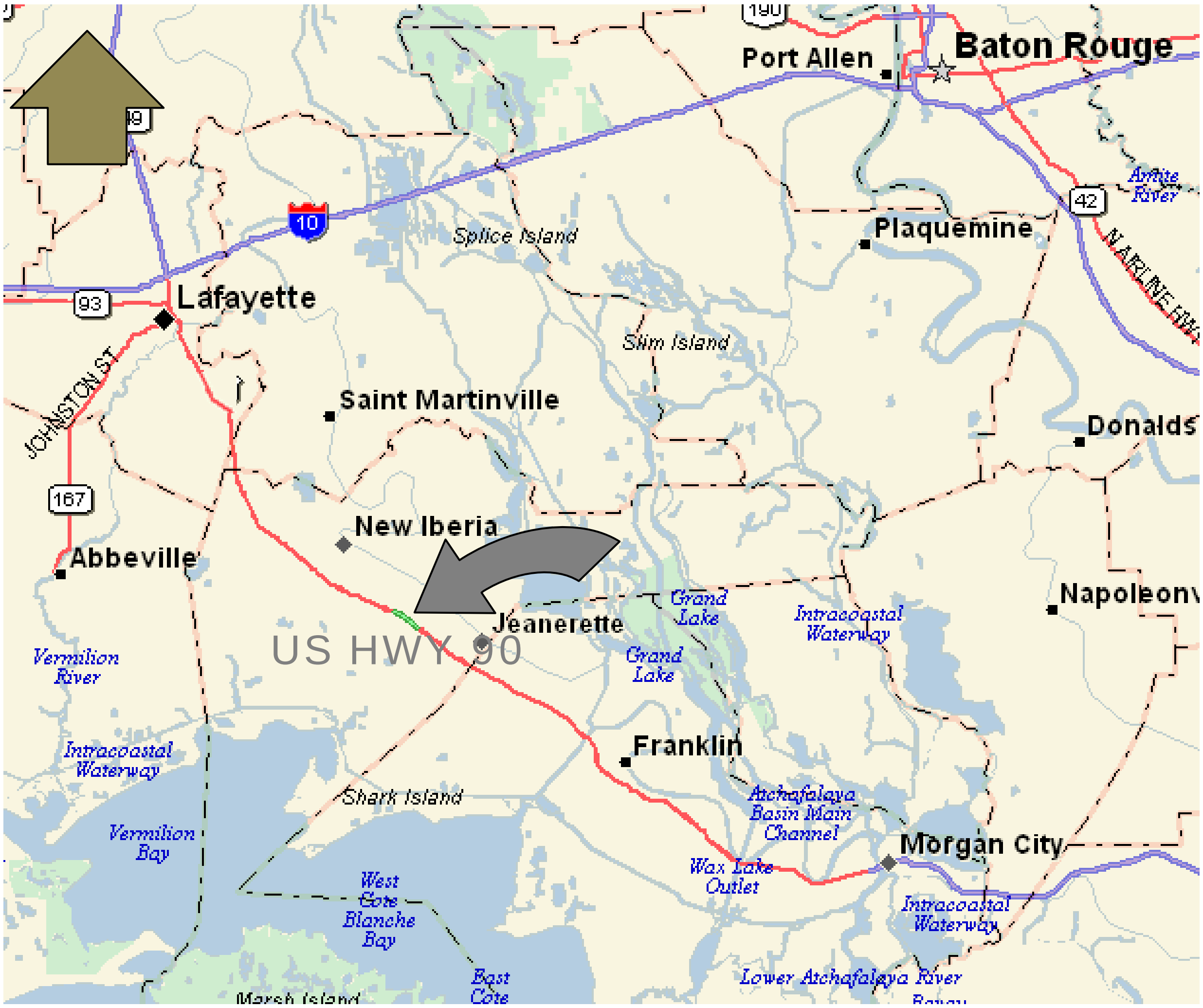


Figure 18
Vicinity map

The construction of frontage roads along U.S. 90 is a preliminary step in the construction of the I-49 Extension between Lafayette and New Orleans. U.S. 90 is currently four lanes from Lafayette to New Orleans. To turn this highway into an Interstate requires removing all driveways and crossovers; and transforming at-grade intersections to include full control of access. The extension and connection of the existing frontage roads will accomplish this goal. Figure 19 shows the relationship of this project (in orange) to the other necessary sections of the Interstate 49 South connection.

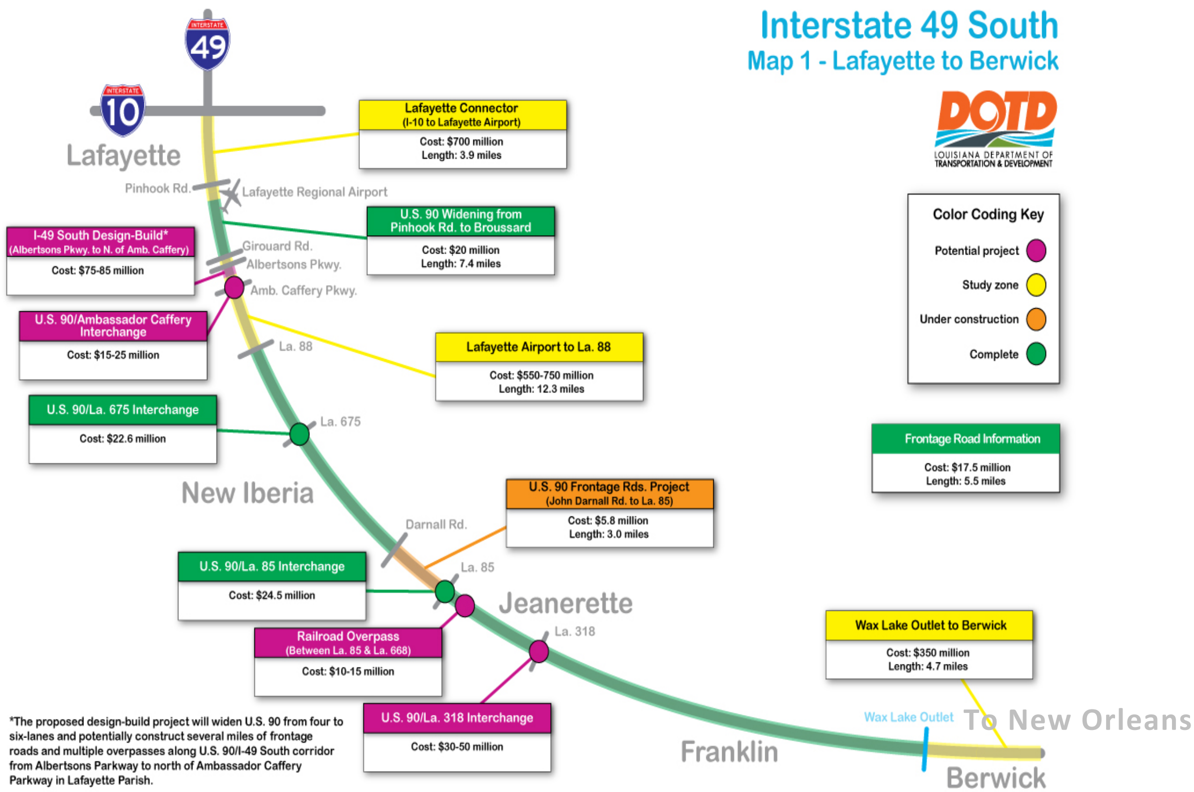


Figure 19
Project overview

The project parameters were ideal for the demo project because it was new construction, which included clearing and grubbing, excavation and embankment, grading, installing drainage structures, subgrade layer, Class II Base course, superpave asphaltic concrete pavement, and related work to transform this section to control-of-access. These new frontage roads would not be open to traffic until complete, which offered a great site for the demonstration and research work.

In hindsight, a site closer to the LTRC office in Baton Rouge would have made for easier planning, travel, and communications, and allowed more, and longer, site visits. The commute to and from the site (over 1.5 hours driving each way) made research field activities difficult (limited time onsite and few spur of the moment trips).

Table 1 presents the typical cross section layers for the frontage roads. The site required some fill in areas, and has several common layers used by DOTD, worth testing with the RICM systems. Thermoplastic markings and reflectorized raised pavement markers will distinguish travel lanes, which will consist of two 11-ft. lanes with a slope of 2.5%, 4-ft. paved shoulders with a slope of 5%, and 4:1 ditch foreslopes.

Table 1
Typical cross-section, State Project #424-04-0053

1.5 in. Superpave Asphaltic Concrete Wearing Course (Level 1)	30 feet wide
2.0 in. Superpave Asphaltic Concrete Binder Course (Level 1)	30 feet wide
Asphaltic Surface Treatment (Type E) (2 applications)	
8.5 in. Class II Base Course (Soil Cement)	31 feet wide
12 in. Cement Treated Subgrade Layer	32 feet wide

Bid Process/Contractor

Items for the RICM were included in the contract; also included in the Special Provisions of the contract were specifications for RICM describing the contractor's responsibilities and requirements. Each specific roller, either on soil or asphalt, would collect data at the completion of each layer in the test section areas as defined in the specification (to be addressed later in this report). All standard DOTD sampling and testing procedures were used for acceptance during the construction of this project, with the data collected from this equipment used to support the LTRC research study.

Bid Information

The project was let for bids on 05/09/12, and awarded on 06/22/12, with the lowest bidder at a cost of $5,812,205.63. A Bid Tabulation Summary is included as Table 2. The Contract time consisted of 200 working days, with a 30-day Assembly Period preceding. The length of the project is 3.004 miles. The project time began in August 2012 and was estimated to be completed by Fall 2013, but extended into 2014.

There was a wide range in the bids for the RICM work. The lump sum bids for the subgrade and base work ranged from $15,000 to $95,000. The lump sum bids for the asphalt work ranged from $7,000 to $100,000. After the award and the preconstruction meeting, it was apparent that the contractor (lowest bidder) was not entirely familiar with the RICM technology. Luckily, part of the project included training by the roller manufacturer(s) selected by the contractor.

Table 2
Bid tabulation summary

Bid Tabulations

http://www.dotd.la.gov/lettings/bidstabs/tabulations/btH.002890.6.asp

Letting of 05/09/2012 LA DOTD Headquarters

Lead Project: H.002890.6

Parish: Iberia

Routes: US 90

Description: US 90 FRONTAGE ROADS: DARNALL RD. - LA 85

Type Const: CLEARING AND GRUBBING, COLD PLANING ASPHALTIC CONCRETE, CLASS II BASE COURSE, SUPERPAVE ASPHALTIC CONCRETE PAVEMENT, AND RELATED WORK.

Estimated Construction Cost: $6,098,250.15

Construction Bidder Rank					- 1 -		- 2 -		- 3 -		- 4 -		- 5 -	
Construction Bid (Total for Project)					$	5,812,205.63	$	5,988,461.87	$	6,140,869.92	$	6,517,941.10	$	6,935,868.31
Line Number	**Item Number**	**Item Description**	**Quantity**	**Unit of Measure**	**Unit Price**	**Total Amount**	**Unit Price**	**Total Amount**	**Unit Price**	**Total Amount**	**Unit Price**	**Total Amount**	**Unit Price**	**Total Amount**
73	NS-DEV-60304	NS Roller Intelligent Compaction Monitoring (RICM) Subgrade and Base	1	LUMP	15,000.00	15,000.00	19,000.00	19,000.00	95,000.00	95,000.00	50,000.00	50,000.00	85,000.00	85,000.00
74	NS-DEV-60305	NS Roller Intelligent Compaction Monitoring Asphalt	1	LUMP	7,000.00	7,000.00	9,000.00	9,000.00	100,000.00	100,000.00	40,000.00	40,000.00	80,000.00	80,000.00

Soil Roller Selection

Manufacturer

The specification allowed several roller manufacturers/providers to be selected for the demonstration project. Due to the low-bid process, the researchers were unaware of the roller selection until after award at the preconstruction meeting. The contractor discussed with DOTD at the preconstruction meeting that they were primarily a Caterpillar (CAT) equipment company. CAT offers both a vibration based roller and the unique technology of Machine Drive Power (MDP). The contractor seemed to initially rely heavily on information from CAT. The soil roller they selected was one that utilized the MDP technology.

The selection of the MDP roller was a surprise to the researchers, though it was possibility among the available manufacturers. The MDP technology is a different philosophy from most manufacturers, and is a unique technology in contrast to the many vendors that provide accelerometer based compaction measurement values/rollers.

Soil Roller Model Information

The CAT Roller was model number CS56B. The roller is a vibratory roller with the MDP technology. A picture of the CAT MDP roller is included as Figure 20, and roller specifications are included in Table 3.

Figure 20
Caterpillar MDP roller *[28]*

Table 3
MDP roller specifications (from CAT)

Operating Weight	25,707 lbs
Drum dimension	84 in. x 51 in.
Frequency	1,400 – 1,830 vpm
Amplitude	0.039 in. / 0.083 in.
Engine	CAT C4.4 with ACERT

Vehicle Display. The onboard display provided information to the roller operator during compaction and measurement passes. Figure 21 shows pictures of some of the roller display screen.

Figure 21
Roller (a) pass screen, (b) Roller data screen

Network Connection. Figure 22 shows the connections for the CAT technology, which connect the roller through the network and linked it to the RTK, GPS measurements. The district furnished the contractor with a digital terrain model (DTM) of the site, which was connected to their system.

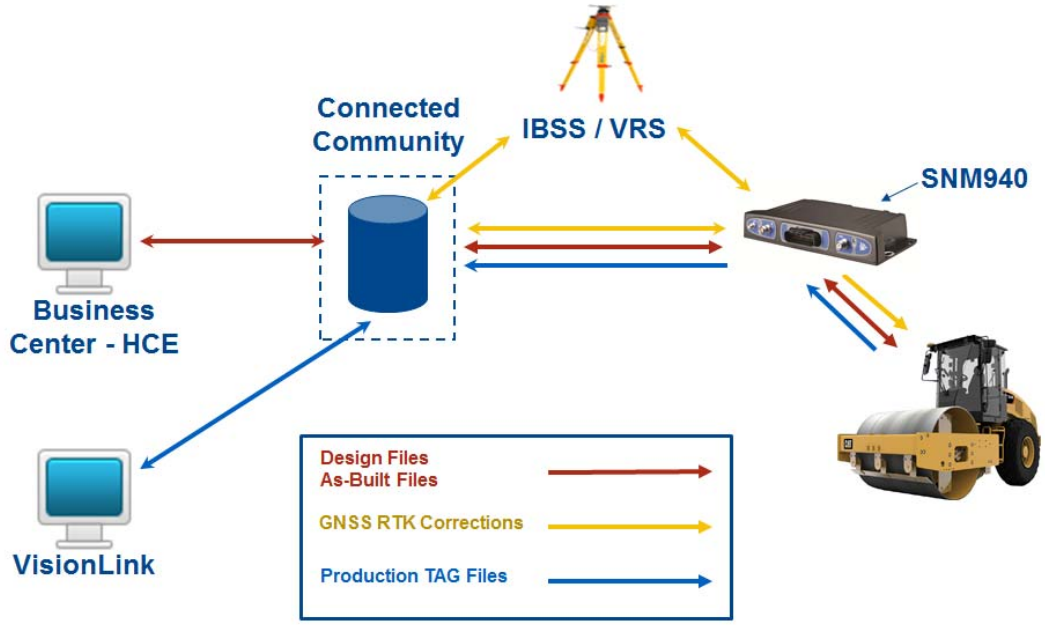


Figure 22
CAT SNM940 connectivity

VisionLink® Software

CAT provided access to their software application, VisionLink®. The software is tied to their maintenance scheduling software for fleet management, and allows vehicles to store and transmit data (hours utilized, oil changes, vehicle history, etc.) to a web-based server. This provides a benefit to the fleet manager and the contractor for maintaining their equipment. Since the roller also has a global positioning system (GPS) on board, it transmitted its position throughout the day. Date filters in VisionLink® allowed for easy tracking of usage and activity throughout the project, and isolate activities.

The VisionLink® software has a separate module for the MDP results. A screenshot from the module, Figure 23, shows the project boundary in orange. The figure has been annotated to show the proximity to New Iberia and relevant highways. The flag in the picture represents the roller's position on the project. The contractor's site representative noted that their owner enjoyed being able to see the roller's utilization and progress by the day, week and month – from his office via the VisionLink® software. LTRC was granted access to the MDP module of VisionLink® during the project via the contractor's account with CAT.

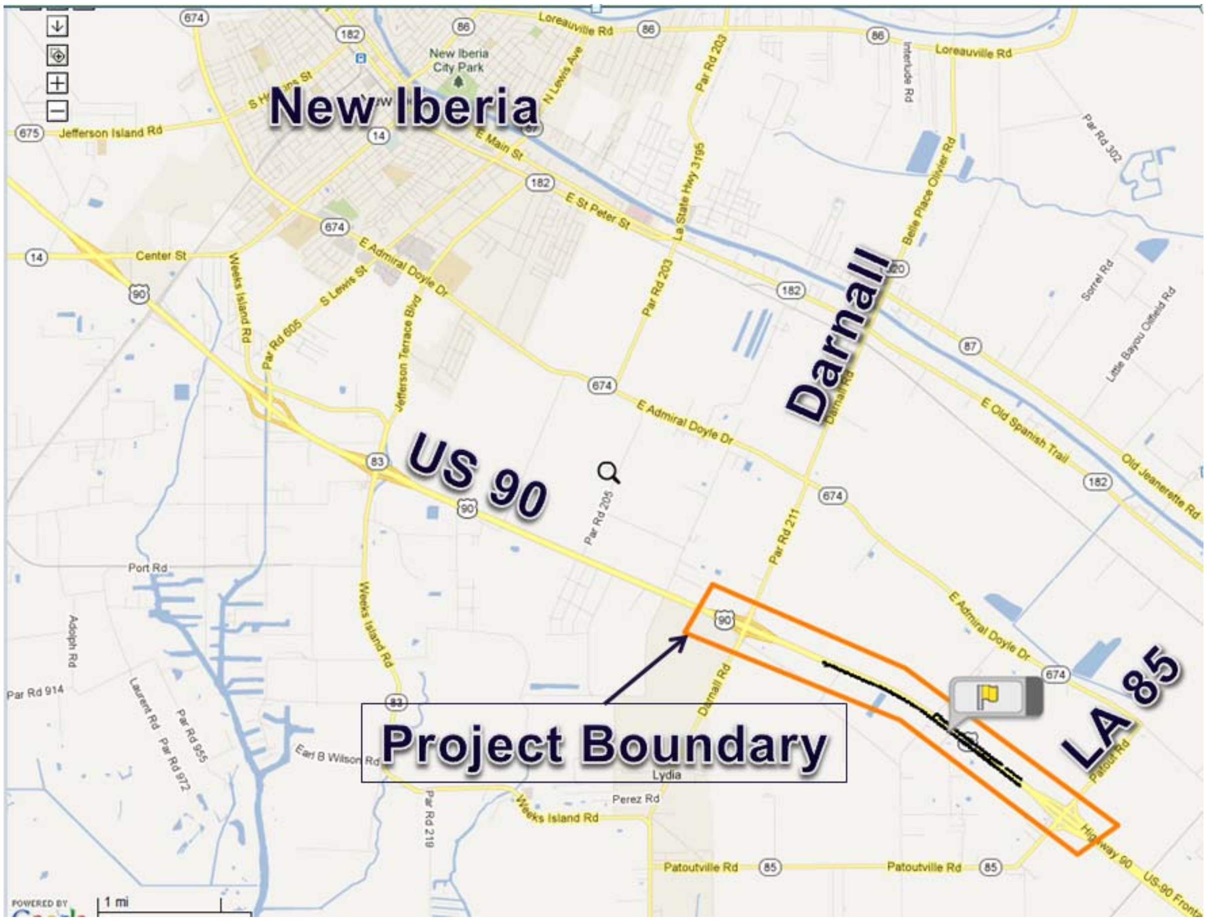


Figure 23
CAT VisionLink® screenshot – annotated project boundaries

In the MDP module, there were tabs for MDP results, coverage, passes, etc. Each could be toggled on or off. Figure 24 shows some generic capabilities of the VisionLink® software. Included are the project boundaries, activity, coverage, and elevation. These pages in the application can also be linked to aerial photos as shown in the coverage screenshot. For clarity, further screenshots will not show the aerial photos for better contrast.

Figure 25 presents a screen shot from VisionLink® software for the MDP compaction values. The target MDP (the maximum value) and the target range values were set at the defaults seen in the figure. Though VisionLink® was very easy to use, the data was exported from VisionLink® then imported to VEDA because LTRC had limited access to VisionLink® via the contractor's account and the data would be needed long term. It was also the desire to import the data into VEDA for analysis and consistent comparisons against the asphalt roller's data. Figure 26 shows an example of VisionLink® to show whether a target number of passes were met, or not. Figure 27 shows the ability of VisionLink® to track the number of passes to an area with various colors representing different pass count values.

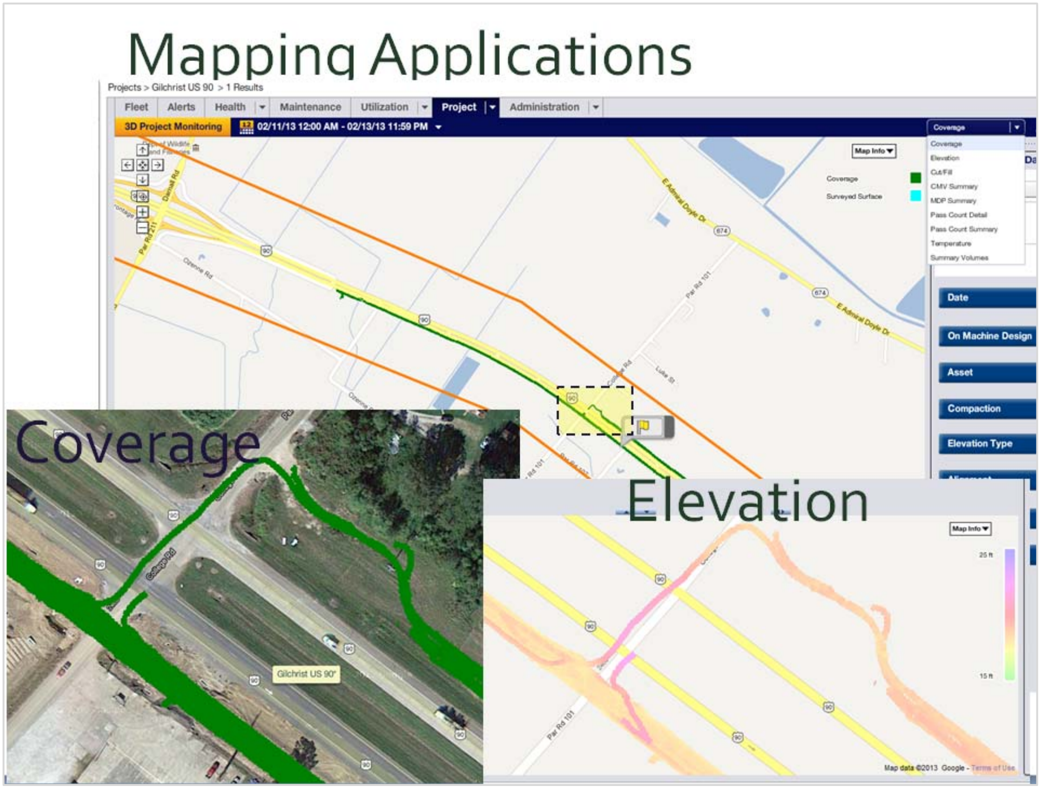


Figure 24
CAT VisionLink® screenshots

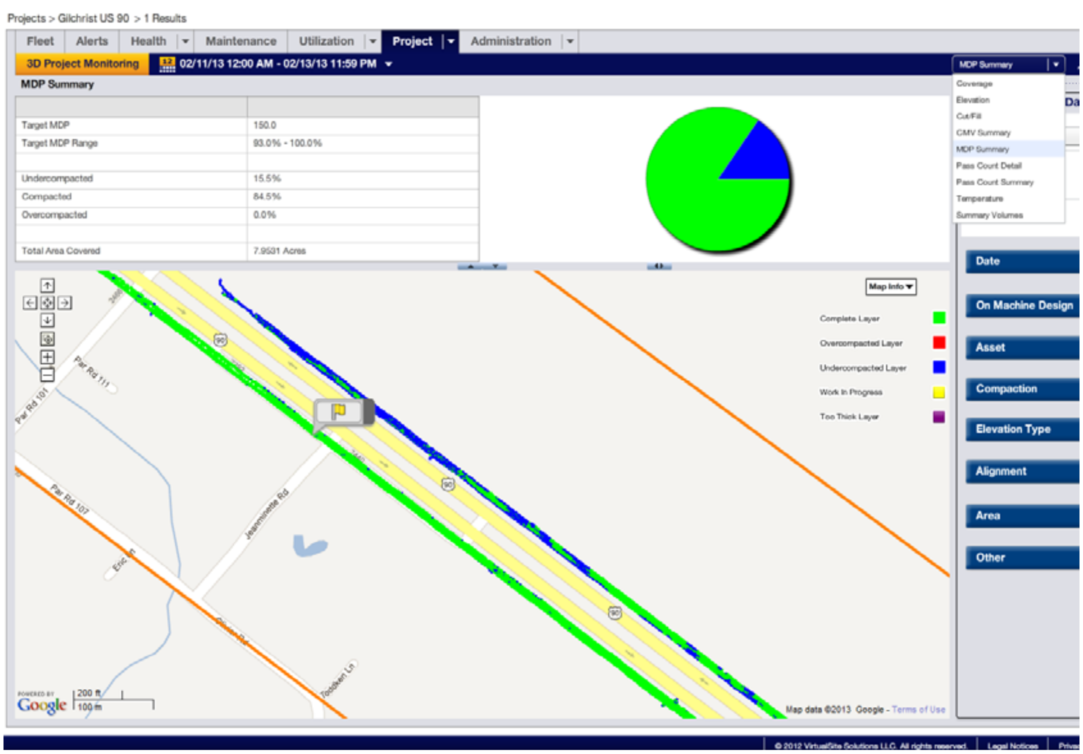


Figure 25
CAT VisionLink® screenshot – MDP compaction values

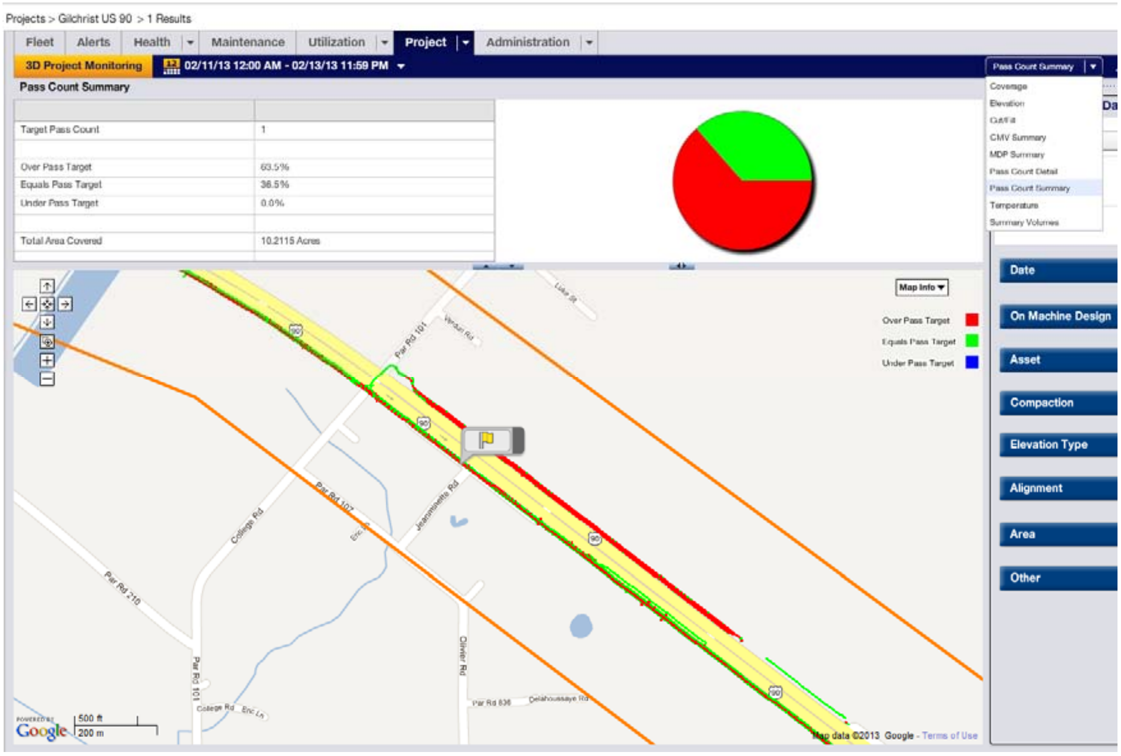


Figure 26
CAT VisionLink® screenshot – pass target screenshot

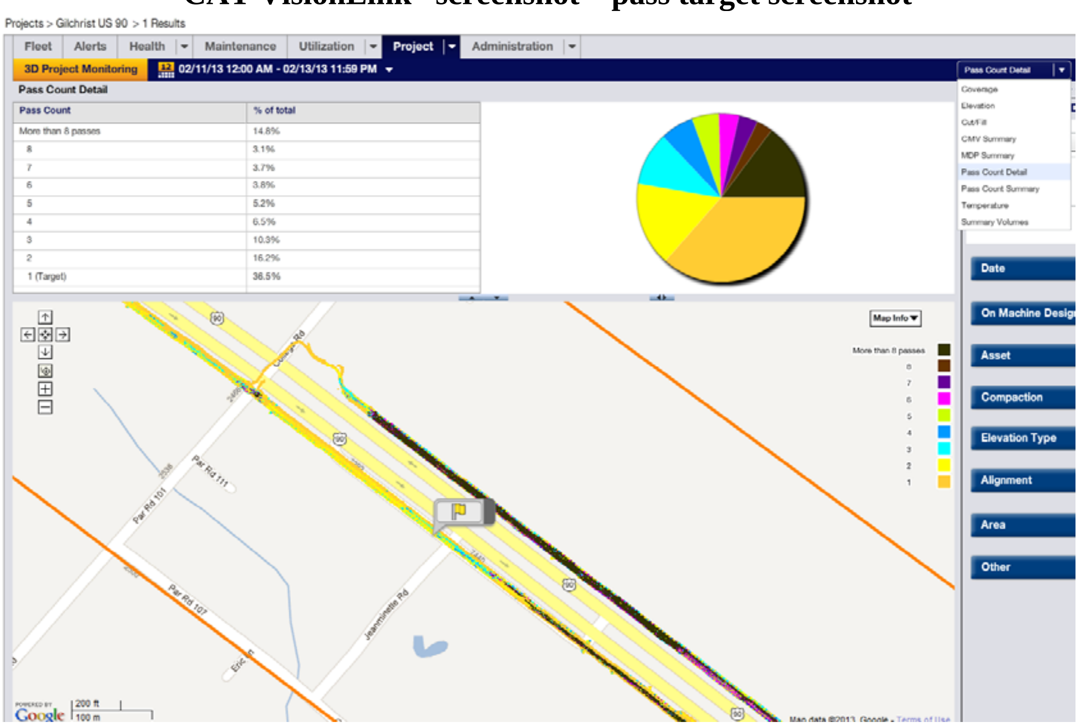


Figure 27
CAT VisionLink® screenshot – pass number example

Subgrade and Base Course MDP results

Since the MDP measurements are a correlation from the energy (and differences) required to advance the roller via the roller engine and hydraulics, the onsite MDP roller did not utilize the vibration mode during measurements on the demo project. The vibrations would have complicated the measurements, and were unnecessary.

The specification, Table 4, detailed when to measure each layer. For soils, the MDP roller passes were collected at the time of acceptance on the embankment, the subgrade, and the base course as baseline measurements; and then again, at 7 days to check the strength gains over time.

The project was initially divided into four quadrants (R1, R2, R3, and R4) with Parish Road 101 (College Drive) as the midpoint, prior to the site construction. However, once let, and subsequent meetings were held with the district and the contractor, the test sections were modified to replicate the district zone information nomenclature. The project was divided up into roughly 1000-ft. zones based on the project extents. Table 5 shows the zones utilized by the district and contractor for earthwork. Figure 28 shows the zones graphically.

Table 4
Layers to measure with RICM roller

	Layer	When to Measure	Roller
1	Embankment	Prior to Mixing	Subgrade or Base RICM
2	Cement Treated Subgrade	Day of Acceptance	Subgrade or Base RICM
3	Cement Treated Subgrade	7 Days after Compaction	Subgrade or Base RICM
4	Soil Cement Base Course	Day of Acceptance	Subgrade or Base RICM
5	Soil Cement Base Course	7 Days after Compaction	Subgrade or Base RICM
6	Superpave AC Binder Course	During Compaction	HMA RICM
7	Superpave AC Wearing Course	During Compaction	HMA RICM

Table 5
Zones for project earthwork, State Project H.002890

ZONE	STATION	STATION	LENGTH
1	498+71	499+54	83' *
	589+58	590+34	76' **
2	499+54	508+40	886'
3	508+40	518+40	1000'
4	518+40	528+40	1000'
5	528+40	534+55	615'
6	534+55	544+00	945'
7	544+00	554+00	1000'
8	554+00	564+00	1000'
9	564+00	574+00	1000'
10	574+00	584+00	1000'
11	584+00	594+00	1000'
12	594+00	604+00	1000'
13	604+00	614+00	1000'
14	614+00	624+00	1000'
15	624+00	635+88	1188'

ZONE	STATION	STATION	LENGTH
1	799+07	799+66	59' *
	888+71	889+47	76' **
16	799+66	807+40	774'
17	807+40	817+40	1000'
18	817+40	827+40	1000'
19	827+40	834+55	715'
20	834+55	845+00	1045'
21	845+00	855+00	1000'
22	855+00	865+00	1000'
23	865+00	875+00	1000'
24	875+00	885+00	1000'
25	885+00	895+00	1000'
26	895+00	905+00	1000'
27	905+00	915+00	1000'
28	915+00	925+00	1000'
29	925+00	936+20	1120'

* BEGINNING TURNOUT

**COLLEGE RD TURNOUT

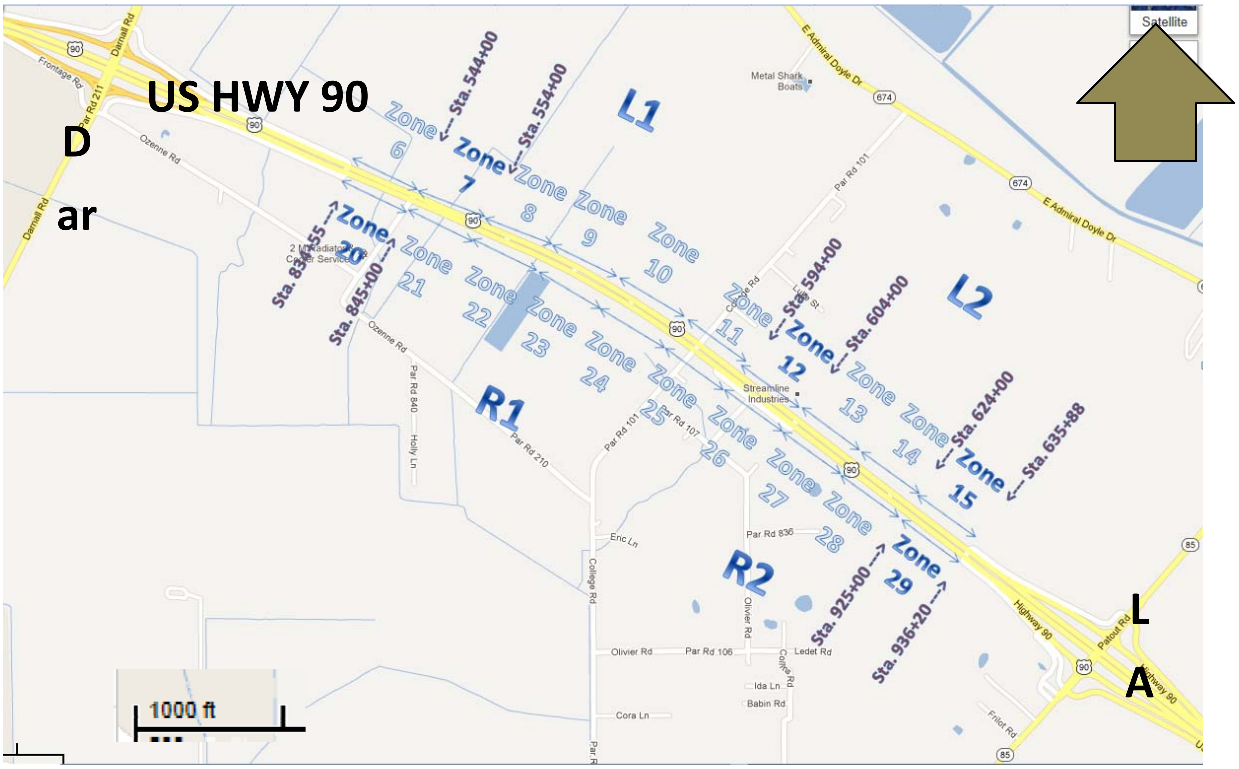


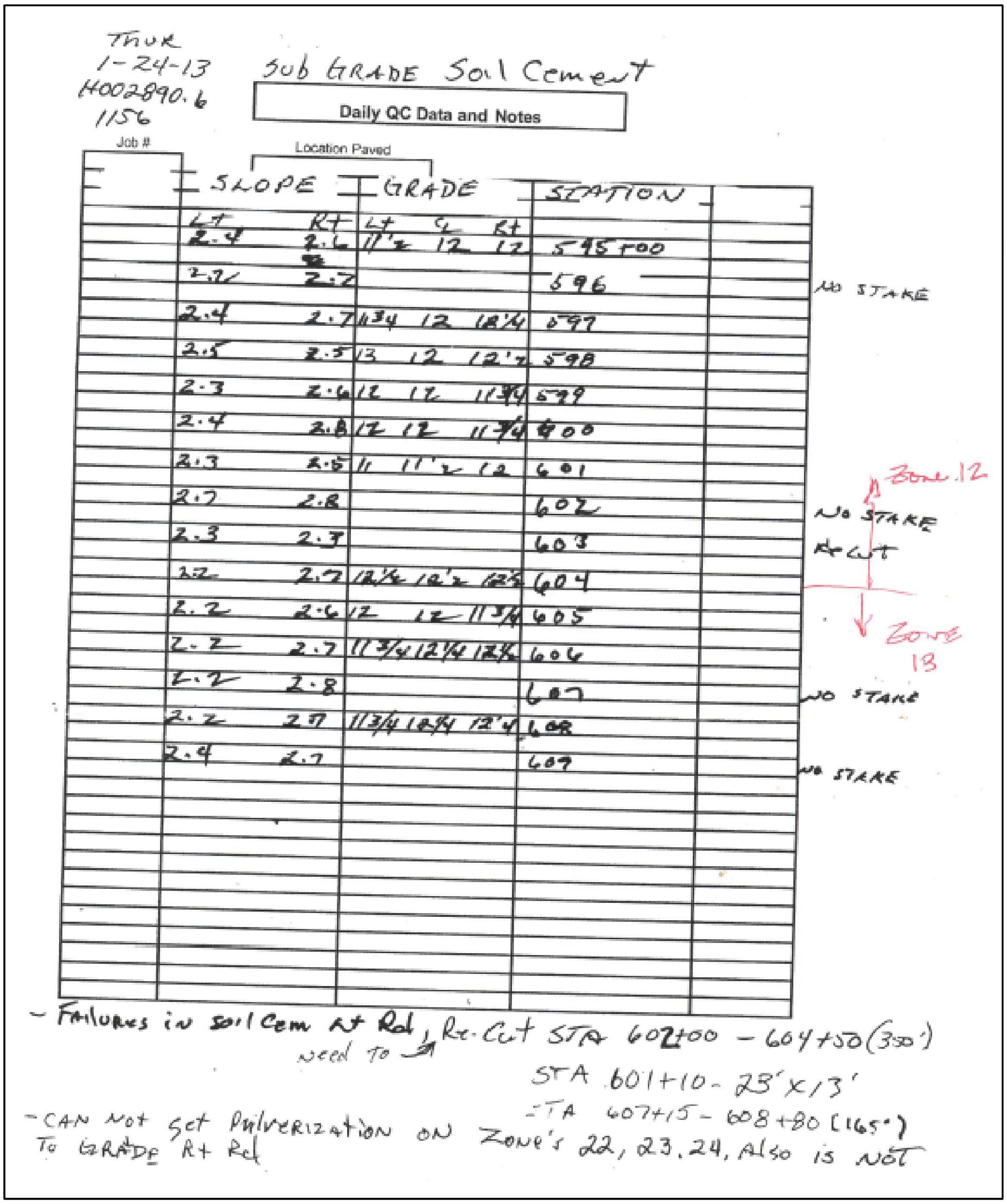
Figure 28
Site map with zones shown

The MDP roller was brought to the site, and a demonstration and training session took place on 09/13/12. The training was conducted so that the contractor, district, and LTRC could learn more about the technology, the roller operations, and the data transfer.

When planning the field events, the logistics of the contractor's schedule, enough notification, travel time to and from the site, and physical test time on site were taken into consideration.

The roller measurements were designed to focus on the frontage straightaways initially divided into L1, L2, R1, and R2, where both the new soil and new asphalt layers would be constructed. Zones 1 thru 5 and 16 thru 19 (not shown in Figure 28) were on the north end of the project and only required base course treatment and HMA overlay operations.

The contractor started earthwork in Zone 29, so this zone was selected and had a considerable amount of research testing. Other zones that were selected for detailed examination were Zones 7, 12, 15, and 20. Zones 29 and 15 were located at the south end of the project and allowed easy access via the existing frontage roads' terminations. Zone 20 was near the contractor's field trailer, also with easy access near existing frontage roads, which reduced the potential for getting field vehicles stuck in muddy conditions. Zones 7 and 12 were selected as focus areas because of some early soft spots that were noted by the contractor and district technician during discussions. Notes on Zone 12, and areas needing rework, are shown in Figure 29, which also notes the early stages of a pulverization issue. Figure 28 was therefore further refined to identify several areas of focus. The contractor notified us when work would be conducted in the Zones 7, 12, 15, 20, and 29.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Job #

Sub Grade Soil Cement

Daily QC Data and Notes

Location Paved

Slope Lt	Slope Rt	Grade Lt	Grade CL	Grade Rt	Station	
2.4	2.6	11½	12	12	595+00	
2.7	2.7				596	No stake
2.4	2.7	11¾	12	12¼	597	
2.5	2.5	13	12	12½	598	
2.3	2.6	12	12	11¾	599	
2.4	2.8	12	12	11¾	600	
2.3	2.5	11	11½	12	601	Zone 12
2.7	2.8				602	No stake
2.3	2.7				603	Re-cut
2.2	2.7	12¼	12½	12¾	604	
2.2	2.6	12	12	11¾	605	Zone 13
2.2	2.7	11¾	12¼	12¾	606	
2.2	2.8				607	No stake
2.2	2.7	11¾	12¾	12¼	608	
2.4	2.7				609	No stake

- Failures in soil cem Rt Rd, need to Re-Cut STA 602+00 – 604+50 (350')
STA 601+10 – 23'x13'
STA 607+15 – 608+80 (165')
- Can not get pulverization on Zone's 22, 23, 24, Also is not To grade Rt Rd

Figure 29
Zone 12 QC data and notes

Soil Properties

Soil subgrade samples were collected by the district laboratory prior to construction and tested to determine their soil properties for design purposes. Table 6 presents the referenced zones and the corresponding sample properties, including Atterberg limits. The existing soil is relatively lean with liquid limits below 45 and plasticity indexes at 22 or below.

Table 6
Existing subgrade soil properties (design samples)

EXISTING SUBGRADE SOIL (Design Subgrade Sample Data)										
Sample No.	Material Code	Station No.	Lab No.	Section (Zone)	Left/Right Frontage Rd.	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Classification, DOTD TR 423	Depth
S-90	801	145+00	03-530038	7	Left	35	22	13	Sty Cl Lm	0' - 3'
S-91	801	145+00	03-530039	7	Left	37	22	15	Sty Cl Lm	3' - 6'
S-88	801	150+00	03-530036	7	Left	32	22	10	Sty Cl Lm & Org	0' - 3'
S-89	801	150+00	03-530037	7	Left	40	22	18	Sty Cl	3' - 6'
S-70	801	195+00	03-530018	12	Left	34	23	11	Sty Cl & Org	0' - 3'
S-71	801	195+00	03-530019	12	Left	38	21	17	Sty Cl Lm	3' - 6'
S-68	801	200+00	03-530016	12	Left	29	22	7	Sty Cl Lm	0' - 3'
S-69	801	200+00	03-530017	12	Left	37	22	15	Sty Cl	3' - 6'
S-58	801	225+00	03-530006	15	Left	40	21	19	Sty Cl	0' - 3'
S-59	801	225+00	03-530007	15	Left	41	22	19	Sty Cl	3' - 6'
S-57	801	230+00	03-530005	15	Left	34	21	13	Sty Cl Lm & Org	1' - 4'
S-56	801	235+00	03-530004	15	Left	40	22	18	Sty Cl & Org	11" - 4'
S-8	801	135+00	03-529852	20	Right	40	24	16	Sty Cl Lm	0' - 3'
S-9	801	135+00	03-529854	20	Right	38	24	14	Sty Cl Lm	3' - 6'
S-10	801	140+00	03-529855	20	Right	40	25	15	Sty Cl Lm & Org	0' - 3'
S-11	801	140+00	03-529856	20	Right	41	23	18	Sty Cl	3' - 6'
S-12	801	145+00	03-529857	20	Right	40	23	17	Sty Cl & Org	0' - 3'
S-13	801	145+00	03-529858	20	Right	43	21	22	Sty Cl	3' - 6'
S-47	801	230+00	03-529995	29	Right	33	23	10	Sty Cl Lm	10.5" - 4'
S-48	801	235+00	03-529996	29	Right	34	22	12	Sty Cl	10" - 4'

NOTE: Classification results were determined by DOTD TR 423 and not by USCS/AASHTO.
NOTE: Locations referenced from C/L of project.
NOTE: Mat. Code 801 - Soil for Preliminary Soil Survey

The top of the subgrade (12 in.) was treated with cement to provide a working table and improve the long-term performance of the pavement structure. The existing soil was therefore collected and tested to determine its properties and the required percentage of cement. Table 7 shows the results from the district laboratory including the classification and percent cement, which was 9 percent.

Table 7
Existing soil for cement treated subgrade (construction samples)

EXISTING SOIL FOR CEMENT TREATED SUBGRADE (Construction Sample Data, Item No. 305-01-04020)									
Sample No.	Material Code	Station No.	Lab No.	Section (ZONE)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Classification, DOTD TR 423	% Cement
4-18	834	548+00	03-548893	7	32	24	8	Sty Cl & Org	9
4-17	834	599+00	03-548892	12	32	25	7	Sty Cl & Org	9
4-13	834	628+15	03-548634	15	32	23	9	Sty Cl Lm & Org	9
4-19	834	630+00	03-549230	15	33	23	10	Sty Cl Lm	
4-11	834	842+20	03-548256	20	23	17	6	Sty Cl	9
4-1	834	930+50	03-548091	29	34	22	12	Sty Cl Lm	

NOTE: Classification results were determined by DOTD TR 423 and not by USCS/AASHTO.
NOTE: Mat. Code 834 - Soil for Subgrade Layer Treatment

The contractor constructed a Class II cement stabilized base course on top of the cement treated subgrade. The contractor hauled soil to the project site, and spread it for the stabilization process. The material was dry and did have some pulverization issues to be discussed later in the report. The material properties and the required cement percentage to reach the 150 psi design strength are shown in Table 8.

Table 8
Hauled in soil for cement stabilized base course (construction samples)

HAULED IN SOIL FOR CEMENT STABLIZED BASE COURSE (Construction Sample Data, Item No. 302-02-04020)									
Sample No.	Material Code	Station No.	Lab No.	Section (ZONE)	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Classification, DOTD TR 423	% Cement
02-017	820	632+00	03-550040	15	27	18	9	Sty Cl	9
02-019	820	839+00	03-550320	20	23	17	6	Cl Lm	9
2-2	802	931+00	03-548632	29	30	17	13	Lt Sty Cl	
2-3	820	930+00	03-549047	29	36	19	17	Lt Sty Cl	12 *
002-3A	820	931+00	03-549084	29	33	18	15	Sty Cl	12
002-3B	820	931+00	03-549085	29	34	19	15	Sty Cl	12

NOTE: Classification results were determined by DOTD TR 423 and not by USCS/AASHTO.
NOTE: Mat. Code 802 - Selected Soil,
Mat. Code 820 - Soil for Soil Cement (Class II Base)
NOTE: * Sample 2-3 failed. Check samples 002-3A and 002-3B passed.

MDP Results

The contractor was required to conduct MDP roller measurement passes when the area/layer was ready for acceptance (quality assurance) testing from the district. The district laboratory nuclear gauge acceptance testing data are summarized in Table 9. The MDP roller results (files) were collected each day and transferred from the contractor to the onsite DOTD inspectors, who uploaded the data files to a departmental network drive available to LTRC in Baton Rouge.

The data transfer strategy worked well for the most part, but the amount of data was substantial, and researchers were not always able to import, view, and analyze the results within the day(s) of collection. It was difficult to review the data in a timely manner, which proved to confirm the decision not to link the IC roller measurements to acceptance and pay for this demonstration project. An IC manager with fulltime review responsibilities would likely be necessary for data evaluation, if controlling pay, so as to not slow earthwork production.

The MDP roller results were exported from VisionLink® and imported to VEDA. Screenshots from VEDA were taken showing events and areas covered. For consistency of scale, and a frame of reference, the screen shots were all taken from the same reference point. The screen shots of the subgrade and base course are presented in Appendix C and Appendix D. The data files were too large to include in this report, but can be made available upon request.

The MDP values are relative valued against a smooth stiff layer with no deflection (MDP = 150) to the weakest of values (MDP = 1). The MDP roller measurements were generally consistent, with little variability, as can be seen in the Appendix data. The research specified that the roller passes be conducted when ready for acceptance, therefore the soil should be relatively consistent – and it was, with most all MDP measurements at or above compaction. As noted before, the MDP roller does not differentiate between layer types (only rolling resistance), did not vibrate through measurement passes, and its influence depth was shallower than an accelerometer based IC roller. Therefore, if the layer were in good shape, the roller would be expected to reach or exceed compaction. Like Figure 111, once on a smooth, relatively stiff surface the roller MDP value would reach its limit. In hindsight, this did not produce much variation in the MDP results. The MDP roller did pick up some weak areas in Zones 7 and 12, and these were reworked by the contractor. Figure 82 of Appendix C shows weak subgrade results in Zone 12 (red color), but Figure 86 shows improvement by the base.

Measurement passes were the focus of the soil research, but construction passes were also allowed by the contractor for his own benefit. Since the measurement passes were conducted at the time of acceptance, when (ideally) the layer is stiff and less likely to flex, the improvement of the layer through subsequent compaction passes was not shown to a great degree. The operator and superintendent understood the benefits of utilizing the roller through construction passes, but did not utilize this capability to the researchers' knowledge. Construction passes for quality control (QC) were therefore not evaluated, but would have shown the most benefit to the contractor. Figure 30-32 show the ability of VEDA to incorporate point test data into the software atop construction pass data (e.g., DCP vs. MDP correlation). Figure 31 shows examples of VEDA's capability to correlate with point density data to MDP stiffness values. Figure 32 is an example of how the contractor could use the resulting correlation to benefit construction passes.

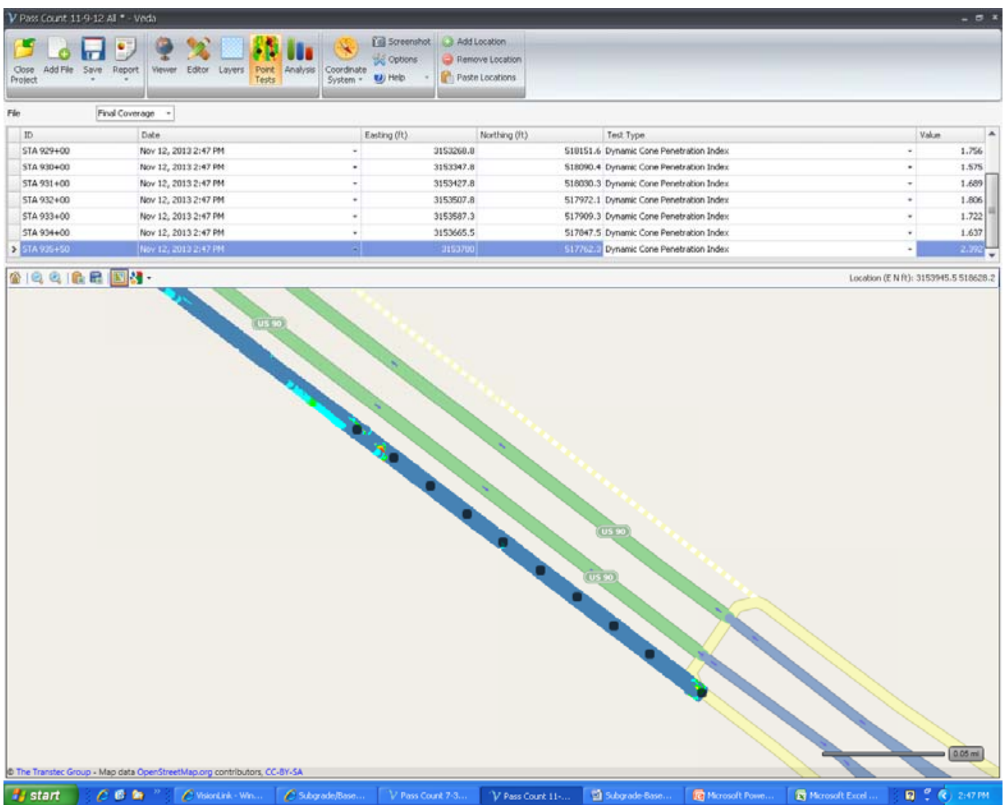


Figure 30
Veda point overlay of DCP data on MDP roller data

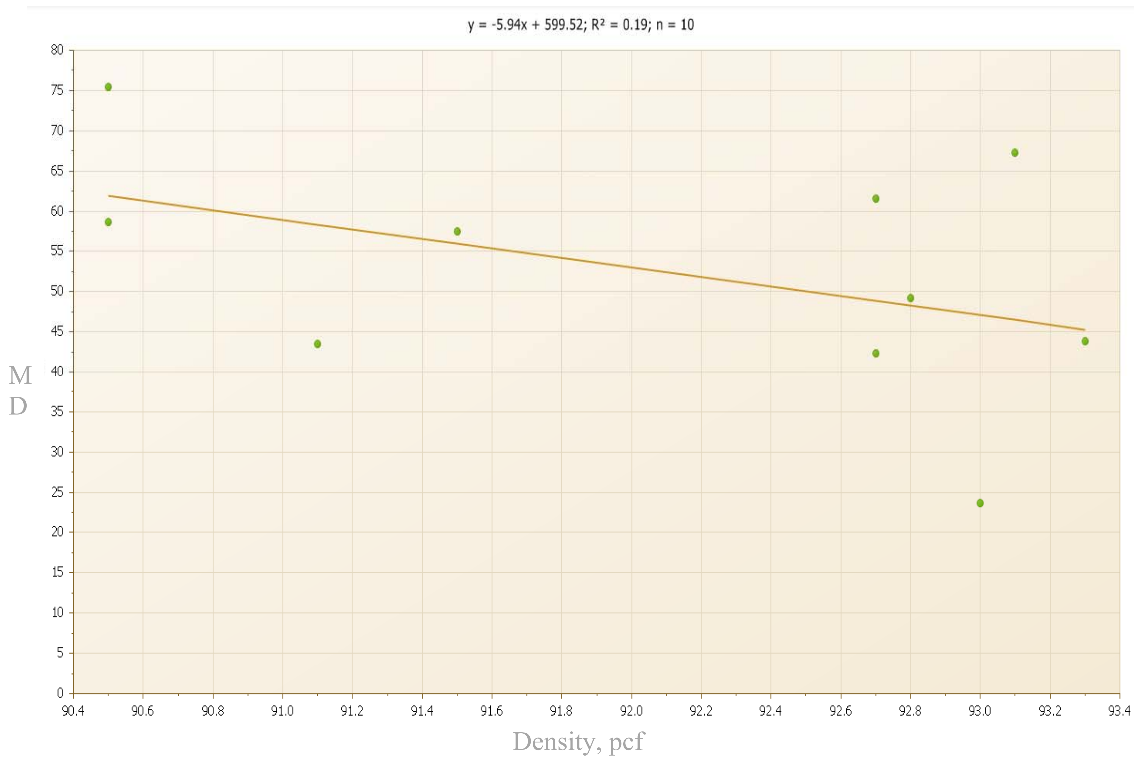


Figure 31
VEDA density vs. MDP correlation (example)

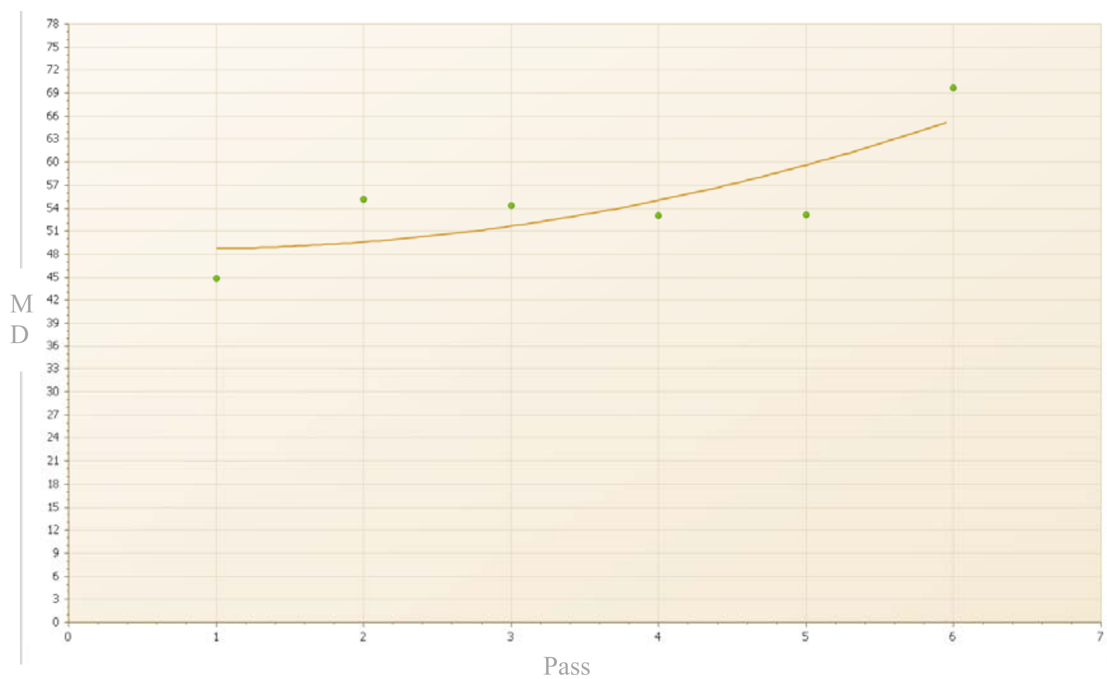


Figure 32
VEDA Pass vs. MDP correlation (example)

Table 10 shows a list of all MDP soil roller activities that occurred during the demo project. This data was pulled from the VisionLink® software and was helpful in connecting the dates of movements with the particular zones on the project. The table is noted to show the zones rolled, times and roughly the number of passes in the note field.

With the data in VEDA, analysis output reports were generated from the data. These reports for the soil layers are included in Appendix G. The VEDA report collected information including pass count, roller speed, sample size, the MDP results, and semi-variogram information. VEDA software defines semi-variogram as a metric for uniformity: "It consists of a plot of field semi-variogram and fitted theoretical model. Fitted parameters include: range, sill, vertical scale, and nuggets. Larger range values in combination with lower sill values indicate better uniformity." A summary of the VEDA reports are included as Table 11.

Since the measurement passes only required one pass, the pass count is relatively low with some overlap, as to be expected. The roller speeds vary from stationary to a value of 67.8 mph, which is likely interpolated from a quick acceleration. The wet weaker areas with low MDP values (MDP <100) are shown in Table 11.

There were some technical errors that were caught during the review of data. At first glance of the MDP roller data, coverage (measurement passes) were shown in certain areas, however upon further review of the data, the MDP roller data results were not in the file. The data was unfortunately not recorded and therefore lost. This led to the missed and limited data reported for the base course in Table 11 primarily around June and July of 2013, but also at other intermittent locations. Figure 33 shows a comparison of coverage maps vs. recorded MDP measurement values. Discussions with the contractor and CAT were two things contributed to the problems (bulleted below). The contractor and CAT resolved the issues shortly after.

- The compaction value normally displayed by the machine was not being reported. A CAT mechanic and updated the firmware versions to the 3 ECM's (CAT's internal factory computers) and after that he began seeing the compaction value.
- During the project, the Project End Date assigned by VisionLink® expired (June/July), thus stopping the transfer of collected data. VisionLink® tech support extended the end date to mid-September allowing data transfer to resume.
- Roller speed settings were changed at some point, and while the machine was at very low speeds in high propel mode, they were getting coverage, but no MDP records.

When the contractor was reminded about the low propel setting and a minimum speed, they started collecting/recording MDP values again.

Table 9
District 03 Laboratory nuclear gauge acceptance testing

Station	Layer	Item No.	Material Code	Date Tested MM/DD/YY	Proctor		Field Nuclear Gauge		% Compaction
					Max Dry Density, pcf	Optimum Moisture, %	Dry Density (avg), pcf	Moisture, %	
ZONE 7									
547+00	Sub 93's	305-01	823	12/18/12	102.5	19.5	96.3	17.4	93.9
552+00	Sub 93's	305-01	823	03/05/13	104.8	19.4	103.6	19.0	98.9
550+75	Sub Mixed	305-01	830	03/27/13	98.9	23.6	98.2	24.2	99.3
548+00	Base 93's	302-02	823	07/02/13	111.9	16.7	107.1	14.7	95.7
546+00	Base Mixed	302-02	820	07/03/13	110.0	17.2	106.4	17.0	96.7
ZONE 12									
595+00	Sub 93's	305-01	823	12/18/12	96.3	23.2	96.1	20.2	99.8
602+00	Sub Mixed	305-01	830	01/23/13	101.5	21.5	99.3	21.0	97.8
598+50	Base 93's	302-02	823	05/16/13	114.1	14.2	107.3	11.4	94.0
601+00	Base Mixed	302-02	820	08/01/13	109.4	19.0	106.8	18.5	97.6
Zone 15									
626+00	Sub 93's	305-01	840	01/28/13	102.4	20.9	97.5	22.0	95.2
626+00	Sub 93's	305-01	823	02/28/13	100.7	22.1	98.3	20.8	97.6
630+00	Sub Mixed	305-01	830	03/01/13	102.4	22.4	98.4	22.1	96.1
634+00	Base 93's	302-02	823	05/06/13	109.0	17.4	103.5	14.8	94.9
631+00	Base Mixed	302-02	820	07/11/13	106.0	18.7	102.5	19.3	96.7
Zone 20									
842+00	Sub 93's			10/29/12	107.8	16.7	105.6	13.1	98.0
839+35	Sub 93's	305-01	823	11/21/12	102.5	19.5	101.5	19.4	99.0
843+80	Sub Mixed	305-01	830	12/08/12	101.4	22.7	100.4	22.3	99.0
843+00	Base 93's	302-02	823	05/16/13	105.2	19.3	98.8	17.7	93.9
841+00	Base Mixed	302-02	820	05/31/13	101.8	21.6	99.0	20.7	97.3
Zone 29									
931+00	Sub 93's	305-01	823	10/30/12	105.2	20.0	103.0	12.9	98.0
933+40	Sub Mixed	305-01	830	11/09/12	103.3	21.6	99.6	19.8	96.4
931+00	Base 93's	302-02	823	04/02/13	101.2	22.5	95.0	20.6	93.9
934+00	Base Mixed	302-02	820	05/21/13	97.8	24.7	94.6	24.5	96.7

NOTES: Max. Dry Density and Optimum Moisture determined by DOTD TR415A or TR415B
Mat. Code 820 - Density & Moisture for Soil Cement Base (Class II),
Mat. Code 823 - Density & Moisture for Soil/Soil-Aggregate Prior to Cement Stabilization (93%)
Mat. Code 830 - Density & Moisture for Subgrade Layer (Additive Treated),
Mat. Code 840 - Density & Moisture for Roadway Subbase (Scarifying & Compacting)

Table 10
MDP soil roller activity – VisionLink®

Machine Operation			LTRC Zone		Coverage				Shaded = LTRC Zone
Date MM/DD/YY	Start Time	End Time	Zone Start	Zone End	Station 1	Station 2	Zones	Focus Zone	Note
11/09/12	4:45 PM	6:00 PM	4:45 PM	5:30 PM	889+00	936+20	25-29	29	multiple passes in 28,29
11/13/12	7:15 AM	5:30 PM			887+00	920+00	25-28		
11/14/12	1:00 PM	2:30 PM			895+00	905+00	26		
11/19/12	9:00 AM	11:45 AM	9:00 AM	10:15 AM	880+00	936+20	24-29	29	multiple passes
11/20/12	10:00 AM	12:00 PM			880+50	893+00	24, 25		
11/29/12	7:06 AM	9:45 AM	7:06 AM	7:08 AM	850+00	936+20	21-24; 26-29	29	single pass in part of 29
11/30/12	7:00 AM	7:30 AM			851+00	859+00	21, 22		
12/01/12	12:00 PM	1:00 PM			890+00	902+00	25, 26		
12/04/12	7:20 AM	10:15 AM	8:00 AM	8:20 AM	837+00	885+00	20,21,24	20	multiple passes in middle of 20
12/12/12	9:30 AM	10:30 AM			868+00	882+00	23-24		
12/15/12	1:00 PM	3:50 PM	1:13 PM	1:20 AM	850+00	936+20	21-29	29	two passes in 29
12/20/12	1:40 PM	2:00 PM	1:40 PM	2:00 PM	834+55	840+00	20	20	section in 20
12/21/12	2:30 PM	6:00 PM	4:51 AM	5:00 AM	836+00	865+00	20,21,22	20	1 pass in part of 20
01/03/12	12:50 PM	1:25 PM	12:50 PM	1:25 PM	622+00	635+88	14,15	15	1 pass
01/05/13	2:30 PM	4:15 PM	2:30 PM	4:15 PM	588+00	620+00	11,12,13,14	12	multiple passes end to end
01/21/13	3:15 PM	5:00 PM	(3:15-3:30 PM)	(4:30-5 PM)	588+00	620+00	11,12,13,14	12	2 passes; multiple on 13 end
01/22/13	11:15 AM	11:35 AM	11:26 AM	11:30 AM	588+00	600+00	11, 12	12	1 pass
01/23/13	7:30 AM	10:00 AM	7:30 AM	10:00 AM	588+00	604+00	11, 12	12	multiple passes
01/24/13	2:15 PM	3:15 PM	2:15 PM	3:15 PM	588+00	604+00	11,12	12	multiple passes
01/28/13	4:00 PM	5:45 PM	(4-4:15 PM)	(4:58-5:01 PM)	(851-885)	(584-618)	21-24;11-14	12	2 passes
02/28/13	6:05 PM	7:05 PM	6:13 PM	6:15 PM	544+00	635+88	7-15	7	single pass
02/28/13	6:05 PM	7:05 PM	6:27 PM	6:30 PM	544+00	635+88	7-15	12	single pass
02/28/13	6:05 PM	7:05 PM	6:37 PM	7:05 PM	544+00	635+88	7-15	15	multiple passes
03/01/13	2:00 PM	3:25 PM	2:00 PM	2:05 PM	574+00	591+00	10,11,12	12	single pass in part of 12
03/02/13	8:10 AM	2:45 PM	8:10 AM	8:45 AM	579+00	635+88	10,11,14,15	15	multiple passes in 14,15
03/03/13	9:45 AM	10:00 AM	9:55 AM	10:00 AM	841+00	885+00	20-24	20	1 pass in part of 20
03/05/13	6:45 PM	7:30 PM			560+00	580+00	8,9,10		
03/06/13	1:45 PM	4:30 PM	1:45 PM	2:15 PM	548+00	604+00	7,9,10,12	7	multiple passes in part of 7
03/06/13	1:45 PM	4:30 PM	2:30 PM	3:00 PM	548+00	604+00	7,9,10,12	12	multiple passes - part of 12

Table 10, Continued									
Machine Operation			LTRC Zone		Coverage				Shaded = LTRC Zone
Date MM/DD/YY	Start Time	End Time	Zone Start	Zone End	Station 1	Station 2	Zones	Focus Zone	Note
03/07/13	1:45 PM	4:15 PM	2:25 AM	4:15 AM	538+00	573+00	6,7,8,9	7	multiple passes
03/08/13	11:00 AM	11:30 AM	11:15 AM	11:20 AM	549+00	569+00	7,8	7	one pass through
03/08/13	3:15 PM	4:15 PM	3:15 PM	4:15 PM	836+00	842+00	20	20	hit middle of zone
03/15/13	7:30 AM	10:22 AM	7:30 AM	7:56 AM	560+00	627+00	8-15;22-24	12	multiple passes
03/15/13	7:30 AM	10:22 AM	7:57 AM	8:20 AM	560+00	627+00	8-15;22-24	15	just partially goes into 15
03/25/13	6:40 PM	7:45 PM			554+00	574+00	8,9		
04/02/13	9:30 AM	11:50 AM	10:48 AM	11:31 AM	544+00	584+00	7,8,9,10	7	multiple passes
05/06/13	4:35 PM	5:09 PM	4:35 PM	4:42 PM	534+55	560+00	6,7,8	7	just 1 pass in 7
05/08/13	11:45 AM	12:30 PM	11:45 AM	12:30 PM	534+55	545+00	6,7	7	just goes into 7
05/18/13	11:00 AM	11:39 AM	11:18 AM	11:30 AM	915+00	936+20	28,29	29	1-2 passes
05/20/13	8:00 AM	12:46 PM	(8:15-9AM)	(10:15-11AM)	887+00	936+20	25,26,27,28,29	29	1-2 passes
05/21/13	5:45 PM	6:32 PM	5:55 PM	6:15 PM	856+00	936+20	22-29	29	multiple passes
05/24/13	1:15 PM	4:35 PM	2:10 PM	3:00 PM	834+55	895+00	20-25	20	multiple passes
05/29/13	7:30 AM	5:30 PM			865+00	915+00	23,24,25,26,27		
05/30/13	5:00 PM	5:45 PM			855+00	875+00	22,23		
05/31/13	4:50 PM	5:47 PM	4:50 PM	5:47 PM	834+55	855+00	20,21	20	multiple Passes
06/04/13	Intelligent Compaction Showcase								
07/02/13	4:35 PM	5:40 PM	4:35 PM	5:40 PM	549+00	564+00	7,8	7	multiple passes in half of 7
07/03/13	5:45 PM	6:30 PM	5:45 PM	6:30 PM	534+55	554+00	6,7	7	multiple passes in 6,7
07/10/13	8:45 AM	11:20 AM			534+55	564+00	6,8		
07/10/13	4:45 PM	6:30 PM	4:45 PM	5:55 PM	602+00	626+00	6, 12-15	12,15	Few passes on edge of Zones 6
07/10/13	5:55 PM	6:30 PM	5:55 PM	6:30 PM	534+00	544+00	6		
07/12/13	11:15 AM	12:00 PM	11:15 AM	12:00 PM	615+00	635+88	14,15	15	multiple passes
07/24/13	1:30 PM	2:00 PM	1:30 PM	2:00 PM	586+00	607+00	11,12,13	12	Few passes (Uneven)
07/25/13	1:00 PM	5:15 PM			574+00	580+00	10		
07/31/13	8:15 AM	9:20 AM	8:15 AM	9:20 AM	618+00	635+88	14,15	15	multiple passes
08/01/13	5:30 PM	7:30 PM	5:30 PM	7:30 PM	587+00	618+00	11,12,13,14	12	multiple passes
08/02/13	6:30 PM	8:00 PM			569+00	594+00	9,10,11		
08/03/13	1:30 PM	3:00 PM	2:00 PM	2:45 PM	551+00	594+00	7-11	7	only part of 7
08/08/13	11:45 AM	2:15 PM	11:45 AM	2:15 PM	590+00	614+00	11,12,13	12	multiple passes

Table 11
Soil roller MDP VEDA summary

Soil Data Final Coverage - Veda Report Summary

	Date File	Sample Size	PASS COUNT					ROLLER SPEED, mph					Sample Size	MDP					SEMI VARIOGRAM		
			Mean	SD	CoV	Min	Max	Mean	SD	CoV	Min	Max		Mean	SD	CoV	Min	Max	Range, ft	Sill & Vert Scale	Nuggets
Zones	Subgrade																				
29	11/09/12	57,130	1	1	68	1	19	3.6	2.4	68	1.0	15.3	41,225	148.82	3.82	3	109.60	150.00	17.06	9.12	0.00
25-28	11/13/12	880,808	4	4	85	1	28	2.9	2.0	68	0.6	35.9	79,417	142.97	8.76	6	11.80	150.00	19.68	53.81	0.00
26	11/14/12	26,939	2	1	59	1	13	3.7	2.5	67	0.7	22.7	26,939	149.68	2.84	2	37.60	150.00	6.56	4.86	0.00
24-29	11/14-29/12	192,164	2	2	78	1	22	3.5	2.4	69	0.7	37.2	154,847	149.14	6.03	4	10.40	150.00	18.37	25.36	0.00
20-26	12/01-12/12	146,680	2	1	57	1	14	2.8	1.5	54	0.6	34.4	128,962	149.01	5.72	4	34.70	150.00	13.12	22.83	0.00
20	12/20/12	9,034	2	1	67	1	11	2.4	1.1	45	0.4	14.6	8,918	147.48	5.68	4	97.80	150.00	27.55	15.77	0.00
12-14	01/05/13	71,865	2	1	50	1	7	3.2	2.1	60	0.9	34.0	68,410	135.38	12.73	9	13.40	150.00	19.68	93.45	0.00
12	01/22-23/13	42,618	5	2	46	1	17	4.5	17	38	0.6	14.9	4,203	118.82	16.87	14	1.60	150.00	14.43	234.52	0.00
10,11,13,15	03/2-6/2013	150,301	1	1	59	1	11	3.8	2.3	60	0.5	34.7	57,834	148.01	8.00	5	17.10	150.00	22.30	30.87	0.00
7,9,10	03/07/13	64,594	1	1	51	1	10	4.4	2.2	51	0.7	34.2	42,075	99.63	69.33	70	0.10	150.00	19.68	1320.88	0.00
8-12,15	03/8-15/13	166,622	1	1	56	1	14	4.3	2.5	57	0.7	67.8	88,105	148.68	8.90	6	0.20	150.00	18.37	50.41	0.00
7-11	04/02/13	83,518	2	1	59	1	14	3.7	2.2	61	0.4	35.5	77,195	50.92	69.74	137	0.10	150.00	14.43	802.81	0.00
6, 7	05/06/13	36,830	1	0	33	1	6	3.7	1.7	45	1.1	14.4	29,279	148.80	10.31	7	32.00	150.00	14.43	54.13	0.00
Zones	Base																				
25-29	5/18-20/13	106,778	2	1	56	1	10	3.4	1.6	46	0.6	43.7	90,141	147.30	18.18	12	0.10	150.00	17.06	309.51	0.00
25-28	5/20-25/13	239,714	2	1	60	1	14	4.1	1.5	37	0.6	43.7	76,501	146.84	19.69	13	0.10	150.00	15.74	333.35	0.00
miss/mult	6/1-30/13	211,630	3	2	78	1	19	5.4	2.2	42	0.7	38.8	35,254	148.01	7.67	5	65.40	150.00	19.68	29.78	0.00
14-15	7/31/2013	38,477	1	1	53	1	11	2.7	0.8	30	0.6	12.8	38,457	149.58	3.77	3	61.20	150.00	9.18	6.86	0.00
8-15	7/31-8/8/13	209,771	3	2	80	1	21	3.8	1.8	48	0.6	32.9	197,679	148.88	5.68	4	61.20	150.00	15.75	27.98	0.00
12-14	8/8/2013	70,167	3	2	70	1	17	4.1	1.5	36	0.8	32.9	66,997	147.04	8.97	6	67.10	150.00	14.43	62.28	0.00

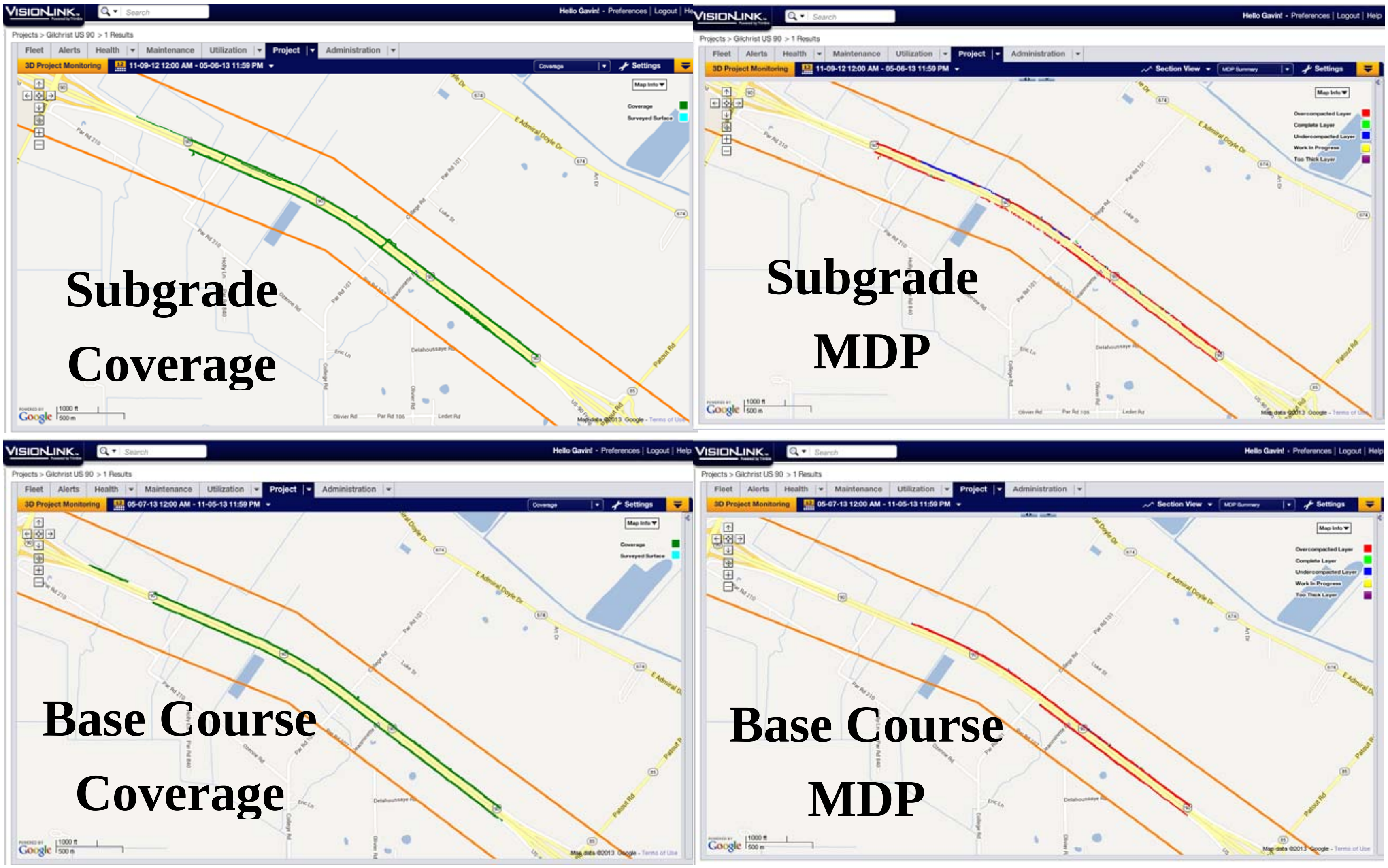


Figure 33
Subgrade and base course maps – coverage vs. recorded MDP values

When reviewing the subgrade MDP results, weak results in Zone 12 can be seen in the 01/05/13 & 01/22-23/13 files (mean MDP results of 135.38 and 118.82, respectively. Subsequent subgrade MDP results in Zone 12 resulted in improved measurements averaging at 148.68 from the 03/8-15/13 file. Weak areas in Zone 7 can be seen in the 03/07/13 and 04/02/13 date files with an MDP value of 99.63 and 50.92, respectively. Subsequent subgrade MDP results in Zone 7 resulted in improved measurements averaging at 148.80 from the 05/06/13 date file.

District nuclear density gauge compaction results, summarized in Table 12, show compaction of the subgrade and class II base course layers ranged between 95 and 99 percent, with each zone representing 1000-ft. sections. All of the compaction results met the compaction criteria. The final compaction results of the reworked areas (Zones 7 and 12) are shown in this table.

Table 12
District 03 Laboratory subgrade and base course compaction results

Zone	Subgrade Layer			Base Course Layer		
	Station	Location	% Compaction	Station	Location	% Compaction
Zone 6	540 + 50	10’ LT of CL	96.0	539+00	3’ RT of CL	99.1
Zone 7	550 + 75	3’ LT of CL	99.3	546+00	12’ LT of CL	96.7
Zone 8	555 + 00	10’ RT of CL	99.0	556+50	9’ RT of CL	97.0
Zone 9	570 + 50	10’ LT of CL	98.6	571+00	10’ LT of CL	96.9
Zone 10	583 + 00	4’ LT of CL	97.7	579+00	9’ RT of CL	96.2
Zone 11	591 + 00	9’ LT of CL	96.4	593+00	9’ LT of CL	98.2
Zone 12	602 + 00	7’ RT of CL	97.7	601+00	9’ RT of CL	97.6
Zone 13	606 + 00	10’ RT of CL	97.2	604+25	9’ RT of CL	97.3
Zone 14	620 + 00	6’ RT of CL	96.2	618+00	9’ LT of CL	96.0
Zone 15	630 + 00	6’ LT of CL	96.1	631+00	9’ LT of CL	96.7
Zone 20	843 + 80	8’ LT of CL	99.0	841 + 00	10’ RT of CL	97.3
Zone 21	850 + 25	7’ LT of CL	95.4	853 + 80	5’ RT of CL	99.2
Zone 22	857 + 00	10’ LT of CL	97.7	860 + 00	6’ RT of CL	97.1
Zone 23	874 + 40	6’ LT of CL	97.4	871 + 75	4’ RT of CL	99.1
Zone 24	883 + 00	4’ LT of CL	98.7	877 + 00	4’ RT of CL	95.1
Zone 25	890 + 80	6’ RT of CL	97.3	891 + 50	10’ RT of CL	99.3
Zone 26	900 + 00	6’ LT of CL	95.2	903 + 00	10’ LT of CL	98.7
Zone 27	913 + 50	5’ RT of CL	99.5	907 + 00	9’ RT of CL	99.3
Zone 28	921 + 00	4’ LT of CL	95.1	917 + 90	3’ RT of CL	99.4
Zone 29	933 + 40	7’ LT of CL	96.4	934 + 00	5’ LT of CL	97.8

LTRC Field Sampling and Testing

LTRC personnel performed various field tests in addition to the District acceptance testing. The testing occurred when the new layers were being constructed or accepted in accordance with Table 4. Figure 34 shows several trucks spreading cement in preparation for the mixing process. Once the cement was spread and mixed, but before compaction began, LTRC collected loose material for laboratory testing. In addition, LTRC excavated the loose soil to install (bury) the pressure cell(s) at the bottom of layers, prior to compaction. Additional soils were collected and molded into samples for compressive strengths. Figure 35 shows the pressure sensor installation and sample collection. Surficial test were normally conducted the same day, after the compaction efforts had occurred. LTRC generally stayed out of the contractor's way, so as not to affect production. The follow-up 7-day testing (or as close as possible) had some variances due to access, weather, equipment availability, personnel, contractor's movements, etc. The results of the LTRC field and laboratory tests are summarized by the different focus zones.

Figure 34
Cement spreading operation

Figure 35
Pressure sensor installation and sample collection

LTRC Tests in Zone 7

Zone 7 Field Test Results

The field nuclear gauge tests shown in Table 13, and were shadowing tests compared to the District acceptance tests. Densities ranged from 94.4 pcf. to 108.7 pcf. Seven day unconfined compression test results of the field-mixed, field-collected, laboratory molded cement treated subgrade materials are shown in below in Table 14.

Table 13
Zone 7 LTRC nuclear gauge results (mix day)

Zone 7 Station No.	Nuclear gauge 12-inch depth, Untreated soil, 3/7/13 DD pcf	WD pcf	M %
544+00	108.7	121.8	12.0
545+00	105.2	120.5	14.5
546+00	101.4	116.7	15.1
547+00	101.0	115.0	13.9
548+00	98.9	113.4	14.7
549+00	94.4	107.2	13.6
550+00	108.3	120.9	11.7
551+00	101.1	119.3	18.1
552+00	97.3	114.6	17.8
553+00	96.2	114.0	18.5
554+00	97.4	116.8	19.9

Table 14
Zone 7 UCS 7-day break results of field mixed samples – cement treated subgrade

Mix Date, Location	Sample #	Dry Density (lbs/cu.ft.)	7 day UCS (psi)	Mold moisture %	Average Dry Density pcf	UCS (psi)	Moisture %
Zone 7	1	96.4	124	18.5			
STA 553+00	2	96.2	102	18.5	96.2	112.3	18.5
3/7/2013	3	96.1	111	18.5			
Zone 7	1	97.1	169	19.9			
STA 554+00	2	96.9	133	19.9	97.3	167.3	19.9
3/7/2013	3	97.9	200	19.9			

Dynamic Cone Penetrometer

DCP tests were conducted on the focus areas mentioned, Zones 7, 12, 15, 20, and 29. DCP results are described in the paragraphs below. The results show the increase in stiffness over time as the cement treated layers increase in strength. There is also a reference line of 4 mm/blow included on each figure. In general, DCP plots that are flatter (more horizontal) are stiffer than lines that are steeper (more vertical). The increase in strength as the soil layers cure can be seen as the layers flatten over time, indicating that more blows are required to penetrate the stiffer layer. Subsequent paragraphs discuss the results from each zone in detail.

Zone 7 included all construction conducted from Station 544+00 to 554+00. DCPs were conducted on the untreated subgrade on 03/07/2013 and DCPI (mm/blow) values ranged from 10 mm/blow – 40 mm/blow, as shown in Figure 36. DCPs were conducted on the cement-treated subgrade after 6-days on 03/13/2013 and DCPI (mm/blow) values ranged from 2 mm/blow – 20 mm/blow, as shown in Figure 37, indicating that the cement-treated subgrade was stiffer than the untreated subgrade. Station 547+00 was the only station that did not show a significant increase in stiffness for the cement-treated subgrade compared to the untreated subgrade, though there was a slight increase. This may possibly be due to a localized soft spot, uneven cement distribution, etc. Average DCPI values are summarized in Table 15.

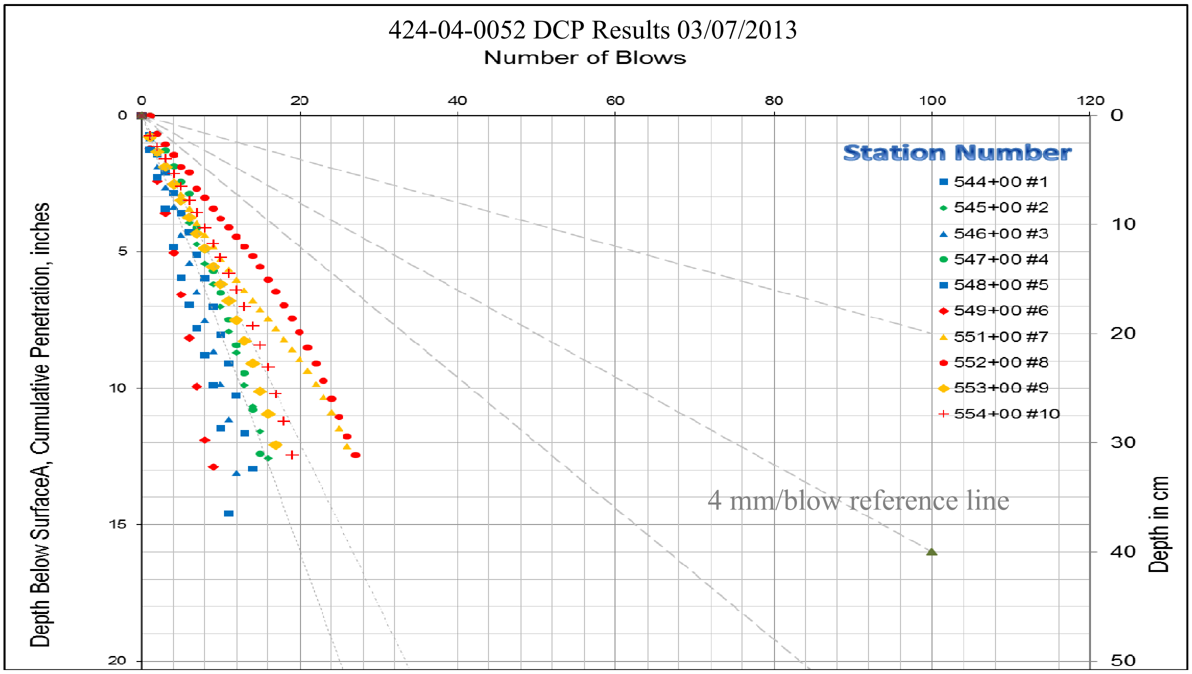


Figure 36
Zone 7 cement treated subgrade (mix day)

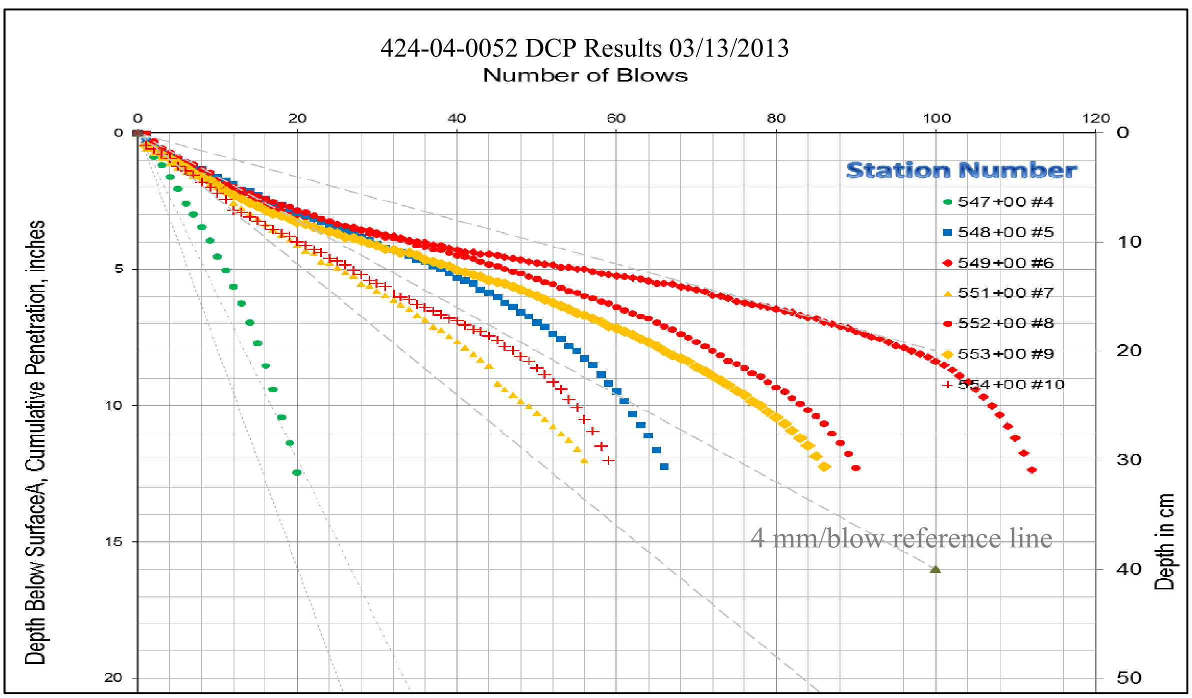


Figure 37
Zone 7 DCP curves, cement treated subgrade (6 day)

Table 15
Zone 7 DCPI results, cement treated subgrade

Station	Inches of 12 in. Layer	Average DCPI (mm/blow)	
		3/7/2013 Mixed	3/13/2013 6 days
544+00	Top 6	29.8	-
	Bottom 6	28.0	-
545+00	Top 6	16.9	-
	Bottom 6	22.6	-
546+00	Top 6	23.2	-
	Bottom 6	29.2	-
547+00	Top 6	18.3	12.1
	Bottom 6	28.3	21.6
548+00	Top 6	19.1	3.3
	Bottom 6	29.5	7.5
549+00	Top 6	32.3	2.0
	Bottom 6	39.8	4.2
551+00	Top 6	12.1	4.6
	Bottom 6	11.1	6.2
552+00	Top 6	9.7	2.7
	Bottom 6	14.8	4.7
553+00	Top 6	15.1	2.9
	Bottom 6	20.8	4.4
554+00	Top 6	12.8	4.4
	Bottom 6	21.1	5.8

FWD and Dynaflect Tests. FWD and Dynaflect tests were conducted on all the focus areas and are summarized in Table 16. The results for the subgrade and base course are shown in the following sections divide by zones. Unfortunately, the FWD and Dynaflect devices were unavailable for the later HMA testing due to mechanical breakdowns and issues on both devices. LTRC is currently working on purchasing new measurement vehicles with hopes that additional measurements could be made in the future on these same focus areas.

Table 16
FWD and Dynaflect testing log

Test Date	Zone #	Surface Tested	Stations Tested From	Stations Tested To	Notes & Comments
11/8/2012	29	Raw Subgrade	935+00	919+00	Basically tested every 50'
11/15/2012	29	Treated Subgrade	935+00	920+50	Basically tested every 50'
1/31/2013	12	Treated Subgrade	604+00	594+50	Basically tested every 50', Parts of this zone shows very weak and I was informed that the contractor would tear out and reconstruct
1/31/2013	20	Treated Subgrade	844+50	843+50	Only small portion of zone was treated and tested at this time due to box curvert being constructed
3/5/2013	15	Treated Subgrade	635+50	624+50	Basically tested every 50'
3/7/2013	15	Treated Subgrade	635+50	624+50	Basically tested every 50'
3/7/2013	20	Treated Subgrade	838+00	845+00	Basically tested every 50', Parts of this zone passes in front of contractors office and this portion was not tested
3/7/2013	7	Raw Subgrade	548+00	544+00	Basically tested every 50', This portion of zone 7 is north of box culvert being constructed
3/7/2013	12	Treated Subgrade	604+00	594+00	Basically tested every 50', This testing done after all or part (?) of this zone was reconstructed
3/7/2013	7	Treated Subgrade	454+00	451+00	Basically tested every 50', This portion of zone 7 is south of box culvert being constructed

In each table below, chainage refers to the station in the tested zone, i.e. 54400 equals station 544+00. The FWD and Dynaflect data was collected in the direction of the chainage (in the table) from the right lane. The zones listed in Table 16 are the focus zones, testing may have overlapped into adjacent zones. Table 17 through Table 19 present the results of the FWD tests for Zone 7; while Table 20 and Table 21 and present the results of Dynaflect tests for Zone 7. The raw subgrade was improved with the addition of cement. The deflections decreased and the subgrade moduli further improved as the cement cured over time.

Table 17
Zone 7 FWD results, raw subgrade (unmixed)

US 90 Frontage Rd. Zone 7 Raw Subgrade Test Dat 3/7/2013

Chainage	Latitude	Longitude	E1 (12" Soil) ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
54400	29.9373567	-91.7585317	2.6	1.3	1.1	75.76	16.1
54450	29.9372950	-91.7583850	2.4	1.8	1.3	41.15	8.9
54500	29.9372400	-91.7582433	3.5	3.3	1.9	51.18	17.5
54600	29.9371350	-91.7579467	4.1	3.3	1.9	44.04	16.7
54650	29.9370817	-91.7578017	2.2	2.5	1.6	69.66	16.2
54700	29.9370283	-91.7576583	3.0	2.3	1.5	57.95	15.8
54750	29.9369700	-91.7575100	4.5	3.8	2.1	44.50	19.0
54800	29.9369050	-91.7573750	4.6	3.9	2.2	42.35	18.5
	AVG		**3.4**	**2.8**	**1.7**	**53.3**	**16.1**

Table 18

Zone 7 FWD results cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 7 12" Treated Subgrade   Test Date 3/7/2013

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
55100	29.9365967	-91.7565050	8.9	4.7	2.5	27.47	20.1
55150	29.9365450	-91.7563567	12.9	4.6	2.5	21.98	20.3
55200	29.9364850	-91.7562133	10.3	4.0	2.2	26.33	19.9
55250	29.9364283	-91.7560633	8.0	4.0	2.2	31.13	19.9
55300	29.9363766	-91.7559200	10.6	4.8	2.5	24.89	20.4
55350	29.9363167	-91.7557850	12.0	3.3	1.9	25.37	19.6
55400	29.9362633	-91.7556367	12.8	4.1	2.2	23.65	20.4
	AVG		**10.8**	**4.2**	**2.3**	**25.8**	**20.1**

Table 19

Zone 7 FWD results, cement treated subgrade (7 days)

US 90 Frontage Rd. Zone 7 12" Treated Subgrade   Test Date 3/14/2013

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
54750	29.9369567	-91.7575116	44.8	7.0	3.4	9.94	22.1
54800	29.9369033	-91.7573700	79.2	6.4	3.1	7.54	22.1
54850	29.9368483	-91.7572267	60.6	7.9	3.7	7.79	21.8
54900	29.9367900	-91.7570867	105.8	8.4	3.9	5.66	21.9
55100	29.9365667	-91.7565034	28.1	6.3	3.1	12.94	21.6
55150	29.9365150	-91.7563567	161.8	7.0	3.4	4.88	21.6
55200	29.9364616	-91.7562133	96.9	7.2	3.5	6.21	21.4
55250	29.9364066	-91.7560666	134.3	6.8	3.3	5.51	22.3
55300	29.9363533	-91.7559233	139.2	7.5	3.6	4.99	20.8
55350	29.9363033	-91.7557767	112.8	6.7	3.3	6.28	22.3
55400	29.9362483	-91.7556334	75.9	6.9	3.3	7.70	22.1
	AVG		**94.5**	**7.1**	**3.4**	**7.2**	**21.8**

Table 20
Zone 7 Dynaflect results, raw subgrade (unmixed)

US 90 Frontage Rd. Zone 7 Raw Subgrade				Test Date : (3/7/2013		
Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
54400	29.9373567	-91.7585317				15.85
54450	29.9372950	-91.7583850		2.5	3.3	8.54
54500	29.9372400	-91.7582433		2.6	3.3	7.45
54600	29.9371350	-91.7579467				9.14
54650	29.9370817	-91.7578017				9.86
54700	29.9370283	-91.7576583				11.56
54750	29.9369700	-91.7575100				7.82
54800	29.9369050	-91.7573750				7.02
	AVG			2.6	3.3	9.7

Table 21
Zone 7 Dynaflect results, cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 7 12" Treated Subgrade				Test Date 3/7/2013		
Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
55100	29.9365967	-91.7565050				5.56
55150	29.9365450	-91.7563567				5.94
55200	29.9364850	-91.7562133				6.94
55250	29.9364283	-91.7560633				7.65
55300	29.9363766	-91.7559200				6.04
55350	29.9363167	-91.7557850				7.77
55400	29.9362633	-91.7556367				6.24
	AVG					6.6

LTRC Tests in Zone 12

Zone 12 Field Test Results

Field samples were not collected from Zone 12, as it was added to the focus areas when the weak areas were identified in the zone. By this time, most the subgrade layer had already been placed. Because this area had some soft spots, the area required reworking. LTRC conducted additional nuclear gauge tests for shadowing purposes, but was limited by the contractor movements, weather, and test time on site due to travel times. Table 22 presents the LTRC nuclear gauge results on the subgrade, and the base course results in Table 23.

The GeoGauge test results on the base course are presented in Table 24. The seven day results for the base course were actually taken a day early (after 6 days) due to scheduling conflicts.

Table 22
Zone 12 LTRC nuclear gauge, cement treated subgrade

Zone 12	Subgrade Nuclear, 12-inch depth 3/7/2013			Subgrade Nuclear, 12-inch depth 3/13/2013		
Station No.	DD pcf	WD pcf	MC %	DD pcf	WD pcf	MC %
604+00	98.2	115.0	17.0	96.6	113.9	17.9
603+00	103.0	119.3	15.8	103.0	119.4	15.9
602+00	100.1	116.4	16.3	98.8	115.7	17.1
601+00	101.0	115.7	14.6	--	--	--
600+00	--	--	--	--	--	--
599+00	108.2	121.3	12.1	--	--	--
598+00	105.6	120.4	14.0	--	--	--
597+00	--	--	--	--	--	--
596+00	--	--	--	--	--	--
595+00	--	--	--	--	--	--
594+00	--	--	--	--	--	--

Table 23
Zone 12 LTRC nuclear gauge, cement stabilized base course

Zone 12	Base Course Nuclear, 8-inch depth 8/2/2013			Base Course Nuclear, 8-inch depth 8/8/2013		
Station No	DD pcf	WD pcf	MC %	DD pcf	WD pcf	MC %
604+00	104.2	119.8	15.0	--	--	--
603+00	104.2	119.0	14.2	--	--	--
602+00	111.1	125.5	13.0	--	--	--
601+00	108.1	123.2	14.0	111.0	123.7	11.4
600+00	110.3	126.1	14.3	104.6	115.7	10.6
599+00	109.7	124.3	13.3	111.0	123.2	11.0
598+00	110.4	123.3	11.7	109.8	120.8	10.0
597+00	--	--	--	110.4	122.0	10.5
596+00	103.3	116.0	12.3	105.5	116.5	10.4
595+00	108.6	121.7	12.1	93.9	105.0	11.8
594+00	103.5	120.2	16.1	104.2	116.0	11.3

Table 24
Zone 12 GeoGauge results, cement stabilized base course

	8/2/2013		8/8/13 (6 Day)	
Station No.	SI-S	SI-Y	SI-S	SI-Y
604+00	14.3	123.8	6.4	55.9
603+00	20.7	179.6	11.9	103.1
602+ 00	17.3	149.9	11.7	101.7
601+00	20.4	177.3	12.6	109.3
600+00	42.3	367.0	9.4	81.1
599+00	28.3	245.4	11.7	101.4
598+00	24.6	213.4	10.6	92.1
597+00	- -	- -	18.2	157.5
596+00	28.0	242.9	13.6	117.8
595+00	45.0	390.6	13.0	112.7
594+00	42.9	375.4	17.6	152.6

SI-S - Stiffness in SI value MN/m (MegaNewton per meter).
SI-Y - Young's modulus in SI values MPa (MegaPascals).

Dynamic Cone Penetration

Zone 12 included all construction conducted from Station 594+00 to 604+00. DCPs were conducted on the untreated subgrade on 03/06/2013 and the DCPI (mm/blow) values ranged from 2 mm/blow – 16 mm/blow, as shown in Figure 38. DCPs were conducted on the cement-treated subgrade after 7-days on 03/13/2013 and DCPI (mm/blow) values ranged from 3 mm/blow – 11 mm/blow, as shown in Figure 39, indicating that the cement-treated subgrade was somehow stiffer than the untreated subgrade. DCPs were conducted on the untreated base course on 08/02/2013 and the DCPI (mm/blow) values ranged from 2 mm/blow – 5 mm/blow, as shown in Figure 40. DCPs were also conducted on the soil cement base course after 7-days on 08/09/2013 and the DCPI (mm/blow) values ranged from 1 mm/blow – 2 mm/blow, as shown in Figure 41, indicating that the soil cement based course was much stiffer than the untreated base course. Station 596+00 showed refusal (10 blows with no movement) on the soil cement base course treated after 7-days.

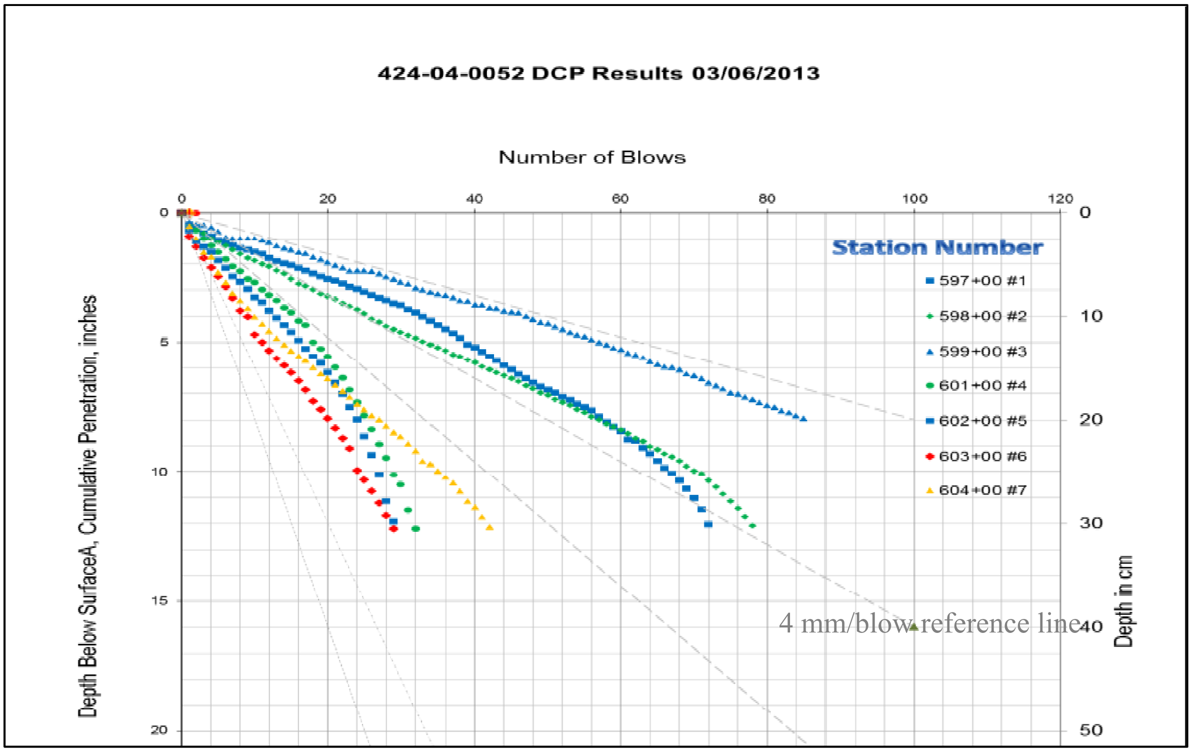


Figure 38
Zone 12 DCP curves, cement treated subgrade (mix day)

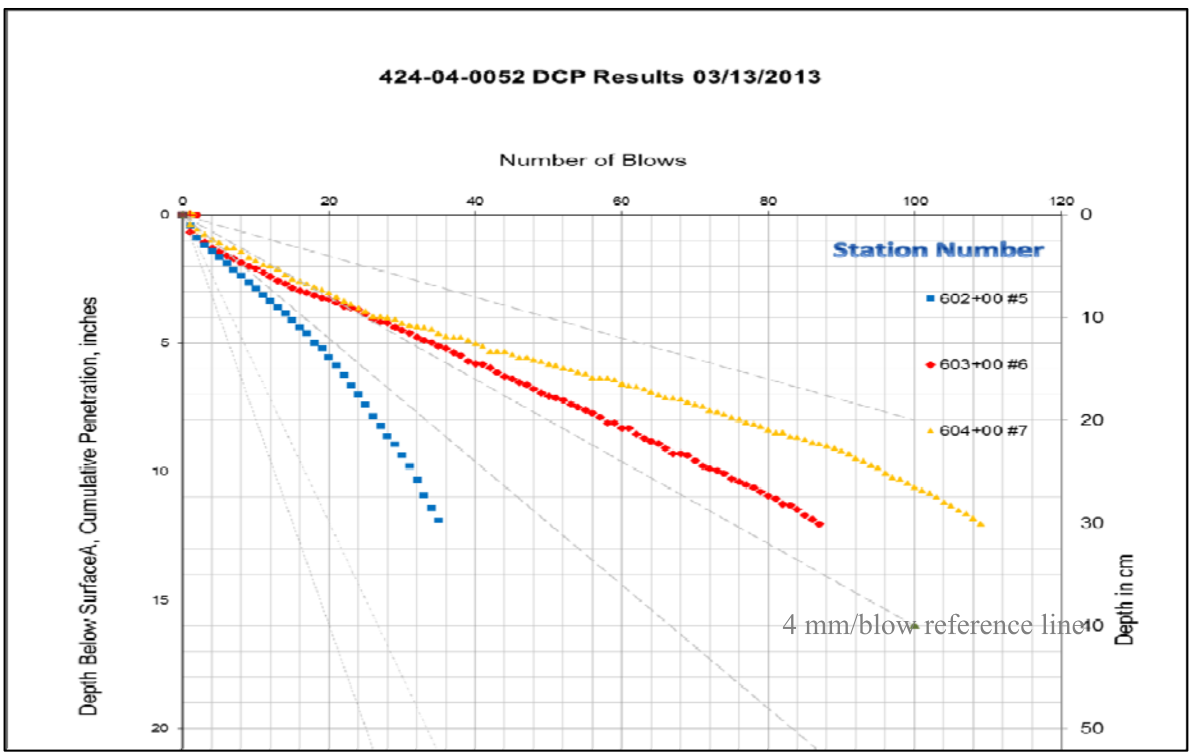


Figure 39
Zone 12 DCP curves, cement treated subgrade (7 day)

Table 25
Zone 12 DCPI results, cement treated subgrade

Station	Inches of 12 in. Layer	Average DCPI (mm/blow)	
		3/6/2013 mixed	3/13/2013 7 days
594+00	Top 6	-	-
	Bottom 6	-	-
595+00	Top 6	-	-
	Bottom 6	-	-
596+00	Top 6	-	-
	Bottom 6	-	-
597+00	Top 6	3.2	-
	Bottom 6	5.6	-
598+00	Top 6	3.5	-
	Bottom 6	4.2	-
599+00	Top 6	2.2	-
	Bottom 6	3.9	-
601+00	Top 6	7.1	-
	Bottom 6	14.4	-
602+00	Top 6	7.3	6.9
	Bottom 6	15.5	10.9
603+00	Top 6	9.8	3.3
	Bottom 6	10.7	3.4
604+00	Top 6	8.2	2.8
	Bottom 6	6.5	2.7

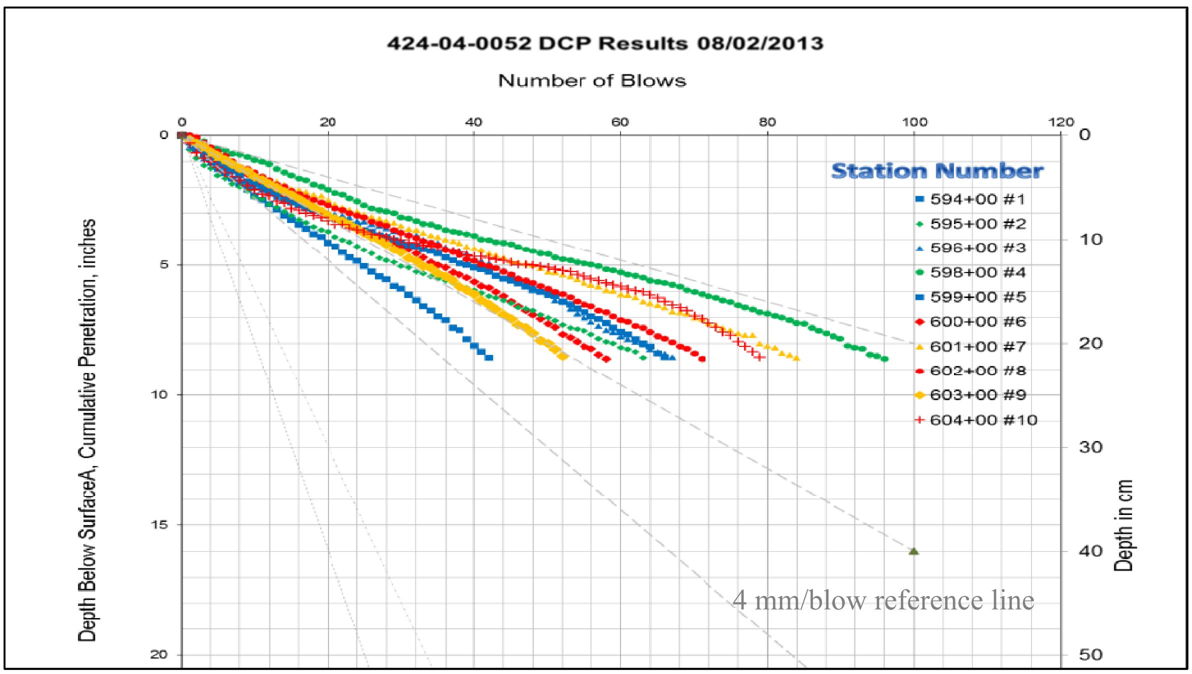


Figure 40
Zone 12 DCP curves, cement stabilized base course (mix day)

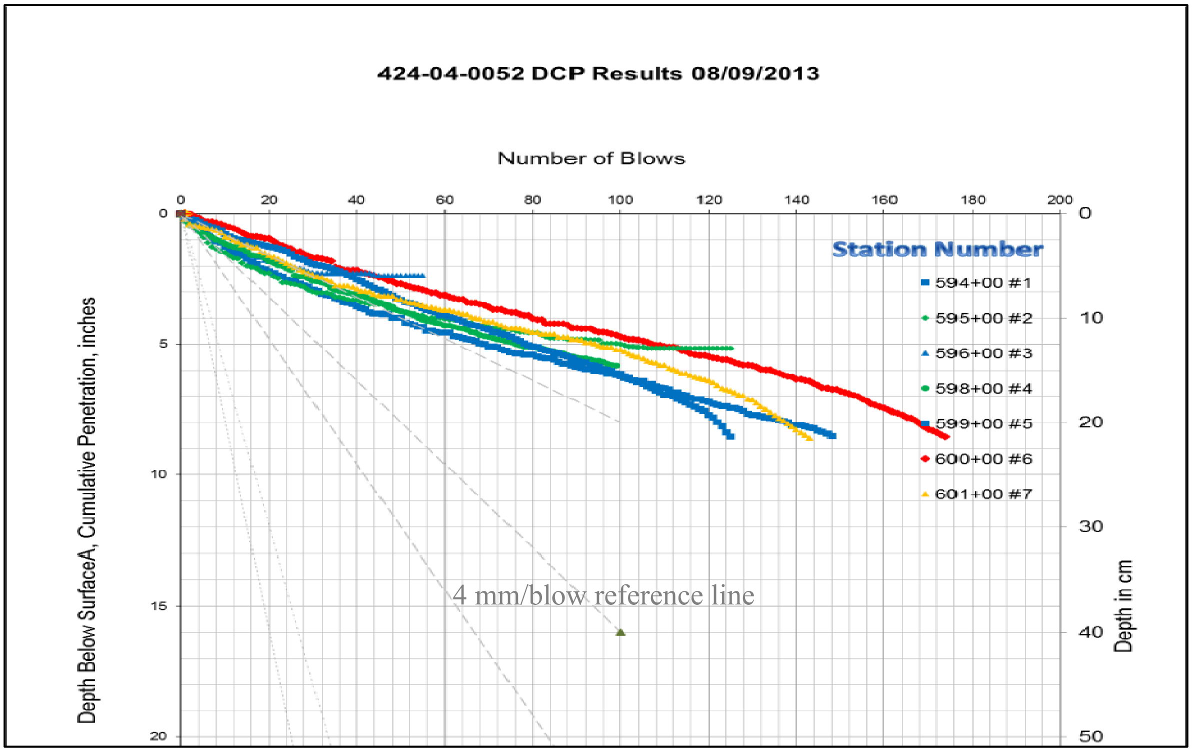


Figure 41
Zone 12 DCP curves, cement stabilized base course (7 day)

Table 26
Zone 12 DCPI results, cement stabilized base course

Station	Inches of 8.5 in. Layer	Average DCPI (mm/blow)	
		8/2/2013 Mixed	8/9/2013 7 days
594+00	Top 4.0	5.1	2.0
	Bottom 4.5	5.1	1.2
595+00	Top 4.0	4.2	1.6
	Bottom 4.5	2.8	Refusal
596+00	Top 4.0	2.8	Refusal
	Bottom 4.5	3.4	Refusal
598+00	Top 4.0	2.5	1.8
	Bottom 4.5	2.1	1.1
599+00	Top 4.0	3.4	1.6
	Bottom 4.5	3.1	1.8
600+00	Top 4.0	3.6	1.3
	Bottom 4.5	3.9	1.2
601+00	Top 4.0	2.8	1.4
	Bottom 4.5	2.4	1.5
602+00	Top 4.0	3.3	-
	Bottom 4.5	3.0	-
603+00	Top 4.0	3.8	-
	Bottom 4.5	4.5	-
604+00	Top 4.0	3.2	-
	Bottom 4.5	2.3	-

FWD and Dynaflect Results

FWD and results for Zone 12 are presented in Table 27 through Table 29 for the cement treated subgrade; and the Dynaflect test results are presented in Table 30 through Table 32. The initial test results in January (Table 27 and Table 30) were taken when there were some weak spots in the area – see Figure 29. The devices could also not access all the areas at that time. The areas were subsequently reworked and later retested in March 2013. The treated values generally improved from 03/07/13 to 03/14/13, though there were apparently still some localized weak spots affecting the overall averages.

Table 27
Zone 12 FWD results, cement treated subgrade – 01/31/13

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade) ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
59450			52.1	4.7	2.5	10.04	21.0
59500			74.0	8.0	3.7	6.85	21.1
59550			53.7	6.2	3.0	8.85	20.7
59600			40.3	4.6	2.4	11.60	20.6
59650			57.9	5.5	2.8	9.13	21.5
59700			62.3	5.1	2.6	9.11	21.3
59750			32.0	5.4	2.8	12.15	20.8
59800			15.2	1.9	1.4	25.94	19.4
59850			45.6	4.3	2.3	11.35	21.3
59900			76.5	5.6	2.8	7.98	21.7
59950			80.2	6.3	3.1	6.93	20.9
60000			64.7	6.1	3.0	8.15	21.5
60050			37.8	5.7	2.8	11.32	21.1
60100			102.5	7.4	3.5	6.20	21.0
60150			18.6	3.3	1.9	19.24	19.8
	AVG		**54.2**	**5.3**	**2.7**	**11.0**	**20.9**

Table 28
Zone 12 FWD results, cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 12 12" Treated Subgrade Test Date : 03/07/2013

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
59400	29.9307433	-91.7447650	69.1	6.2	3.1	7.90	21.5
59450	29.9306717	-91.7446217	21.2	3.4	2.0	18.25	20.2
59500	29.9306000	-91.7444883	52.6	7.5	3.6	8.68	21.5
59550	29.9305150	-91.7443567	46.1	5.7	2.9	10.00	21.2
59600	29.9304350	-91.7442300	32.5	5.8	2.9	12.38	21.3
59650	29.9303516	-91.7441067	38.8	6.1	3.0	10.47	20.8
59700	29.9302684	-91.7439833	30.3	5.4	2.7	12.83	20.4
59750	29.9301850	-91.7438567	29.3	5.7	2.9	12.41	20.7
59800	29.9301033	-91.7437317	8.8	1.9	1.4	34.73	18.6
59850	29.9300184	-91.7436017	31.6	4.6	2.4	13.52	20.9
59900	29.9299367	-91.7434783	67.9	5.4	2.8	8.39	21.5
59950	29.9298533	-91.7433566	61.7	6.2	3.0	7.57	19.6
60200	29.9294266	-91.7427416	24.7	4.5	2.4	15.43	20.9
60250	29.9293584	-91.7425983	11.3	3.1	1.9	27.12	19.9
60300	29.9292850	-91.7424683	29.3	5.2	2.7	13.65	20.9
60350	29.9292017	-91.7423450	14.9	3.3	1.9	23.58	20.6
60400	29.9291217	-91.7422216	48.5	6.6	3.2	9.09	21.2
	AVG		**36.4**	**5.1**	**2.6**	**14.5**	**20.7**

Table 29
Zone 12 FWD results, cement treated subgrade (7 day)

US 90 Frontage Rd. Zone 12 12" Treated Subgrade Test Date : 03/14/2013

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
59450	29.9306850	-91.7446117	25.6	4.3	2.3	15.52	21.1
59500	29.9306033	-91.7444883	43.6	8.8	4.1	9.00	22.0
59550	29.9305133	-91.7443583	58.5	6.4	3.2	8.29	21.1
59600	29.9304333	-91.7442333	28.6	6.4	3.1	12.51	21.2
59650	29.9303500	-91.7441083	30.8	5.8	2.9	12.42	21.4
59700	29.9302700	-91.7439866	46.7	5.9	3.0	9.93	21.5
59750	29.9301883	-91.7438616	40.2	6.6	3.2	9.96	20.9
59800	29.9301083	-91.7437350	12.1	2.7	1.7	27.43	20.1
59850	29.9300217	-91.7436050	47.2	4.7	2.5	10.87	21.8
59900	29.9299367	-91.7434834	63.3	5.6	2.8	8.83	21.9
59950	29.9298500	-91.7433566	40.7	7.1	3.4	9.90	21.8
60100	29.9296000	-91.7429833	8.8	4.2	2.3	28.87	20.2
60150	29.9295183	-91.7428567	14.0	4.0	2.2	22.06	20.8
60200	29.9294383	-91.7427317	19.7	4.1	2.2	18.26	20.8
60250	29.9293600	-91.7426067	6.2	4.4	2.4	35.13	19.5
60300	29.9292817	-91.7424783	73.2	6.8	3.3	7.55	21.8
60350	29.9291850	-91.7423533	129.4	5.5	2.8	6.20	22.0
60400	29.9291017	-91.7422317	145.2	8.0	3.7	4.95	22.2
	AVG		**46.3**	**5.6**	**2.8**	**14.3**	**21.2**

Table 30
Zone 12 Dynaflect results, cement treated subgrade – 01/31/13

US 90 Frontage Rd. Zone 12 12" Treated Subgrade Test Date : 01/31/2013

Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
59450						5.04
59500			0.9	2.6	3.3	3.12
59550						3.88
59600						4.73
59650						4.33
59700						4.70
59750						3.96
59800						9.70
59850						5.50
59900						4.05
59950			0.1	2.5	3.3	3.91
60000						4.02
60050						5.20
60100						3.70
60150						6.81
	AVG		**0.5**	**2.6**	**3.3**	**4.8**

Table 31
Zone 12 Dynaflect results, cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 12 12" Treated Subgrade Test Date : 03/7/2013

Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
59400	29.9307433	-91.7447650				3.60
59450	29.9306717	-91.7446217				6.53
59500	29.9306000	-91.7444883				3.58
59550	29.9305150	-91.7443567				4.37
59600	29.9304350	-91.7442300	0.1	2.6	3.3	3.87
59650	29.9303516	-91.7441067				4.00
59700	29.9302684	-91.7439833				5.34
59750	29.9301850	-91.7438567				4.51
59800	29.9301033	-91.7437317				8.91
59850	29.9300184	-91.7436017				5.70
59900	29.9299367	-91.7434783	0.0	2.6	3.3	4.16
59950	29.9298533	-91.7433566	0.2	2.8	3.4	3.57
60200	29.9294266	-91.7427416				5.60
60250	29.9293584	-91.7425983				7.04
60300	29.9292850	-91.7424683				5.17
60350	29.9292017	-91.7423450				7.30
60400	29.9291217	-91.7422216	0.6	2.9	3.4	3.20
	AVG		**0.2**	**2.7**	**3.4**	**5.1**

Table 32
Zone 12 Dynaflect results, cement treated subgrade (7 day)

US 90 Frontage Rd. Zone 12 12" Treated Subgrade Test Date : 03/14/2013						
Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
59450	29.9306850	-91.7446117				5.64
59500	29.9306033	-91.7444883	0.8	2.7	3.4	3.27
59550	29.9305133	-91.7443583				3.59
59600	29.9304333	-91.7442333		3.2	3.6	3.83
59650	29.9303500	-91.7441083		3.1	3.5	4.41
59700	29.9302700	-91.7439866				4.82
59750	29.9301883	-91.7438616	0.2	2.5	3.3	3.88
59800	29.9301083	-91.7437350				7.58
59850	29.9300217	-91.7436050				5.20
59900	29.9299367	-91.7434834				4.35
59950	29.9298500	-91.7433566		3.3	3.6	3.58
60100	29.9296000	-91.7429833				5.97
60150	29.9295183	-91.7428567				5.89
60200	29.9294383	-91.7427317				5.41
60250	29.9293600	-91.7426067		3.3	3.6	5.53
60300	29.9292817	-91.7424783	0.8	2.7	3.4	3.35
60350	29.9291850	-91.7423533				3.37
60400	29.9291017	-91.7422317	1.3	3.4	3.7	2.39
	AVG		0.0	3.0	3.5	4.6

LTRC Tests in Zone 15

Field Molded Samples

Zone 15 was near the end of an existing frontage road on the south end of the project. The contractor usually started work from the south toward the north. The Intelligent Compaction Workshop was held in this zone. Field mixed material was collected and molded into samples, which were tested in the laboratory 7 days later. The UCS results for the subgrade and base course are presented in Table 33. The UCS results of the subgrade samples are at or above 150 psi. The base course UCS results have more variability, but also have higher strengths near 300 psi at material molded from station 634+00.

Table 33
Zone 15 UCS 7-day break results of field mixed samples – cement treated subgrade

Mix Date, Location	Sample #	Dry Density (lbs/cu.ft.)	7 day UCS (psi)	Mold moisture %	Average Dry Density pcf	Average UCS (psi)	Average Actual moisture %
Zone 15 STA 628+00 3/1/2013	1	98.2	169	20.5	98.2	167.0	20.5
	2	98.5	152	20.5			
	3	97.8	180	20.5			
Zone 15 STA 630+00 3/1/2013	1	94.2	183	21.0	96.1	172.3	21.0
	2	98.6	172	21.0			
	3	95.4	162	21.0			
Zone 15 STA 632+00 3/1/2013	1	97.7	162	20.4	95.0	175.7	20.4
	2	92.1	173	20.4			
	3	95.1	192	20.4			

Table 34
Zone 15 UCS 7-day break results of field mixed samples – cement stabilized base course

Station	Sample #	7 day UCS (psi)
632+00	1	189.8
	2	198.5
633+00	1	146.0
	2	166.0
634+00	1	284.0
	2	257.0

Field Density and GeoGauge Tests

Field nuclear gauge and GeoGauge tests were conducted in addition to the district acceptance testing in Zone 15. The nuclear gauge results for the subgrade and base course are presented in Table 35 and Table 36, respectively. The results of GeoGauge tests for the subgrade and base course of Zone 15 are presented in Table 37 and Table 38, respectively.

Table 35
Zone 15 LTRC nuclear gauge, cement treated subgrade (6 day)

	3/7/2013, 12-inch depth, day 6		
	DD	WD	MC
Station No	pcf	pcf	%
635+00	99.6	117.7	18.2
634+00	99.8	117.3	17.5
633+00	101.2	119.2	17.8
632+00	104.2	121.3	16.3
631+00	98.2	117.5	19.7
630+00	107.7	124.7	15.8
629+00	106.1	122.1	15.1
628+00	104.5	122.6	17.3
627+00	103.2	120.5	16.8
626+00	105.9	120.6	13.9
625+00	104.6	119.0	13.8

Table 36
Zone 15 LTRC nuclear gauge, cement stabilized base course

	7/12/2013, 8-inch depth			7/19/2013, 8-inch depth		
	DD	WD	MC	DD	WD	MC
Station No.	pcf	pcf	%	pcf	pcf	%
635+00	107.3	124.7	16.2	109.1	126.0	15.5
634+00	107.5	125.0	16.3	105.6	123.6	17.0
633+00	100.9	117.4	16.4	100.7	117.8	17.0
632+00	105.4	122.5	16.2	98.9	116.6	17.9
631+00	101.5	118.6	16.8	97.3	115.3	18.5
630+00	99.1	119.2	20.3	99.4	115.4	16.1
629+00	101.9	119.6	17.4	100.6	119.0	18.3
628+00	102.8	119.8	16.5	104.0	121	16.3
627+00	104.7	121.8	16.3	105.6	122.6	16.1
626+00	103.8	120.7	16.3	106.3	122.6	15.3
625+00	105.7	122.8	16.2	107.1	122.6	14.5

Table 37
Zone 15 GeoGauge results, cement treated subgrade (mix day)

	3/1/2013	
Station No.	SI-S	SI-Y
635+00	8.8	76.3
634+00	4.6	39.9
633+00	11.4	99.2
632+00	8.2	70.8
631+00	19.6	169.6
630+00	20.2	175.6
629+00	16.8	145.9
628+00	21.8	188.9
627+00	13.2	114.4
626+00	- -	- -
625+00	- -	- -
624+00	- -	- -

SI-S = Stiffness in SI value MN/m (MegaNewton per meter).
SI-Y = Young's modulus in SI values MPa (MegaPascal)

Table 38
Zone 15 GeoGauge results, cement stabilized base course

	7/12/2013		7/19/2013	
Station No.	SI-S	SI-Y	SI-S	SI-Y
635+00	32.1	278.4	17.1	148.0
634+00	22.8	197.8	33.6	291.3
633+00	38.0	329.7	22.8	197.5
632+00	23.6	204.9	22.3	193.4
631+00	28.3	245.5	13.4	116.6
630+00	34.9	302.6	31.9	276.5
629+00	32.7	283.2	33.2	287.9
628+00	31.1	283.4	21.9	190.3
627+00	29.7	257.7	22.0	190.6
626+00	39.2	339.8	32.2	279.5
625+00	45.5	394.9	24.1	209.1
624+00	35.4	306.7	15.4	134.0

SI-S = Stiffness in SI value MN/m (Mega Newton per meter).
SI-Y = Young's modulus in SI values MPa (Mega Pascal)

Dynamic Cone Penetrometer

Zone 15 was marked from Station 624+00 to 635+00. DCPs were conducted on the cement treated subgrade on mix day just after compaction (03/01/2013) and the DCPI (mm/blow) values ranged from 7 mm/blow – 24 mm/blow, as shown in Figure 42. DCPs were conducted on the cement-treated subgrade after 7-days on 03/08/2013 and the DCPI (mm/blow) values ranged from 2 mm/blow – 5 mm/blow, as shown in Figure 43, indicating that the cement-treated subgrade was much stiffer than the cement treated subgrade on mix day. Station 627+00 showed refusal (10 blows with no movement) on the cement-treated subgrade after 7-days. Table 39 presents a summary of the average DCPI values. The layer was split to compare the top and bottom halves' average DCPI values. There was significant improvement (reduction in the mm/blow) after, and due to, the 7 day curing time.

DCPs were conducted on the cement stabilized base course on mix day just after compaction (07/12/2013) and DCPI (mm/blow) values ranged from 3 mm/blow – 7 mm/blow, as shown in Figure 44. DCPs were conducted on the soil cement base course after 7-days on 07/19/2013 and DCPI (mm/blow) values ranged from 1 mm/blow – 5 mm/blow, as shown in Figure 45, indicating that the soil cement base course was stiffer than the mix-day, compacted cement stabilized base course. Table 40 presents a summary of the average DCPI values. The layer was split to compare the top and bottom halves' average DCPI values. There was significant improvement (reduction in the mm/blow) after, and due to, the 7 day curing time.

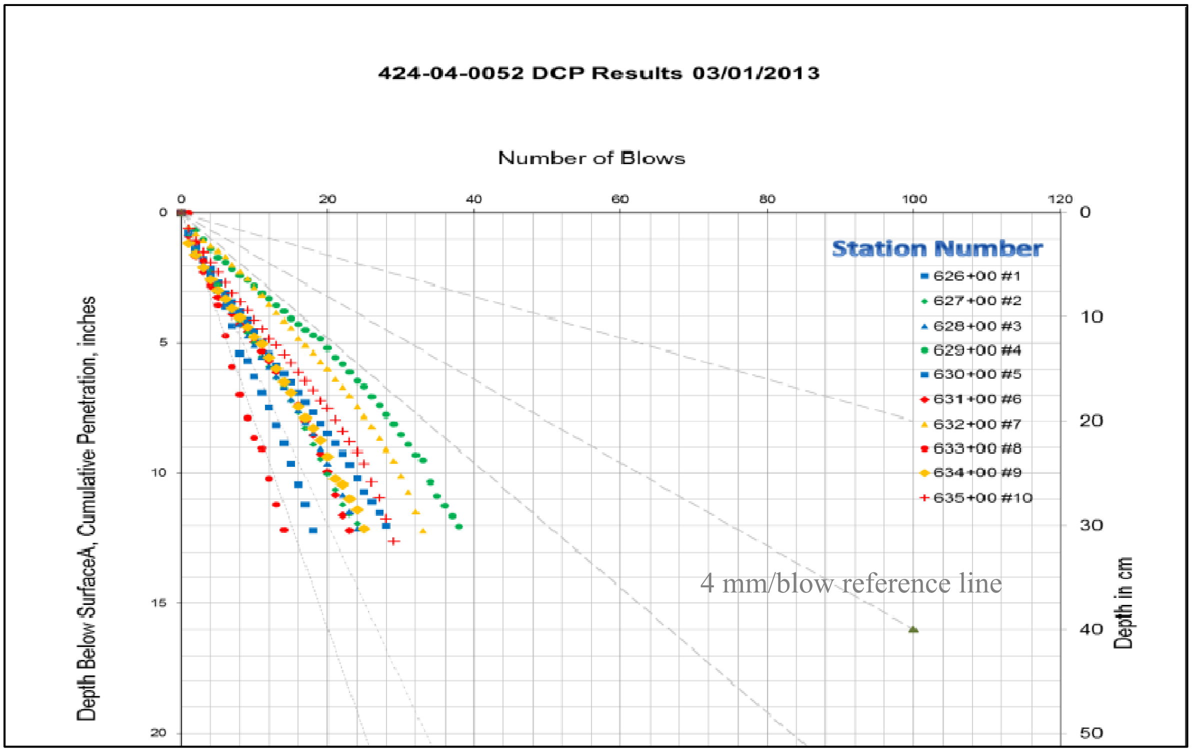


Figure 42
Zone 15 DCP curves, cement treated subgrade (mix day)

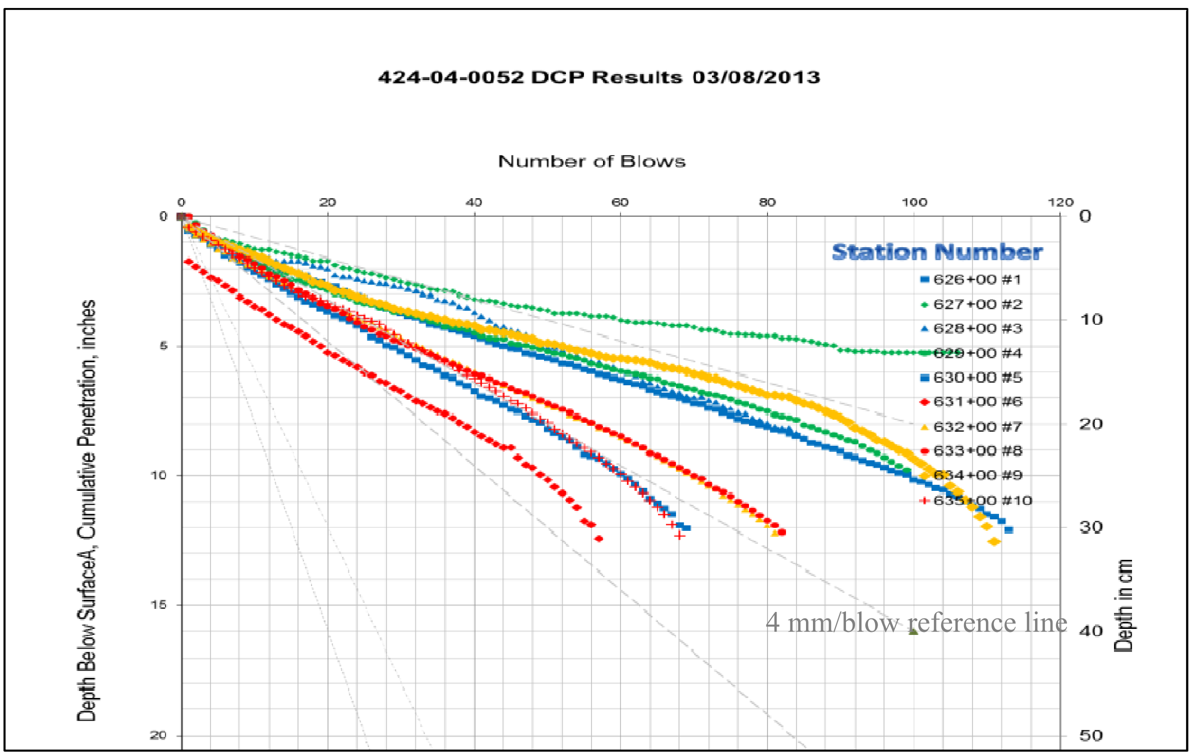


Figure 43
Zone 15 DCP curves, cement treated subgrade (7 day)

Table 39
Zone 15 DCPI results, cement treated subgrade

Station	Inches of 12 in. Layer	Average DCPI (mm/blow)	
		3/1/2013 mixed	3/8/2013 7 days
626+00	Top 6	10.8	2.5
	Bottom 6	10.4	2.7
627+00	Top 6	11.8	Refusal
	Bottom 6	12.3	-
628+00	Top 6	12.0	2.4
	Bottom 6	13.2	3.0
629+00	Top 6	6.6	2.5
	Bottom 6	9.9	3.1
630+00	Top 6	15.9	4.1
	Bottom 6	18.4	4.3
631+00	Top 6	11.1	4.5
	Bottom 6	15.1	4.8
632+00	Top 6	7.3	3.6
	Bottom 6	12.2	3.8
633+00	Top 6	24.2	3.9
	Bottom 6	22.7	3.6
634+00	Top 6	10.2	2.1
	Bottom 6	13.0	3.7
635+00	Top 6	9.4	3.8
	Bottom 6	12.5	5.2

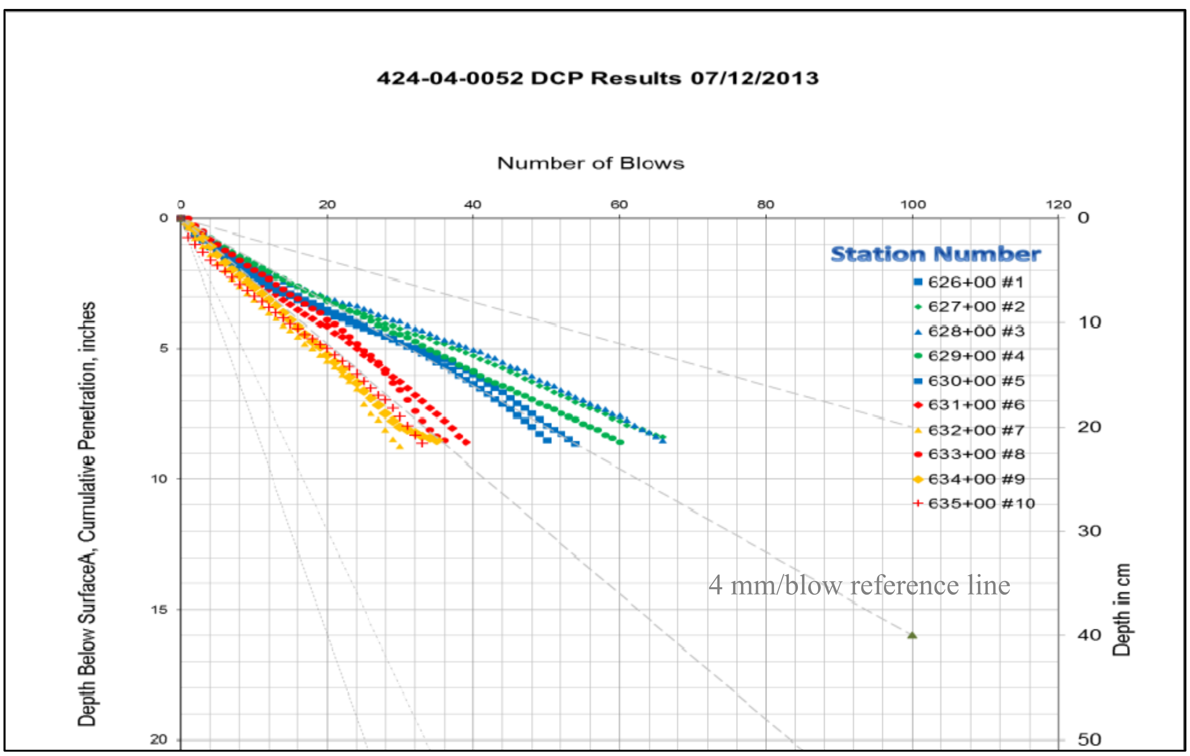


Figure 44
Zone 15 DCP curves, cement stabilized base course (mix day)

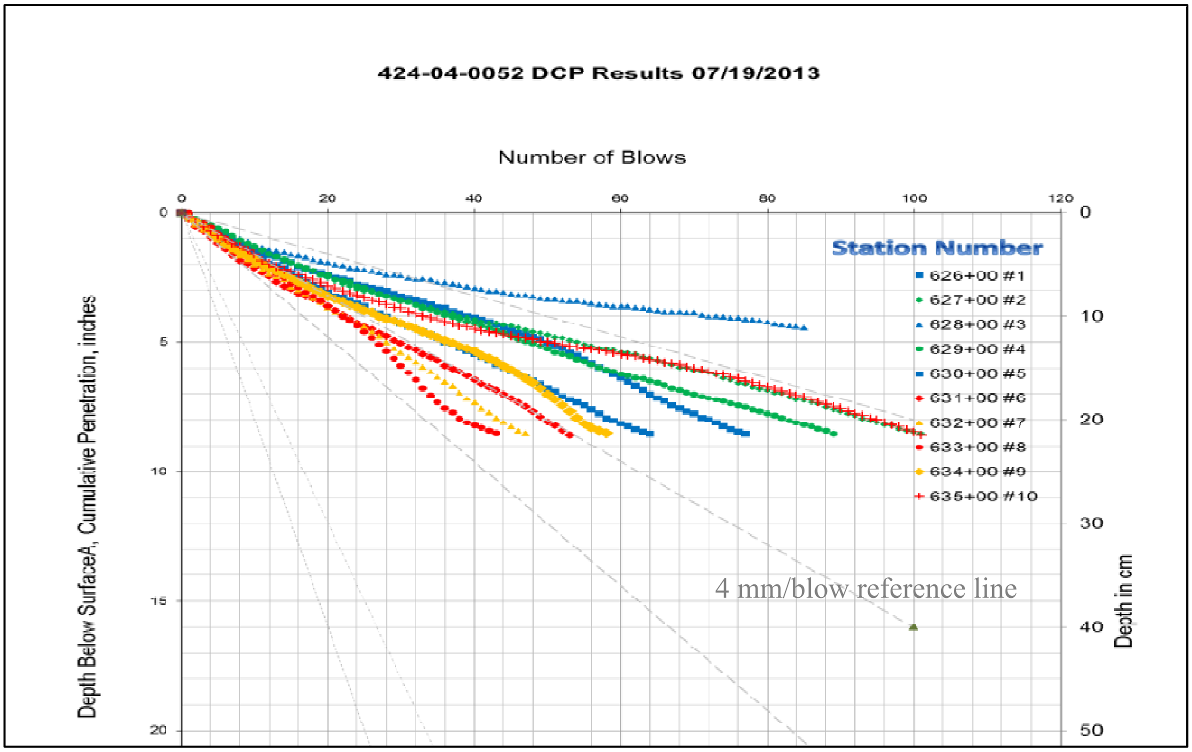


Figure 45
Zone 15 DCP curves, cement stabilized base course (7 day)

Table 40
Zone 15 DCPI results, cement stabilized base course

Station	Inches of 8.5 in. Layer	Average DCPI (mm/blow)	
		7/12/2013 mixed	7/19/2013 7 days
626+00	Top 4.0	4.2	2.6
	Bottom 4.5	3.8	3.1
627+00	Top 4.0	3.7	2.6
	Bottom 4.5	2.9	1.8
628+00	Top 4.0	3.2	1.3
	Bottom 4.5	3.2	1.3
629+00	Top 4.0	3.8	2.7
	Bottom 4.5	3.5	2.2
630+00	Top 4.0	4.1	3.6
	Bottom 4.5	4.4	3.2
631+00	Top 4.0	5.2	4.4
	Bottom 4.5	5.7	3.8
632+00	Top 4.0	7.3	4.5
	Bottom 4.5	7.4	4.6
633+00	Top 4.0	5.1	4.8
	Bottom 4.5	7.3	5.4
634+00	Top 4.0	6.6	3.7
	Bottom 4.5	5.9	3.7
635+00	Top 4.0	6.1	3.0
	Bottom 4.5	6.4	1.7

FWD and Dynaflect Results

Zone 15 FWD results on the subgrade are presented in Table 41 through Table 43. The Dynaflect results for the subgrade in Zone 15 are presented in Table 44 and Table 45 The FWD and Dynaflect testing could not occur on the initial mixing day, so tests were conducted shortly after on 03/05/13, then again on 03/07/13. The test results show minimal increase in moduli over the few days due to cement treated base to cure. Significant gains likely occurred during the first few days after mixing.

Table 41
Zone 15 FWD results, cement treated subgrade (5 day)

US 90 Frontage Rd. Zone 15 12" Treated Subgrade Test Date : 03/05/2013

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
62450	29.9238667	-91.7343033	22.9	14.6	6.3	8.56	16.8
62500	29.9239533	-91.7344267	129.2	9.8	4.4	4.89	21.4
62550	29.9240350	-91.7345517	142.8	10.9	4.9	4.40	21.8
62600	29.9241184	-91.7346816	107.6	12.2	5.4	5.01	22.0
62650	29.9242000	-91.7348050	70.1	17.1	7.3	5.20	21.5
62700	29.9242800	-91.7349283	21.7	20.9	8.8	10.67	22.1
62750	29.9243617	-91.7350533	43.5	12.9	5.7	7.71	22.2
62800	29.9244500	-91.7351817	81.8	16.0	6.9	4.80	21.4
62850	29.9245317	-91.7353050	68.9	18.2	7.7	5.00	20.7
62900	29.9246133	-91.7354333	42.6	19.4	8.2	6.63	21.4
62950	29.9246950	-91.7355583	42.3	18.2	7.8	7.06	21.9
63000	29.9247783	-91.7356850	75.1	13.1	5.7	5.27	22.0
63050	29.9248583	-91.7358100	85.5	13.9	6.1	4.91	21.2
63100	29.9249450	-91.7359367	182.3	11.7	5.2	3.42	20.8
63150	29.9250266	-91.7360617	50.7	12.0	5.3	7.24	21.7
63200	29.9251100	-91.7361883	70.7	12.0	5.3	6.00	21.4
63250	29.9251933	-91.7363117	101.4	9.3	4.3	5.12	20.4
63300	29.9252800	-91.7364400	103.9	11.2	5.0	5.13	21.8
63350	29.9253617	-91.7365650	125.9	14.7	6.4	4.26	21.7
63400	29.9254466	-91.7366900	207.4	9.4	4.3	3.65	21.0
63450	29.9255300	-91.7368134	105.3	9.9	4.5	5.26	21.7
63500	29.9256150	-91.7369383	254.1	8.7	4.1	3.61	22.1
63550	29.9256967	-91.7370650	172.9	14.4	6.2	3.45	22.0
	AVG		**100.4**	**13.5**	**5.9**	**5.5**	**21.3**

Table 42
Zone 15 FWD results, cement treated subgrade (7 day)

US 90 Frontage Rd. Zone 15 12" Treated Subgrade Test Date : 03/07/2013

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
62450	29.9257083	-91.7370617	90.9	10.6	4.8	5.37	20.9
62500	29.9256267	-91.7369400	50.1	13.2	5.8	7.23	22.4
62550	29.9255417	-91.7368134	127.0	10.2	4.6	4.66	21.7
62600	29.9254600	-91.7366900	67.3	13.7	6.0	6.16	22.5
62650	29.9253750	-91.7365616	248.7	11.8	5.2	3.27	22.3
62700	29.9252917	-91.7364383	38.9	19.1	8.1	7.48	22.8
62750	29.9252083	-91.7363117	24.6	18.2	7.7	10.42	22.8
62800	29.9251250	-91.7361883	116.0	14.2	6.2	4.24	21.7
62850	29.9250400	-91.7360600	256.0	11.7	5.2	2.76	19.6
62900	29.9249584	-91.7359367	97.5	14.8	6.4	4.67	21.8
62950	29.9248783	-91.7358100	148.0	13.0	5.7	3.94	22.4
63000	29.9247983	-91.7356867	44.4	19.0	8.0	6.58	21.1
63050	29.9247133	-91.7355583	58.8	16.6	7.1	5.95	22.5
63100	29.9246317	-91.7354350	47.5	17.9	7.6	6.68	22.3
63150	29.9245483	-91.7353083	68.4	10.3	4.7	6.30	21.4
63200	29.9244666	-91.7351833	76.3	10.4	4.7	6.37	22.3
63250	29.9243834	-91.7350550	166.3	9.1	4.2	4.44	22.2
63300	29.9242984	-91.7349300	114.9	12.4	5.5	4.70	22.0
63350	29.9242100	-91.7348067	46.1	12.9	5.7	6.55	21.2
63400	29.9241283	-91.7346834	136.5	10.9	4.9	4.46	21.8
63450	29.9240383	-91.7345584	101.7	10.0	4.5	5.31	21.8
63500	29.9239517	-91.7344400	131.0	13.9	6.0	4.11	22.2
63550	29.9238683	-91.7343133	332.5	11.9	5.3	2.67	21.6
	AVG		**112.6**	**13.3**	**5.8**	**5.4**	**21.9**

Table 43
Zone 15 FWD results, cement treated subgrade (14 day)

US 90 Frontage Rd. Zone 15 12" Treated Subgrade	Test Date : 03/14/2013						
Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress (psi)
62450	29.9256917	-91.7370717	50.7	6.3	3.1	4.87	11.8
62500	29.9256100	-91.7369483	83.3	13.6	5.9	5.27	22.3
62550	29.9255267	-91.7368217	204.9	9.2	4.2	4.02	21.9
62600	29.9254450	-91.7366983	158.3	11.8	5.2	4.16	22.6
62650	29.9253633	-91.7365667	197.1	12.2	5.4	3.74	22.5
62700	29.9252783	-91.7364433	109.3	15.7	6.8	4.56	23.0
62750	29.9251950	-91.7363167	149.4	12.6	5.6	3.98	22.1
62800	29.9251134	-91.7361933	173.2	13.5	5.9	3.47	21.7
62850	29.9250284	-91.7360650	58.1	21.3	9.0	5.50	22.3
62900	29.9249467	-91.7359417	59.1	17.3	7.4	5.70	22.0
62950	29.9248633	-91.7358133	82.4	14.3	6.2	5.16	21.7
63000	29.9247817	-91.7356883	124.4	12.9	5.7	4.26	22.2
63050	29.9246967	-91.7355617	132.8	15.0	6.5	3.89	22.0
63100	29.9246167	-91.7354350	65.2	18.4	7.8	5.43	21.8
63150	29.9245333	-91.7353083	89.4	11.9	5.3	5.31	22.2
63200	29.9244534	-91.7351850	48.7	15.4	6.7	6.72	21.8
63250	29.9243667	-91.7350567	191.9	16.1	6.9	2.92	21.8
63300	29.9242833	-91.7349317	52.1	10.1	4.6	7.04	21.7
63350	29.9242000	-91.7348067	86.8	16.0	6.9	4.27	21.4
63400	29.9241184	-91.7346834	238.8	9.6	4.4	3.41	21.7
63450	29.9240283	-91.7345584	75.0	7.7	3.6	6.58	21.7
	AVG		**115.8**	**13.4**	**5.9**	**4.8**	**21.5**

Table 44
Zone 15 Dynaflect results, cement treated subgrade (5 day)

US 90 Frontage Rd. Zone 15 12" Treated Subgrade Test Date : 03/05/2013

Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
62450	29.9238667	-91.7343033	1.2	3.3	3.6	2.49
62500	29.9239533	-91.7344267	1.9	3.1	3.5	2.13
62550	29.9240350	-91.7345517	1.7	2.8	3.4	2.39
62600	29.9241184	-91.7346816	1.6	3.1	3.5	2.27
62650	29.9242000	-91.7348050	2.1	3.3	3.6	1.92
62700	29.9242800	-91.7349283	1.8	3.4	3.7	2.08
62750	29.9243617	-91.7350533	1.8	3.2	3.6	2.28
62800	29.9244500	-91.7351817	1.9	3.9	3.9	1.98
62850	29.9245317	-91.7353050	2.2	3.3	3.6	1.85
62900	29.9246133	-91.7354333	2.1	3.3	3.6	1.94
62950	29.9246950	-91.7355583	2.0	3.4	3.7	1.90
63000	29.9247783	-91.7356850	1.6	3.5	3.7	2.18
63050	29.9248583	-91.7358100	1.9	3.9	3.9	1.98
63100	29.9249450	-91.7359367	1.9	3.9	3.9	1.98
63150	29.9250266	-91.7360617	1.1	2.8	3.4	2.74
63200	29.9251100	-91.7361883	1.5	1.7	3.0	2.51
63250	29.9251933	-91.7363117	1.7	2.7	3.4	2.32
63300	29.9252800	-91.7364400	1.9	2.8	3.4	2.24
63350	29.9253617	-91.7365650	1.2	3.8	3.8	2.19
63400	29.9254466	-91.7366900	1.5	3.2	3.6	2.31
63450	29.9255300	-91.7368134	1.4	3.3	3.6	2.33
63500	29.9256150	-91.7369383	1.7	3.3	3.6	2.17
63550	29.9256967	-91.7370650	1.9	3.5	3.7	1.94
	AVG		**1.7**	**3.2**	**3.6**	**2.2**

Table 45
Zone 15 Dynaflect results, cement treated subgrade (7 day)

US 90 Frontage Rd. Zone 15 12" Treated Subgrade Test Date : 03/07/2013						
Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
62450	29.9257083	-91.7370617	1.4	2.9	3.4	2.51
62500	29.9256267	-91.7369400	1.4	3.2	3.6	2.31
62550	29.9255417	-91.7368134	1.9	2.9	3.4	2.24
62600	29.9254600	-91.7366900	1.9	3.2	3.6	2.14
62650	29.9253750	-91.7365616	2.2	3.2	3.6	1.95
62700	29.9252917	-91.7364383	1.6	3.4	3.7	2.12
62750	29.9252083	-91.7363117	1.7	2.9	3.4	2.31
62800	29.9251250	-91.7361883	1.7	3.4	3.7	2.02
62850	29.9250400	-91.7360600	2.4	3.4	3.7	1.77
62900	29.9249584	-91.7359367	1.8	3.3	3.6	2.05
62950	29.9248783	-91.7358100	1.8	3.2	3.6	2.16
63000	29.9247983	-91.7356867	1.9	3.3	3.6	2.00
63050	29.9247133	-91.7355583	1.8	3.3	3.6	2.09
63100	29.9246317	-91.7354350	1.8	3.3	3.6	2.12
63150	29.9245483	-91.7353083	1.2	3.0	3.5	2.58
63200	29.9244666	-91.7351833	1.5	2.8	3.4	2.46
63250	29.9243834	-91.7350550	1.5	3.1	3.5	2.36
63300	29.9242984	-91.7349300	1.6	2.9	3.4	2.30
63350	29.9242100	-91.7348067	-0.4	4.4	4.1	3.13
63400	29.9241283	-91.7346834	1.4	3.1	3.5	2.49
63450	29.9240383	-91.7345584	1.0	3.3	3.6	2.72
63500	29.9239517	-91.7344400	0.9	3.8	3.8	2.36
63550	29.9238683	-91.7343133	1.8	3.5	3.7	1.91
	AVG		1.6	3.3	3.6	2.3

LTRC Tests in Zone 20

Field Molded Samples

Zone 20 was near the north end of the project, at the end of the straightaway section, and at the transition to and overlay only portion near the intersection of Darnall Road (Zones 16 to 19). The DOTD inspector's and contractor's trailers were located near Zone 20. Not all tests could be conducted for this zone as mentioned earlier. The completed tests are discussed below.

Field mixed material from the cement stabilized base course was collected immediately after mixing and molded into samples, which were broken in the laboratory 7 days later. The UCS results for these cement stabilized base course samples are presented in Table 46. The base course UCS results for this zone were at or above 300 psi with two slight exceptions.

Table 46
Zone 20 UCS 7-day break results, cement stabilized base course

Station	Sample #	7 day UCS (psi)
837+00	1	288.7
	2	303.9
	3	292.0
838+00	1	429.8
	2	408.5
	3	402.0
839+00	1	428.8
	2	407.5
	3	402.2

Field Density and GeoGauge Tests

Field nuclear gauge and GeoGauge tests were conducted in addition to the district acceptance tests.in Zone 20. The nuclear gauge results for the cement stabilized base course are presented in Table 47, and match closely with the district acceptance testing. The GeoGauge results for the Zone 20 base course are presented in Table 48.

Table 47
Zone 20 LTRC nuclear gauge results, cement stabilized base course (mix day)

	6/13/2013, 8-inch depth		
Station No.	DD pcf	WD pcf	MC %
840+50	105.7	121.9	15.3
839+00	106.6	121.7	14.2
838+00	113.0	128.6	13.8
837+00	111.3	128.8	15.7
836+00	112.8	128.7	14.1
835+00	96.9	116.4	20.1

Table 48
Zone 20 GeoGauge results, cement stabilized base course (mix day)

Station No	SI-S	SI-Y
840+50	32.9	285.7
839+00	46.8	405.6
838+00	34.4	298.1
837+00	42.3	367.1
836+00	26.2	227.3
835+00	24.1	208.7

SI-S = Stiffness in SI value MN/m (Mega Newton per meter).
SI-Y = Young's modulus in SI values MPa (Mega Pascal)

Dynamic Cone Penetrometer

Zone 20 measured from Station 835+55 to 845+00. DCPs were conducted on the cement treated subgrade on mix day just after compaction (01/31/2013), and the DCPI (mm/blow) values ranged from 1 mm/blow – 3 mm/blow, as shown in Figure 46. Station 844+50 showed refusal (10 blows with no movement) on the untreated subgrade. This is unusual and may be due to some prior site pretreatment and increased activity (construction traffic) at the contractor's laydown yard and office, which was in Zone 20. Table 49 shows the average DCPI results for the cement treated subgrade. Seven day DCPI values were not available due to schedule conflicts.

DCPs were also conducted on the cement stabilized base course on mix day just after compaction (06/13/2013) and DCPI (mm/blow) values ranged from 5 mm/blow – 10 mm/blow, as shown in Figure 47. Secondary DCP tests were not performed in the Zone due to schedule conflicts. Table 50 shows the average DCPI values collected in Zone 20 on the cement stabilized base course.

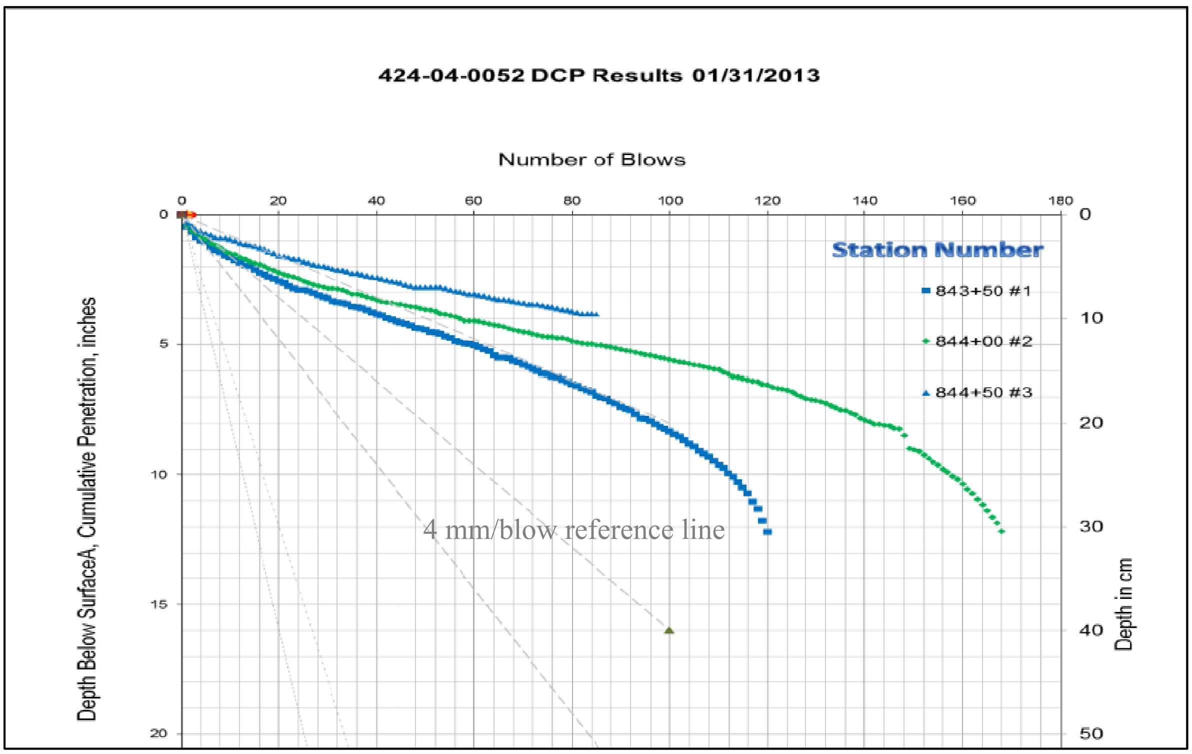


Figure 46
Zone 20 DCP curves, cement treated subgrade (mix day)

Table 49
Zone 20 DCPI results, cement treated subgrade

Station	Inches of 12 in. Layer	Average DCPI (mm/blow)	
		1/31/2013	
843+50	Top 6	2.0	- -
	Bottom 6	3.3	- -
844+00	Top 6	1.3	- -
	Bottom 6	2.7	- -
844+50	Top 6	Refusal	- -
	Bottom 6	-	- -

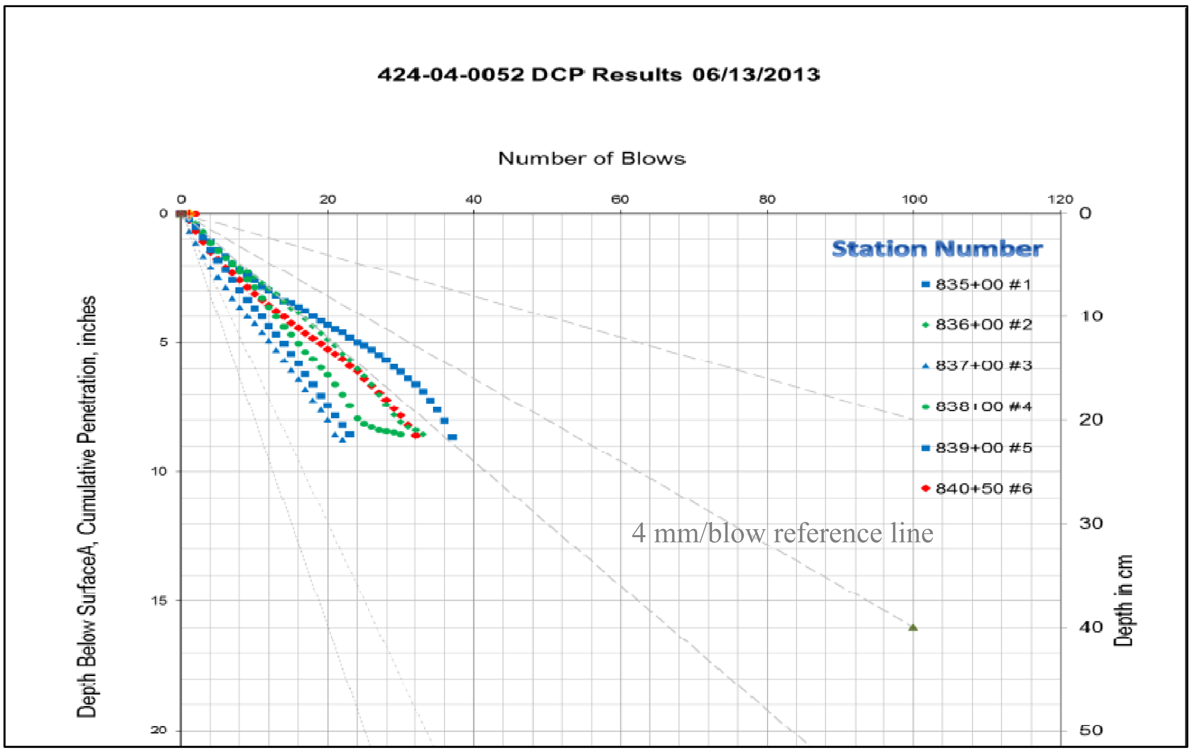


Figure 47
Zone 20 DCP curves, cement stabilized base course (mix day)

Table 50
Zone 20 DCPI results, cement stabilized base course

Station	Inches of 8.5 in. Layer	Average DCPI (mm/blow)	
		6/13/2013	
835+00	Top 4.0	5.5	- -
	Bottom 4.5	6.3	- -
836+00	Top 4.0	6.5	- -
	Bottom 4.5	7.0	- -
837+00	Top 4.0	10.4	- -
	Bottom 4.5	9.3	- -
838+00	Top 4.0	8.3	- -
	Bottom 4.5	7.1	- -
839+00	Top 4.0	9.8	- -
	Bottom 4.5	9.6	- -
840+50	Top 4.0	7.2	- -
	Bottom 4.5	6.4	- -

FWD and Dynaflect Results

Zone 20 FWD results on the cement treated subgrade are presented in Table 51 through Table 53. The Dynaflect results for the cement treated subgrade in Zone 20 are presented in Table 54 and Table 55. There are minimal improvements over results, and additional measurements were unavailable due to mechanical and technical breakdowns of the FWD and Dynaflect. New devices are being purchased in hopes to continue monitoring operations and further comparisons.

Table 51
Zone 20 FWD results, cement treated subgrade (limited area)

US 90 Frontage Rd. Zone 20 12" Treated Subgrade Test Date : 01/31/2013

Chainage	Latitude	Longitude	E1 (12" Treated Subgrade) ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
84350			44.2	10.2	4.6	8.30	21.6
84400			70.8	9.8	4.5	6.46	21.3
84450			113.3	9.2	4.2	4.63	21.0
	AVG		**76.1**	**9.8**	**4.4**	**6.46**	**21.3**

Table 52
Zone 20 FWD results, cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 20 12" Treated Subgrade	Test Date : 03/07/2013						
Chainage	Latitude	Longitude	E1 (12" Treated Subgrade)	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
83800	29.9374000	-91.7605333	154.7	9.7	4.4	4.44	22.5
83850	29.9373466	-91.7603900	94.1	7.6	3.6	6.30	22.1
83900	29.9372833	-91.7602483	101.7	11.3	5.1	5.06	21.8
83950	29.9372267	-91.7601067	148.4	7.9	3.7	4.90	21.5
84000	29.9371733	-91.7599650	3.1	1.7	1.3	64.42	16.3
84050	29.9371200	-91.7598183	7.4	4.8	2.5	31.13	19.9
84100	29.9370650	-91.7596767	6.2	3.8	2.1	36.40	19.6
84150	29.9370083	-91.7595333	3.6	2.3	1.6	56.02	17.7
84200	29.9369516	-91.7593783	3.9	5.1	2.6	37.94	15.6
84250	29.9368984	-91.7592350	7.4	4.7	2.5	31.48	20.4
84300	29.9368400	-91.7590867	10.5	4.6	2.4	24.99	20.6
84350	29.9367867	-91.7589417	124.1	7.0	3.4	5.39	21.8
84400	29.9367317	-91.7587933	142.3	9.1	4.2	4.39	21.5
84450	29.9366800	-91.7586500	90.3	8.3	3.9	5.92	21.8
84500	29.9366267	-91.7585084	29.2	16.4	7.0	8.91	22.1
	AVG		**61.8**	**7.0**	**3.4**	**21.8**	**20.3**

Table 53
Zone 20 FWD results cement treated subgrade (7 day)

US 90 Frontage Rd. Zone 20 12" Treated Subgrade	Test Date : 03/14/2013						
Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
83800	29.9373800	-91.7605317	113.2	7.4	3.5	5.78	21.9
83850	29.9373267	-91.7603883	52.5	9.4	4.3	7.76	21.2
83900	29.9372766	-91.7602434	140.7	8.2	3.8	4.82	22.0
83950	29.9372233	-91.7600900	98.2	11.1	5.0	5.31	21.6
84000	29.9371717	-91.7599467	136.3	9.9	4.5	4.81	22.2
84050	29.9371167	-91.7597967	107.6	9.6	4.4	5.61	22.2
84100	29.9370633	-91.7596533	120.4	6.9	3.3	5.54	21.4
84150	29.9370067	-91.7595050	129.9	9.1	4.2	4.79	21.7
84200	29.9369567	-91.7593600	62.0	8.0	3.7	7.81	21.8
84250	29.9369033	-91.7592150	93.8	8.3	3.9	5.68	21.9
84300	29.9368483	-91.7590717	82.5	9.5	4.3	5.73	20.8
84350	29.9367933	-91.7589266	25.9	8.9	4.1	7.13	13.2
84400	29.9367350	-91.7587866	103.7	8.8	4.1	5.68	22.3
	AVG		**97.5**	**8.9**	**4.1**	**5.9**	**21.1**

Table 54
Zone 20 Dynaflect results, cement treated subgrade (limited area)

US 90 Frontage Rd. Zone 20 12" Treated Subgrade			Test Date : 01/31/2013			
Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
84350			0.9	2.4	3.2	2.96
84400			1.2	2.7	3.4	2.68
84450			1.3	2.7	3.4	2.71
	AVG		1.1	2.6	3.3	2.8

Table 55
Zone 20 Dynaflect results, cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 20 12" Treated Subgrade			Test Date : 03/07/2013			
Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
83800	29.9374000	-91.7605333	1.1	2.6	3.3	2.92
83850	29.9373466	-91.7603900	1.1	2.5	3.3	3.18
83900	29.9372833	-91.7602483	1.5	2.6	3.3	2.51
83950	29.9372267	-91.7601067				2.83
84000	29.9371733	-91.7599650				10.25
84050	29.9371200	-91.7598183		4.6	4.1	5.84
84100	29.9370650	-91.7596767				7.32
84150	29.9370083	-91.7595333				9.82
84200	29.9369516	-91.7593783		2.8	3.4	5.90
84250	29.9368984	-91.7592350				5.38
84300	29.9368400	-91.7590867		2.7	3.4	5.41
84350	29.9367867	-91.7589417	1.1	2.6	3.3	2.95
84400	29.9367317	-91.7587933	1.1	2.7	3.4	2.88
84450	29.9366800	-91.7586500		2.8	3.4	3.11
84500	29.9366267	-91.7585084	1.9	2.9	3.4	2.26
	AVG			2.9	3.4	4.8

Resilient Modulus Test Results

Figure 48 shows the resilient modulus data of the cement stabilized base course at Station 839+00 (Zone 20) cured for 7-day and 28-day periods. As expected, higher confining pressures (CP) stresses resulted in higher resilient modulus values. Also, the resilient modulus values increased with curing time and the material behaved as a stress-hardening material (i.e., an increase in deviator stress caused an increase in resilient modulus).

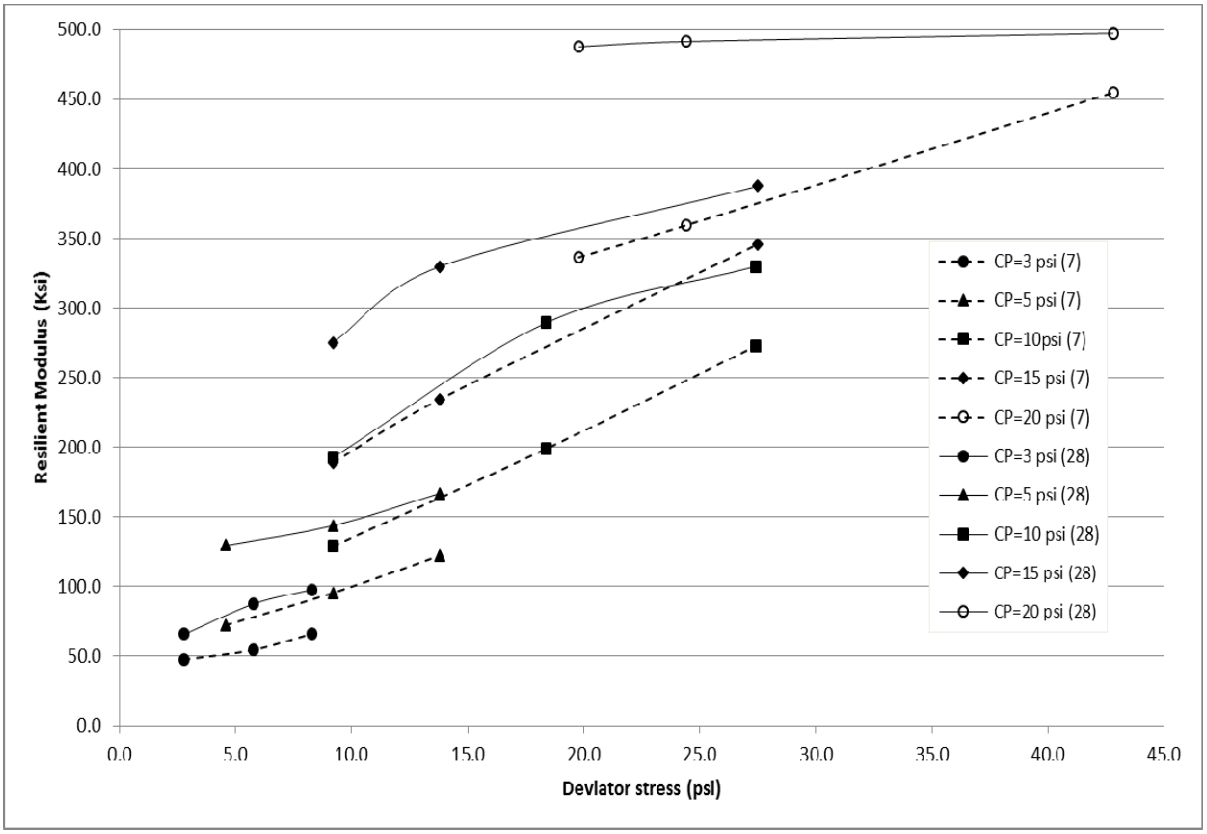


Figure 48
Zone 20 7-day and 28-day curing modulus data

LTRC Tests in Zone 29

Field Molded Samples

Zone 29 was located at the south end of the southbound lane of US 90, and was adjacent to previously constructed frontage roads as part of the LA 85 overpass and interchange. This section was the starting point for most of the contractor's operations (subgrade treatment, base course, and HMA work), which continued north toward the contractor trailer in Zone 20.

Field mixed material was collected during the construction operation and molded into samples, which were broken in the laboratory 7 days later. The UCS results for the subgrade and base course are presented in Table 56. The subgrade results were around 250 psi, and the base course results were unexpectedly lower, however district operations and testing confirmed acceptance.

Table 56
Zone 29 UCS 7-day break results, cement treated subgrade

Station	Sample #	7 day UCS (psi)
11/9/2013 935+00	1	262.5
	2	243.3
	3	286.9

Table 57
Zone 29 UCS 7-day results, cement stabilized base course

Station 5/28/13	Sample #	7 day UCS (psi)
931+25	1	114.5
	2	95.5
	3	104.5
932+00	1	76.0
	2	114.3
	3	106.5
933+00	1	145.3
	2	160.2
	3	139.7

Field Density and GeoGauge Tests

Field nuclear gauge and GeoGauge tests were conducted in addition to the district acceptance testing.in Zone 29. The nuclear gauge results for the cement treated subgrade and cement stabilized base course are presented in Table 58 and Table 59, respectively. The GeoGauge results for the Zone 29 cement treated subgrade and cement stabilized base course are presented in Table 60 and Table 61, respectively. There are some gaps in the tables due to contractor activity in the zone and the limited on-site time.

Table 58
Zone 29 LTRC nuclear gauge results, cement treated subgrade

	11/9/2012, 12-inch depth			11/16/2012, 12-inch depth		
	DD	WD	MC	DD	WD	MC
Station No.	pcf	pcf	%	pcf	pcf	%
935+50	101.8	118.6	16.5	102.7	118.5	15.4
935+00	- -	- -	- -	100.2	118.3	18.1
934+00	104.7	120.8	15.4	97.6	113.6	16.4
933+00	101.1	117.8	16.5	100.2	114.7	14.5
932+00	106.7	122.9	15.2	96.7	116.8	20.8
931+00	105.1	122.4	16.5	98.3	118.0	20.0
930+00	104.3	121.8	16.8	103.9	124.4	19.7
929+00	101.1	118.6	17.3	97.9	116.8	19.3
928+00	107.0	123.9	15.8	100.6	121.1	20.4
927+00	109.0	125.1	14.8	103.2	122.7	18.9
926+00	104.6	121.3	16.0	- -	- -	- -

Table 59
Zone 29 LTRC nuclear gauge results, cement stabilized base course

	5/21/2013, 8-inch depth			5/31/2013, 8-inch depth		
	DD	WD	MC	DD	WD	MC
Station No.	pcf	pcf	%	pcf	pcf	%
935+50	92.0	112.6	22.4	- -	- -	- -
935+00	99.3	118.5	19.3	100.6	116.9	16.2
934+00	97.2	116.5	19.9	95.2	112.6	18.3
933+00	92.1	108.2	17.5	98.0	115.6	18.0
932+00	- -	- -	- -	99.7	116.3	16.7
931+00	- -	- -	- -	105.7	118.9	12.5
930+00	- -	- -	- -	103.5	116.6	12.7
929+00	- -	- -	- -	93.6	111.8	19.4
928+00	- -	- -	- -	100.5	118.5	17.9
927+00	- -	- -	- -	- -	- -	- -
926+00	- -	- -	- -	- -	- -	- -

Table 60
Zone 29 GeoGauge results, cement treated subgrade

	11/9/2012		11/16/2012	
Station No.	SI-S	SI-Y	SI-S	SI-Y
935+50	13.1	113.4	56.2	487.9
935+00	- -	- -	8.4	72.8
934+00	7.2	62.5	25.4	220.5
933+00	6.0	52.0	29.3	254.1
932+00	10.2	88.5	25.3	214.7
931+00	9.2	80.0	58.0	503.1
930+00	7.3	63.4	5.2	53.3
929+00	10.4	89.9	18.2	166.3
928+00	8.8	76.2	11.7	101.8
927+00	9.3	80.8	20.8	180.6
926+00	10.1	87.8	- -	- -

SI-S - Stiffness in SI value MN/m (MegaNewton per meter).
SI-Y - Young's modulus in SI values Mpa (MegaPascals).

Table 61
Zone 29 GeoGauge results, cement stabilized base course

	5/21/2013	
Station No.	SI-S	SI-Y
935+50	19.1	165.4
935+00	21.2	184.2
934+00	12.3	106.1
933+00	26.5	230.3
932+00	- -	- -
931+00	- -	- -
930+00	- -	- -
929+00	- -	- -
928+00	- -	- -
927+00	- -	- -
926+00	- -	- -

SI-S - Stiffness in SI value MN/m (MegaNewton per meter).
SI-Y - Young's modulus in SI values Mpa (MegaPascals).

Dynamic Cone Penetrometer

Zone 29 included construction from Station 925+00 to 936+00. DCPs were conducted on the cement treated subgrade on mix day, just after compaction (11/09/2012), and DCPI (mm/blow) values ranged from 11 mm/blow – 27 mm/blow, as shown in Figure 49. DCPs were conducted on the cement-treated subgrade after 7-days on 11/16/2012 and DCPI (mm/blow) values ranged from 2 mm/blow – 9 mm/blow, as shown in Figure 50, indicating that the cement-treated subgrade was much stiffer than the cement treated subgrade on mix day.

DCPs were conducted on the untreated base course on 05/21/2013 and DCPI (mm/blow) values ranged from 6 mm/blow – 12 mm/blow, as shown in Figure 51. DCPs were conducted on the soil cement base course after 7-days on 05/28/2013 and DCPI (mm/blow) values ranged from 1 mm/blow – 5 mm/blow, as shown in Figure 52, indicating that the soil cement base course was much stiffer than the untreated base course.

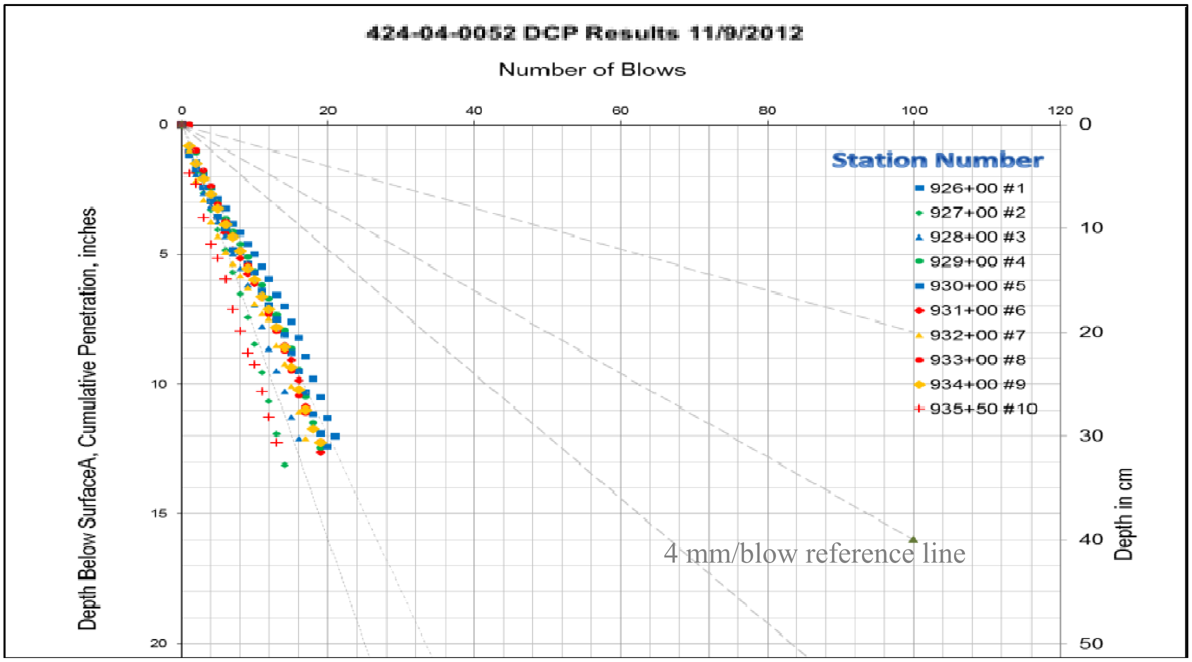


Figure 49
Zone 29 DCP curves, cement treated subgrade (mix day)

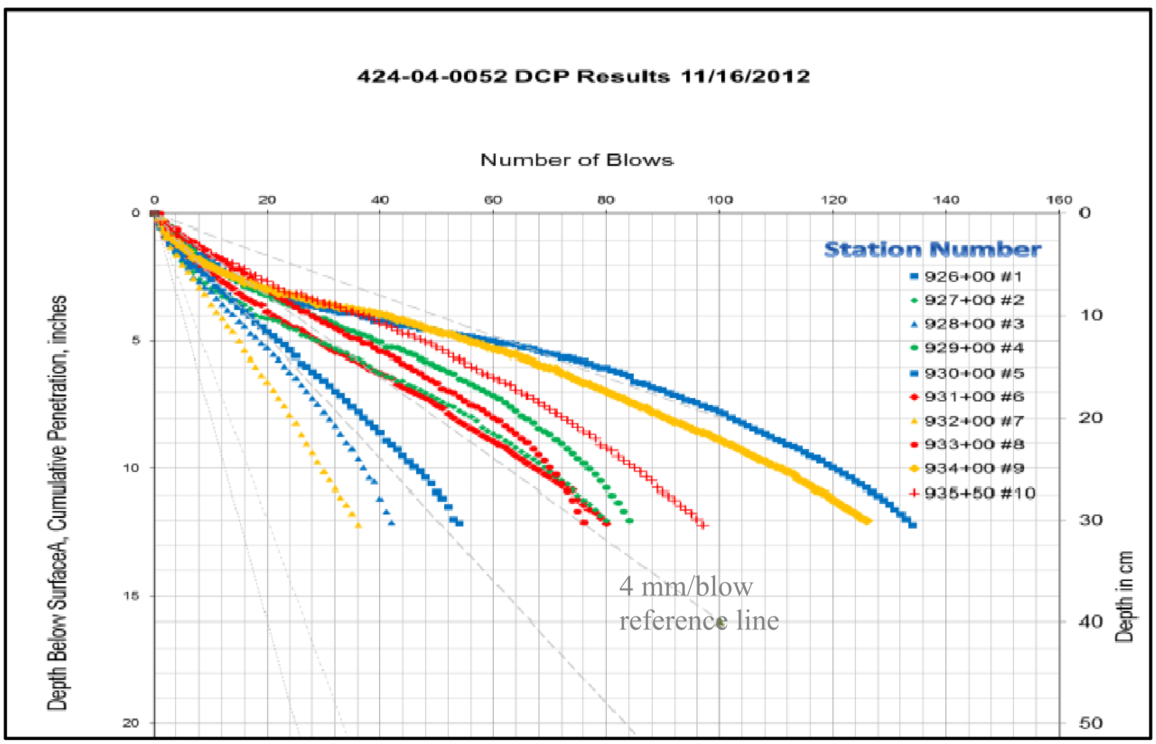


Figure 50
Zone 29 DCP curves, cement treated subgrade (7 day)

Table 62
Zone 29 DCPI results, cement treated subgrade

Station	Inches of 12 in. Layer	Average DCPI (mm/blow)	
		11/9/2012 mixed	11/16/2012 7 days
926+00	Top 6	11.3	1.8
	Bottom 6	17.1	2.9
927+00	Top 6	19.0	3.8
	Bottom 6	27.0	3.7
928+00	Top 6	15.7	6.3
	Bottom 6	20.9	8.2
929+00	Top 6	14.5	3.0
	Bottom 6	19.2	4.5
930+00	Top 6	12.9	5.5
	Bottom 6	17.0	5.8
931+00	Top 6	14.3	3.8
	Bottom 6	18.3	3.7
932+00	Top 6	17.6	8.2
	Bottom 6	17.7	8.7
933+00	Top 6	16.0	3.3
	Bottom 6	17.4	5.0
934+00	Top 6	14.6	2.1
	Bottom 6	17.7	2.7
935+50	Top 6	20.6	2.6
	Bottom 6	22.9	3.9

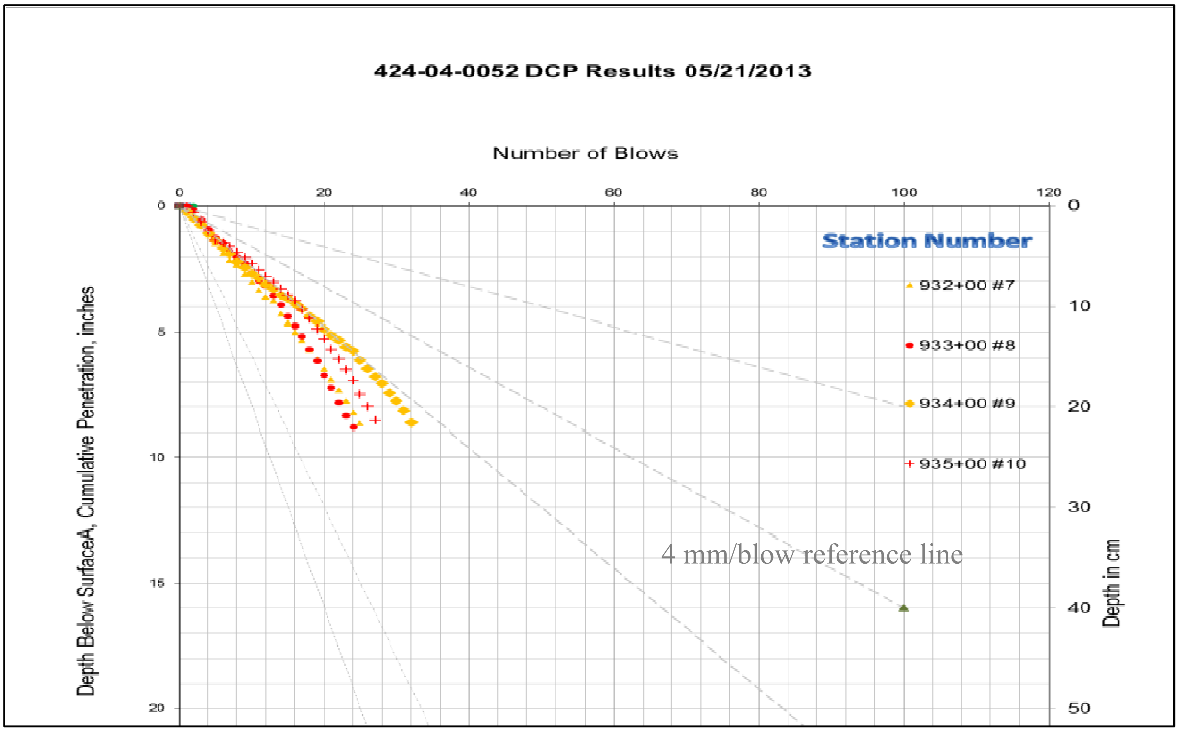


Figure 51
Zone 29 DCP curves, cement stabilized base course (mix day)

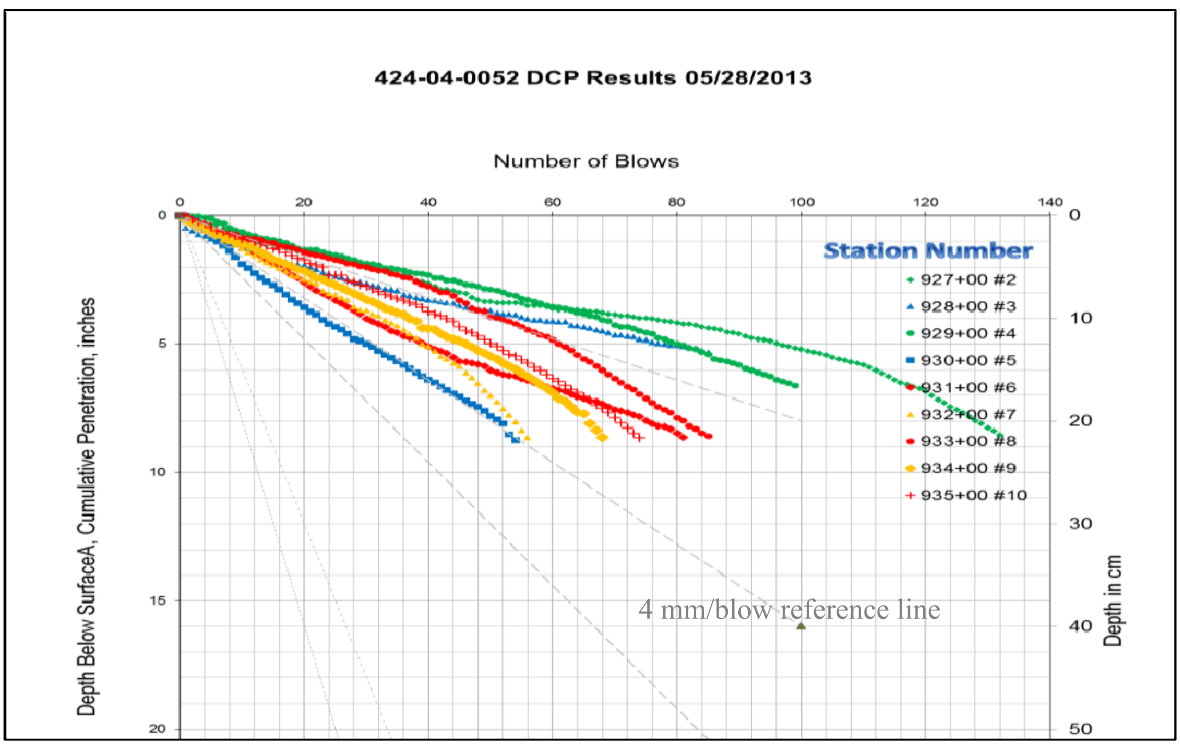


Figure 52
Zone 29 DCP curves, cement stabilized base course (7 day)

Table 63
Zone 29 DCPI results, cement stabilized base course

Station	Inches of 8.5 in. Layer	Average DCPI (mm/blow)	
		5/21/2013 mixed	5/28/2013 7 days
926+00	Top 4.0	-	-
	Bottom 4.5	-	-
927+00	Top 4.0	-	1.3
	Bottom 4.5	-	2.1
928+00	Top 4.0	-	1.6
	Bottom 4.5	-	1.9
929+00	Top 4.0	-	1.5
	Bottom 4.5	-	2.1
930+00	Top 4.0	-	4.6
	Bottom 4.5	-	3.9
931+00	Top 4.0	-	3.4
	Bottom 4.5	-	2.3
932+00	Top 4.0	7.7	3.1
	Bottom 4.5	10.3	5.0
933+00	Top 4.0	8.0	2.0
	Bottom 4.5	12.4	3.4
934+00	Top 4.0	6.2	2.7
	Bottom 4.5	7.5	3.8
935+00	Top 4.0	6.3	2.4
	Bottom 4.5	11.0	3.8

FWD and Dynaflect Results

Zone 29 FWD results on the cement treated subgrade are presented in Table 64 and Table 65 respectively. The Dynaflect results for the cement treated subgrade in Zone 29 are presented in Table 66 and Table 67, respectively. Additional measurements were unavailable due to mechanical and technical breakdowns of the FWD and Dynaflect.

Table 64
Zone 29 FWD results, cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 29 Raw Subgrade Test Date : 11/08/2012

	Chainage	Latitude	Longitude	E1 (12" Soil) ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stre ps
	93500	29.9233500	-91.7346950	3.2	4.4	2.3	54.13	18.
	93450	29.9234317	-91.7348216	5.4	7.3	3.5	34.32	20.
	93400	29.9235133	-91.7349450	8.1	8.4	3.9	25.57	20.
	93350	29.9235966	-91.7350717	6.9	7.3	3.5	28.37	19.
	93300	29.9236783	-91.7351950	5.2	3.1	1.9	41.17	18.
Zone 29	93250	29.9237617	-91.7353200	4.3	2.1	1.5	50.62	17.
	93200	29.9238483	-91.7354550	4.6	1.6	1.3	51.63	17.
	93150	29.9239317	-91.7355800	3.8	2.1	1.5	55.50	17.
	93100	29.9240133	-91.7357066	3.0	2.0	1.4	63.34	16.
	93050	29.9240967	-91.7358316	3.7	1.3	1.2	63.70	16.
	93000	29.9241783	-91.7359566	3.6	1.9	1.4	59.44	17.
	92950	29.9242617	-91.7360800	3.0	2.3	1.5	62.13	17.
	92900	29.9243517	-91.7362116	4.0	2.3	1.5	51.95	17.
	92850	29.9244333	-91.7363366	4.0	2.2	1.5	53.04	17.
	92800	29.9245183	-91.7364616	2.8	1.6	1.3	69.61	16.
	92750	29.9246017	-91.7365850	4.6	1.4	1.2	52.70	16.
	92700	29.9246817	-91.7367100	5.8	4.4	2.4	36.24	19.
	92650	29.9247650	-91.7368350	5.0	3.9	2.1	40.69	18.
	92600	29.9248500	-91.7369617	5.4	5.9	2.9	36.45	20.
	92550	29.9249333	-91.7370867	6.2	6.1	3.0	32.36	19.
	92500	29.9250150	-91.7372217	8.2	5.4	2.7	27.44	19.
Zone 28	92450	29.9251017	-91.7373433	4.7	6.5	3.2	37.43	18.
	92400	29.9251834	-91.7374650	6.5	7.2	3.4	31.00	20.
	92350	29.9252666	-91.7375917	6.5	7.4	3.5	29.80	19.
	92300	29.9253483	-91.7377167	6.4	4.0	2.2	32.86	18.
	92250	29.9254300	-91.7378417	6.9	5.3	2.7	29.93	19.
	92170	29.9255633	-91.7380433	5.5	5.6	2.8	36.14	19.
	92150	29.9256150	-91.7381166	3.3	5.3	2.7	50.02	18.
	92100	29.9256817	-91.7382150	3.4	6.6	3.2	48.22	19.
	92050	29.9257633	-91.7383416	5.6	5.4	2.8	34.94	19.
	92000	29.9258467	-91.7384666	4.3	5.3	2.7	41.16	18.
	91950	29.9259300	-91.7385900	3.1	4.9	2.6	35.48	12.
	91900	29.9260133	-91.7387133	6.1	5.2	2.7	33.36	19.
		AVG		**4.9**	**4.4**	**2.4**	**43.36**	**18.**

Table 65
Zone 29 FWD results, cement treated subgrade (7 day)

US 90 Frontage Rd. Zone 29 12" Treated Subgrade Test Date : 11/15/2012

	Chainage	Latitude	Longitude	E1 (12" Treated Subgrade), ksi	E2 (Subgrade) ksi	Corr Subgrade ksi	D1 (mils)	Stress psi
Zone 29	93500	29.9233633	-91.7347083	80.0	12.7	5.6	4.84	19.4
	93450	29.9234450	-91.7348317	208.2	12.0	5.3	3.00	19.6
	93400	29.9235350	-91.7349550	95.1	14.2	6.2	4.37	20.2
	93350	29.9236167	-91.7350766	113.6	11.2	5.0	4.43	20.5
	93300	29.9237116	-91.7352000	101.0	10.1	4.6	5.55	19.7
	93250	29.9237933	-91.7353250	152.0	8.5	3.9	4.21	19.4
	93200	29.9238717	-91.7354517	78.2	10.5	4.7	5.43	19.8
	93150	29.9239500	-91.7355783	25.3	5.3	2.7	13.13	19.6
	93100	29.9240283	-91.7357050	25.6	4.3	2.3	13.67	20.2
	93050	29.9241100	-91.7358316	25.3	4.2	2.3	13.75	19.1
	93000	29.9241967	-91.7359667	112.9	7.2	3.4	5.57	21.0
	92950	29.9242800	-91.7360917	114.8	8.4	3.9	5.14	20.7
	92900	29.9243617	-91.7362167	83.5	9.9	4.5	5.81	20.7
	92850	29.9244433	-91.7363384	123.8	8.9	4.1	4.56	20.4
	92800	29.9245267	-91.7364616	81.6	6.6	3.2	6.31	20.2
	92750	29.9246066	-91.7365867	61.0	5.4	2.7	8.13	19.6
	92700	29.9246983	-91.7367233	108.7	11.9	5.3	4.28	19.3
	92650	29.9247800	-91.7368483	140.5	9.9	4.5	4.16	19.6
	92600	29.9248617	-91.7369733	75.4	12.6	5.5	5.12	19.4
	92550	29.9249434	-91.7370967	207.4	10.6	4.8	3.25	19.1
	92500	29.9250284	-91.7372233	108.2	8.9	4.1	4.92	20.1
Zone 28	92450	29.9251100	-91.7373466	136.9	10.3	4.7	4.16	19.3
	92400	29.9251900	-91.7374716	77.9	11.2	5.0	5.45	20.0
	92350	29.9252717	-91.7375966	113.0	11.4	5.1	4.27	19.5
	92300	29.9253600	-91.7377300	115.3	8.5	3.9	4.86	20.4
	92250	29.9254417	-91.7378583	178.1	10.8	4.9	3.68	20.4
	92170	29.9255767	-91.7380567	122.0	8.5	3.9	5.08	20.7
	92150	29.9256100	-91.7381067	132.7	9.6	4.4	4.30	19.7
	92100	29.9256900	-91.7382266	163.4	7.9	3.7	4.59	19.9
	92050	29.9257716	-91.7383533	90.5	9.4	4.3	5.49	20.3
		AVG		**108.4**	**9.4**	**4.3**	**5.72**	**19.9**

Table 66
Zone 29 Dynaflect results, cement treated subgrade (mix day)

US 90 Frontage Rd. Zone 29 Compacted Soil **Test Date : 11/08/2012**

	Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
	93500	29.9233500	-91.7346950		3.3	3.6	6.27
	93450	29.9234317	-91.7348216		3.5	3.7	4.47
	93400	29.9235133	-91.7349450		3.0	3.5	4.38
	93350	29.9235966	-91.7350717		3.3	3.6	4.58
	93300	29.9236783	-91.7351950		2.5	3.3	8.84
	93250	29.9237617	-91.7353200				11.38
	93200	29.9238483	-91.7354550				14.23
	93150	29.9239317	-91.7355800				11.37
	93100	29.9240133	-91.7357066				11.37
Zone 29	93050	29.9240967	-91.7358316				17.45
	93000	29.9241783	-91.7359566				14.84
	92950	29.9242617	-91.7360800				10.17
	92900	29.9243517	-91.7362116				10.62
	92850	29.9244333	-91.7363366				12.49
	92800	29.9245183	-91.7364616				16.87
	92750	29.9246017	-91.7365850				18.23
	92700	29.9246817	-91.7367100		2.8	3.4	6.47
	92650	29.9247650	-91.7368350		2.8	3.4	6.47
	92600	29.9248500	-91.7369617		2.5	3.3	5.11
	92550	29.9249333	-91.7370867		2.9	3.4	5.02
	92500	29.9250150	-91.7372217				6.48
	92450	29.9251017	-91.7373433		2.8	3.4	5.37
	92400	29.9251834	-91.7374650		2.6	3.3	5.41
	92350	29.9252666	-91.7375917		2.7	3.4	5.48
Zone 28	92300	29.9253483	-91.7377167				7.14
	92250	29.9254300	-91.7378417				5.84
	92170	29.9255633	-91.7380433		2.9	3.4	5.81
	92150	29.9256150	-91.7381166		2.9	3.4	5.84
	92100	29.9256817	-91.7382150		2.9	3.4	5.24
	92050	29.9257633	-91.7383416		2.7	3.4	6.26
	92000	29.9258467	-91.7384666		2.7	3.4	6.16
	91950	29.9259300	-91.7385900		3.2	3.6	5.30
	91900	29.9260133	-91.7387133		2.8	3.4	5.76
		AVG			**2.9**	**3.4**	**8.4**

Table 67
Zone 29 Dynaflect results, cement treated subgrade (7 day)

US 90 Frontage Rd. Zone 29 12" Treated Subgrade — Test Date : 11/15/2012

	Chainage	Latitude	Longitude	SN	Es ksi	Es (Correllated) ksi	D1 (mils)
Zone 29	93500	29.9233633	-91.7347083	1.4	3.3	3.6	2.30
	93450	29.9234450	-91.7348317	2.0	3.4	3.7	1.95
	93400	29.9235350	-91.7349550	1.8	3.3	3.6	2.03
	93350	29.9236167	-91.7350766	1.3	3.4	3.7	2.35
	93300	29.9237116	-91.7352000	1.3	3.4	3.7	2.35
	93250	29.9237933	-91.7353250	1.2	2.7	3.4	2.70
	93200	29.9238717	-91.7354517	0.9	2.8	3.4	2.98
	93150	29.9239500	-91.7355783				5.32
	93100	29.9240283	-91.7357050		2.6	3.3	4.76
	93050	29.9241100	-91.7358316				6.26
	93000	29.9241967	-91.7359667	0.5	2.7	3.4	3.76
	92950	29.9242800	-91.7360917	1.4	2.8	3.4	3.14
	92900	29.9243617	-91.7362167	1.5	2.9	3.4	2.89
	92850	29.9244433	-91.7363384	1.1	2.7	3.4	2.80
	92800	29.9245267	-91.7364616	0.8	2.6	3.3	3.68
	92750	29.9246066	-91.7365867				4.64
	92700	29.9246983	-91.7367233	1.8	3.0	3.5	2.47
	92650	29.9247800	-91.7368483	1.6	2.9	3.4	2.48
	92600	29.9248617	-91.7369733	1.4	2.9	3.4	2.49
	92550	29.9249434	-91.7370967	1.9	3.0	3.5	2.14
	92500	29.9250284	-91.7372233	0.9	2.9	3.4	2.96
Zone 28	92450	29.9251100	-91.7373466	1.5	3.1	3.5	2.31
	92400	29.9251900	-91.7374716	1.2	3.0	3.5	2.63
	92350	29.9252717	-91.7375966	1.3	3.1	3.5	2.48
	92300	29.9253600	-91.7377300	0.7	2.8	3.4	3.23
	92250	29.9254417	-91.7378583	1.6	3.0	3.5	2.34
	92170	29.9255767	-91.7380567	1.1	2.8	3.4	2.71
	92150	29.9256100	-91.7381067	1.1	3.0	3.5	2.68
	92100	29.9256900	-91.7382266	1.4	3.0	3.5	2.44
	92050	29.9257716	-91.7383533	1.1	2.8	3.4	2.79
		AVG			3.0	3.5	3.0

Results of Plate Load Tests (PLTs)

Plate Load Tests

Plate load tests were conducted during the field events at locations in Zones 12, 15, 20, and 29. Of the four PLTs conducted, three were on top of the cement treated subgrade layer (Station 935+00, Station 935+50, and Station 632+00) and one on top of the cement stabilized base layer (Station 595+50). Pictures from the plate load tests are shown in Figure 53.

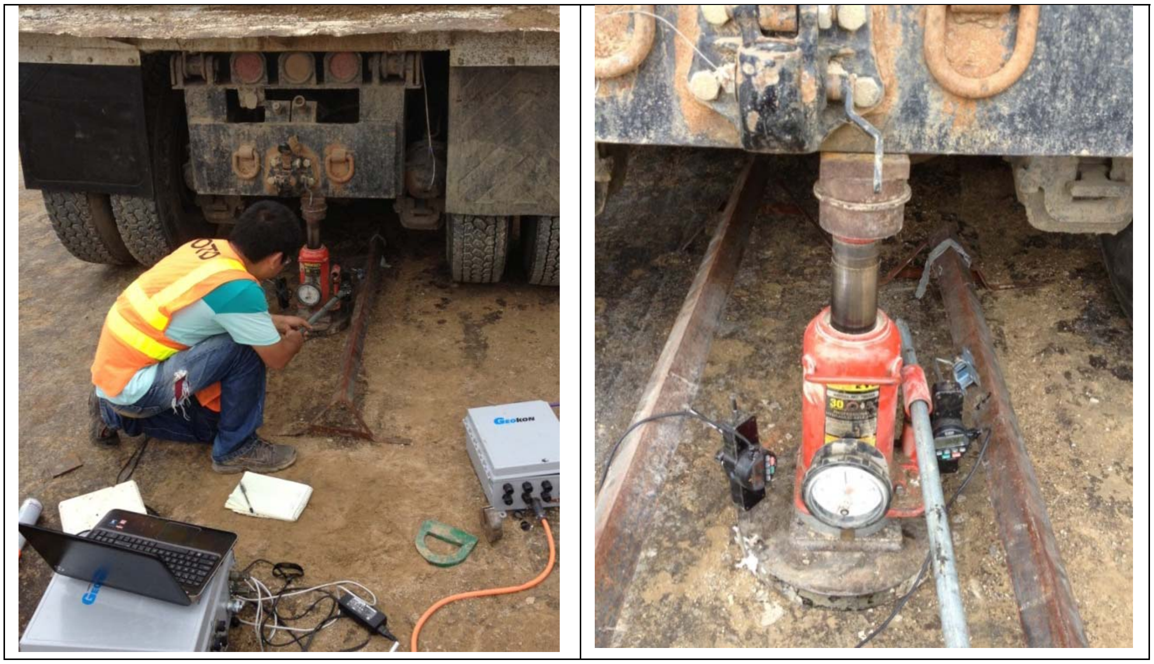


Figure 53
Plate load setup

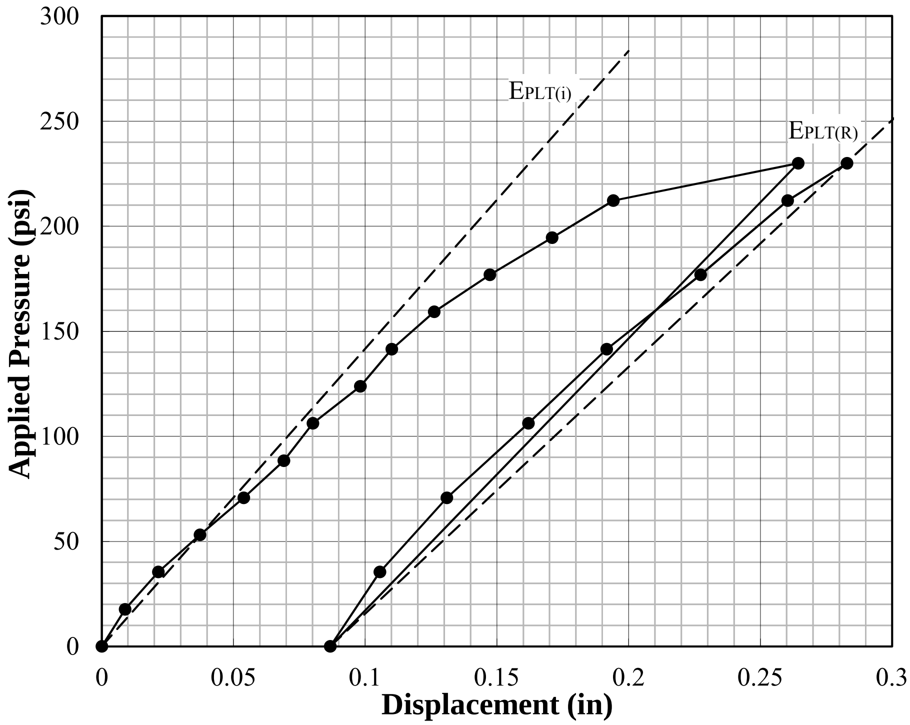
The stress-deformation curves obtained for the four PLTs are presented in Figure 54. Using equation (7), the $E_{PLT(i)}$ and $E_{PLT(R)}$ moduli were calculated for the four PLTs and the results are summarized in Table 68. The resilient modulus of treated subgrade soil layer were back-calculated from $E_{PLT(R)}$ using the following equation (Chen and Abu-Farsakh 2010) and presented in Table 69.

$$E_{PLT(R)} = \left[\frac{M_{r\_t\_s}{}^{1/3} h_{t\_s} i_{p\_t\_s} + M_{r\_s}{}^{1/3} h_s i_{p\_s}}{h_{t\_s} i_{p\_t\_s} + h_s i_{p\_s}} \right]^3 \tag{7}$$

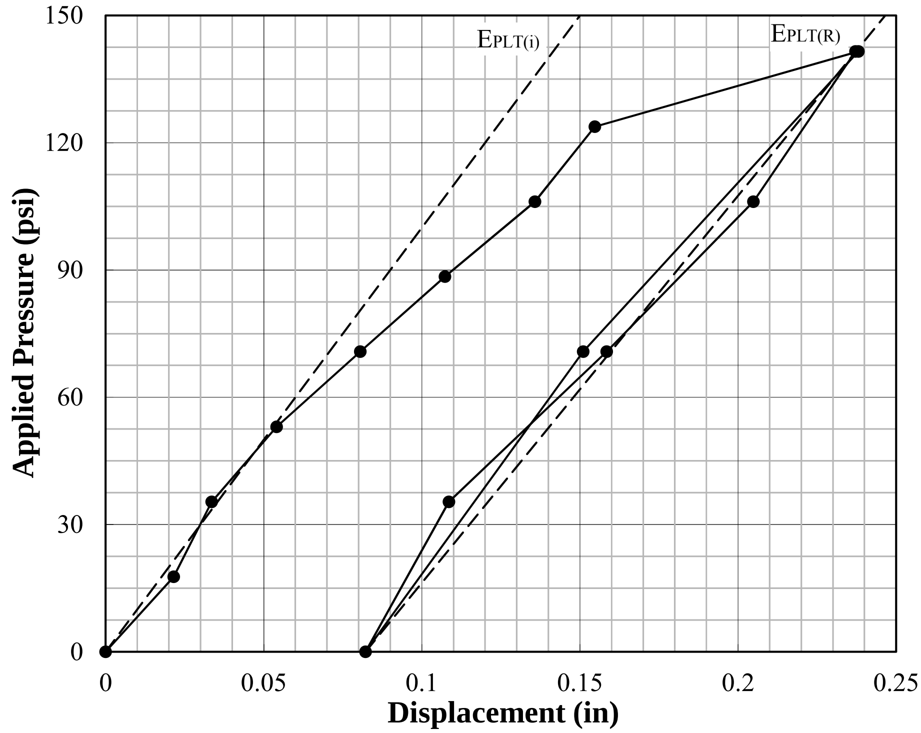
where, $M_{r\_t\_s}$ and M_{r_s} are the resilient modulus of cement treated subgrade and untreated subgrade soil, respectively; h_{t_s} and h_s are the thickness of cement treated subgrade and subgrade soil layer contributing to the $E_{PLT(R)}$, respectively; $i_{p\_t\_s}$ and i_{p_s} are the position factors of cement treated subgrade and untreated subgrade layer, respectively. An influence depth of 1.5*D* (*D*: diameter of the plate) is assumed here. The resilient modulus of the subgrade soil was estimated from DCP test using the following equation (Mohammad et al. 2008).

$$M_{r\_s} = \frac{151.8}{DCPI^{1.096}} \tag{8}$$

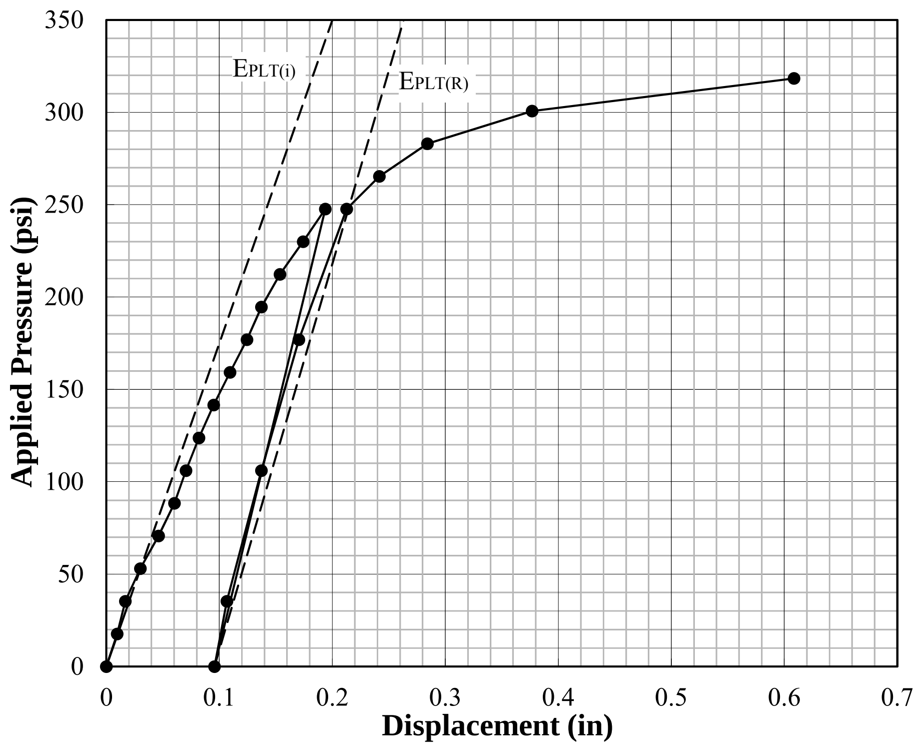
Figure 54 shows the stress registered by the pressure cell during the PLTs. The nonlinear relationship between the applied plate pressures and the registered stresses as the layer interface is expected because of the nonlinear behavior of the geomaterials.



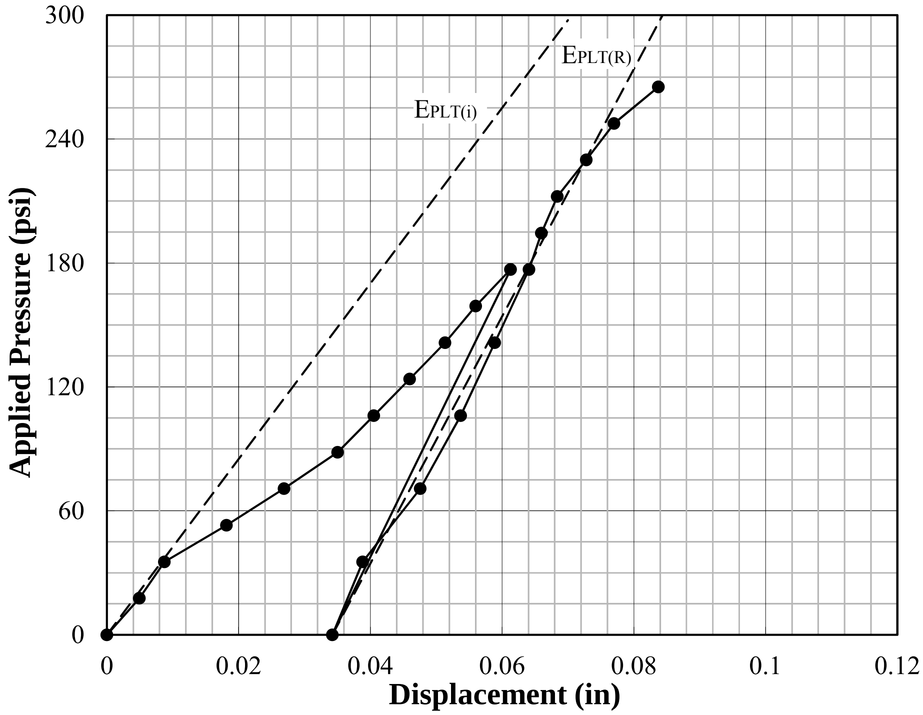
(a) Station 935+50



(b) Station 935+00



(c) Station 632+00



(d) Station 595+50

Figure 54
Stress-displacement curves for PLTs

Table 68
Summary of PLT results

Zone	Station	$E_{PLT(i)}$ (ksi)	$E_{PLT(R)}$ (ksi)	Comments
29	935+50	12.2	10.1	PLT performed on top of cement treated subgrade soil layer, 7 days after mixing and compaction
29	935+00	8.6	7.8	
15	632+00	15.0	17.9	
12	595+50	38.5	54.5	PLT performed on top of cement stabilized base layer, 14 days after mixing and compaction

Table 69
Back-calculated resilient modulus of treated subgrade soil layer

Zone	Station	$E_{PLT(R)}$ (ksi)	M_{r}_s (ksi)*	$M_{r\_t\_s}$ (ksi)
29	935+50	10.1	4.4	12.0
29	935+00	7.8	6.7	8.0
15	632+00	17.9	14.0	19.0

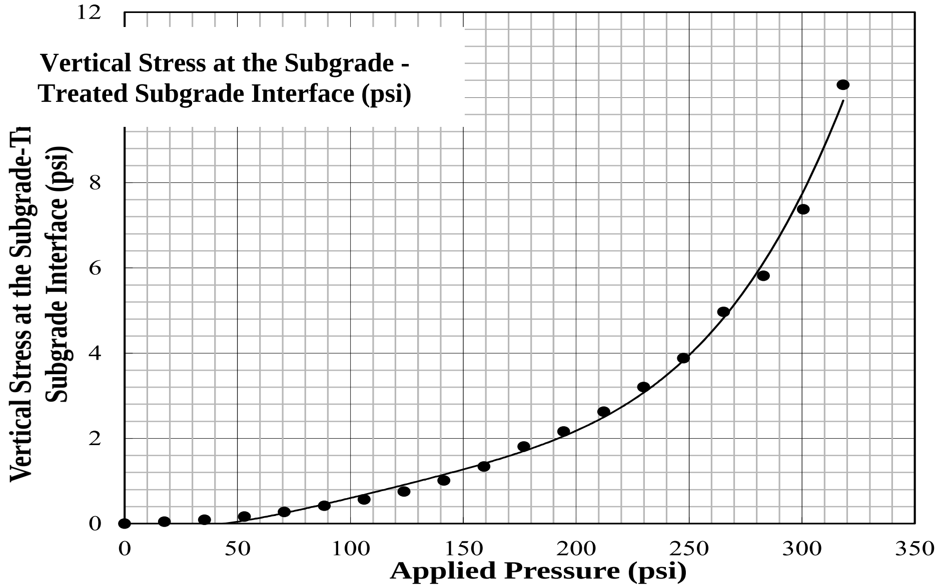
*Estimated from DCP

Pressure Cells

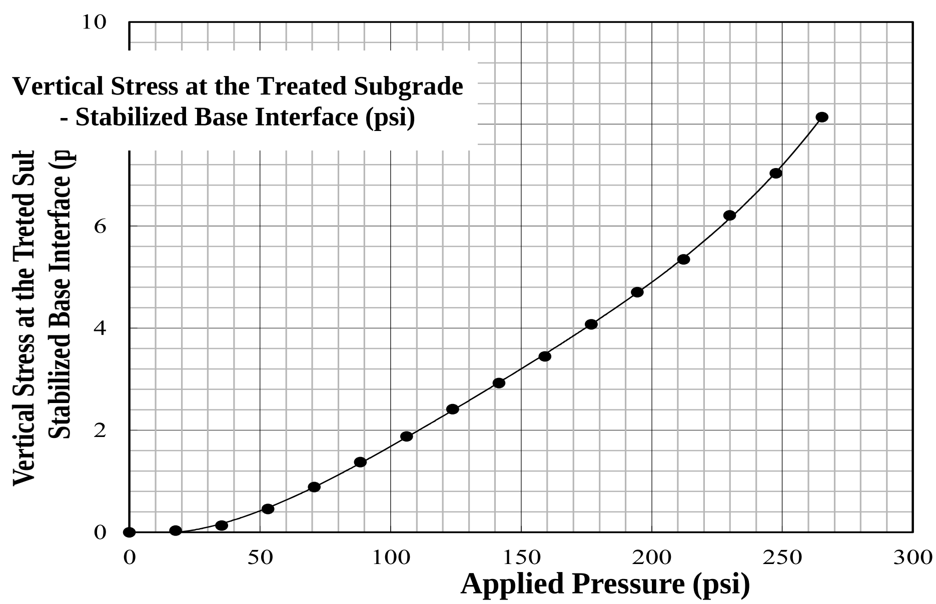
The plate load tests in Zones 12 and 15 were conducted above pressure cells installed at those same locations. The pressure plate at Zone 15 was installed below the cement treated subgrade, while the plate at Zone 12 was installed below the cement stabilized base course. The wires for the pressure plates were buried and extended to the side of the embankment, however some were damaged. The plate load transferred through the layer above, and received by the pressure cell was measured. Figure 55 shows the stress registered by the pressure cell during the PLTs. The nonlinear relationship between the applied plate pressures and the registered stresses as the layer interface is expected because of the nonlinear behavior of the geomaterials.

Once the plate load test was complete at Zone 15 (station 632+00) the MDP roller was brought to the plate load site. A series of roller movements were conducted over the buried pressure sensor to measure pressure effect on the buried pressure sensor. The movements compared the MDP influence depth to the influence depth of a vibratory roller. The MDP roller, as stated before, had vibration capability, but it was not utilized during measurement passes. Some of these passes utilized vibration to simulate a vibratory roller. The passes were collected via the data acquisition and the plot is annotated with the different type of roller movements.

The MDP roller passed atop the cement treated subgrade while the Zone 15 pressure cells measured the transferred loads at the bottom of that same layer (atop the untreated subgrade). Figure 56 shows the vertical stress registered by the pressure cells in Zone 15 as the MDP roller made passes on the top of that treated subgrade layer. As can be seen from the figure, negligible stresses were registered by the pressure cell when the roller compactor was moving without vibration. On the other hand, appreciable stresses were registered when the roller compactor was in vibration mode and these stresses increased with the amplitude of vibration. This observation may suggest that better compaction would be achieved with the roller compactor in vibration mode because of its deeper influence zone. It is also noticed that the pressure cells at Station 632+00 performed a little bit differently than at Station 632+50. The initial stress registered by the pressure cell at Station 632+00 was about 1.7 psi instead of zero (the stresses induced by the weight of soil are not included), as shown in Figure 55b. This is because, before this measurement process, the PLT was just conducted at Station 632+00 and the lock-in/residual stresses were developed. Interestingly, the vibration of roller compactor helped quickly release these lock-in stresses generated from PLT.

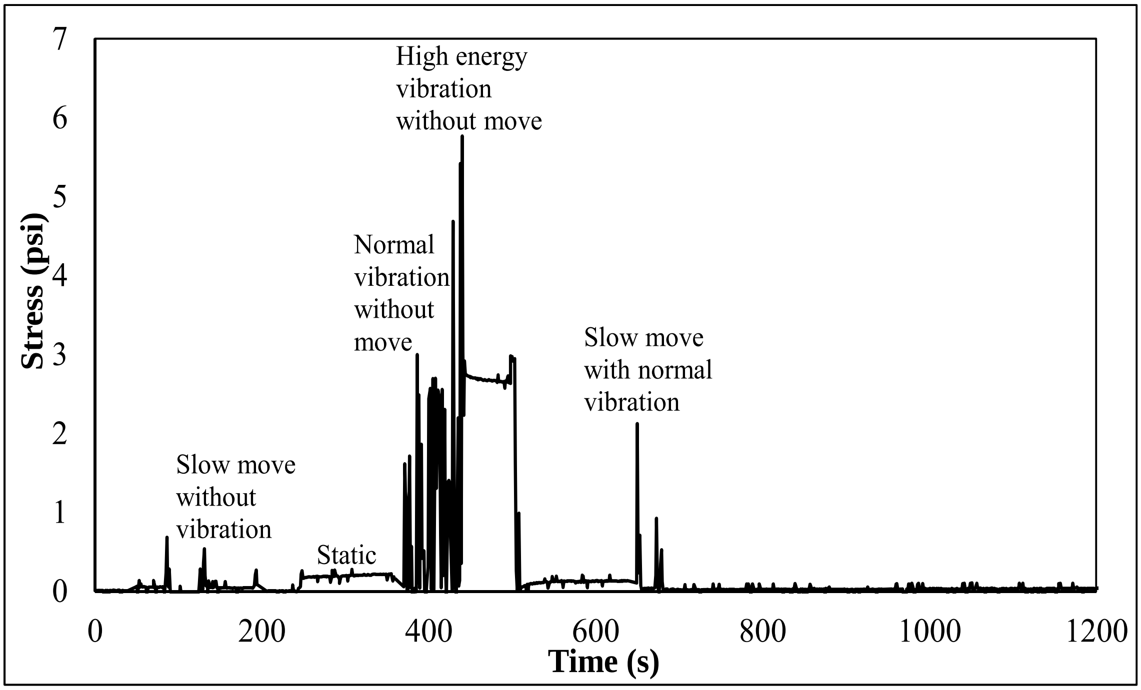


(a) Station 632+00 (Zone 15)

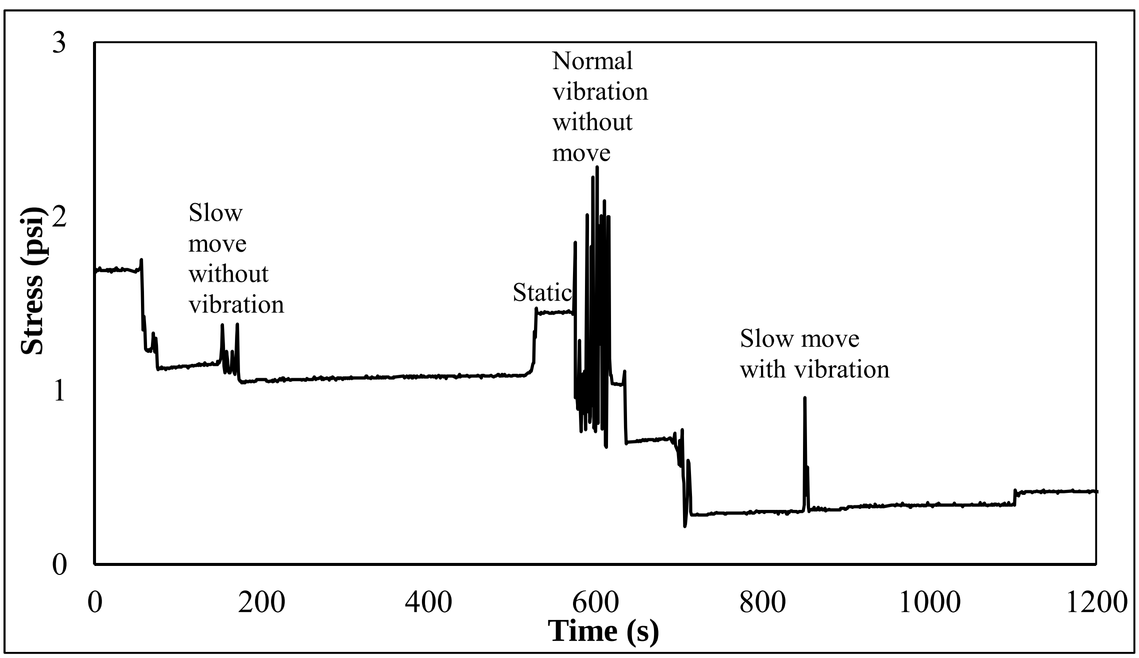


(b) Station 595+50 (Zone 12)

Figure 55
Variation of vertical stresses with the applied plate pressures during the PLT



(a) Station 632+50



(b) Station 632+00

Figure 56
Variation of vertical stresses at the subgrade-treated subgrade interface with roller compactor moving on the top of treated subgrade soil layer

Table 70 presents a summary of the tests conducted on the cement treated subgrade in comparison to the MDP values. The values represent average values for the test sections. The consistency in the MDP measurement can be seen in the readings with three averaging near the max of 150. The lower reading of 99.6 is matched by the highest mm/blow from the DCP, the lowest DCP M_r, and the highest deflection from the FWD. As stated earlier Zone 7 and Zone 12 were chosen because they had some weak areas, but some rework tests were unavailable due to schedule conflicts.

Table 70
Test summary – cement treated subgrade

Cement Treated Subgrade (mix day)												
Zone	DD	MDP	DCPI	DCP Mr	GeoGauge		FWD		Dynaflect	PLT (~7day), ksi		
	pcf		mm/blow	ksi	MN/m	Mpa	Mr, ksi	D1	D1	E_{PLT}(i)	E_{PLT}(R)	$M_{r\_t\_s}$
7	99.3	99.6	21.7	5.3	- -	- -	10.8	25.8	6.6	- -	- -	- -
12	97.8	- -	7.3	17.9	- -	- -	36.4	14.5	5.1	- -	- -	- -
15	96.1	148.0	13.0	9.2	13.8	120.1	- -	- -	- -	15.0	17.9	19.0
20	99.0	149.0	2.4	65.2	- -	- -	76.1	6.46	2.8	- -	- -	- -
29	96.4	148.8	17.6	6.6	9.2	79.4	4.8	18.3	9.8	10.4	9.0	10.0

Table 71 presents a summary of the tests conducted on the cement stabilized base course in comparison to the MDP values. The values represent average values for the test sections. The consistency in the MDP measurement can be seen in the readings with three averaging near the max of 150. The lower reading of 147.3, though still relatively high correlates with the higher mm/blow from the DCP, lower DCP M_r, and lower GeoGauge results.

Table 71
Test summary – cement stabilized base course

Cement Stabilized Base Course (mix day)									
Zone	DD	MDP	DCPI	DCP Mr	GeoGauge		PLT (~7day), ksi		
	pcf		mm/blow	ksi	MN/m	Mpa	E_{PLT}(i)	E_{PLT}(R)	$M_{r\_t\_s}$
7	96.7	- -	- -	- -	- -	- -	- -	- -	- -
12	97.6	148.9	3.4	39.7	28.9	246.5	38.5	54.5	- -
15	96.7	149.6	5.0	26.0	32.8	285.4	- -	- -	- -
20	97.3	- -	7.8	16.0	- -	- -	- -	- -	- -
29	97.8	147.3	8.7	14.7	19.8	171.5	- -	- -	- -

Subgrade and Base Course Project Challenges

Weather. Early in the project, during the subgrade and base course work, the site experienced heavy rainfall, which stymied the earthwork operations since the site was low-lying sugarcane farmland. Figure 57 shows a brief glimpse of this time period along with temperatures. Louisiana generally averages around sixty plus inches per year.

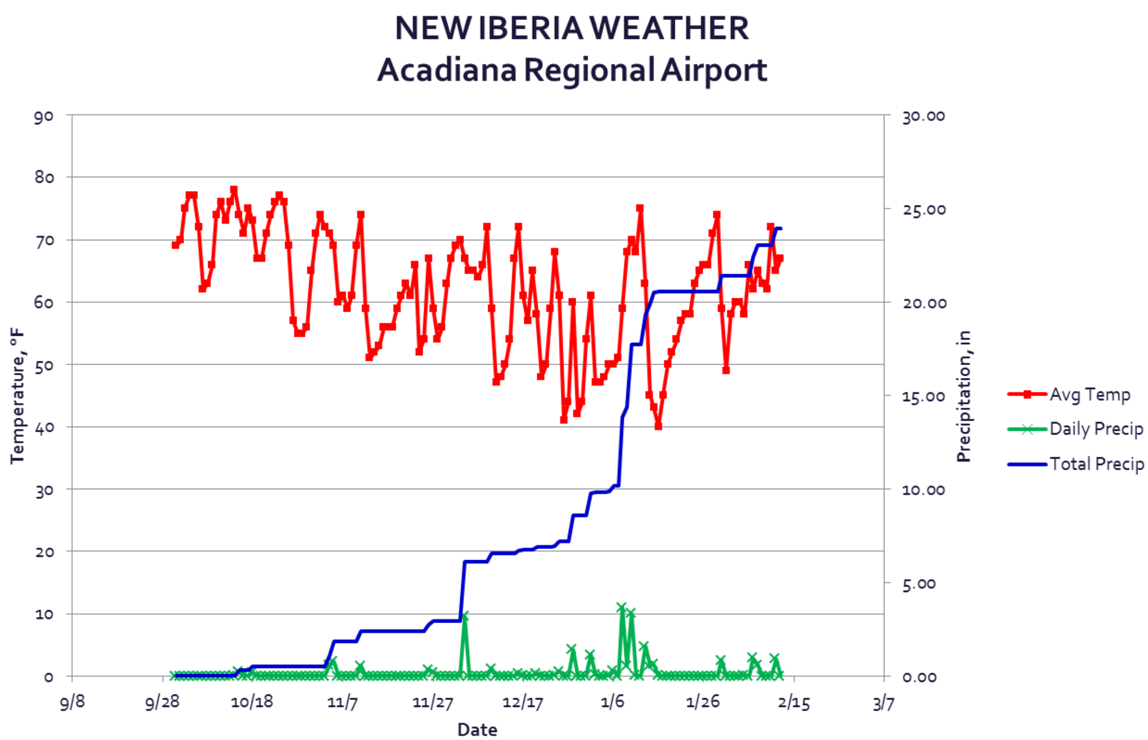


Figure 57
Weather challenges early in the project

Pulverization. The site's Class II base course consisted of material imported to the site that would be stabilized with cement. DOTD specification, 302.05 Mixing, states that *A minimum of 70 percent of the pulverized soil, as determined by DOTD TR 431, shall pass the No.4 (4.75 mm) sieve after mixing.* The dry clay imported to the site, was difficult to pulverize to the size requirement, requiring additional efforts, including an addition of lime to mellow the material and help break down the material. These efforts caused additional project delays.

Communication. Combined with the site's distant location and inability for quick visits, communication between the district, contractor, and LTRC was generally good, but could have been better. The contractor learned a lot about intelligent compaction and RICM, and was cooperative and helpful throughout the project. The project did undergo some changes on the contractor's team about midway through (April 2013), when three successive levels (superintendent, project lead, and project manager) departed the company within a few weeks' time. This change in leadership was a setback to the research in that continuity of communication, experience, research goals, and lessons learned did not all transfer to the newer contractor representatives, or back to the researchers. Efforts were made to recap the lessons learned from the prior staff, but they were unavailable.

Automated Machine Guidance

The contractor also utilized Automate Machine Guidance (AMG) during the earthwork operations. The grader shown in Figure 58 was on the project, but was not part of the research project. The contractor had incorporated the technology into their operations, and continued its use on this project to improve quality and efficiency.

Figure 58
Contractor's use of Automated Machine Guidance (AMG)

Asphalt Roller Selection

Manufacturer

The specification allowed several roller providers. At the preconstruction meeting, intelligent compaction was discussed, including the specification for the asphalt roller passes. The contractor primarily used Caterpillar (CAT) equipment, and were unclear if their rollers could meet the asphalt spec. The contractor may have initially interpreted the specification as requesting density (instead of stiffness or compaction value). At that time in the project, the asphalt roller was not needed, so the contractor was allowed more time to evaluate their options. They did more research (with the help of LTRC, Mark Arceneaux-District 03, and Dr. David White-Iowa State) and got into contact with Sakai for an asphalt roller.

At a secondary IC meeting on 07/30/12, Sakai representatives were with the contractor. The discussion included how the specification requires a single drum for the soil portion and a double drum for the asphalt portion, and that the measurement passes would likely be done on a smooth surface. The contractor mentioned that a double drum roller was part of their normal asphalt compaction process. Because of this, the researchers discussed the possibility of a double drum roller being allowed to conduct the measurement passes on the surface of the soil layers too… therefore all layers. The contractor mentioned that this could help them, in that only one roller would be needed. The contractor mentioned that the spec was unclear regarding manufacturers, but all agreed that they could not name/select specific roller manufacturer(s) in the specification. The contractor mentioned that they were going to end up going about $50K over what they estimated.

The DOTD project manager later notified LTRC that the contractor would use the CAT roller for the soil portion and the Sakai roller for the asphalt, but may ask for a change order to account for Caterpillar's not meeting the Asphalt Roller Specification. A change order was never submitted.

Asphalt Roller Model Information

The contractor selected a SAKAI roller for the asphalt work. The roller is model Sakai SW 990 with Compaction Information System (CIS).and a picture of the roller is shown in Figure 59 *[31]*. The roller's dash and display are shown in Figure 60, and the roller specifications are shown in Table 72.

Figure 59
Sakai SW 990, 84 inch roller *[31]*

Figure 60
Sakai display and dash *[31]*

Table 72
Sakai SW 990 specifications

Operating Weight	**30,800 lbs.**
Drum dimension	84 inch x 55 inch
Frequency	2,500 / 3,000 / 4,020 vpm
Amplitude	.013 inch / .026 inch
Engine	Deutz Tier 3 water cooled engine

Figure 61 shows a photo of the Sakai roller, which has cross-mounted drive and vibration motors for a balanced design, stable tracking, and smoothness, and to eliminate machine torque on the mat. Figure 62 shows a label on the roller, which defined compaction temperatures.

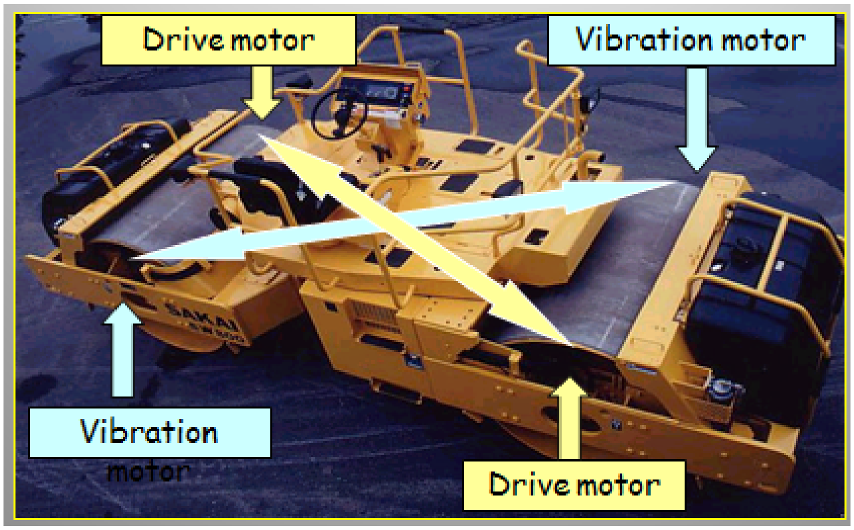


Figure 61
Sakai cross-mounted drive and vibration motors

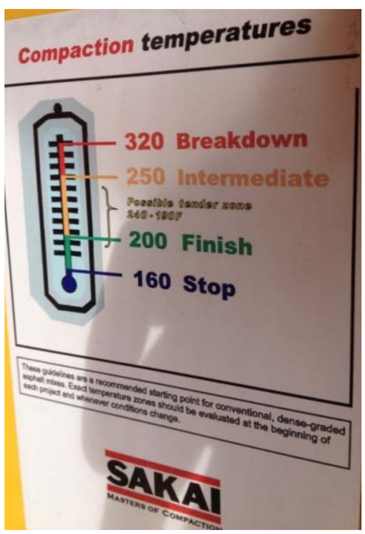


Figure 62
Sakai compaction temperatures

Software and Compaction Measurement Value (CMV)

The Sakai roller utilized an accelerometer-based method of determining the compaction measurement value (CMV). The double drum roller had the capability of varying eccentricity of the weights within the drum to apply certain forces to the mat. Figure 63 shows the how the weights are adjusted to vary the force. Accelerometers were located on the roller to detect the response of the pavement layers. These responses, along with the GPS location, and other data, were saved to a file within the roller. These files were transferred, like the soil MDP values, to the district, which then posted to a common network drive for LTRC to access. Figure 64 shows example screen shots from the Sakai roller display.

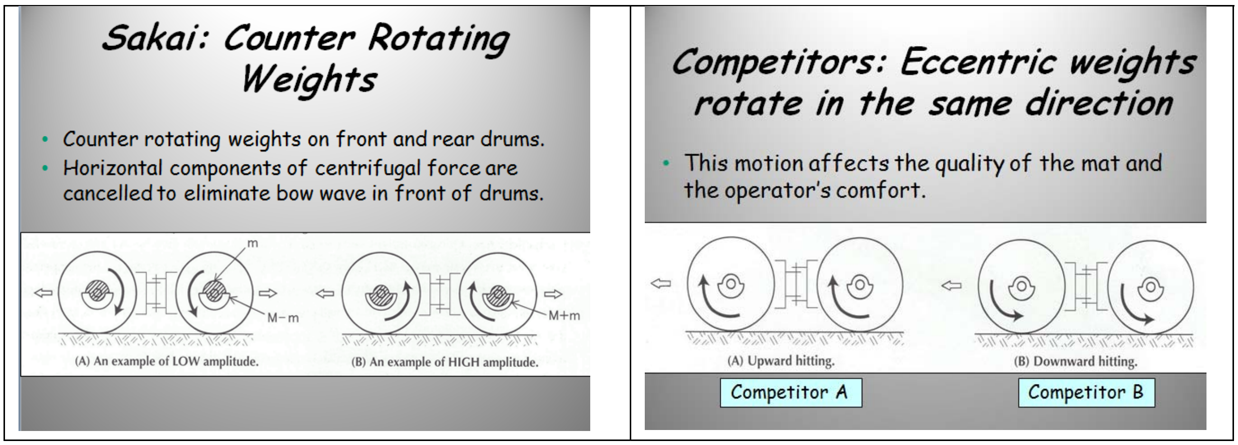


Figure 63
Sakai eccentric weight application (from Sakai)

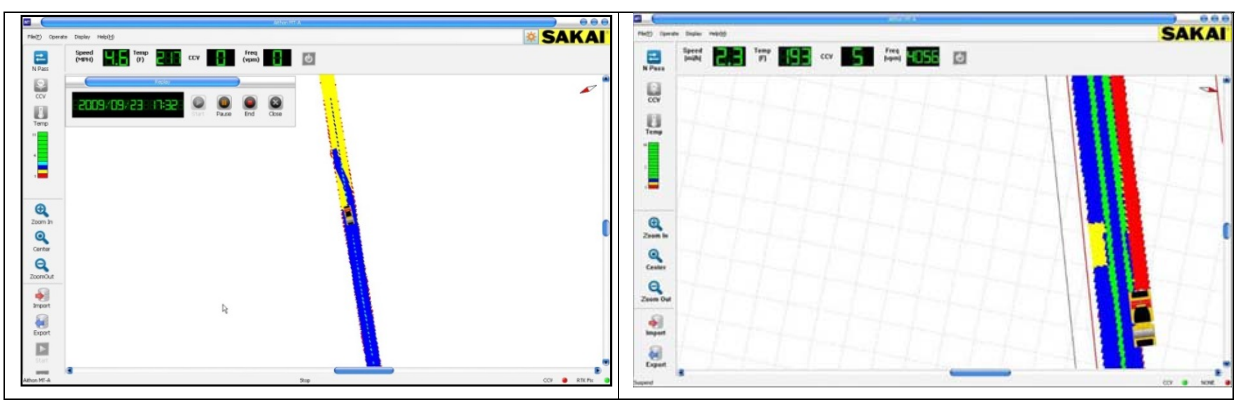


Figure 64
screen shots a) What the operator sees b) Longitudinal joint overlap

Network Connection and Software

Figure 65 shows how the Sakai hardware communicates with the roller and the GPS. Like the Cat roller, the Sakai roller utilized the contractor's RTK GPS network, and the collected files were transferred daily from the contractor to the DOTD inspector, who then uploaded them to a DOTD network location accessible to LTRC.

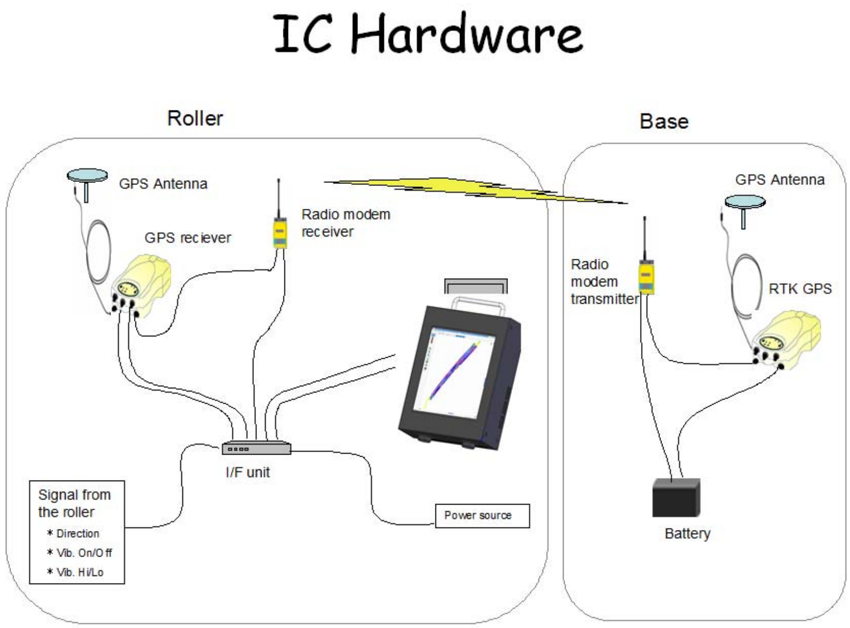


Figure 65
Sakai network communication *[31]*

The software within the roller and on its display is named AithonMT. The Sakai representatives provided training to the contractor, LTRC, and the district. A secondary software, AithonPDST was also necessary to operate and export the data from the proprietary software. This software operated on a Windows XP software, which is now obsolete. The Sakai representatives were helpful and provided instruction manuals and technical support to LTRC. The software was functional, but would benefit from an upgrade to a newer Windows version with more user-friendly features.

Mixture Design

Three asphalt mixtures were evaluated to compliment the intelligent compaction evaluation. The binder course (US90FR-BC-1 & US90FR-BC-2) was produced by two different contractors, while a third contractor produced the wearing course mixture (US90FR-WC). There were complications in the production and construction of US90FR-BC-1, which resulted in another mixture (US90FR-BC-2) to be used. The complications involved a problem with the latex blending, in that the amount of latex blended, exceed the target percentage. Aggregates commonly used in Louisiana (siliceous limestone, granite, sandstone, river gravel, and coarse natural sand) were used in mix preparation. Table 73 shows the job mix formulas for the project.

Table 73
Job mix formulas

Mixture Designation	US90FR-BC-1	US90FR-BC-2	US90FR-WC
Mix Type	19.0 mm	19.0 mm	12.5 mm
Binder type	PG 70-22L	PG 70-22L	PG 70-22M
Binder Content, %	3.8	3.9	4.8
G_{mm}	2.514	2.504	2.494
% G_{mm} at N_{Ini}	87.2	88.7	90.7
% G_{mm} at N_{Max}	97.8	96.9	97.3
Design air void, %	3.6	3.5	3.6
VMA, %	12.0	12.0	13.0
VFA, %	71	71	72
Metric (U.S.) Sieve	Composite Gradation Blend		
37. 5 mm (1½ in.)	100	100	100
25.0 mm (1 in.)	100	100	100
19.0 mm (3/4 in.)	98	99	100
12. 5 mm (1/2 in.)	83	84	88
9. 5 mm (3/8 in.)	65	66	76
4. 75 mm (No. 4)	41	39	66
2. 36 mm (No. 8)	31	31	43
1. 18 mm (No. 16)	25	25	30
0.600 mm (No. 30)	19	22	25
0.300 mm (No. 50)	11	16	15
0.150 mm(No. 100)	6	7	7
0.075 mm (No. 200)	4.3	4.2	4.9
D:A	1.2	1.1	1.2

BC: Binder Course; WC: Wearing Course; M: Elastomeric Polymer Modified; L: Latex Modified; D:A : Dust to Effective Asphalt Ratio

Mixture Analysis

The following section details the results of the mixture evaluation.

Asphalt Binder Content. Table 74 presents the results of the ignition test to determine asphalt binder content. As shown in the table, the results of laboratory testing indicate the asphalt content of the mixtures was produced as designed for the binder course mixtures. However, the wearing course mixture has 0.3% less asphalt than the JMF target. The acceptable deviation in DOTD is 0.2%.

Table 74
Asphalt Binder Content Results

Mixture	Asphalt Content 1	Asphalt Content 2	Average Asphalt Content	JMF Target
US90FR-BC-1	3.68	3.71	3.7	3.8
US90FR-BC-2	3.87	3.87	3.9	3.9
US90FR-WC	4.54	4.48	4.5	4.8

Aggregate Gradation. Figure 66 presents the results of the aggregate gradation as determined by AASHTO T30. The figure shows the binder course mixtures were produced according to their design. The deviations observed are within the DOTD tolerance indicating good production. The wearing course mixture does not meet the JMF requirements. This may explain the construction issues encountered.

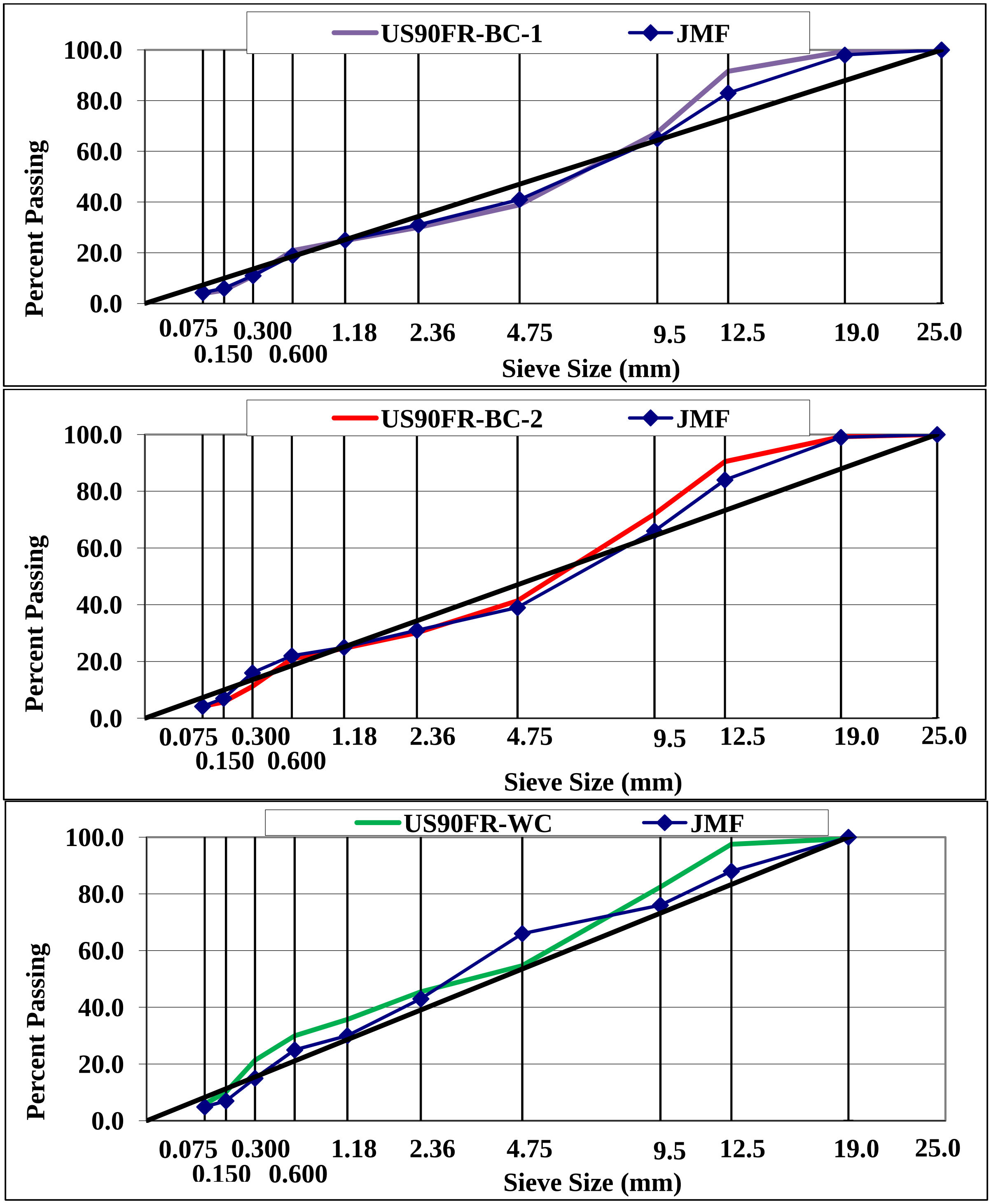


Figure 66
Aggregate gradation results

Asphalt Binder Testing

Table 75 presents the results of asphalt binder grading conducted according to AASHTO R29. As presented in the table, the asphalt binder used to produce US90FR-BC-2 did not pass the requirements for PG70-22. This is the reason for the production of US90FR-BC-1, which does meet the asphalt binder requirements.

Table 75
Asphalt binder testing results

Property	Spec	US90FR-BC-1	US90FR-BC-2	US90FR-WC
		Test on Original Binder		
Dynamic Shear,G*/Sin(δ), (kPa), AASHTO T315	1.30^+ @ 64°C	3.2	2.00	3.6
Dynamic Shear,G*/Sin(δ), (kPa), AASHTO T315	1.00^+ @ 70°C	1.55	0.95	1.8
Dynamic Shear,G*/Sin(δ), (kPa), AASHTO T315	1.00^+ @ 76°C	0.80	----	0.9
Rotational Viscosity @ 135°C (Pa·s), AASHTO T316	3.0^-	1.3	0.6	0.9
		Tests on RTFO		
Dynamic Shear,G*/Sin(δ), (kPa), AASHTO T315	2.20^+ @ 64°C	7.71	4.97	7.99
Dynamic Shear,G*/Sin(δ), (kPa), AASHTO T315	2.20^+ @ 70°C	3.67	2.27	3.05
Dynamic Shear,G*/Sin(δ), (kPa), AASHTO T315	2.20^+ @ 76°C	1.93	1.09	2.02
		Tests on (RTFO+ PAV)		
Dynamic Shear, @ 25°C, G*Sin(δ), (kPa), AASHTO T315	5000^-	2960	4270	----
BB Creep Stiffness, @ -12°C, (MPa), AASHTO T313	300^-	149.5	188	----
Bending Beam, m-value@ -12°C, AASHTO T313	0.300^+	0.324	0.322	----
Actual PG Grading		**PG 70-22L**	**PG 64-22L**	**PG 70-22M**

Lots vs. Zones

For the districts and contractor, the zone nomenclature changed to lots once the asphalt portion of the project began. LTRC continued to use some of the same zone information Figure 28, to identify project areas.

Density Report

Table 76 presents the roadway density measure during the construction of the binder course section. The average density was 94.1%. The DOTD minimum density requirement in 92%. All the measurements meet the DOTD specified minimum.

Table 76
Binder course roadway density report

Sample	Station	Zone	Density
A-2			93.7
B-1			93.7
C-3			96.0
D-3			92.8
E-1			95.0
173A-1	818+94	18	92.1
173A-2	834+90	20	93.4
173A-3	847+15	21	92.9
173B-1	806+68	16	93.9
173B-2	805+82	16	96.1
173B-3	815+63	17	96.0
173C-1	513+03	3	95.3
173C-2	822+26	18	94.2
173C-3	834+74	20	96.1
173D-1	557+55	8	94.1
173D-2	581+80	10	94.2
173D-3	512+57	3	92.9
173E-1	526+16	4	95.1
173E-2	555+20	8	94.5
173E-3	571+37	9	95.1
A-3			93.8
B-2			91.8
174A-1	585+43	11	94.2
174A-2	605+22	13	93.8
174A-3	616+86	14	94.0
174B-1	633+97	15	95.9
174B-2	601+98	12	93.2
174B-3	622+23	14	91.9
		Average	**94.1**

Table 77 presents the density determined during the construction of the wearing course. The average density was 92.5%. However, several locations indicate the density did not meet the DOTD minimum of 92%. This may be explained by the deviations in aggregate structure and asphalt content presented in the previous sections. The contractor may not have received full pay for the lots with low density.

Table 77
Wearing course roadway density report

Sample	Station		Density
A-3			92.6
B-5			91.2
C-5			91.5
D-5			92.6
E-4			91.2
122A-1	873+30	23	93.1
122A-2	903+28	26	92.7
122A-3	920+00	28	92.8
122B-1	844+95	20	93.3
122B-2	910+30	27	93.0
122B-3	927+20	29	92.7
122C-1	805+53	16	92.4
122C-2	827+65	19	93.2
122C-3	626+84	15	93.3
122D-1	585+12	11	92.5
122D-2	631+50	15	92.8
122D-3	884+92	24	92.7
122E-1	816+47	17	92.2
122E-2	838+66	20	92.4
122E-3	615+02	14	93.3
A-1			92.9
B-4			90.4
C-4			91.0
124A-1	593+69	11	92.9
124A-2	549+84	7	93.5
124A-3	572+60	9	92.9
122B-1	503+58	2	92.5
122B-2	522+92	4	92.4
122B-3	518+28	3	91.9
122C-1			92.3
122C-2			91.7
122C-3			93.2
		Average	**92.5**

Asphalt Roller Data

During the asphalt construction passes, the Sakai roller was placed in the breakdown position. A secondary roller, a Hamm Roller, was also utilized during the asphalt layer construction. Overlap between the rollers was not be measured or recorded during the demonstration project as the secondary roller was not required to have IC capabilities. In hindsight, this would be helpful to create an accurate depiction of the layer stiffness and temperature changes. As the project was let, LTRC learned that Hamm has IC capabilities that allow two Hamm rollers to communicate with each other to create a unified map of total passes including passes from both rollers. Had this occurred earlier in the project creation, Hamm would have likely been added to the list of roller manufacturers.

Figure 67
Hamm roller utilized as secondary roller

The raw asphalt data files were transferred, like the soil data files, from the contractor to the district technicians, which then uploaded them to a DOTD common drive. LTRC then had access to the files and plugged them into the Sakai CIS software. The two software packages AithonMT and AithonPDST were tough to learn, and crashed the Windows XP computers many times while processing the larger data files. Other smaller files were difficult and would not open. To help clarify some technical issues, the raw data files were reviewed by Sakai, who determined some issues with the data.

- The Setting of the “Coordinate Format; Survey or Mathematics” (AithonMT; Project -> Global Setting -> Coordinate System Setting) are difference between when measuring at site and when making the .plns file. Because of this all .pln and .plns files, LTRC initially made, were wrong. So Sakai corrected the files, and sent them with Veda files to use.

- While measuring at site, the system created some small files, where no movement occurred. In this case, the AithonMT software could not make any data for .pln and .plns files for viewing or analysis in Veda.
- During the initial setup of the roller, the CCV data looked good, but under closer examination, the roller speed and temperature were not working. Sakai representatives and the contractor worked to resolve the problem.

From the CIS software, the data was imported into VEDA, where analysis output reports were generated. These reports for the asphalt layers are included in Appendix G, and contain pass count, roller speed, sample size, frequency, temperature, the CCV, and semi-variogram information. A summary of the VEDA reports are included as Table 78. The table shows the gap in temperature and roller information at the top, and then the corrected values begin. The table shows some files in yellow that were either small, for test purposes only, or not part of the package reviewed by Sakai.

Screen shots of the temperature and CCV maps for the binder layer are included as Appendix E. Screen shots of the temperature and CCV maps for the wearing course are also included as Appendix F.

When reviewing the CCV data in the table, there is an increase in the average of the CCV mean from the binder to the wearing. This is likely due to the additional layers below the wearing. This can be further seen in Figure 68, where the roller traverses across the transition of new frontage road and existing frontage road on the wearing course. Both layers have the same binder and wearing HMA layers, so the difference is in the subgrade and base course layers. The new frontage road was designed and constructed with a treated subgrade and a treated base course, in contrast to the older sections of existing frontage road, which did not have subgrade or base improvements during this project. The benefits of treating these lower pavement layers have been recommended by LTRC in other projects, and can be realized in the data and photograph.

Table 78
Asphalt roller CCV - VEDA summary

Asphalt Data Final Coverage - Veda Report Summary

	Date File	Time	Sample Size	PASS COUNT					ROLLER SPEED, mph					FREQUENCY, vpm					TEMPERATURE, °F					CCV					SEMI VARIOGRAM			
				Mean	SD	CoV	Min	Max	Mean	SD	CoV	Min	Max	Mean	SD	CoV	Min	Max	Mean	SD	CoV	Min	Max	Mean	SD	CoV	Min	Max	Range	Sill	Vert. Scale	Nuggets
Zone	BINDER COURSE																															
29-26	6/25/2013	0710	43,123	6	4	61	1	20	0.0	0.0	--	0.0	0.0	2750	740	27	0	4074	32.0	0.00	0	32.0	32.0	19.91	13.51	68	0.0	100.0	10.49	160.09	160.09	0.00
26-18	6/26/2013	0706	123,657	6	3	46	1	18	0.0	0.0	--	0.0	0.0	2710	393	15	0	5994	32.0	0.00	0	32.0	32.0	14.78	12.37	84	0.0	100.0	10.50	133.17	133.17	0.00
29-25	6/28/2013	0709	124,795	4	3	68	1	18	0.0	0.0	--	0.0	0.0	2632	497	19	0	5922	32.0	0.00	0	32.0	32.0	20.93	16.09	77	0.0	100.0	11.81	206.22	206.22	0.00
24	6/28/2013	1600	299	1	0	0	1	1	0.0	0.0	--	0.0	0.0	1737	968	56	0	2994	32.0	0.00	0	32.0	32.0	17.24	8.77	51	0.0	100.0	6.63	48.19	48.19	0.00
20 & 7	6/29/2013	1031	4,906	4	3	78	1	11	5.6	1.2	22	1.9	7.7	2799	557	20	0	5994	179.5	43.79	24	32.0	233.4	18.99	19.92	105	0.0	100.0	22.30	263.78	263.78	0.00
20 Test	6/29/2013	1050	49	1	0	0	1	1	2.5	0.1	6	2.0	2.7	1939	289	15	0	1998	32.0	0.00	0	32.0	32.0	35.59	14.48	41	0.0	69.4	9.73	188.33	188.33	0.00
20 Test	7/2/2013	1346	1,237	2	0	22	1	2	4.6	0.8	17	1.2	5.3	2937	84	3	2256	3120	99.3	3.42	3	89.1	103.1	52.39	23.20	44	11.8	98.7	5.24	0.40	0.40	0.00
22-19	7/10/2013	0717	46,515	6	4	61	1	17	4.6	0.4	8	0.0	6.0	2746	678	25	0	5994	174.7	30.13	17	90.1	246.4	22.06	22.78	103	0.0	100.0	10.50	319.10	319.10	0.00
19-17	7/10/2013	1320	78,455	6	4	67	1	18	5.6	1.0	18	0.1	10.2	2802	647	23	0	5994	188.2	26.76	14	111.2	263.5	17.82	18.17	102	0.0	100.0	11.81	303.52	303.52	0.00
17-16	7/12/2013	0810	16,423	6	4	60	1	16	4.4	0.7	16	1.3	5.7	2698	785	29	0	5994	165.0	19.24	12	101.1	245.4	13.46	21.92	163	0.0	100.0	10.50	435.65	435.65	0.00
18-16	7/12/2013	1120	3,911	7	5	68	1	22	4.5	0.6	12	1.2	5.8	2714	786	29	0	5994	181.7	23.75	13	115.2	240.4	12.93	20.95	162	0.0	100.0	11.80	411.19	411.19	0.00
6-1	8/27/2013	0654	4,441	8	4	55	1	21	4.7	0.6	13	0.0	8.4	2740	751	27	0	5994	190.5	18.14	10	111.2	270.5	12.41	18.78	151	0.0	100.0	10.50	341.53	341.53	0.00
7-1	8/28/2013	0715	68,553	5	4	68	1	17	6.0	1.1	19	0.8	13.2	2739	772	28	0	5994	176.9	35.57	20	82.1	248.4	16.01	20.61	129	0.0	100.0	11.81	391.84	391.84	0.00
15-10	8/29/2013	0705	42,366	7	4	62	1	17	4.9	0.9	19	0.2	8.9	2764	693	25	0	5454	179.5	20.38	11	91.1	245.4	20.98	17.60	84	0.0	100.0	10.49	10.49	10.49	0.00
15-10	8/29/2013	1429	74,955	5	4	69	1	15	6.8	1.1	16	1.5	10.9	2823	627	22	0	5994	192.6	29.17	15	104.1	283.5	19.14	17.64	92	0.0	100.0	11.81	280.24	280.24	0.00
			average	**5**	**3**	**52**	**1**	**14.3**	**3.6**	**0.6**	**15**	**0.7**	**5.7**	**2635**	**618**	**24**	**150**	**5167**	**125.9**	**16.69**	**9.3**	**72.5**	**169.3**	**20.98**	**17.79**	**97**	**0.8**	**97.9**	**11.06**	**232.92**	**232.92**	**0.00**
Zone	WEARING COURSE																															
24-20	12/4/2013	0632	404,213	5	2	53	1	15	4.9	0.6	13	0.0	11.0	2790	513	18	0	5994	184.9	30.93	17	32.0	271.5	41.27	24.67	60	0.0	100.0	20.97	302.06	302.06	0.00
29-21	12/5/2013	0158	3,528	3	1	31	1	6	4.9	0.6	13	2.0	5.7	2756	506	18	0	5382	200.3	21.53	11	105.1	257.4	60.93	20.22	33	0.0	100.0	14.43	319.34	319.34	0.00
29-25	12/5/2013	0551	5,090	3	1	39	1	6	5.3	0.4	7	2.5	6.8	2773	536	19	0	5994	180.9	29.36	16	98.1	248.4	51.59	23.82	46	0.0	100.0	15.74	377.55	377.55	0.00
19-16	12/17/2013	0250	27,913	3	1	39	1	5	4.7	0.6	13	0.0	5.7	2814	444	16	0	2976	204.2	24.07	12	131.2	269.5	23.08	13.80	60	0.0	100.0	10.50	167.20	167.20	0.00
20-19	12/17/2013	0317	5,302	2	1	60	1	5	4.9	0.6	12	2.6	5.6	2493	595	24	0	3006	201.0	24.91	12	151.2	258.4	31.02	19.93	64	0.0	100.0	26.24	231.20	231.20	0.00
15-10	12/17/2013	2215	46,019	3	1	34	1	6	4.6	0.6	12	1.1	5.7	2787	500	18	0	5790	119.5	24.00	12	32.0	271.5	47.19	18.70	40	0.0	100.0	11.81	269.09	269.09	0.00
29-28	12/18/2013	0355	16,377	3	1	50	1	7	5.1	0.6	12	1.8	5.9	2732	649	24	0	5328	179.7	31.40	17	85.1	249.4	57.66	28.89	50	0.0	100.0	14.43	624.58	624.58	0.00
25-16	12/18/2013	1918	89,955	3	1	47	1	7	5.1	0.5	9	0.6	6.1	2802	514	18	0	5994	174.7	30.26	17	32.0	267.5	45.75	32.22	70	0.0	100.0	13.12	487.79	487.79	0.00
16	12/19/2013	1811	2,527	2	1	46	1	4	3.0	0.5	18	1.6	4.2	2295	920	40	0	2934	121.2	40.00	33	32.0	209.3	35.16	24.14	69	0.0	100.0	16.34	579.02	579.02	0.00
15-10	12/19/2013	2026	42,094	5	3	54	1	13	5.1	0.5	10	2.3	6.0	2818	465	16	0	5994	166.9	28.03	17	79.1	245.4	42.93	23.92	56	0.0	100.0	14.43	504.53	504.53	0.00
10-3	1/13/2014	1854	50,137	3	1	34	1	6	4.7	0.6	13	1.5	5.9	2866	465	17	0	5994	171.3	24.47	12	73.1	271.5	42.49	19.06	45	0.0	100.0	15.75	225.77	225.77	0.00
4-2	1/13/2014	2334	17,907	2	1	44	1	7	5.3	0.4	8	2.4	5.9	2295	393	14	0	5994	121.2	30.69	18	85.1	265.5	23.17	13.40	58	0.0	100.0	13.12	153.81	153.81	0.00
1	1/14/2014	1647	7,913	2	1	38	1	4	4.3	0.7	16	2.6	5.4	2655	668	25	0	3546	182.8	27.31	15	85.1	269.5	30.23	15.85	52	0.0	100.0	9.18	226.60	226.60	0.00
10-1	1/15/2014	1254	75,706	3	1	39	1	7	5.0	0.6	13	1.1	11.0	2781	522	19	0	5994	185.1	28.36	15	73.1	267.5	37.84	19.13	51	0.0	100.0	13.12	280.80	280.80	0.00
			average	**3**	**1**	**43**	**1**	**7**	**4.8**	**0.6**	**12**	**1.6**	**6.5**	**2690**	**549**	**20**	**0**	**5066**	**171.0**	**28.24**	**16**	**78.2**	**258.7**	**40.74**	**21.27**	**54**	**0.0**	**100.0**	**14.94**	**339.24**	**339.24**	**0.00**

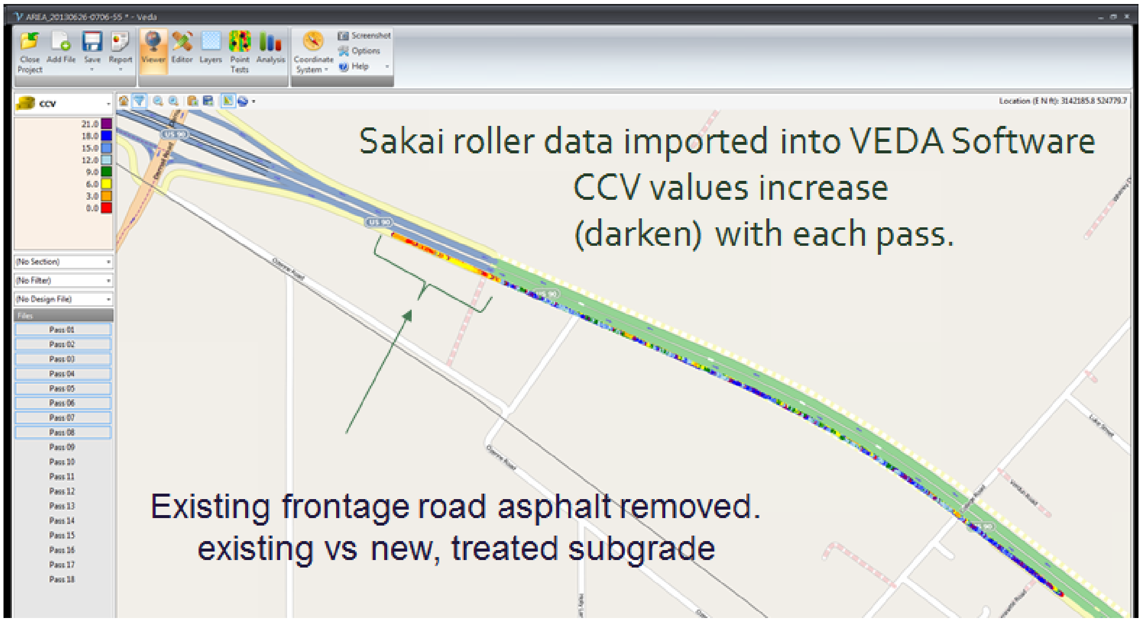


Figure 68
Veda screenshot – Sakai CCV values

Figure 69 shows the test pass that was conducted away from HMA operations near the contractor trailer. The pass shows that the temperature settings were resolved and the roller was collecting accurate temperatures. The visualization settings (colors and ranges) can be adjusted to reflect the temperatures encountered. They should also be dialed in to reflect the scale of the measurements, for example one reason the temperature measurement were initially thought to be working, was that the values displayed as 100 degrees even though the readings were 32 degrees Fahrenheit (which was a converted value from a zero in Celsius). The values were less than 100 so they plotted as 100. Operators and data analyzers should therefore be cognizant of the potential ranges and adjust the scales (and colors) accordingly to catch the desired ranges and possible error ranges.

Since the roller was in the breakdown position, the temperature of the layer does not show the second roller's efforts or effect on temperature. Figure 70 shows an example of the temperature screen shot with various temperatures shown via successive passes. A final coverage map can also be made via the Aithon software for analysis with some extra steps. The advantage of having a second instrumented roller, ideally communicating with the breakdown roller to record the passes would more accurately describe the pass and temperature relationship, though having a second instrumented roller would likely add to the equipment costs for the contractor.

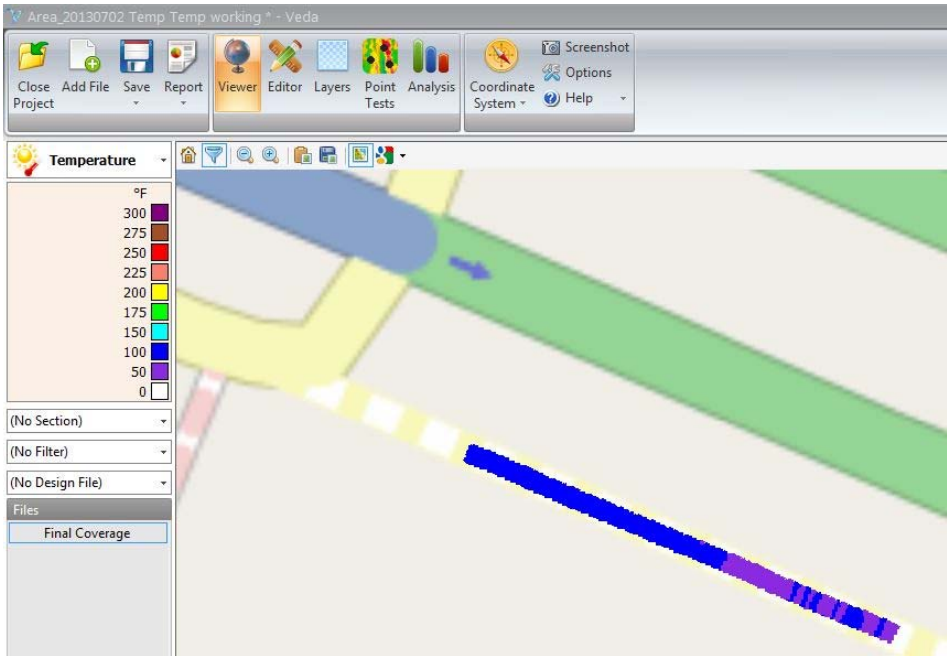


Figure 69
Verification that temperature was working. – 07/02/13

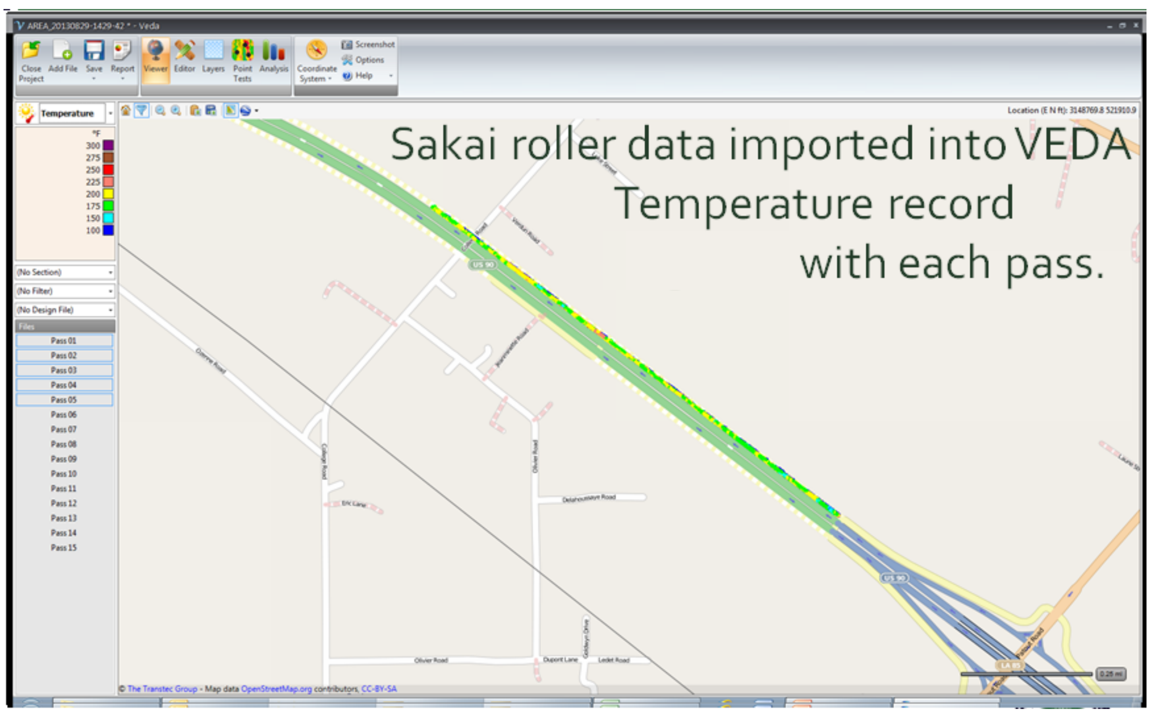


Figure 70
Veda screenshot – Sakai temperature values

Technology Transfer

Intelligent Compaction Showcase

The Intelligent Compaction Showcase coordinated by LTRC held on 06/04/13, in New Iberia, LA, highlighted the IC technology and the US 90 Frontage Roads project, which collected both soil and asphalt data with two different rollers. The Showcase was a great opportunity to introduce the IC technology to various contractors and engineers, and to promote the research and technology. The Showcase included presentations (conference PowerPoint and field equipment demonstrations) from researchers, DOTD, FHWA, and manufacturers. The project was well attended and well received. Additional events to share the IC technology with a wider range of attendees and locations may be helpful.

Every Day Counts Initiative

An Every Day Counts (EDC) Exchange for Local and Tribal Agencies on Intelligent Compaction was held on 04/03/14, and attended by the Project Review Committee and local contractors. The national webinar was another way for contractors and the department to understand and realize the value that IC can bring to a project. The webinar was viewed at the Louisiana Association of General Contractors (LAGC) Baton Rouge office. The Webinar was publicized prior to the event by the LAGC and the Louisiana Asphalt Pavement Association (LAPA) with hopes that the contracting industry would attend to discuss the future of this technology in Louisiana. As part of the webinar meeting, the technology was discussed on a state level with those in the room, the demonstration project was discussed reviewed, and the next steps reviewed and evaluated by all. A total of 14 people participated including DOTD (3), LTRC (2), FHWA (2), and Boh Bros. Construction (7). The attendance numbers seemed low, even though advertised via the LAPA and LAGC. The new IC technology and its implementation are not currently required by the department. Should this occur, more contractors would likely make time to learn and invest in the technology.

State and Regional Conferences

The lead author also presented on intelligent compaction at the statewide Louisiana Transportation Conference on 02/20/13; and at the Southeastern Asphalt User Producer Group (SEAUPG) Annual Meeting on 11/13/13.

SUMMARY AND CONCLUSIONS

Developed over recent years, the intelligent compaction (IC) technology has made great strides in combining old and new compaction technologies. Instrumentation, computer technology, and GPS have transformed the slow roller into one of the smartest devices on a jobsite. The goals of uniform and consistent compaction, while reducing project delays are key advantages to the IC technology. The IC and RICM systems are, however, not presumed to be a silver bullet or magic wand, but they can serve the contractor and the State Departments of Transportation as a valuable tool in the toolbox. The RICM systems do not adjust the moisture and temperature levels in the pavement layers, so the desired densities and stiffness moduli for soil are still affected by moisture; and similarly, HMA densities and moduli will be affected if the material is outside of the temperature range or mix requirements. Contractor means and methods in these areas are still needed to sculpt a successful project.

When this research began, there were limited specification templates for IC compaction available. SHRP2 and NCHRP researchers assisted in the development of IC specifications and provided guidance to The LTRC research team early in the demonstration project. Now, there are many more publications, references, and specifications available via websites, especially Intelligent Compaction.com. However, each of these would still need to be customized to meet specific agency's particular needs.

The demonstration project provided an opportunity to evaluate the various implementation and measurement aspects of intelligent compaction technologies. Project specifications were developed and allowed the incorporation of the rollers into the project. The specification went through the competitive bidding process and produced a wide range of cost numbers. The item for the soil roller had a range of bids from $15,000 to $95,000. The item for the asphalt roller had a range in bids from $7,000 to $100,000. The wide range may be attributed to the lack of knowledge and familiarity with intelligent compaction technology in the State of Louisiana.

This project helped improve the knowledge and familiarity of the IC technology through the conduct of the demonstration project, hosting an Intelligent Compaction Showcase, participation in the national webinar, and through other presentations about the research and technology.

The New Iberia demonstration site was chosen for its length, number of layers, and that it was new construction. A site closer to LTRC, possibly smaller in size may have fostered more communication between the contractor, operators, and researchers by allowing more frequent and longer site visits.

A multitude of roller manufacturers exists, each with its own innovative approach, which is great for innovation. However, that can cause difficulties to State Departments of Transportation and the contractor in implementing the intelligent compaction technology like the following concerns.

- Because each roller and methodology is different, and low bid is used within the department, the department would not know the selected roller until the project is let and the preconstruction meeting is held. Over several projects, QA personnel could have different rollers, requiring advanced IT knowledge, mastery of several IC equipment systems and several software packages (including VEDA), and enough time for data, transfer, and analysis. This is especially true if real-time transfer and review of data for acceptance is desired. A full time QA position would likely be required due to vast amounts of data, and to keep up with the contractor's production. From an agency perspective, there appears to be a delicate battle/balance between innovation and standardization. The tough question of "How to standardize the method, results, software, and analysis, without stifling roller innovation?" still exists.

- The contractor would need to consider include the purchase/rental of the roller equipment, software costs, and the need for an operator with relatively higher skill and knowledge than a standard roller operator. These rollers require additional costs over a standard roller, and some contractors may not be ready for the full investment and/or realizing the potential benefit in accelerating compaction. Combined with the decision of which roller brand to buy, indecision can heighten, especially since DOTD cannot specify or require a specific brand name roller. An investment into and selection of one manufacturer (over others) could be a tough choice, because it is not known which manufacturer/methodology could eventually wind up on "top" (a la Betamax vs. VHS).

By shadowing the normal acceptance process in the demonstration project, the research learning curve did not detrimentally affect the earthwork or HMA productivity. The contractor did experience difficulties with weather, pulverization, and some internal staffing issues, which affected their construction schedule and communication continuities regarding the research. Combining these obstacles with the newness of the IC technology, the contractor cooperated during the project, but did not appear to embrace the new IC technology fully in our opinion. Follow up conversations with the contractor were unfortunately not reciprocated or possible due to the turnover in staff.

The MDP roller selected by the contractor was not necessarily the expected choice of roller when the project was designed. The rolling resistance logic differs dramatically from the acceleration-based systems. This project shadowed acceptance, so when layers were complete and stiff, the single measurement pass had little variation in the MDP values. It did identify some week areas in Zones 7 and 12, which were subsequently reworked. Utilizing the MDP roller during construction passes (vs. measurement passes), was allowed, but those measurements were not recorded as part of the research. The contractor's superintendent in a discussion, agreed that construction passes would be helpful, but it is unknown if the contractor/operator utilized this capability.

The ability of the MDP roller to measure without a vibration/accelerometer system has benefits when dealing with Louisiana's wet and weak, clay based, subgrade soils. The MDP roller was gentle on the soft wet clayey soils by not imparting any unwanted vibration energy into the layer, which could induce pumping or damage to these lower layers of the pavement structure.

Manufacturer equipment and software training/support are critical to the success of an IC project, which includes good communication throughout. In our case, the contractor had relationships with each roller manufacturer, and LTRC was able to interact with roller and manufacturer. Initial setup of roller and GPS connections was a challenge with both project rollers, as LTRC local roller representatives and the contractor were generally learning about the details of the technology for the first time. National roller representatives were helpful, but could not be on site at all times. The contractor's survey staff became proficient in the two systems; and needed GPS knowledge, capable, accurate, and reliable GPS equipment, as well as the ability to connect properly and effectively with the rollers' on-board software.

The contractor can realize some advantages through the utilization of the rollers. Operators can adjust patterns and time based on real-time reactions/display, and the roller display can show and track coverage, passes, and compaction effort (measurement values) hopefully speeding production and assisting with quality control. Weak areas can be visually identified for rework.

Through the use of the IC technology by the contractor, Departments of Transportation can also realize some advantages. The rollers continuous coverage records (vs. point tests at roughly 1000' spacing) can speed construction with contractor's use (appropriate passes/energy). The technology promotes consistent and uniform pavement layers, which can be visually verified. With further research, this technology has the potential to serve as a quality assurance tool, and viable alternative or replacement for the nuclear density gauge. The features of RICM can help improve the construction quality of roadway compaction in Louisiana.

RECOMMENDATIONS

The new technology will hopefully benefit the contracting community the most. The rollers can speed compaction by focusing efforts where needed to control uniformity. The technology is still new and not mainstream yet, though its advantages are many, including consistency of coverage, digital documentation of efforts, visual representation of roller movements, possible alternatives to nuclear gauges, and stiffness measurements with location position.

Based on this research experience with the IC rollers and roller-instrumented compaction monitoring (RICM) the researchers have the following recommendations.

- The contracting community should examine and evaluate the benefits of each system, and hopefully utilize a system to increase confidence, consistency, quality, and efficiency in production. It is a valuable contractor tool for Quality Control (QC).

- Initiatives to continue to promote the technology to the contracting community will help spread knowledge regarding these systems and the benefits they offer.

- The specification developed and utilized in this project are not ready for implementation. As experience and contractor demand grow within Louisiana, specifications for implementation of quality assurance and acceptance criteria should be reevaluated.

- Quality assurance (QA) and acceptance by DOTD through the use of these rollers in Louisiana is not is not readily implementable or recommended at this time.

Possible Next Steps

- To further the technology, the Department should consider selecting additional projects (with possible incentives) to utilize intelligent compaction and RICM technologies on the quality control side by the contractor.

ACRONYMS, ABBREVIATIONS, AND SYMBOLS

AASHTO	American Association of State Highway and Transportation Officials
AC	Asphalt Content
ACE	Ammann Compaction Expert
ACD	Asphalt Documentation System (Geodynamik)
AFC	Automatic Feedback Control
LAGC	Louisiana Association of General Contractors
BC	Binder Course
BVC	Bomag Vario Control (Bomag)
CAC	Continuous Asphalt Compaction (Geodynamik)
CAA	Coarse Aggregate Angularity
CAT	Caterpillar Company
CCC	Continuous Compaction Control
CIS	Compaction Information System
CMV	Compaction Measurement Value
cm	centimeter(s)
D:A	Dust to Effective Asphalt Ratio
DCP	Dynamic Cone Penetrometer
DCPI	Dynamic Cone Penetrometer Index, mm/blow
DD	Dry Density
DOTD	Louisiana Department of Transportation and Development
E_{roller}	European Roller Modulus
E_{Vib}	Bomag roller-based stiffness measurement
FAA	Fine Aggregate Angularity
FHWA	Federal Highway Administration
ft.	foot (feet)
FWD	Falling Weight Deflectometer
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System
HMA	Hot Mix Asphalt
HQ	Headquarters
IC	Intelligent Compaction
in.	inch(es)
JMF	Job Mix Formula
LAPA	Louisiana Asphalt Paving Association
lb.	pound(s)

lbf	pound force
LFWD	Light Falling Weight Deflectometer
LSU	Louisiana State University
LTRC	Louisiana Transportation Research Center
LWT	Loaded Wheel Tracking
L	Latex Modified
m	meter(s)
M	Elastic Polymer Modified
MC	Moisture Content
MDP	Machine Drive Power
MPa	Mega Pascal
MV	Measurement Value
PG	Performance Grade
PLT	Plate Load Test
psi	Pounds per square inch
QA	Quality Assurance
QC	Quality Control
RICM	Roller Integrated Compaction Monitoring
RTFO	Rolling Thin Film Oven
RTK	Real Time Kinematic
SCB	Semi-Circular Bending
SHRP2	Strategic Highway Research Program
TRIS	Transportation Research Information Services
TRID	Transportation Research International Database
VFA	Voids Filled with Asphalt, Percent of VMA
VMA	Voids in the Mineral Aggregate
vpm	Vibrations per minute
WC	Wearing Course
WD	Wet Density

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APPENDIX A

Appendix A, Non-Standard (NS) Roller Integrated Compaction Monitoring (RICM) Specification for the New Iberia Demonstration Project

NS Roller Integrated Compaction Monitoring (RICM) (11/11)

DESCRIPTION. This specification describes the Contractor's responsibilities for furnishing and operating roller integrated compaction monitoring (RICM) (i.e., intelligent compaction (IC) or continuous compaction control (CCC)) equipped rollers with global positioning system (GPS) mapping, training, testing, acquiring measurement data, and transmitting electronic data files to the Engineer and research team in support of the research study. RICM refers to the compaction of road materials, including subgrade soils, aggregate bases, stabilized materials, and asphalt-paving materials, using modern rollers equipped with an integrated IC or CCC measuring system. The RICM measurement values (IC-MVs) include roller operation parameters (speed, vibration frequency and amplitude, gear, etc.).

a) Measurement Passes on Subgrade and Base layers: Compaction of these layers shall be accomplished with standard rollers or the RICM roller(s). Conduct all measurement passes in the test sections with a smooth single-drum RICM roller. Do not utilize automatic feedback during measurement passes. Measurement passes are defined in Equipment and listed in Table 3.

b) Compaction of Asphalt Layers: At least one double-drum RICM roller(s) shall be utilized in the breakdown position (directly behind the paver) to compact the HMA layers within the test sections; and continuously record IC-MV, time, temperature, and GPS location of the roller at all times and passes. Contractor shall be responsible for setting roller patterns that will provide material that meets standard specifications.

Intelligent Compaction (IC) refers to the compaction of road materials, such as soils, aggregate bases, or asphalt pavement materials, using modern vibratory rollers equipped with an in-situ measurement system and feedback control. Often, Global Positioning System (GPS) based mapping is included, and software that automates documentation of the results. By integrating measurement, documentation, and control systems, the use of IC rollers allow for real-time corrections in the compaction process. IC rollers also maintain a continuous record of color-coded plots that include number of roller passes, roller-generated material stiffness measurements, and precise location of the roller (IntelligentCompaction.com). For this specification, the option of feedback control may be used during the compaction of soils and base course material, but not during measurement passes.

This specification will primarily focus on "Continuous Compaction Control" (CCC). Specifically, the gathering of data from self-propelled roller integrated compaction systems including the measurement and recording of roller position, date/time, speed, vibration frequency, vibration amplitude, surface temperature (for HMA rollers), pass count, travel direction, and an IC-MV. Real Time Kinematic (RTK) based GPS with base station corrections shall be used for determining the position of the roller compactor. Results from the RICM roller shall be displayed to the roller operator on a color-coded computer screen in real-time during roller operations and the data saved for transfer and viewing by the Engineer. Automatic feedback control can be used for soil and aggregate compaction passes, but measurement passes must be conducted at constant operating settings for roller speed, vibration amplitude, and frequency.

Quality acceptance for soils (subgrade and base layers) will be based on the Louisiana Department of Transportation and Development (LADOTD) 2006 Edition of the Louisiana Standard Specifications for Roads and Bridges (LSSRB 2006 Edition).

The RICM roller results will not be used for approval or rejection of the project's materials testing but support the Louisiana Transportation Research Center (LTRC) research study.

Quality acceptance for Hot Mix Asphalt (HMA) production will be based on the LADOTD, LSSRB 2006 Edition The RICM roller will be used for the compaction of HMA layers within the test section areas to continuously record the location, time, temperature, and response of compactive effort; but will not be used for approval or rejection of the project's materials testing. The data from RICM equipment will support the LTRC research study.

Definitions:

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a) Automatic Feedback Control: Automatic adjustment of roller Operating Parameters such as vibration frequency and amplitude based on real-time feedback from measurement system.

b) Breakdown Roller: The first roller directly behind the asphalt paver.

c) Compaction Pass: A static or vibratory roller pass performed during subgrade and base compaction, not necessarily employing an Instrumented Roller within the test section. HMA Compaction Passes in contrast, shall utilize an Instrumented Roller within the test section.

d) Continuous Compaction Control (CCC): Continuous monitoring and documentation of compaction using an Instrumented Roller.

e) Double Jumping: Wherein the drum loses contact for more than one cycle of vibration at a time. Some RICM rollers automatically decrease the vertical vibration force when undesirable operating conditions are detected (e.g., jump mode).

f) HMA Compaction Passes: A vibratory roller pass performed during HMA compaction employing an Instrumented Roller in the breakdown position.

g) IC-MV: The parameter used by the roller to assess compaction based on vibration measurements.

h) Instrumented Roller: A roller compactor outfitted with drum vibration instrumentation or other means of compute a Roller Measurement Value, onboard computer, and position monitoring equipment.

i) Intelligent Compaction: The combined use of an Instrumented Roller and Automatic Feedback Control in an attempt to improve compaction.

j) Measurement Pass: A pass performed by an Instrumented Roller over the full pavement width of a test section, during which all required information, including Roller Measurement Values and machine position, are recorded. Roller Operating Parameters must be held constant, and thus no Automatic Feedback Control is permitted during a Measurement Pass. Maintain Operating Parameters within controlled limits to ensure reliable data collection during the measurement pass.

k) MV Reporting Rate: The time-dependent rate at which new Roller Measurement Values are reported:

l) Operating Parameters: Roller machine parameters used during operation, including forward speed, driving direction, vibration frequency, and amplitude setting. Operate the roller per manufacturer guidelines to ensure reliable data collection during the measurement pass (i.e. minimizing double jump, etc.)

m) Pass Sequence: A record of the roller pass history (pass number, Operating Parameters) over a specified area.

n) Roller Integrated Compaction Monitoring (RICM)

o) Roller Measurement Value (MV): The roller-based parameter used for assessment of soil stiffness during compaction and based on roller vibration measurements.

p) Rolling Pattern: The path traversed by the roller during a Measurement Pass.

q) Test Section: The area of the project where this specification is applicable.

MATERIALS. Furnish machinery, tools, and equipment necessary for proper execution of the work in accordance with the plans and applicable specifications of LADOTD. The contractor shall be responsible for providing and transporting the RICM rollers to and from the job site. The contractor will be responsible for onsite transportation and fuel during training, measurement passes, compaction of asphalt layers, and test section assistance.

a) Provide RICM roller equipment as required for measurement passes on the subgrade and base; and compaction of each asphalt layer within the test sections as described in this project.

1) Measurement Passes on Subgrade and Base layers: Compaction of these layers may be accomplished with standard rollers or the RICM roller(s). Conduct all measurement passes in the test section with a smooth-drum RICM roller; and continuously record IC-MV, time, and GPS location of the roller at all times and passes. Do not utilize automatic feedback during measurement passes. Measurement passes are defined in Construction Requirements.

2) Compaction of Asphalt Layers: At least one double-drum RICM roller(s) shall be utilized in the breakdown position (directly behind the paver) to compact the HMA layers within the test sections; and continuously record IC-MV, time, temperature, and GPS location of the roller at all times and passes. Contractor shall be responsible for setting roller patterns that will provide material that meets standard specifications.

b) Instrumented Roller Compactor Requirements. Provide self-propelled RICM rollers in accordance with the approved RICM roller manufacturer list shown in Table 1. Ensure the RICM roller manufacturer provides a knowledgeable representative on the project to ensure proper operation of the equipment. Show published evidence that data from each selected roller correlates to the standard specification of density (or modulus) for the applicable layer (subgrade, stabilized, asphalt).

Table 1
RICM Roller Manufacturers

Manufacturer	
BOMAG America, Inc. 2000 Kentville Rd. Kewanee, IL 61443 Tel: (309) 853-3571 Fax: (309) 852-0350 Chris.connolly@bomag.com	**Dynapac, USA, Inc.** 16435 I.H. 35 North Selma, TX. 78154 Tel: (210) 474-5770 Fax: (210) 474-5780 Mike.Pritchard@us.atlascopco.com
Case Construction Equipment 621 State Street Racine, WI 53122 Tel: +1 262 636-4959 Fax: +1 262 636-5310 George.whitaker@casece.com	**Sakai America, Inc.** 90 International Parkway, Adairsville, GA 30103 Tel: (800) 323-0535 Todd Mansell t-mansell@sakaiamerica.com
Caterpillar, Inc. 100 North East Adams Street Peoria, Illinois 61629 Tel: (612) 209-1230 Hourscht_Steve_E@cat.com	**Volvo Construction Equipment** One Volvo Drive Asheville, NC 28803 Telephone: (828) 650-2429 Mobile: (828) 337-0586 bob.marcum@volvo.com

1) RICM General Requirements.
   a) Self propelled, vibratory roller compactor
      Subgrade: Smooth single-drum
      Base: Smooth single-drum
      Asphalt: Smooth Double-drum
   b) Weighs at least 22,000 pounds (10,000 kg)
   c) Instrumented with the following:
      1) Accelerometer-based, or Drive-Power based system
      2) Global Positioning System
      3) Onboard computer display of IC-MV output for each pass, including display of 2-dimensional design files linked to project GPS coordinates.
      4) Data acquisition capability, storage software and hardware (data stored for transfer to the Engineer and LTRC for viewing on a laptop computer), including IC-MV, GPS, etc. for each measurement pass.
   d) Capable of controlling and maintaining operating parameters during measurement passes.
   e) Provide evidence that Roller IC-MV correlates to standard specification (density, plate load test, or falling weight deflectometer.

Table 2
Roller accuracy requirements

Operating Parameter	Accuracy
Global Positioning System	± 3 inches (76 mm) in the horizontal and vertical directions (RTK-GPS)
Rolling Speed	±0.3 mph (0.5 km/h)
Frequency	± 2 Hz
Amplitude Setting	±0.0008 in (0.2 mm)

d) GPS Requirements: To ensure accurate and consistent survey grade data collection during the research time period, the following capabilities for the RICM roller GPS systems are required:

1. RTK-GPS (Real Time Kinematic-GPS) systems on machines and one hand held "rover" unit.
2. System records and reports values as XYZ position in Louisiana State Plane South Zone NAD 83 coordinates for the project site.
3. If an offset is necessary between GPS antenna and center of drum, it has been input and validated.
4. IC rollers shall meet the accuracy limits described in Table 2.
5. Technical assistance by the roller manufacture(s) and GPS equipment manufacturer(s) will be provided at no additional cost to the Department in accordance with the following requirements:
    a. On-site staff with sufficient technical knowledge to setup roller and roller-mounted GPS equipment and provide input to the research team in equipment operation during training and on the first day of the scheduled field data collection effort.
    b. Contact information of personnel with sufficient technical knowledge to assist the research team with technical questions during field-testing when on-site technical assistance is not available.

e) Provide the roller-mounted GPS receiver/radio and a separate base station. Prior to measurement passes during the training session, validate the GPS setup by using a survey grade hand-held GPS "rover" unit to ensure that the roller-mounted GPS is providing accurate positioning data.

f) Provide both the Engineer and LTRC with a copy of the RICM roller vendor software for viewing results.

g) All RICM rollers shall have the capability to continuously measure and record IC-MV and location parameters in an ASCII (American Standard Code for Information Interchange) format data file. Furnish to the Engineer and LTRC the vendor data file (hardcopy) and the electronic data file with information exported in a comma, colon, or space delimited ASCII file format before each subsequent measurement or compaction pass. As a minimum, the file transfer shall occur immediately following the compaction operations on each working day. The Engineer may request data at any time during RICM roller operations.

At a minimum, the following data shall be contained in the data files:

Machine Model, Type, and Serial/Machine Number
Drum Dimensions (Width and Diameter)
Roller and Drum Weights
File Name
Date Stamp
Time Stamp
RTK Based GPS position: XYZ Coordinates in Louisiana State Plane South Zone NAD 83
Roller Travel Direction (e.g., forward, reverse)
Pass Count
Rolling Speed
Vibration Setting (e.g., On or Off)
Vibration Amplitude
Vibration Frequency
Peak Vertical Amplitude (theoretical)
Indicator of Double Jumping
IC-MV
Automatic Feedback Control (e.g., On or Off)
Surface temperature (HMA)

h) Training. For the RICM roller(s) provide one-day classroom training and two working days of field training by the RICM equipment manufacturer and GPS provider to operators, LADOTD personnel, and LTRC. Include training on data and correlation analysis. Make available all personnel responsible for roller operations to attend training. Include training details in the RICM Work Plan. Coordinate the schedule with the Engineer and LTRC at least 1-week prior to training. The training location should be within relatively close proximity to the project as discussed during the preconstruction meeting. The measurement, recording, and GPS systems should be running and effective during training.

CONSTRUCTION REQUIREMENTS

a) RICM Work Plan: The Contractor will develop with the RICM vendor/manufacturer a project specific RICM work plan for the roller(s) to be used. Deliver three copies to the Engineer at least two weeks prior to the Pre-Construction Conference. Describe in the work plan the following information for the chosen roller(s):

1. Vendor information
2. Roller model,
3. Roller dimensions and weight,
4. Description of the RICM measurement system,
5. Description of the IC-MV,
6. Near continuous
    a. GPS capabilities,
    b. Data Documentation system,
    c. Temperature measurement system (for HMA)
7. Software information and capability
8. Operator display description (screen shots, parameters, etc.).

9. Roller data collection methods, including sampling rates, intervals, and data file types.
10. Data transfer procedures to the LADOTD and LTRC, including method, timing, and personnel responsible. Data transfer shall occur at a minimum of once per day or as directed by LADOTD and LTRC.
11. Training plan and schedule for roller operators, LADOTD and LTRC personnel; including both classroom and field training.
12. Communication protocol for informing the LTRC's point of contact concerning construction progress and schedule to facilitate research field-testing and data collection.
13. Evidence of IC-MV correlations with various in-situ point measurements including: density, Plate Load Test, Falling Weight Deflectometer, etc.

b) Operation. Operate the RICM roller according to manufacturer's recommendations and approved RICM Work Plan to provide reliable and repeatable operating settings. Record all data including roller operations forward and reverse directions. Ensure roller track overlap does not exceed 10 percent of the drum width during measurement passes.

1. Measurement Passes on Subgrade and Base layers.
   Keep vibration frequency and amplitude constant during roller operations during measurement passes.
   The RICM roller may be used for compaction of these layers throughout the project, but must be available for measurement passes.
2. Compaction of Asphalt layers.
   Keep vibration frequency and amplitude constant during roller operations for comparing successive passes as approved by LTRC.
   The RICM roller shall be utilized to compact the HMA layers in the breakdown position; and continuously record IC-MV, time, temperature, and GPS location of the roller at all times and passes. Contractor shall be responsible for setting roller patterns that will provide material that meets standard specifications.

c) Notification: Provide the Engineer and LTRC 24 hours coordination notice before starting measurement passes or compaction on HMA.

d) Measurement Passes: RICM rollers shall be used and available for all measurement passes within the designated test section area(s). Conduct full coverage (test section length by full pavement width) measurement passes with the RICM roller as specified in Table 3 and on the plans. Contact Engineer if over-compaction is observed.

Table 3
Layers to measure with RICM roller

	Layer	When to Measure	Roller
1	Embankment	Prior to Mixing	Subgrade or Base RICM
2	Cement Treated Subgrade	Day of Acceptance	Subgrade or Base RICM
3	Cement Treated Subgrade	7 days after compaction	Subgrade or Base RICM
4	Soil Cement Base Course	Day of Acceptance	Subgrade or Base RICM
5	Soil Cement Base Course	7 days after compaction	Subgrade or Base RICM
6	Superpave AC Binder Course	During Compaction	HMA RICM
7	Superpave AC Wearing Course	During Compaction	HMA RICM

1) Measurement Passes on Subgrade and Base layers: Measurement passes will shadow the normal acceptance process, and mirror the normal acceptance testing frequency by LADOTD (i.e. when a layer is complete and ready for acceptance). Measurement passes will occur at the top of each lift or layer of the cross section in the test section area(s) as defined in Table 3. Collect data as specified in Section Equipment. Type of roller passes may include:

a) RICM roller display NOT visible to (hidden from) the operator, to gauge normal procedure regarding pass coverage. Test areas are designated as L1 and R1 on the site plan.

b) RICM roller display of pass and IC-MV visible and available to the operator to assist roller operator' movement/pass coverage on layer. Test areas are designated as L2 and R2 on the site plan.

2) Compaction of Asphalt Layers: Measurement passes during HMA compaction in the test section area(s) will record IC-MV, time, temperature, and GPS location of the roller at all times and passes. Contractor shall be responsible for setting roller patterns that will provide material that meets standard specifications. Measurement passes will occur on HMA layers in the test section area(s) as defined in Table 3. Collect data as specified in the Equipment Section. Type of roller passes may include:

a) RICM roller display NOT visible to (hidden from) the operator, to gauge normal procedure regarding pass coverage. Test areas are designated as L1 and R1 on the site plan.

b) RICM roller display of pass and stiffness information visible and available to the operator during layer compaction to assist roller operator's pass coverage and compaction efforts on layer. Test areas are designated as L2 and R2 on the site plan.

e) Shadow Testing: LTRC will shadow the normal acceptance process and conduct research test when a layer is ready for acceptance. Coordination with the Engineer and LTRC shall include notification 24 hours prior to acceptance testing. LTRC may conduct additional testing using LTRC equipment.

1) Time Frame

Shadow testing by LTRC will occur during normal QA testing timeframe per layer acceptance. LTRC field tests in the test section areas are generally quick and self-sufficient.

2) Tests and Equipment

LTRC field tests in the test section areas will include but will not be limited to the following at the time of acceptance: DCP, moisture-density tests, light falling weight deflectometer (LFWD), falling weight deflectometer (FWD), Dynaflect, GeoGauge, plate load tests (PLT), and Portable Seismic Property Analyzer (PSPA), and Asphalt Cores. Most tests are quick (several minutes) and will be performed simultaneously by LTRC groups (pavement, geotechnical, LSU).

Certain sensors, such as pressure cells and bender elements, may be installed within subgrade and base layers by LTRC research team. Assist LTRC with the installation of instrumentation (wire trench, dig pressure plate hole, etc.)

LTRC will work in-concert with the contractor to find a suitable location for any sensors or equipment. The contractor shall use caution when performing any work near the instrumentation. The contractor will be responsible for the replacement, repair, and installation of any instrumentation that may be damaged by his equipment.

3) Research Support

Provide a minimum 15-Ton reaction vehicle for plate load tests (PLT) at the time of acceptance. The plate load (ASTM D1195) is a stationary test that takes about 2 hours. Three to five PLTs will be conducted per layer per test section.

MEASUREMENT. RICM equipment, support, and measurement passes and compaction passes in the test section areas will be paid as a lump sum items.

PAYMENT. RICM equipment and support will be paid for at the lump sum contract price for providing assistance for the implementation of the research project as described herein. Payment will be full compensation for materials, equipment, fuel, operators, electricity, and delay during testing program, site preparation, utilization of GPS System, water tank, discing to control moisture, content, or any other services required for progress of the RICM research program.

PAYMENT:

a) Payment for Soil and Base Measurement Passes and HMA Compaction Passes will be the lump sum contract price.

b) Payment is full compensation for all work associated with providing RICM equipped rollers, transmission of electronic data files, two copies of RICM equipment manufacturer software, training, and preparing and maintaining work space for LADOTD/LTRC vehicles. Partial Payments will be made as follows:

1) After mobilization of the RICM roller onsite and equipment training, 50 percent of the lump sum bid price.

2) The remaining 50 percent will be paid based on acceptance of the final data.

c) Delays due to GPS satellite reception of signals to operate the RICM equipment or RICM rollers will not be considered justification for contract modifications or contract extensions.

Payment will be made under:

Item No.	**Pay Item**	**Pay Unit**
NS-DEV-60304	Roller Intelligent Compaction Monitoring (RICM) Subgrade and Base	Lump Sum
NS-DEV-60305	Roller Intelligent Compaction Monitoring Asphalt	Lump Sum

APPENDIX B

APPENDIX B, Notes from Meeting with SHRP2 Personnel

Appendix B

SHRP2 R-07 Performance Specification LTRC Demonstration Project: Application of Intelligent Compaction (IC) and Mechanistic-Based Point Measurement Technologies in a New Statistical Acceptance Framework

[Updated 5/18/10]

Objectives

Demonstrate SHRP2 R-07 performance specifications for rapid renewal using non-destructive IC technology and mechanistic-based in situ point measurements on a new pavement section including subgrade, subbase, and HMA layers.

Establish the value of using IC and mechanistic-based point measurement technologies for rapid renewal projects by benchmarking against sections built using standard construction techniques. The objectives would be to:

- Improve value and reduce frequency of traditional sampling required through improved construction process control and resulting uniformity,
- Real time quality control of compaction operations to accelerate construction and reduce re-work, and
- Evaluate the potential for using IC data for acceptance and linking to properties that relate more directly to design (e.g. modulus) and in-service performance.

Develop field data collection and evaluation expertise in light of a newly proposed statistical framework.

Establish long-term monitoring sections for LTRC to document impact of implementing these technologies and specification approach.

LTRC Team

Identify Project Scope to include subgrade, subbase, and HMA pavement construction.

- Foundation (Sub-base and Base) and Pavement construction test sections performed in the same construction season.
- Baseline (standard) specifications and test procedures.

Provide LTRC/DOTD Staffing and testing equipment for benchmarking evaluations

Three test sections approximately 1000 to 2000ft/section (each section would contain at least 2 lanes and shoulders). Two sections would use IC technology and various mechanistic-based point measurements. The remaining sections would use standard construction techniques and serve as the control section. All three sections would be constructed using similar materials and layer thickness/properties.

The parallel evaluation testing for Soils, Subbase, and HMA would require the following:

- Soils/Subbase
  - DCP – One per100 ft. minimum on two lines = 40 tests/section.
  - Moisture – Same locations as DCP
  - FWD – Same locations as DCP
  - LWD – Same locations as DCP
  - Other mechanistic (e.g.CPT, GeoGauge, etc.) for comparison
- HMA
  - Cores – Same locations (2 cores/600tons)
  - FWD - Same locations/lift
  - Mat and surface temperature

Attend FHWA IC demonstration http://www.intelligentcompaction.com/index.php?q=node/13

APPENDIX C

APPENDIX C, Screen Shots of Subgrade MDP activity

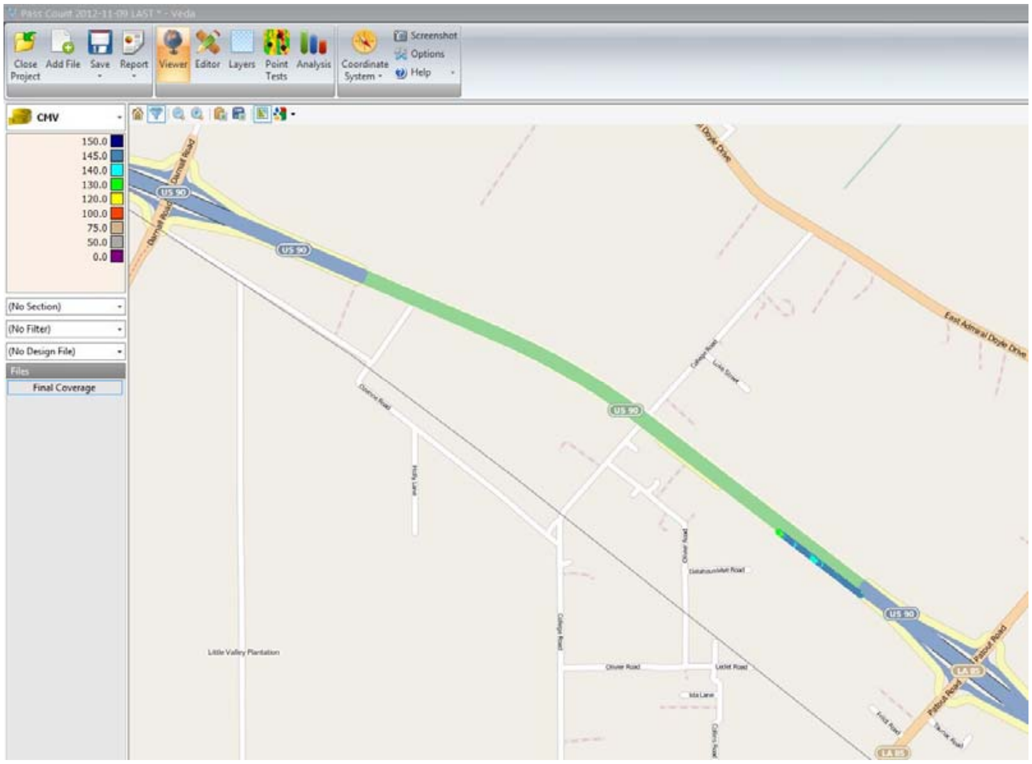


Figure 71
Subgrade MDP map from Veda – 11/09/2012

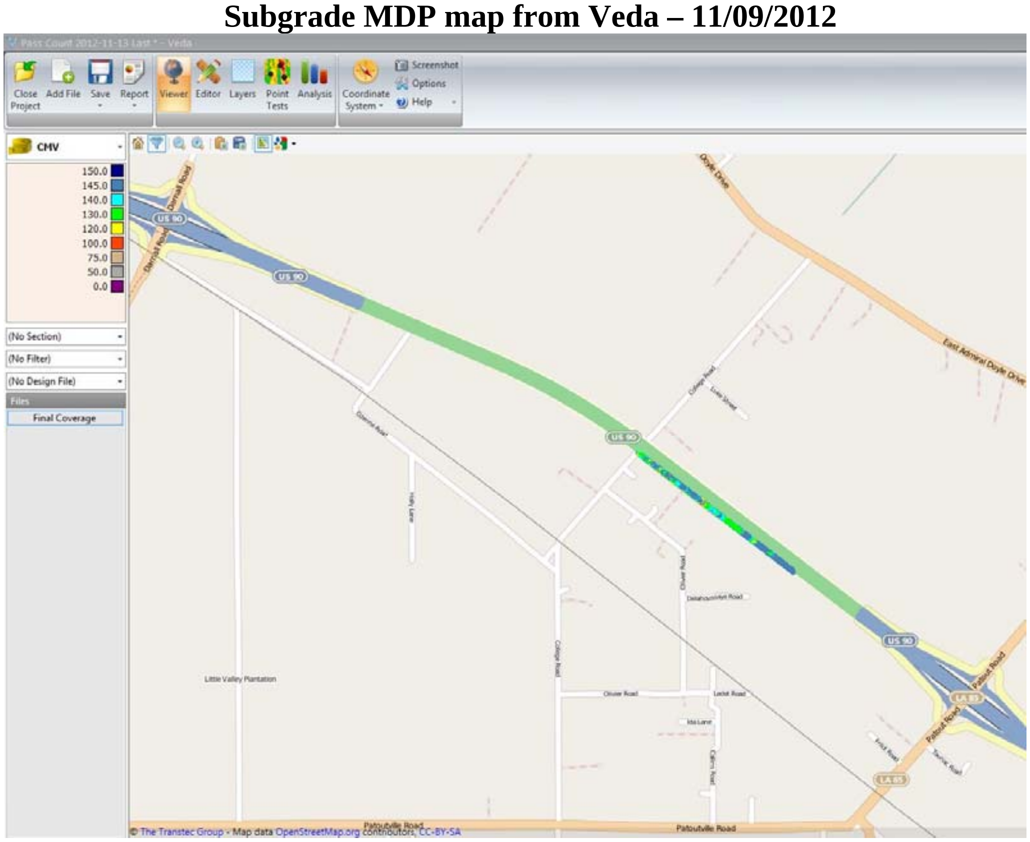


Figure 72
Subgrade MDP map from Veda – 11/13/2012

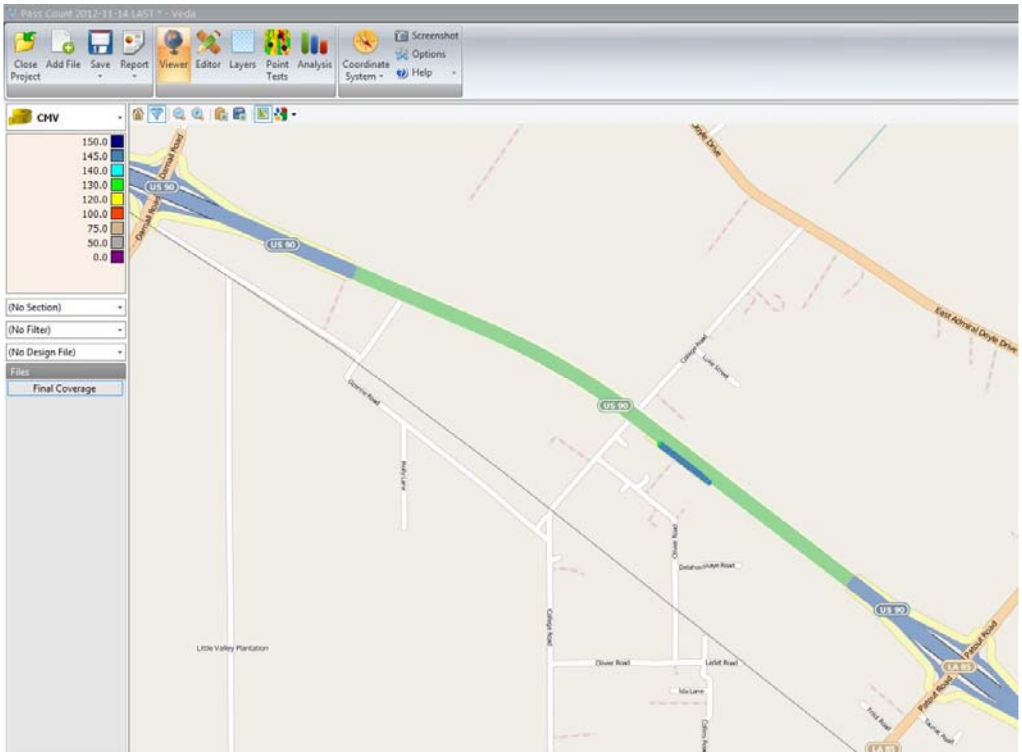


Figure 73
Subgrade MDP map from Veda – 11/14/2012

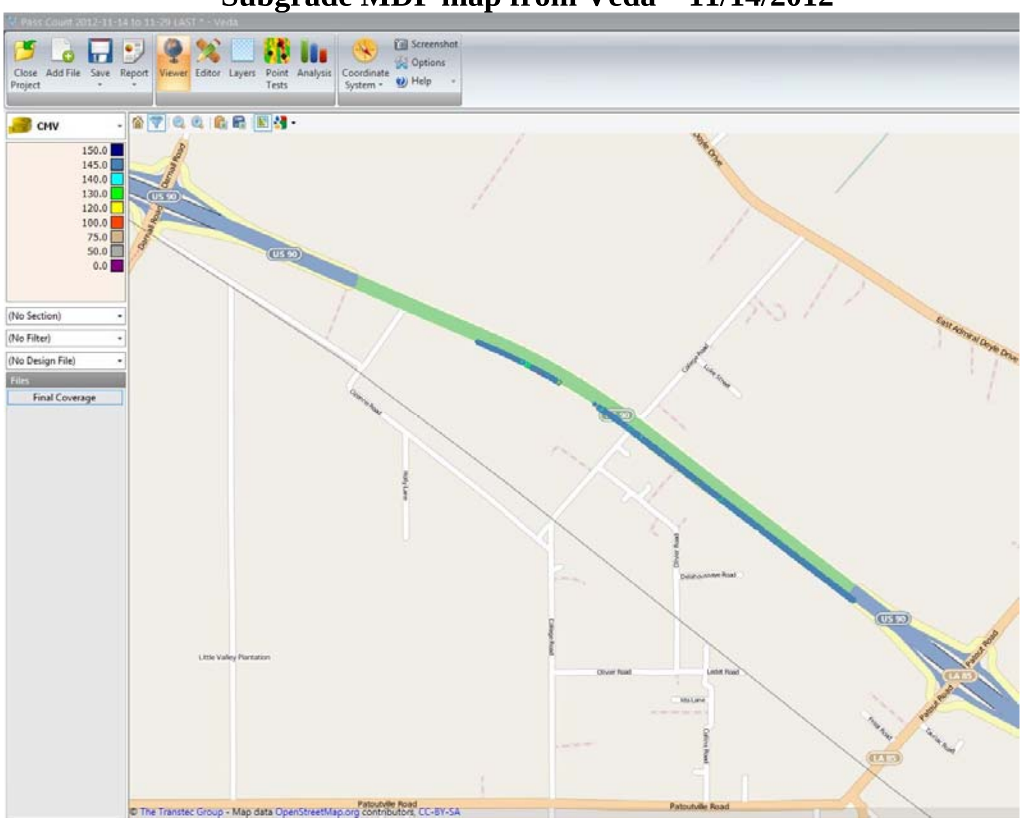


Figure 74
Subgrade MDP map from Veda – 11/14 to 11/29/2012

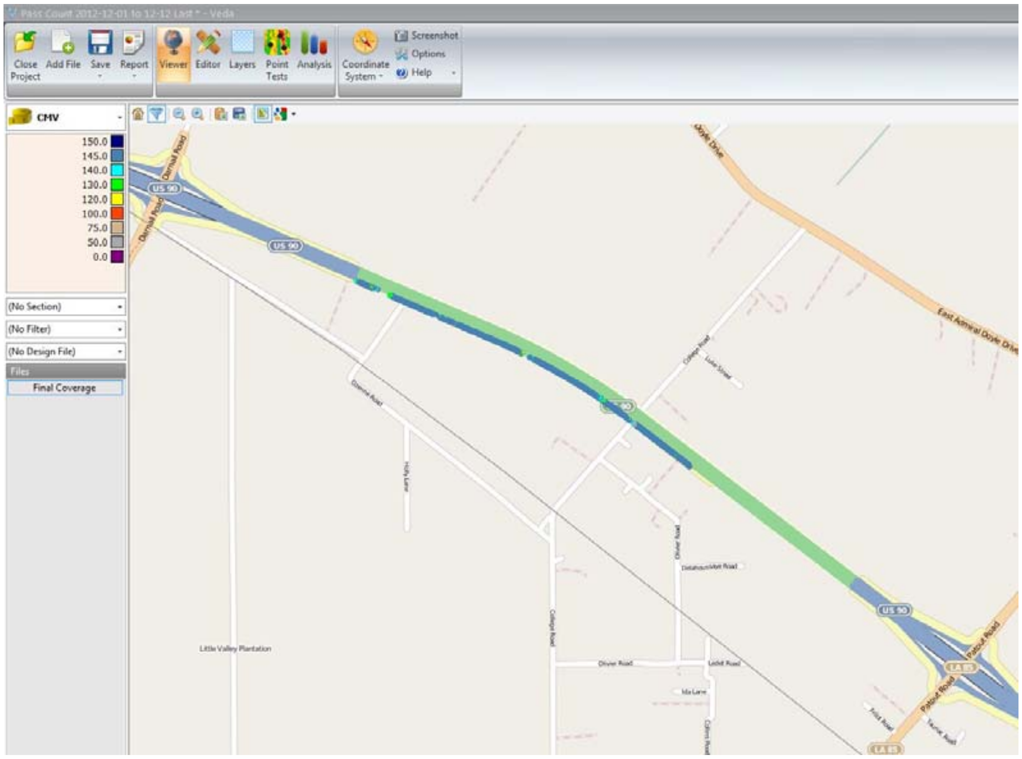


Figure 75
Subgrade MDP map from Veda – 12/01 to 12/12/2012

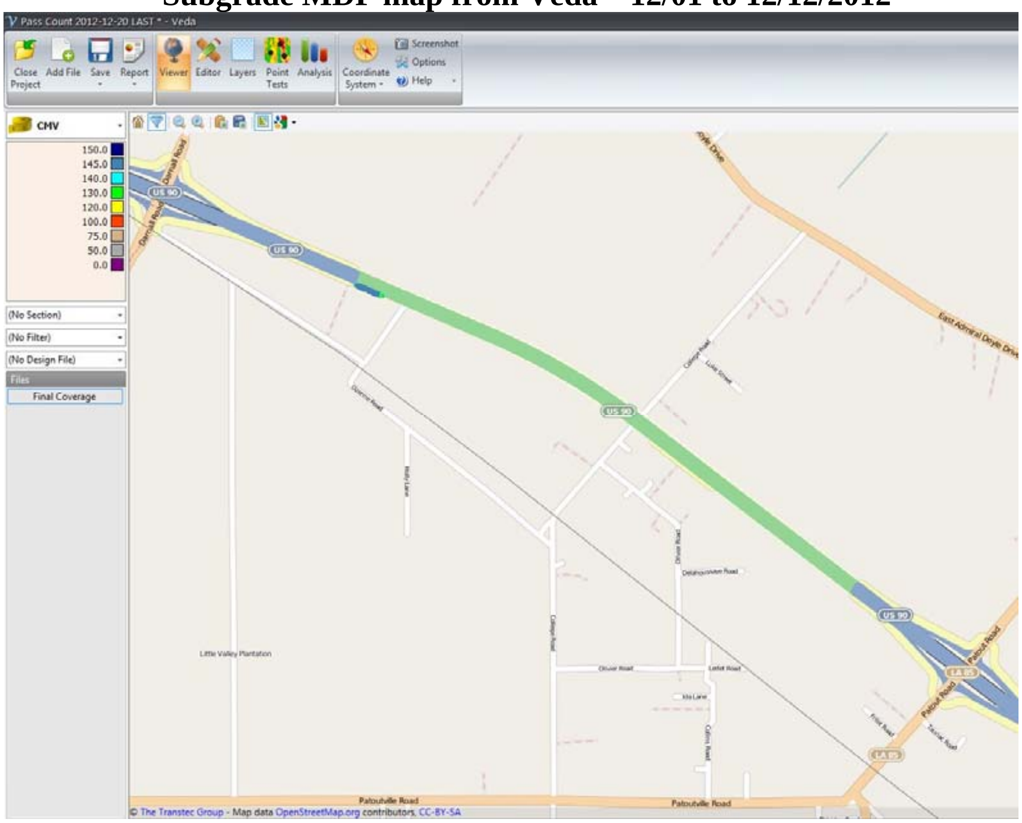


Figure 76
Subgrade MDP map from Veda – 12/20/2012

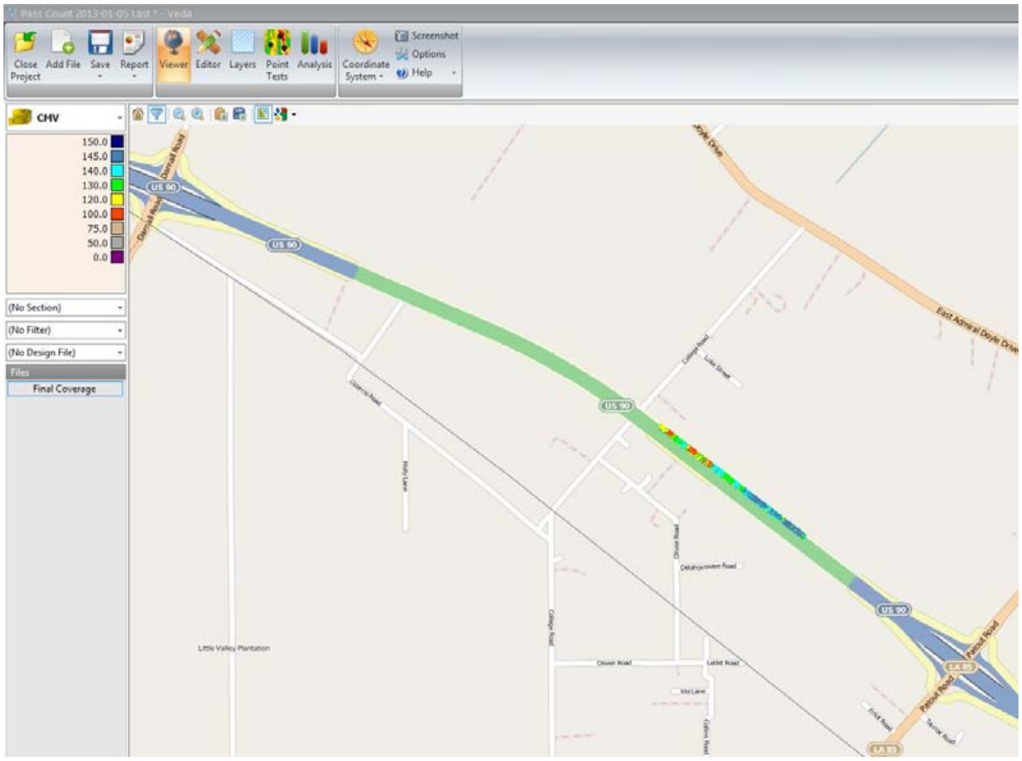


Figure 77
Subgrade MDP map from Veda – 01/05/2013

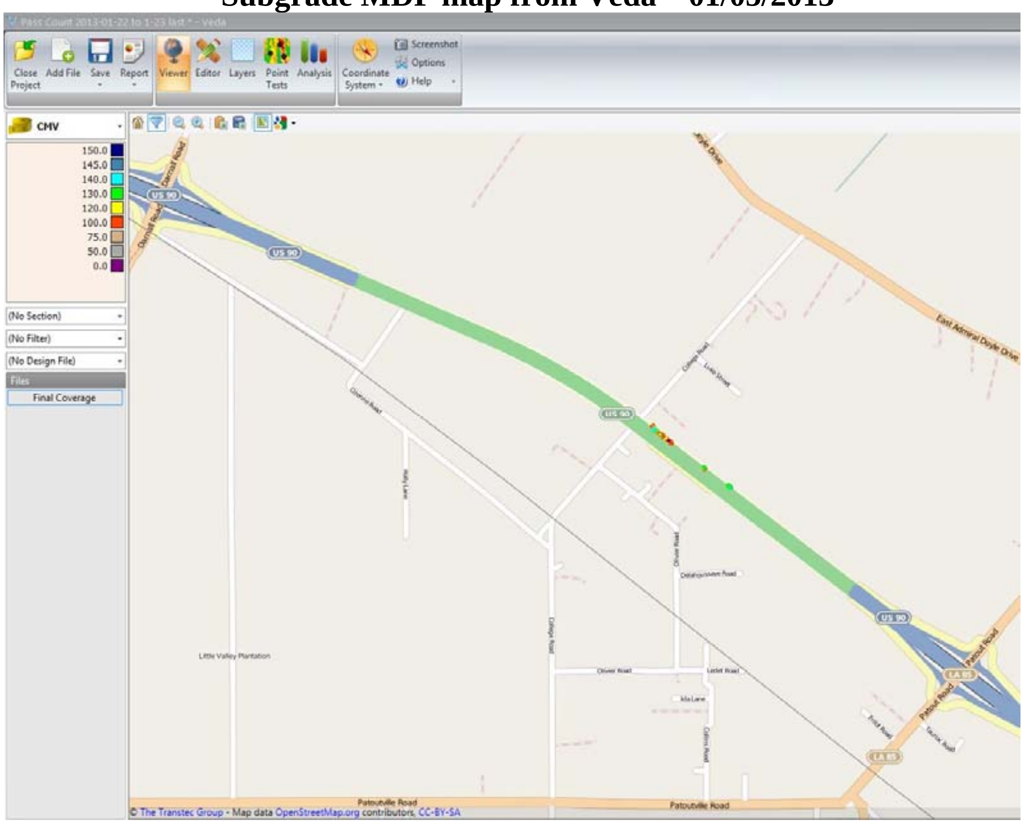


Figure 78
Subgrade MDP map from Veda – 01/22 to 01/23/2013

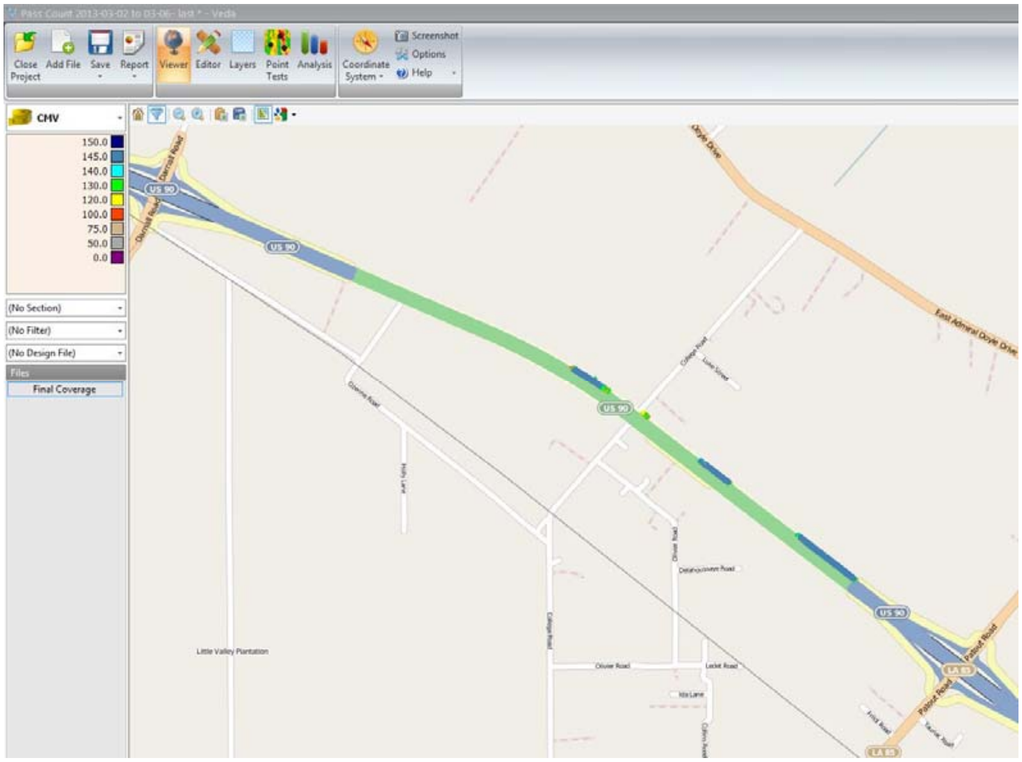


Figure 79
Subgrade MDP map from Veda – 03/02 to 03/06/2013

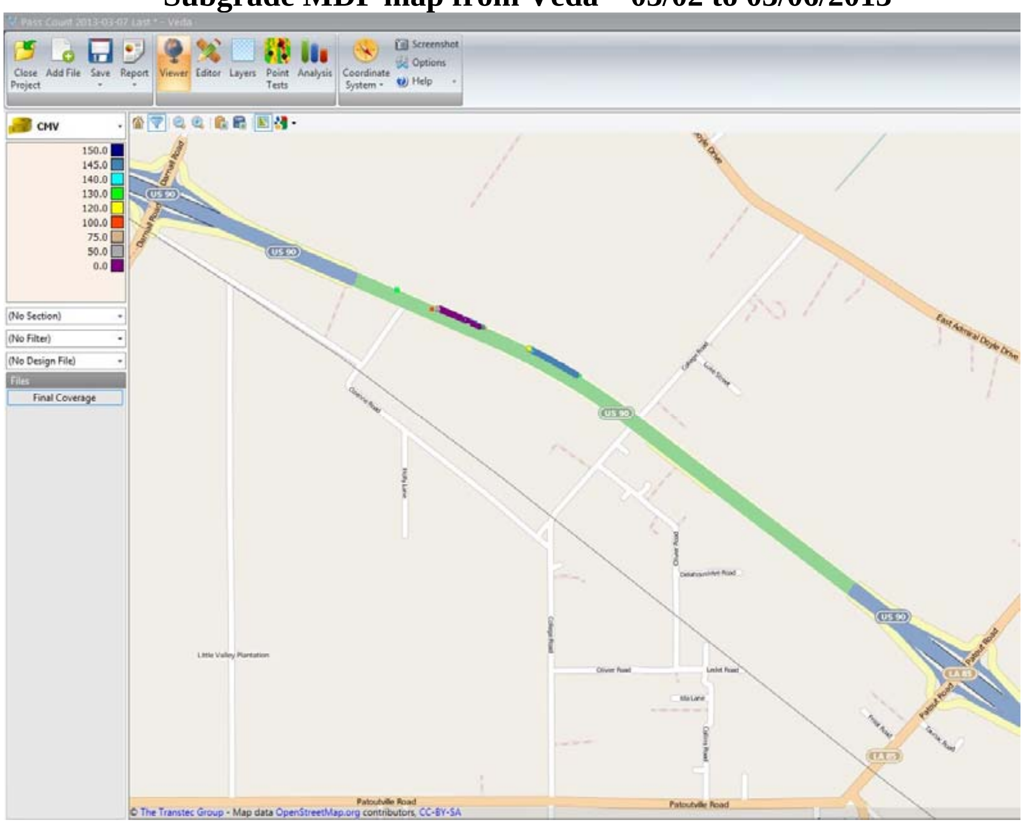


Figure 80
Subgrade MDP map from Veda – 03/07/2013

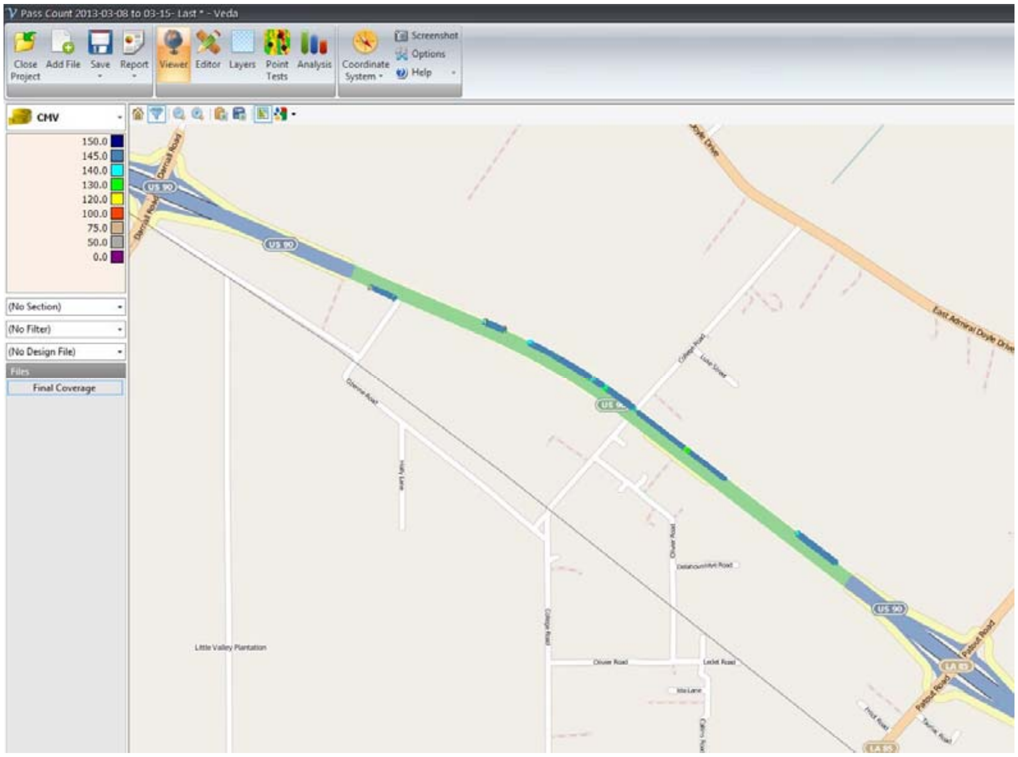


Figure 81
Subgrade MDP map from Veda – 03/08 to 03/15/2013

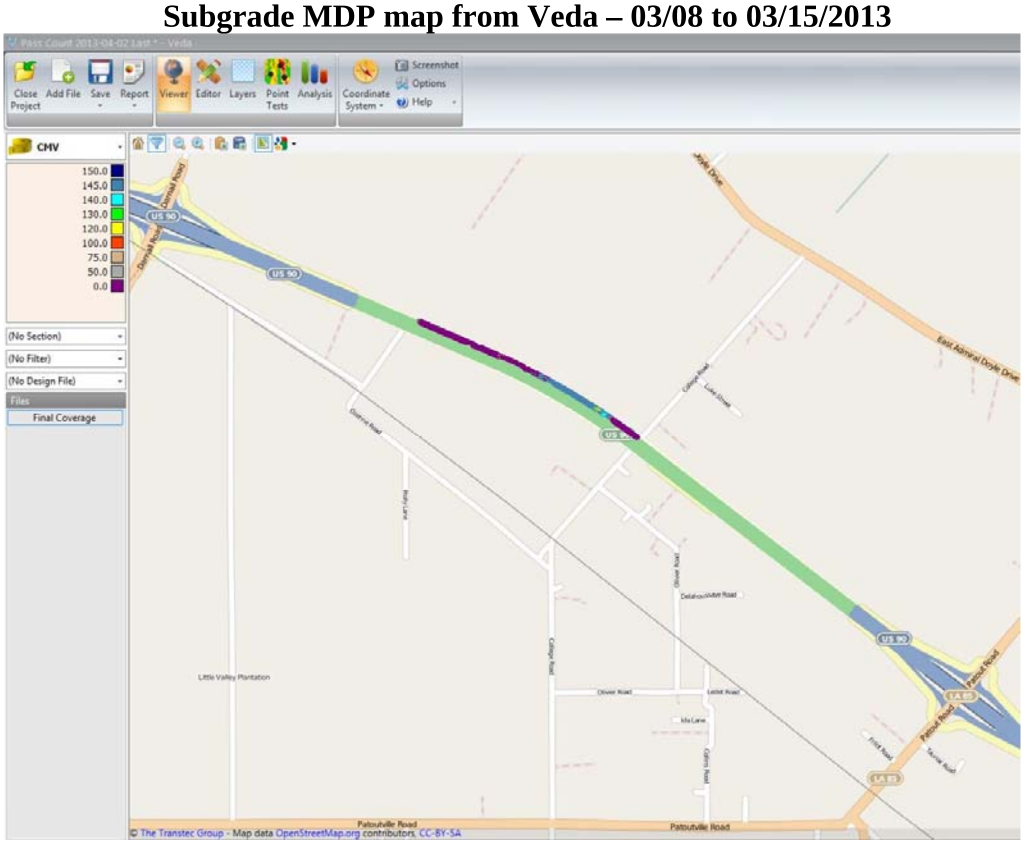


Figure 82
Subgrade MDP map from Veda – 04/02/2013

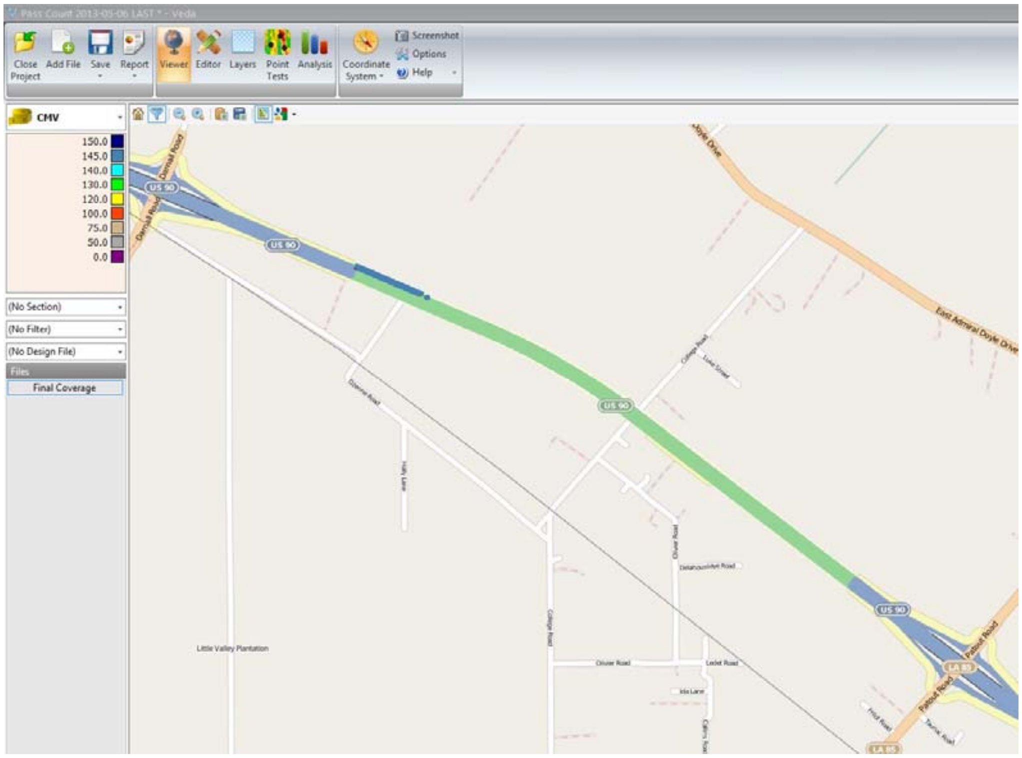


Figure 83
Subgrade MDP map from Veda – 05/06/2013

APPENDIX D

APPENDIX D, Screen Shots of Base Course MDP activity

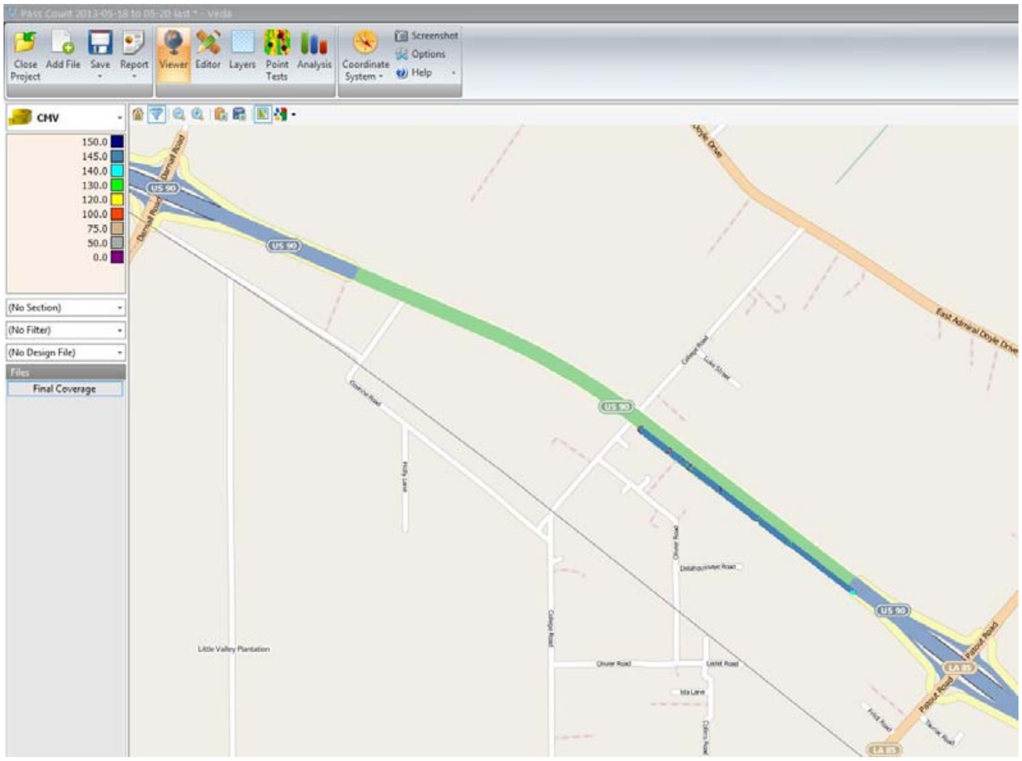


Figure 84
Base MDP map from Veda – 05/18-20/2013

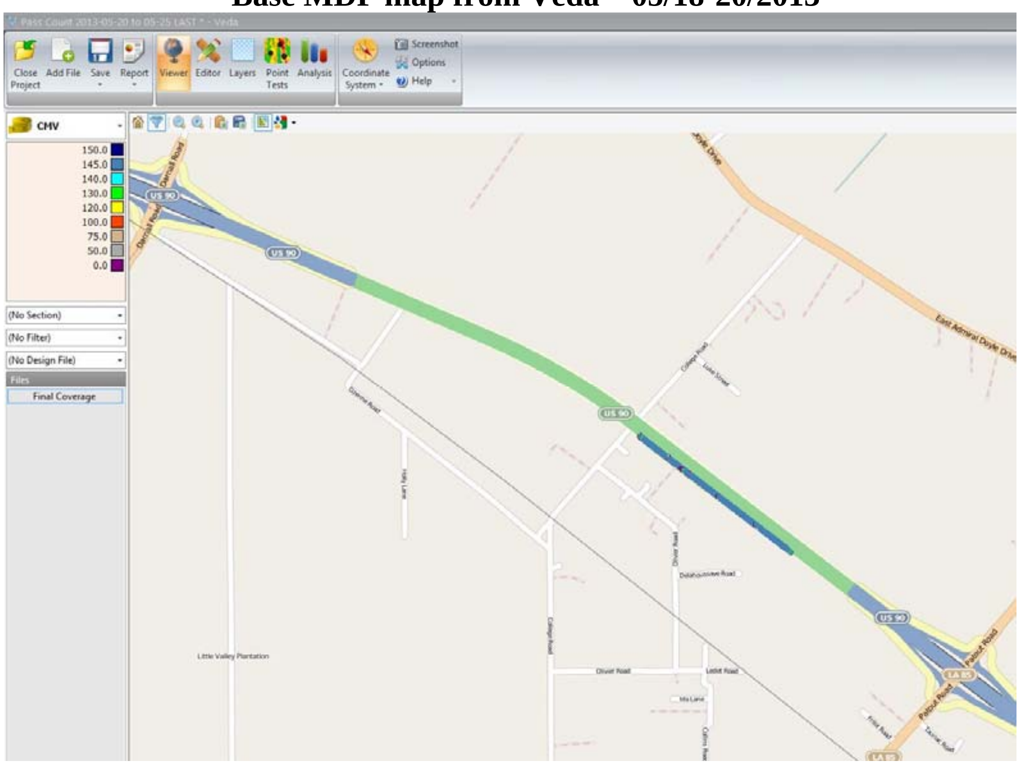


Figure 85
Base MDP map from Veda – 05/20-25/2013

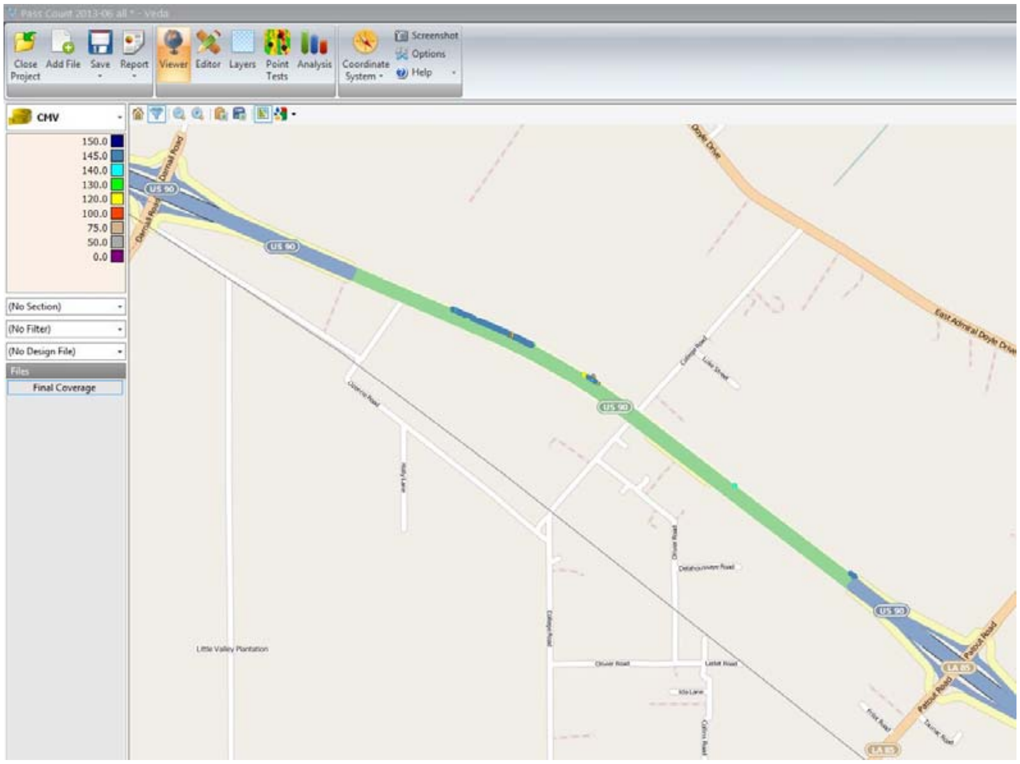


Figure 86
Base MDP map from Veda – 06/3/02 to 06/30/2013

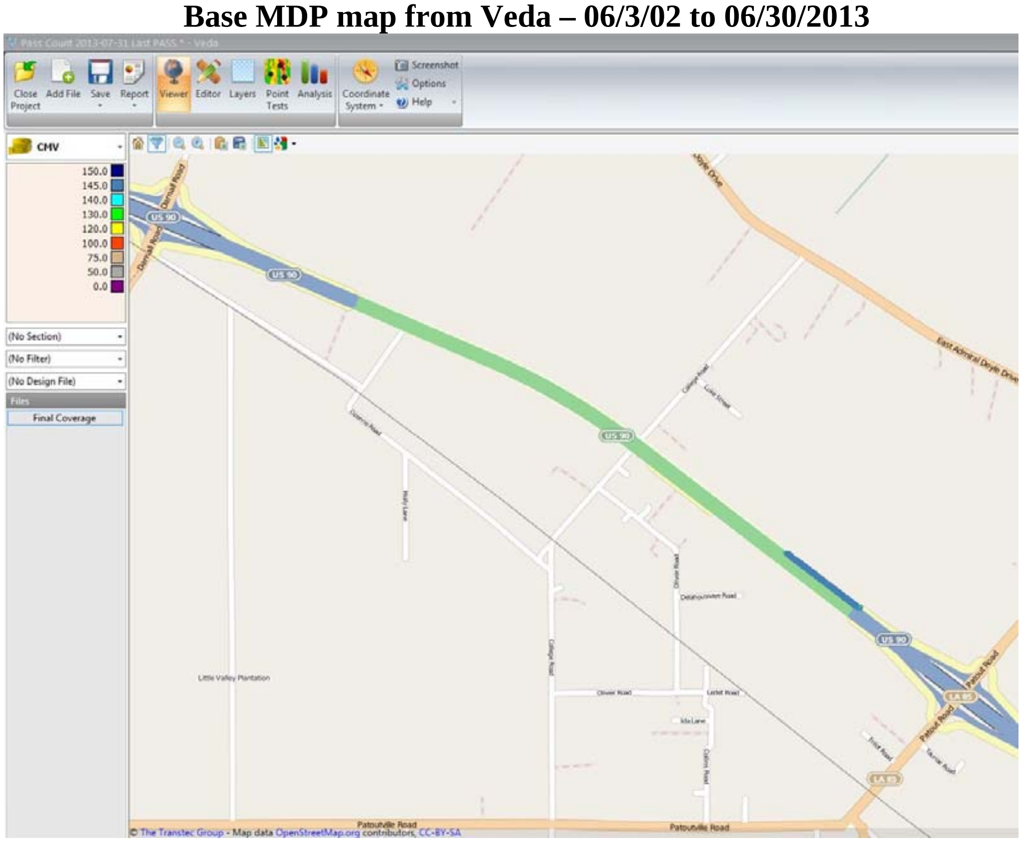


Figure 87
Base MDP map from Veda – 07/31/2013

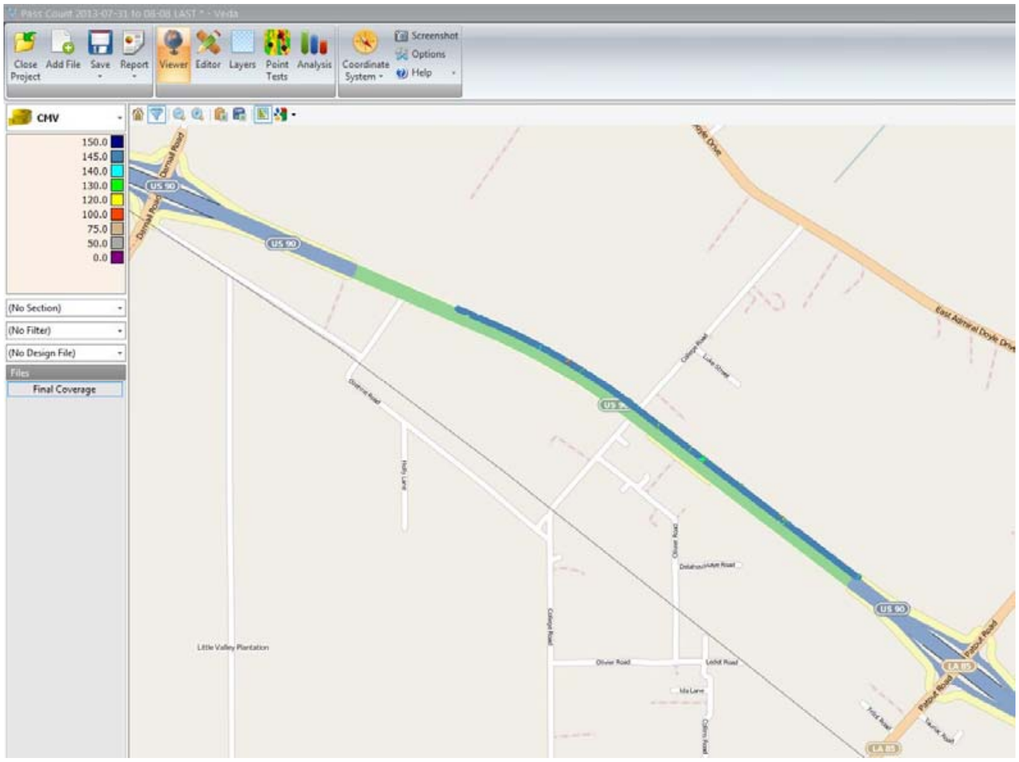


Figure 88
Base MDP map from Veda – 07/31 to 08/08/2013

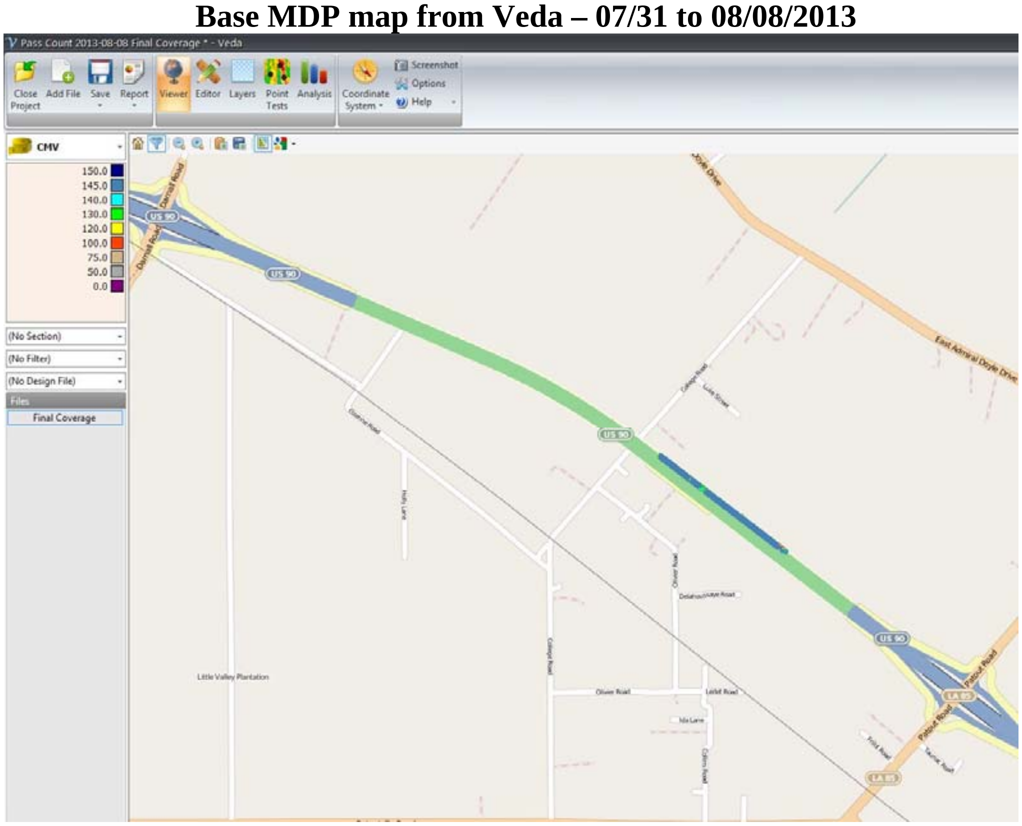


Figure 89
Base MDP map from Veda – 08/08/2013

APPENDIX E

APPENDIX E, Screen Shots of Binder activity

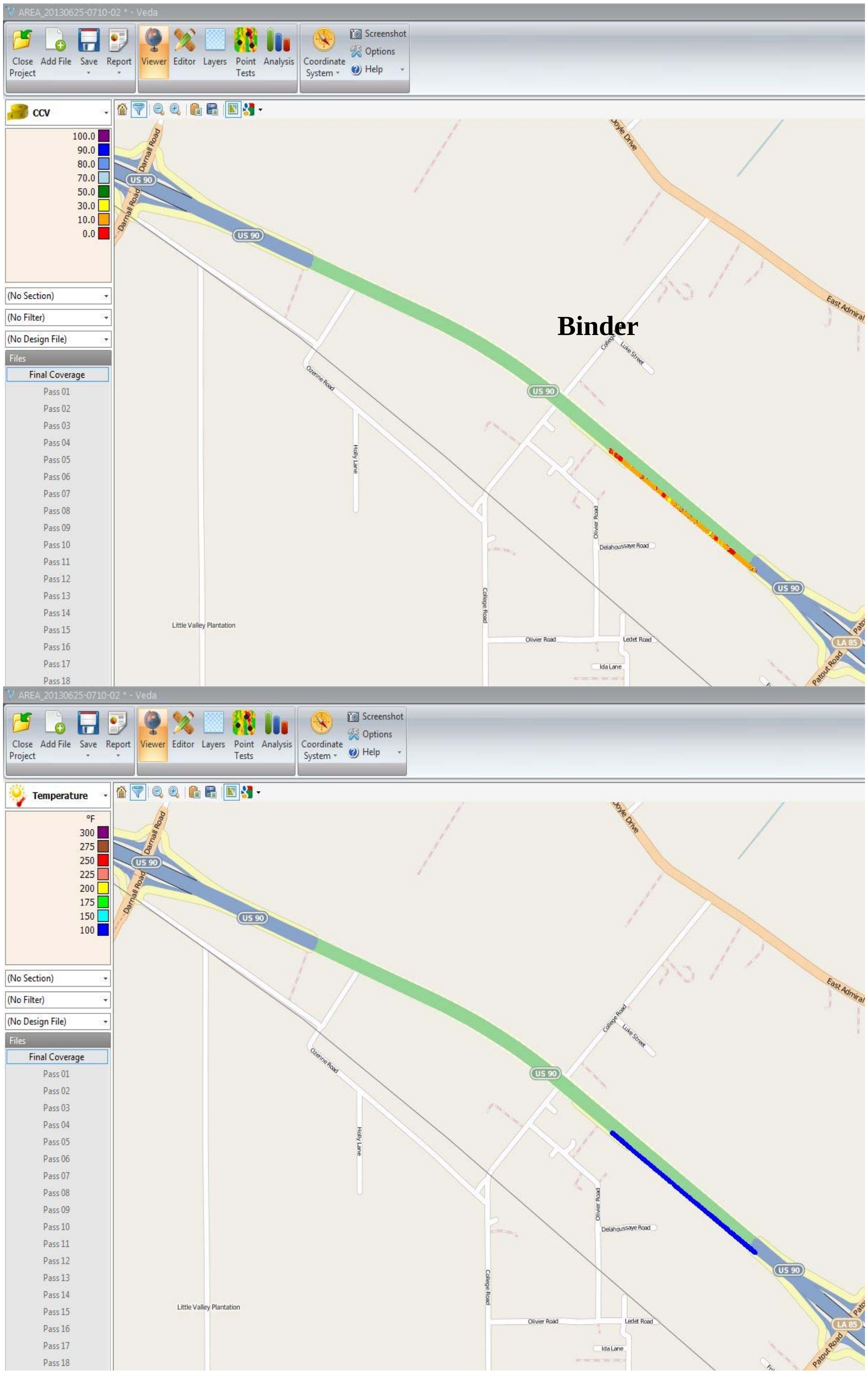


Figure 90
Binder CCV and Temperature map from Veda – 6/25/2013-0710

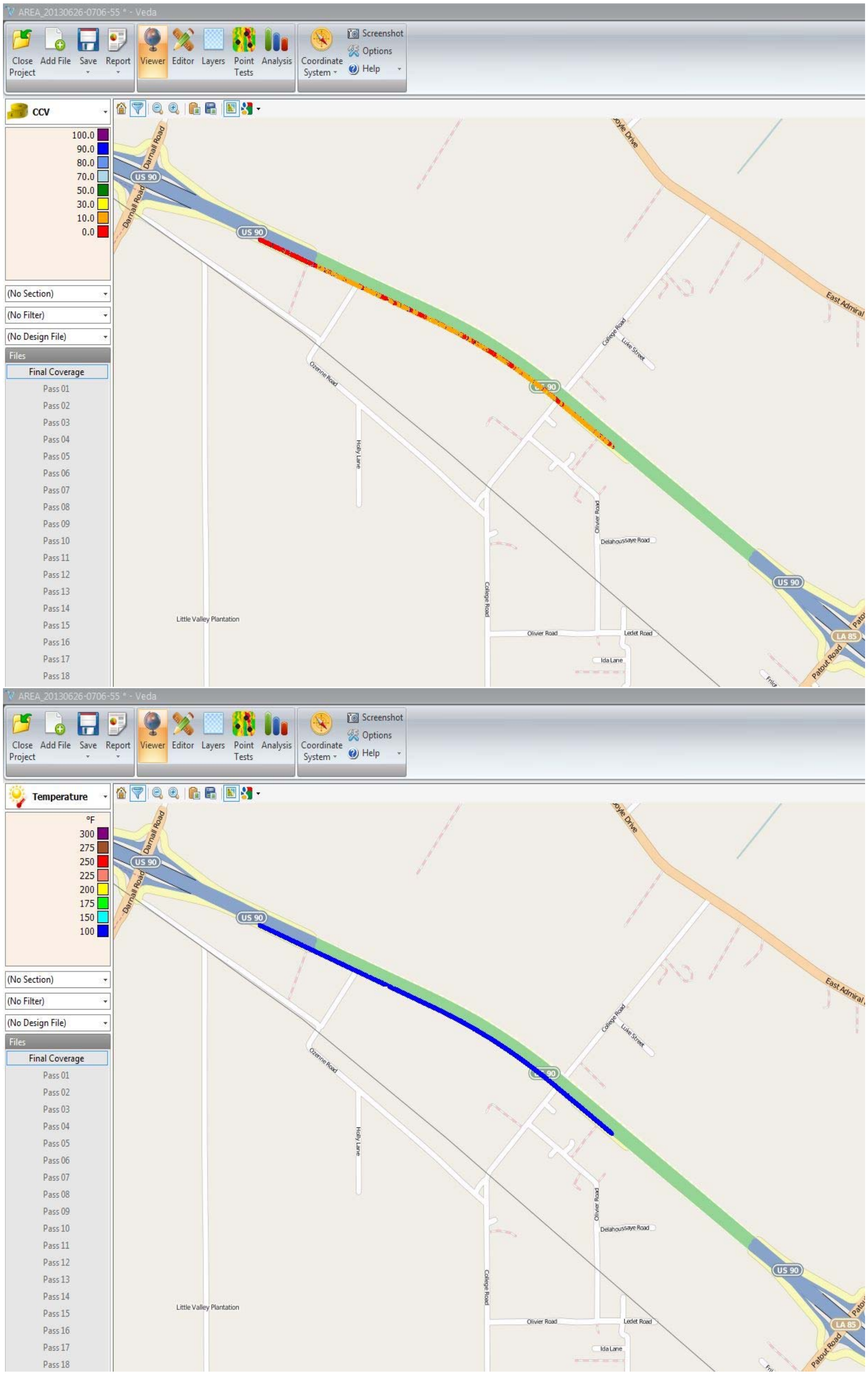


Figure 91
Binder CCV and Temperature map from Veda – 6/26/2013-0706

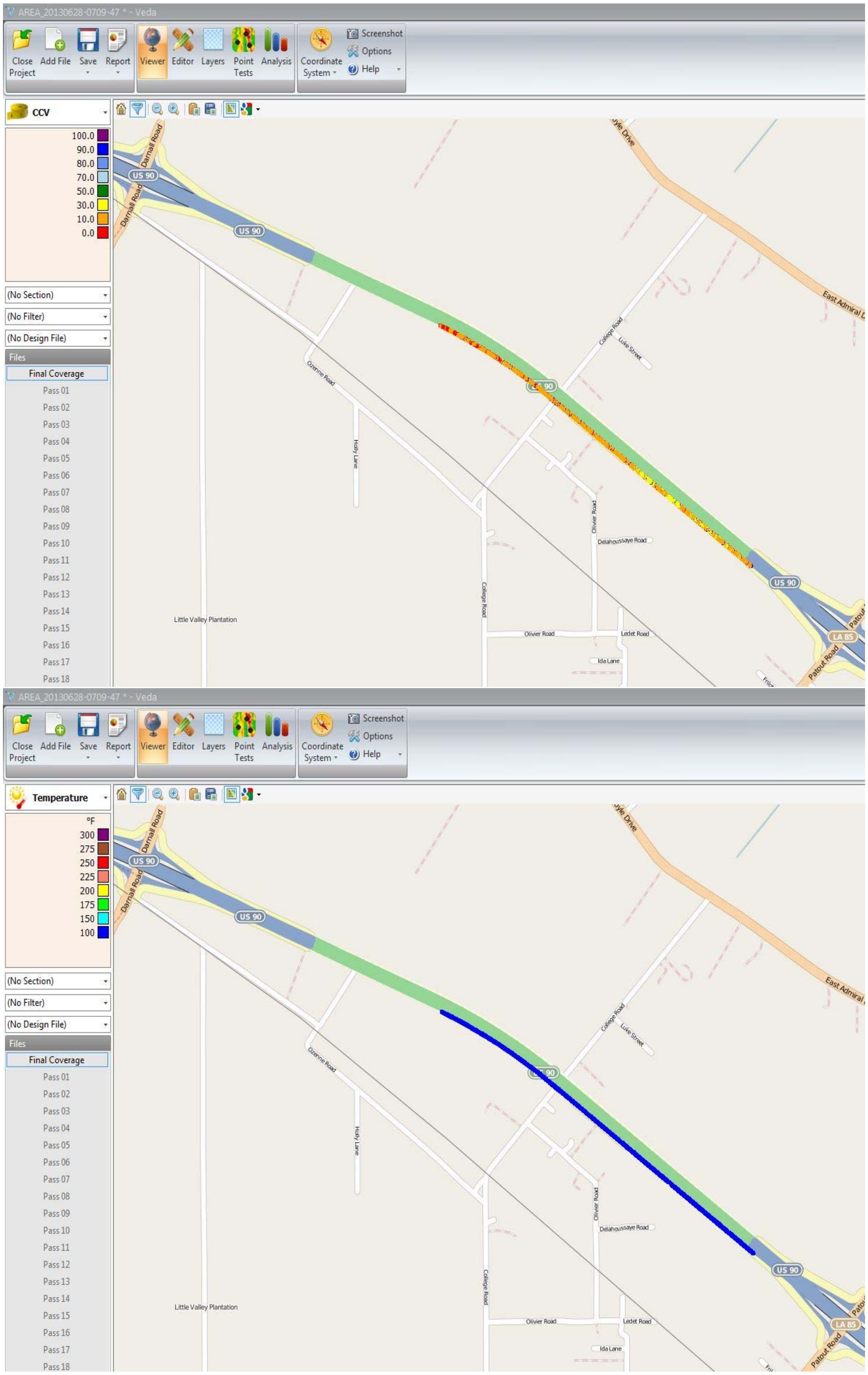


Figure 92
Binder CCV and Temperature map from Veda – 6/28/2013-0709

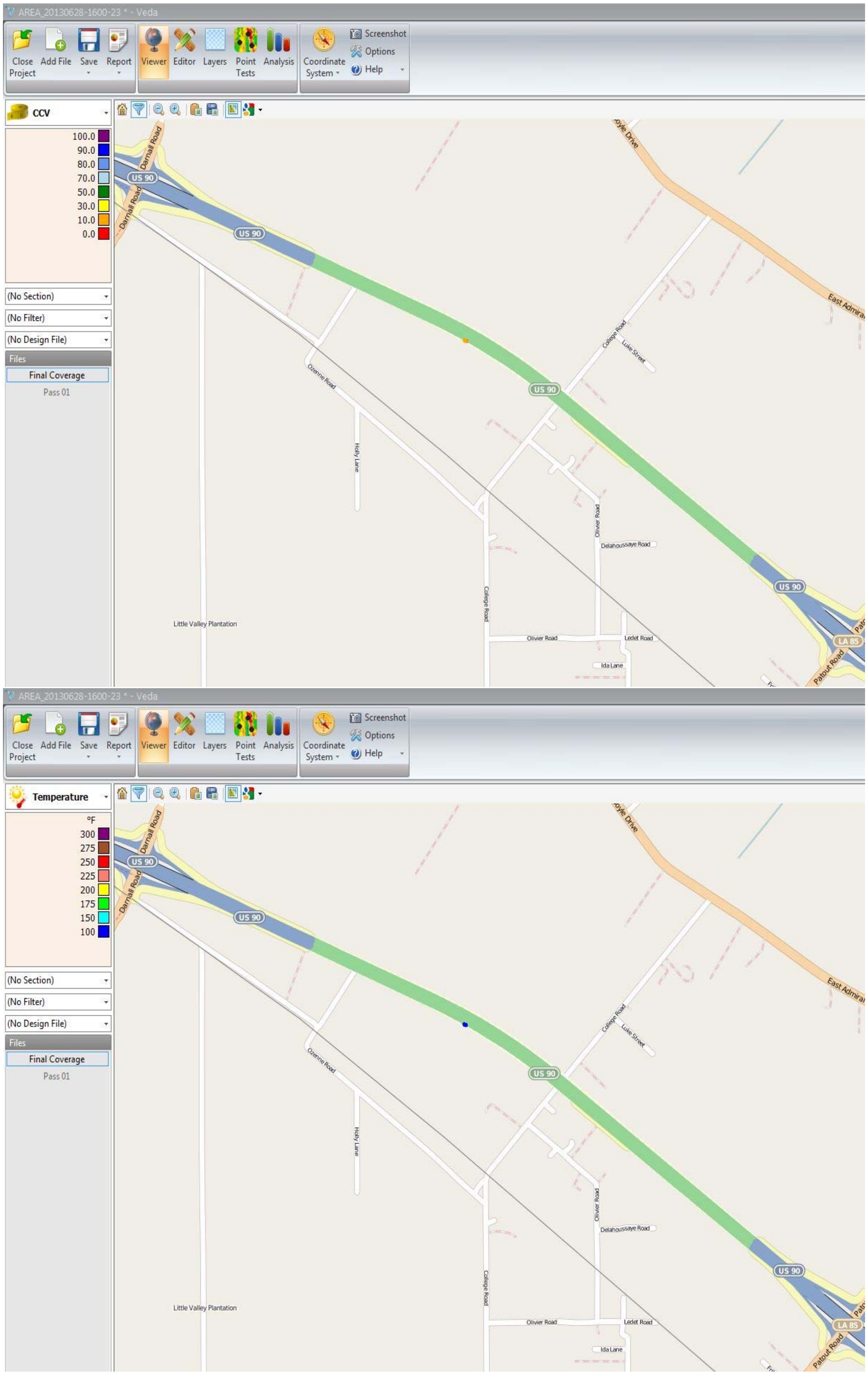


Figure 93
Binder CCV and Temperature map from Veda – 6/28/2013-1600

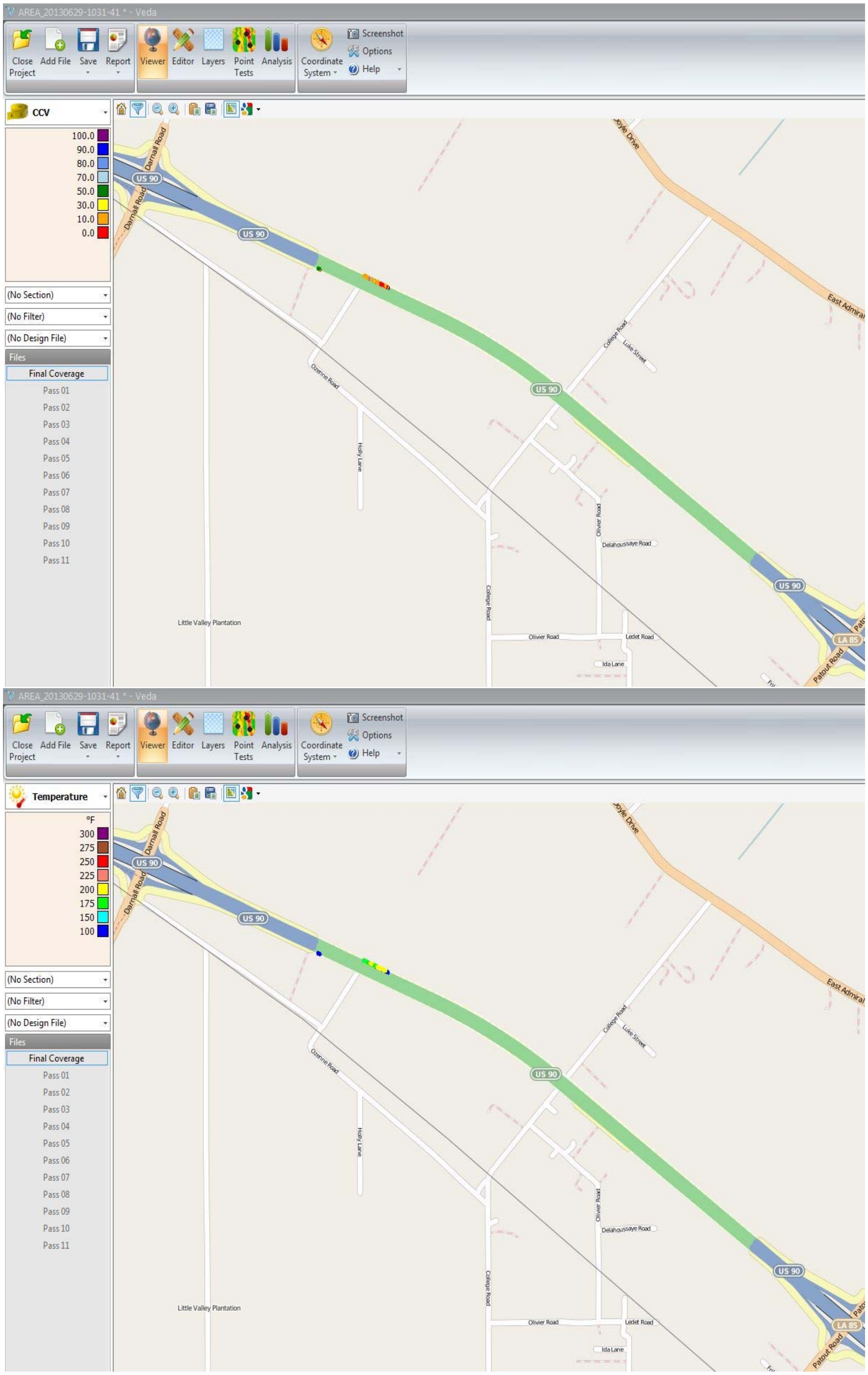


Figure 94
Binder CCV and Temperature map from Veda – 6/29/2013-1031

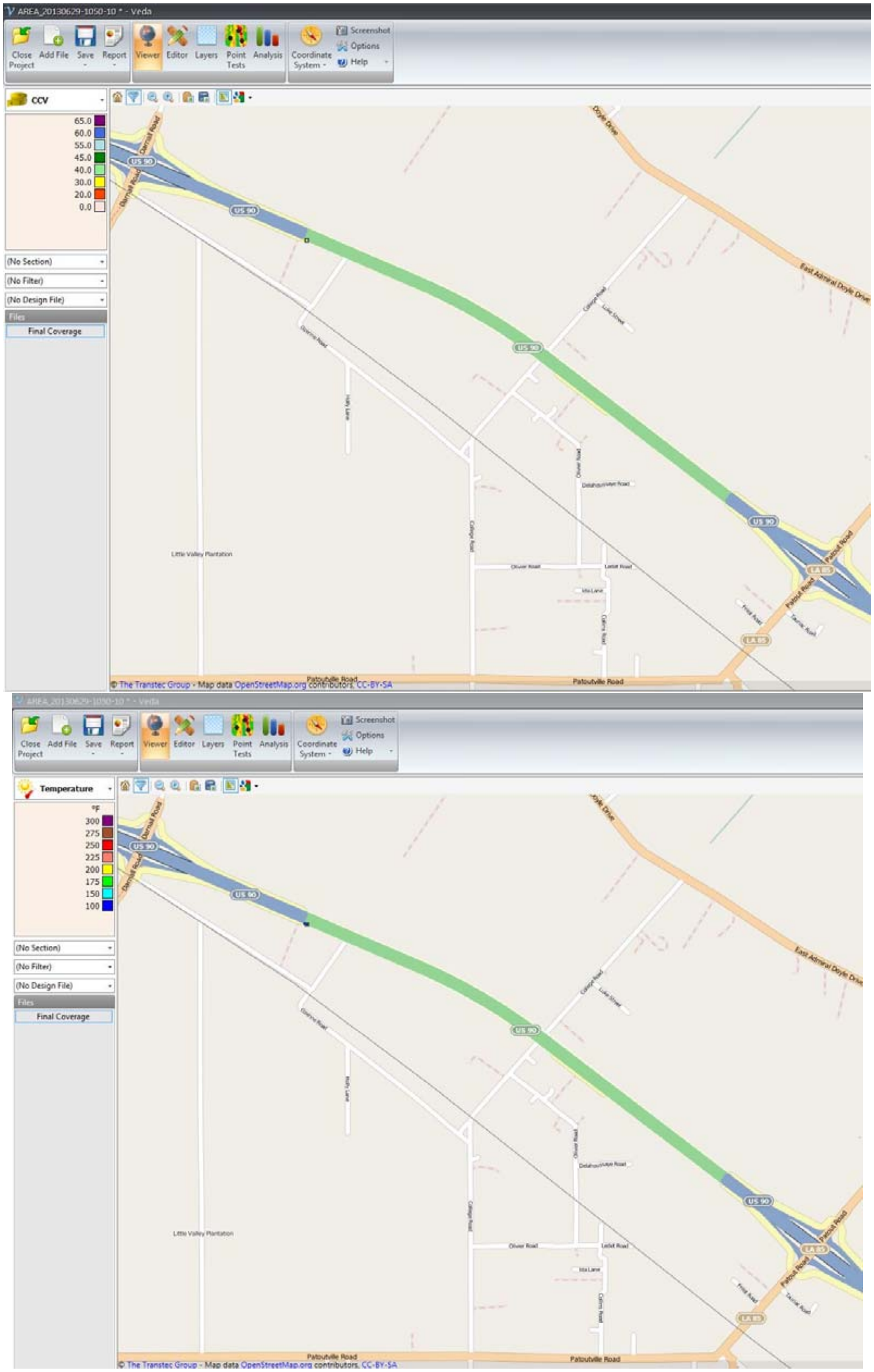


Figure 95
Binder CCV and Temperature map from Veda – 6/29/2013-1050

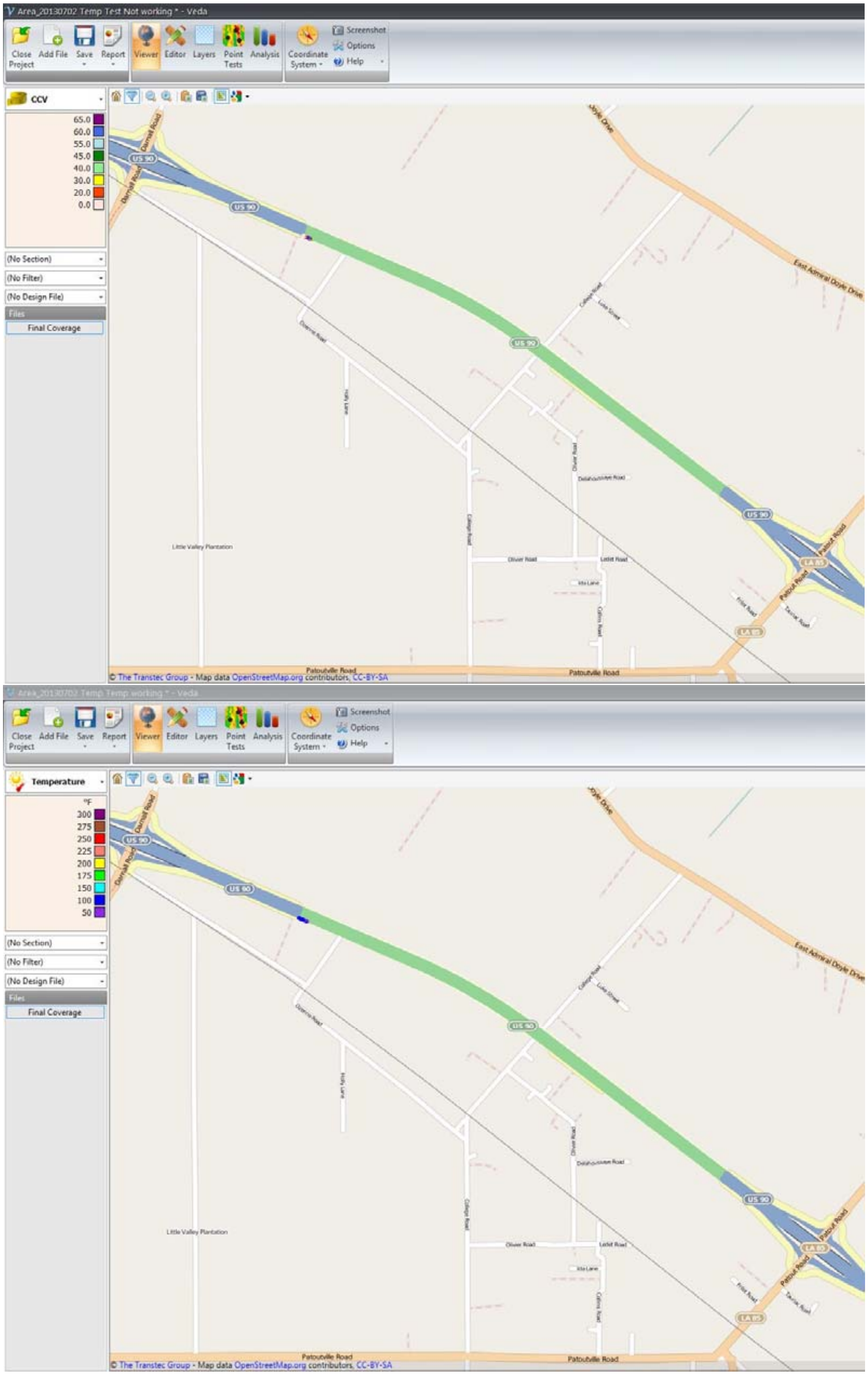


Figure 96
Binder CCV and Temperature map from Veda – 7/2/2013

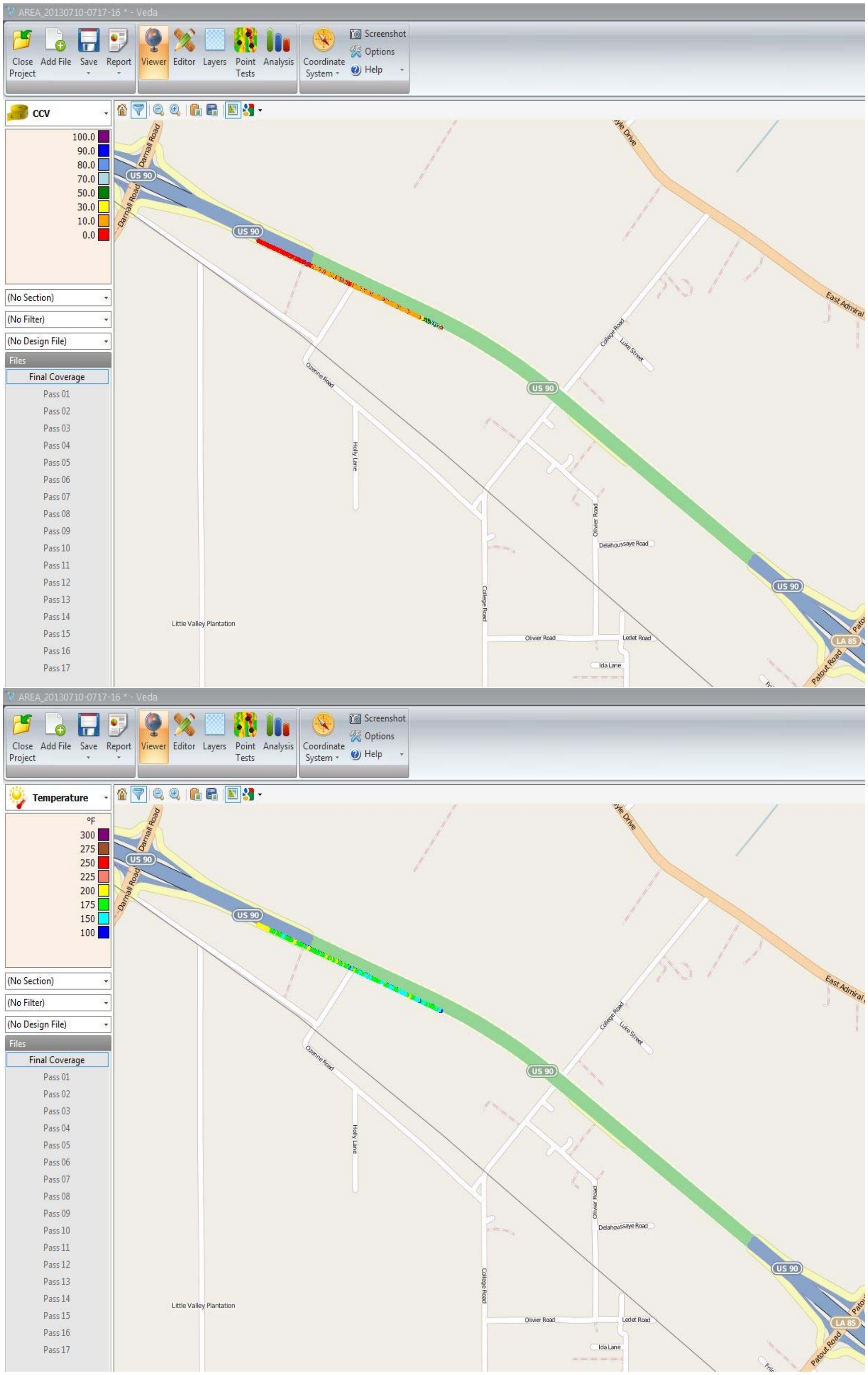


Figure 97
Binder CCV and Temperature map from Veda – 7/10/2013-0717

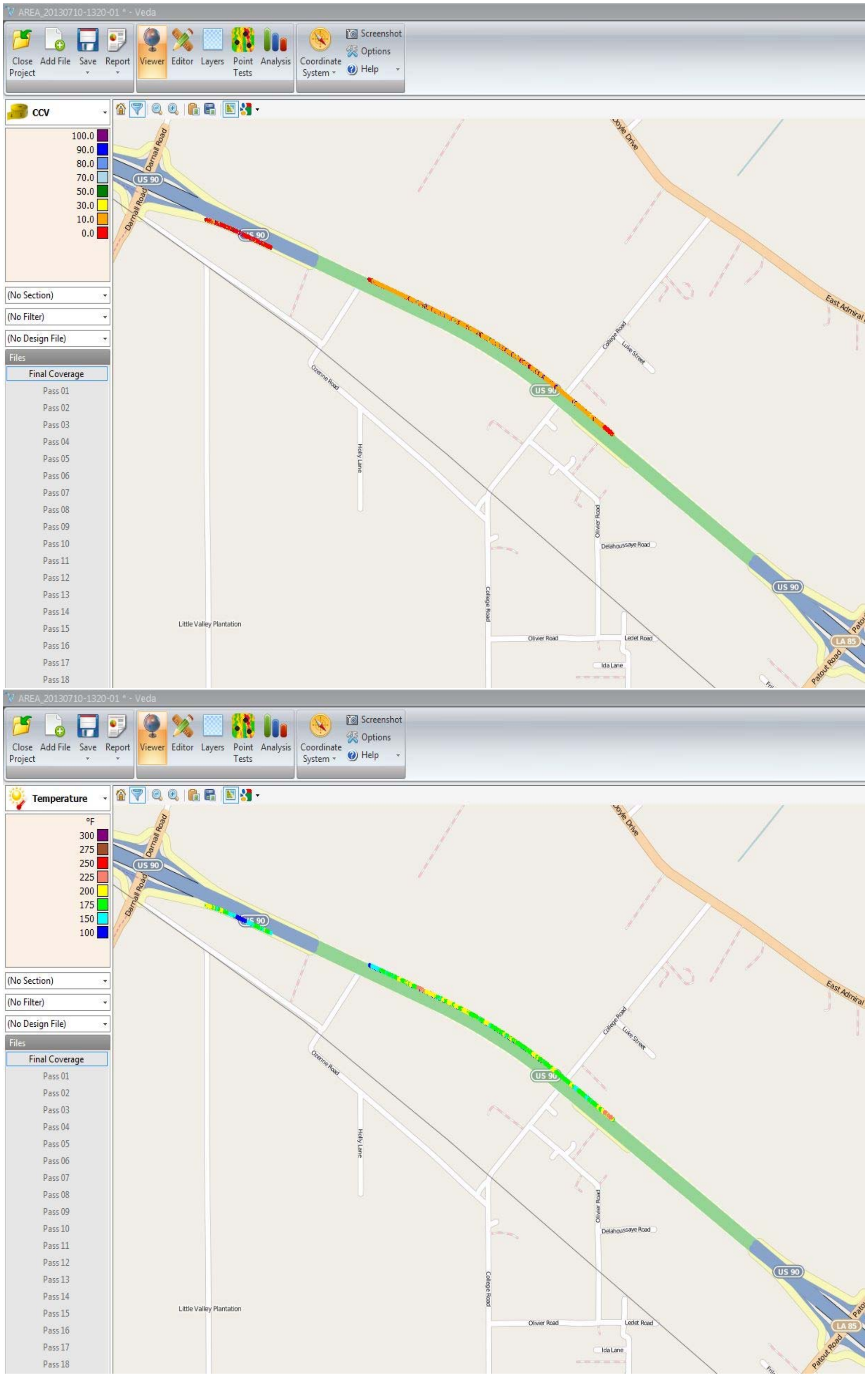


Figure 98
Binder CCV and Temperature map from Veda – 7/10/2013-1320

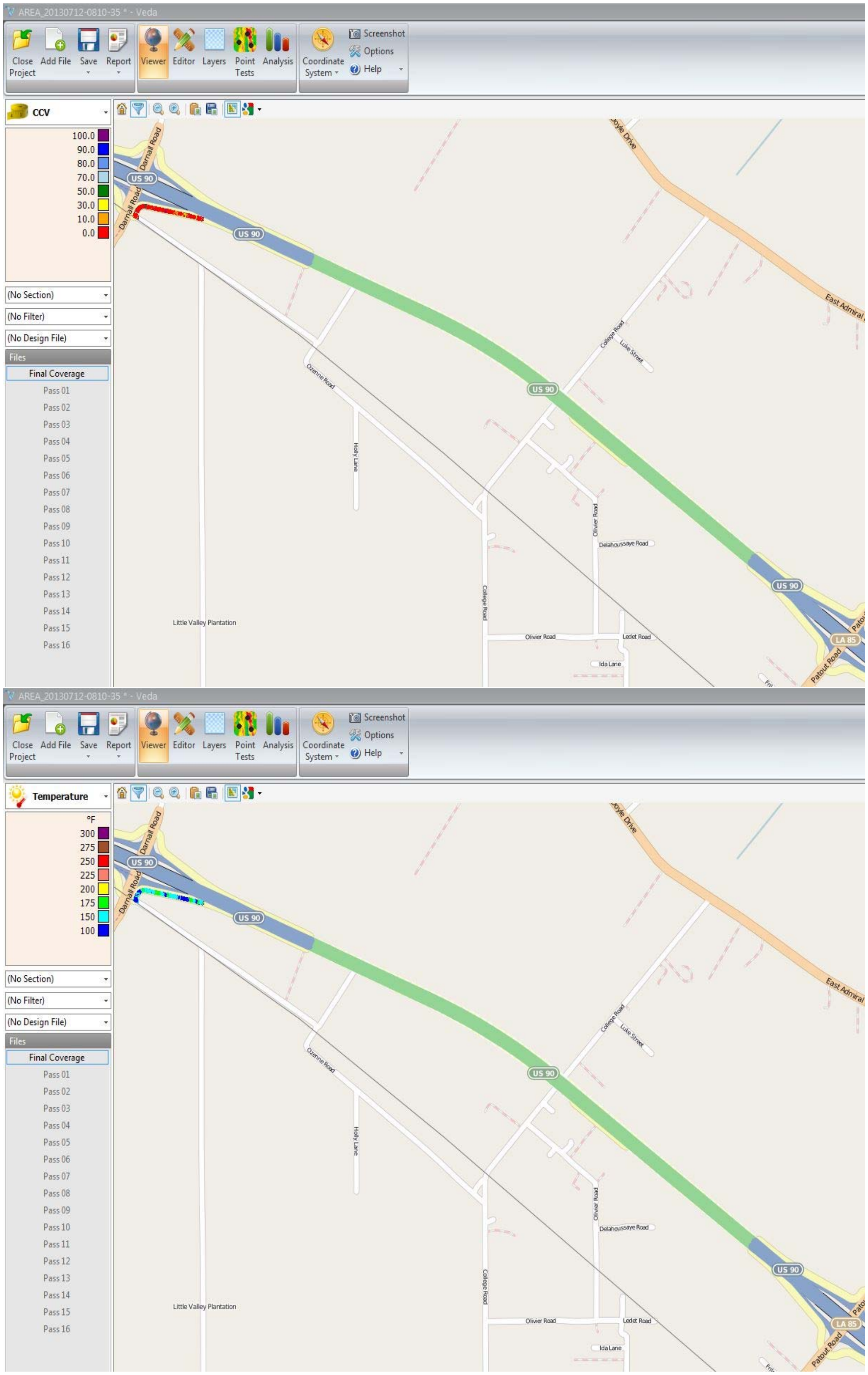


Figure 99
Binder CCV and Temperature map from Veda – 7/12/2013-0810

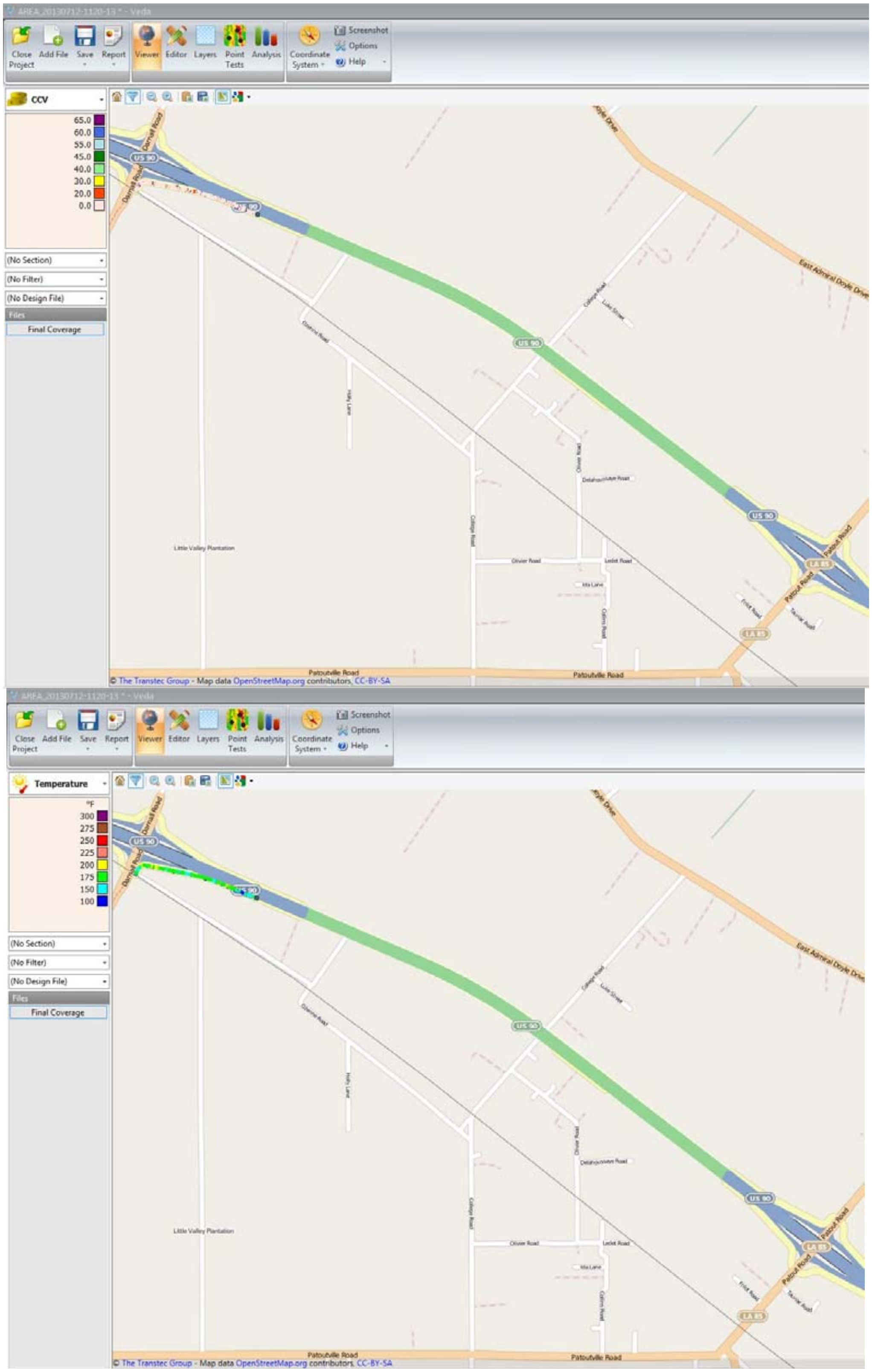


Figure 100
Binder CCV and Temperature map from Veda – 7/12/2013-1120

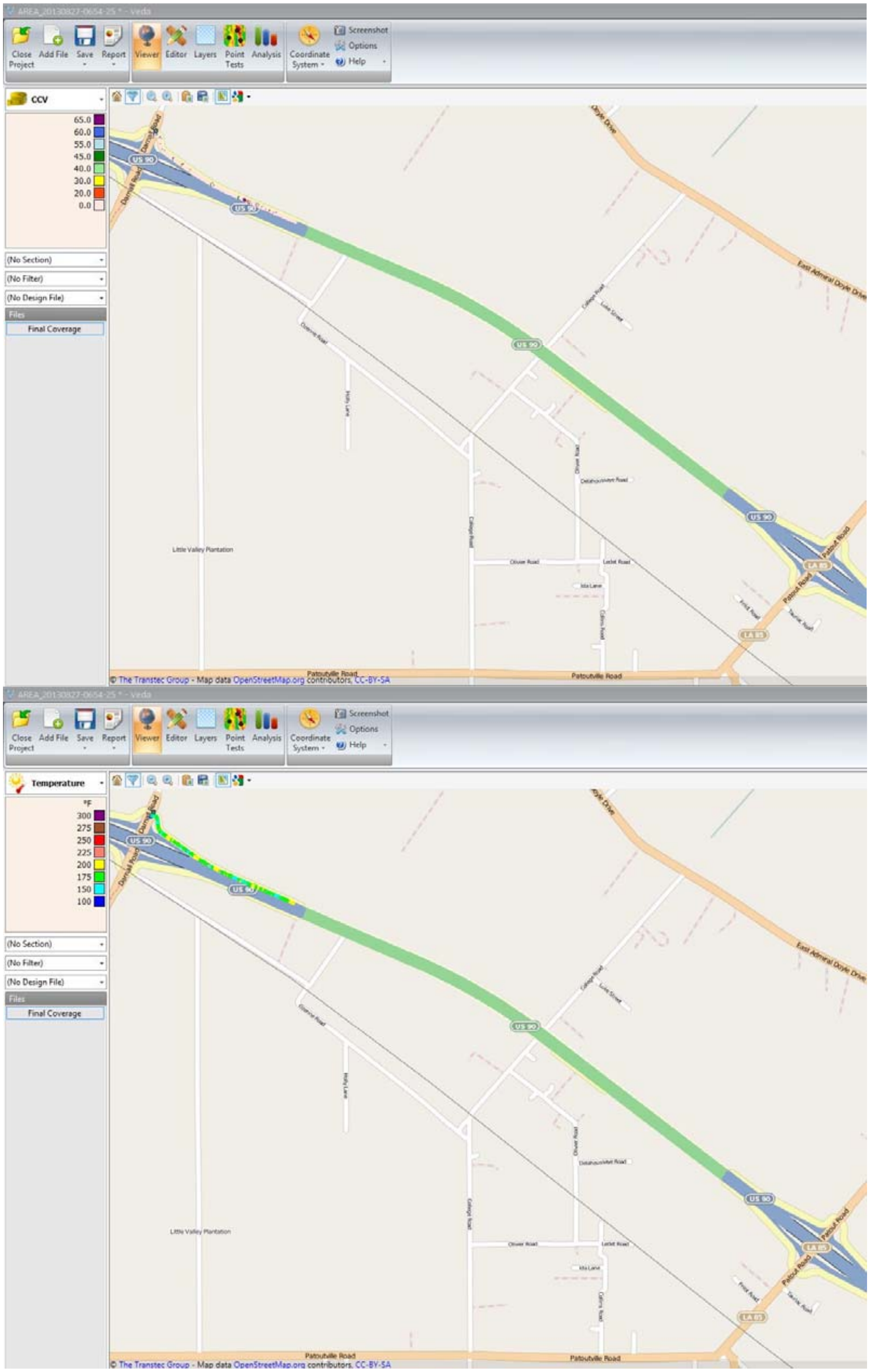


Figure 101
Binder CCV and Temperature map from Veda – 8/27/2013-0654

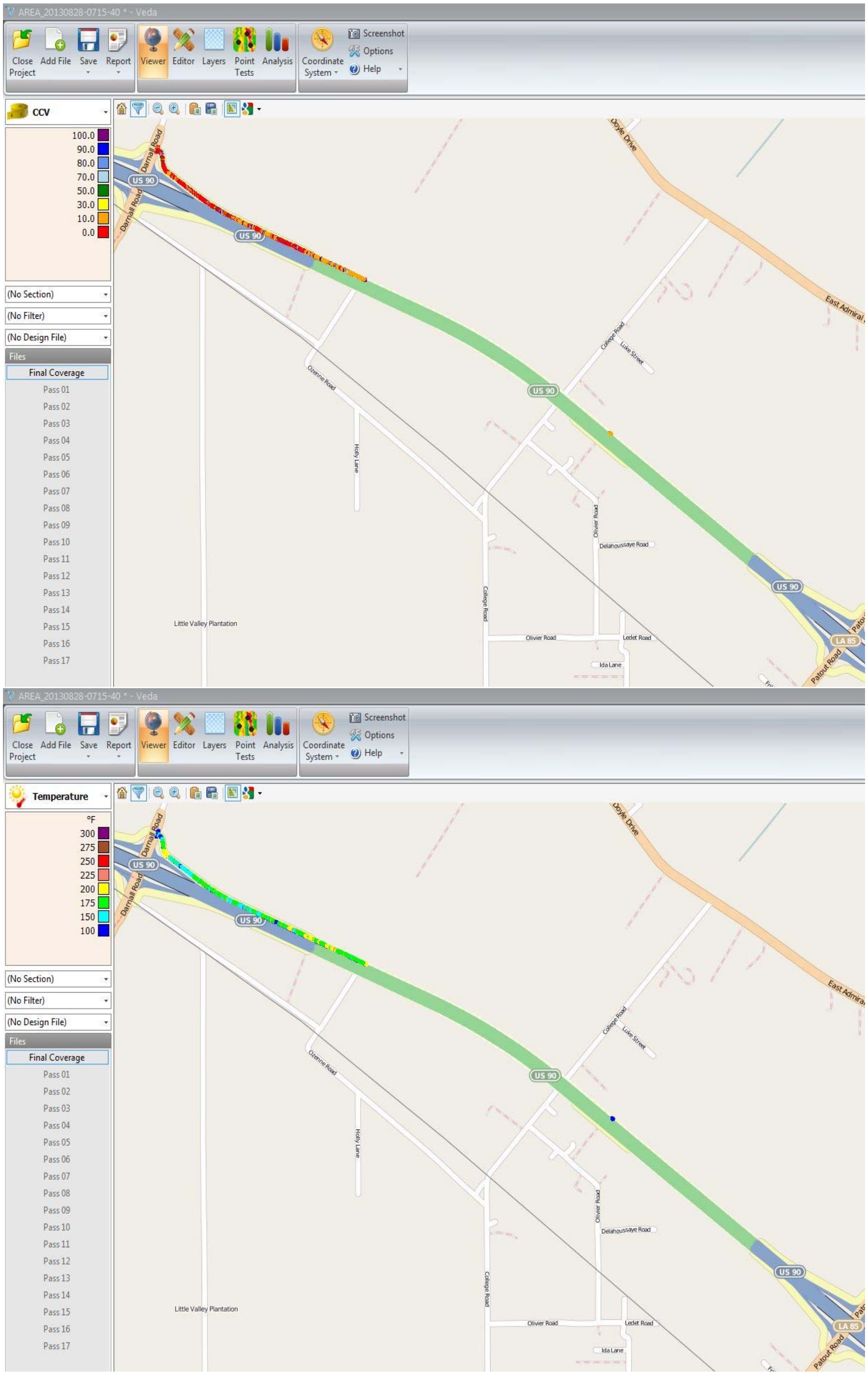


Figure 102
Binder CCV and Temperature map from Veda – 8/28/2013-0715

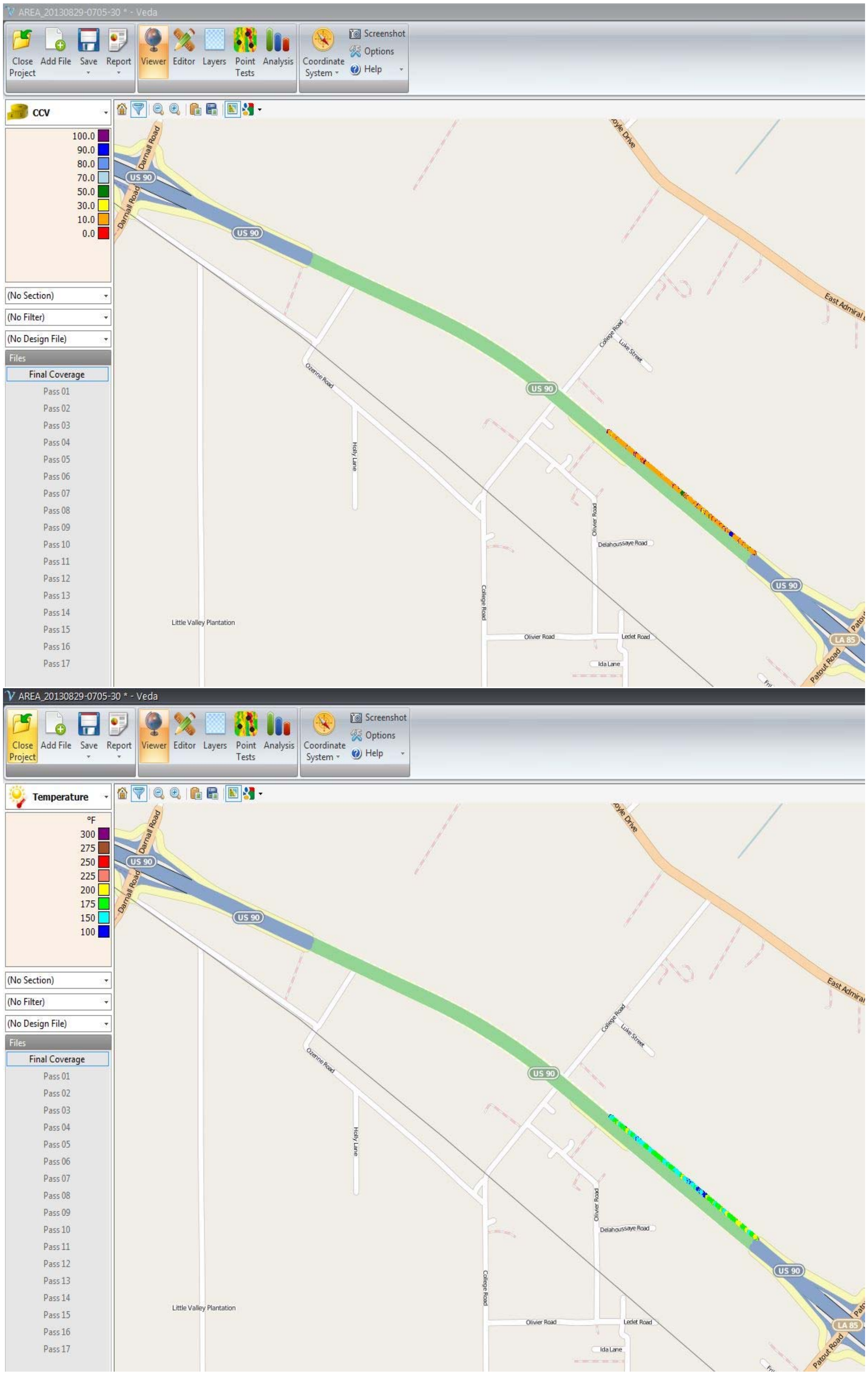


Figure 103

Binder CCV and Temperature map from Veda – 8/29/2013-0705

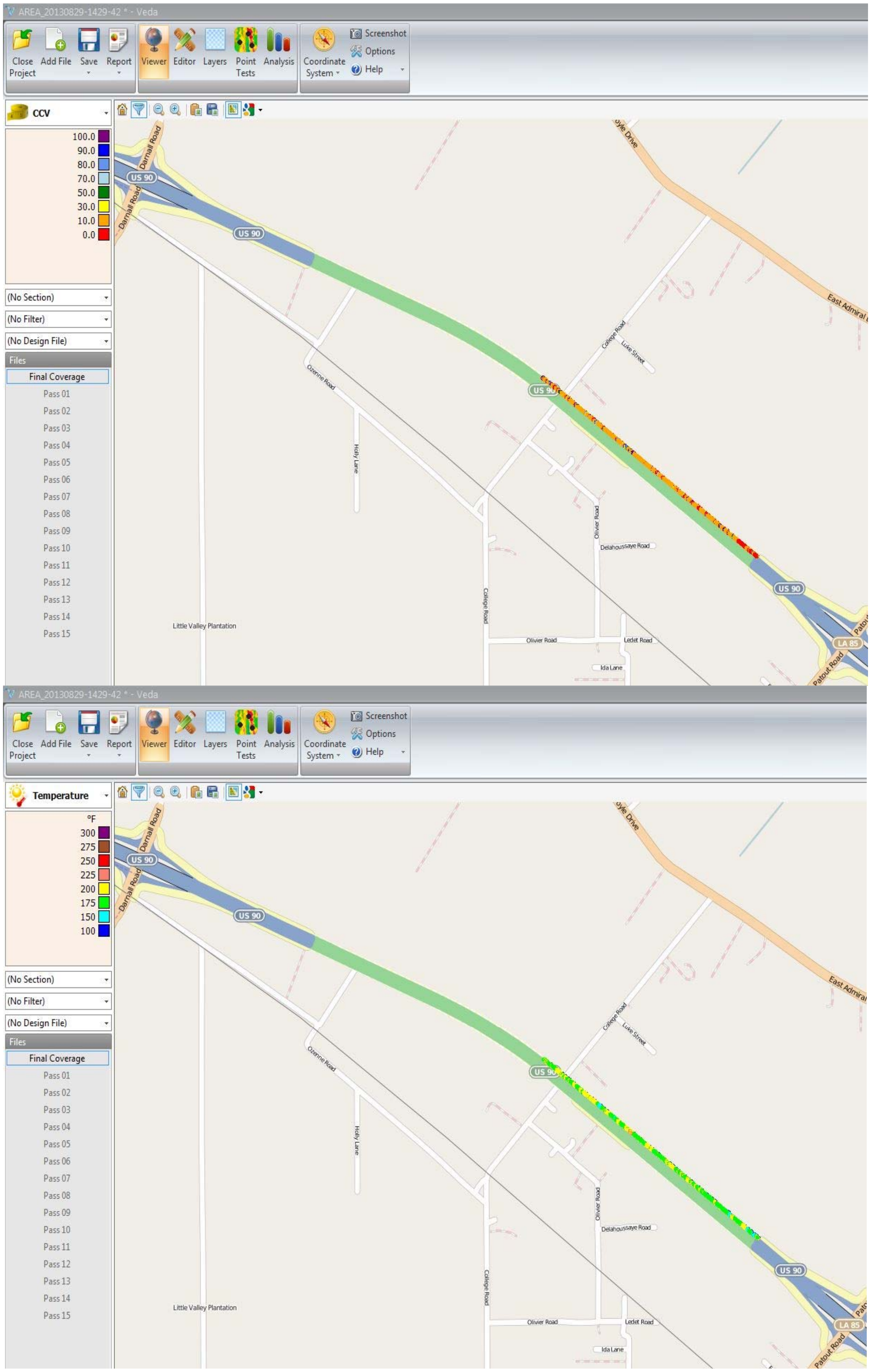


Figure 104
Binder CCV and Temperature map from Veda – 8/29/2013-1429

APPENDIX F

APPENDIX F, Screen Shots of Wearing Course activity

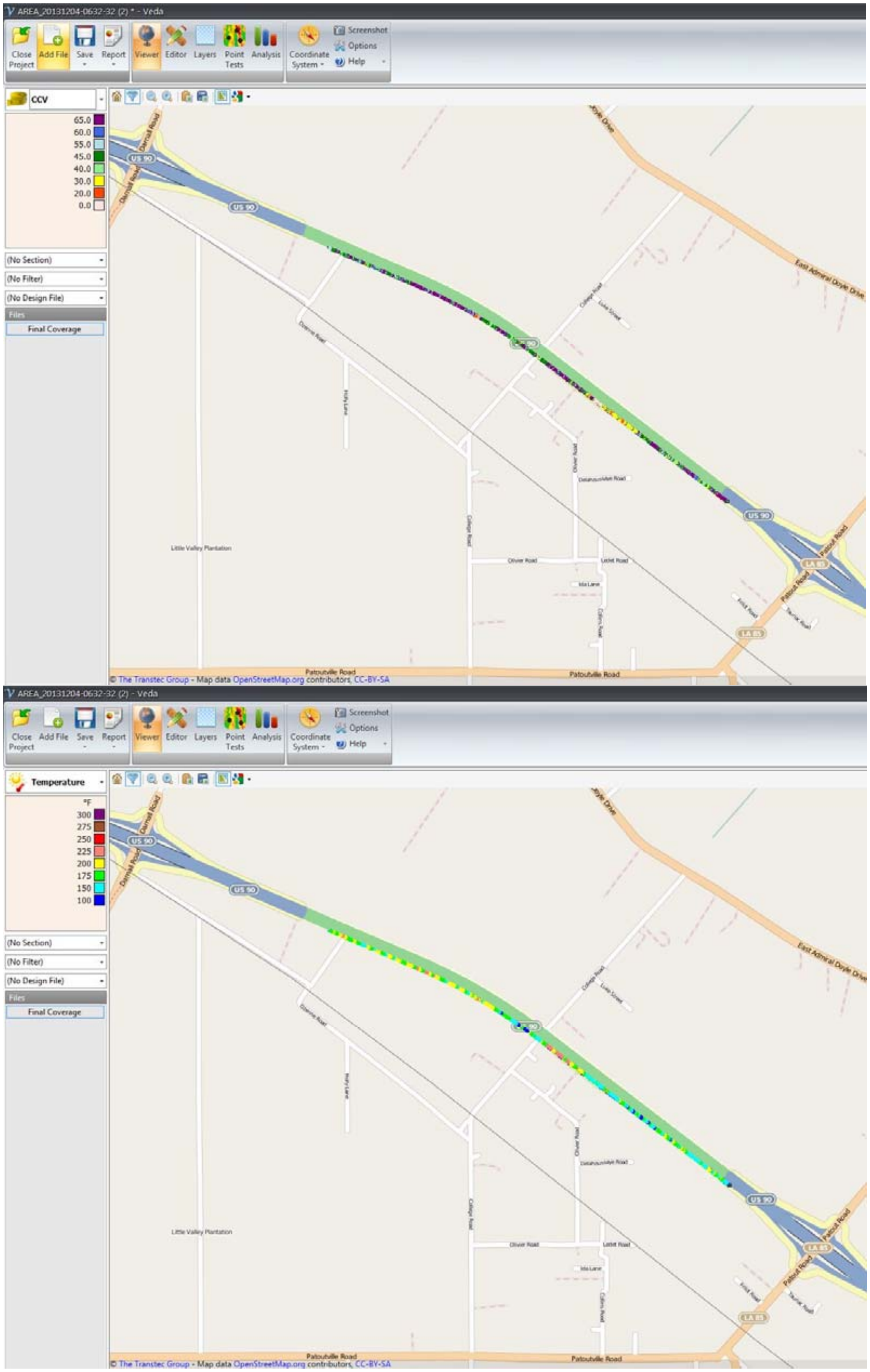


Figure 105
Wearing CCV and Temperature map from Veda – 12/04/2013-0632

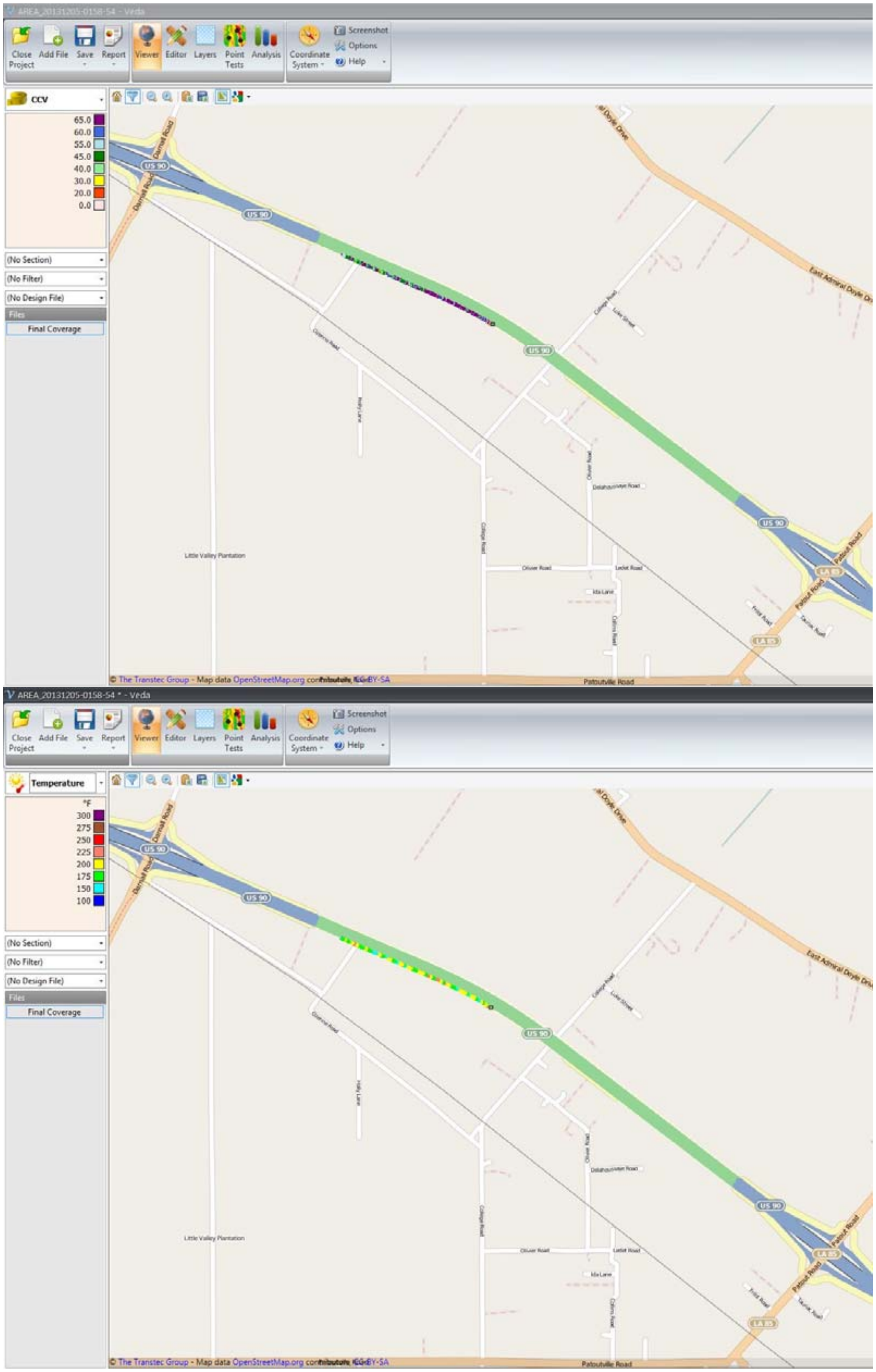


Figure 106
Wearing CCV and Temperature map from Veda – 12/05/2013-0158

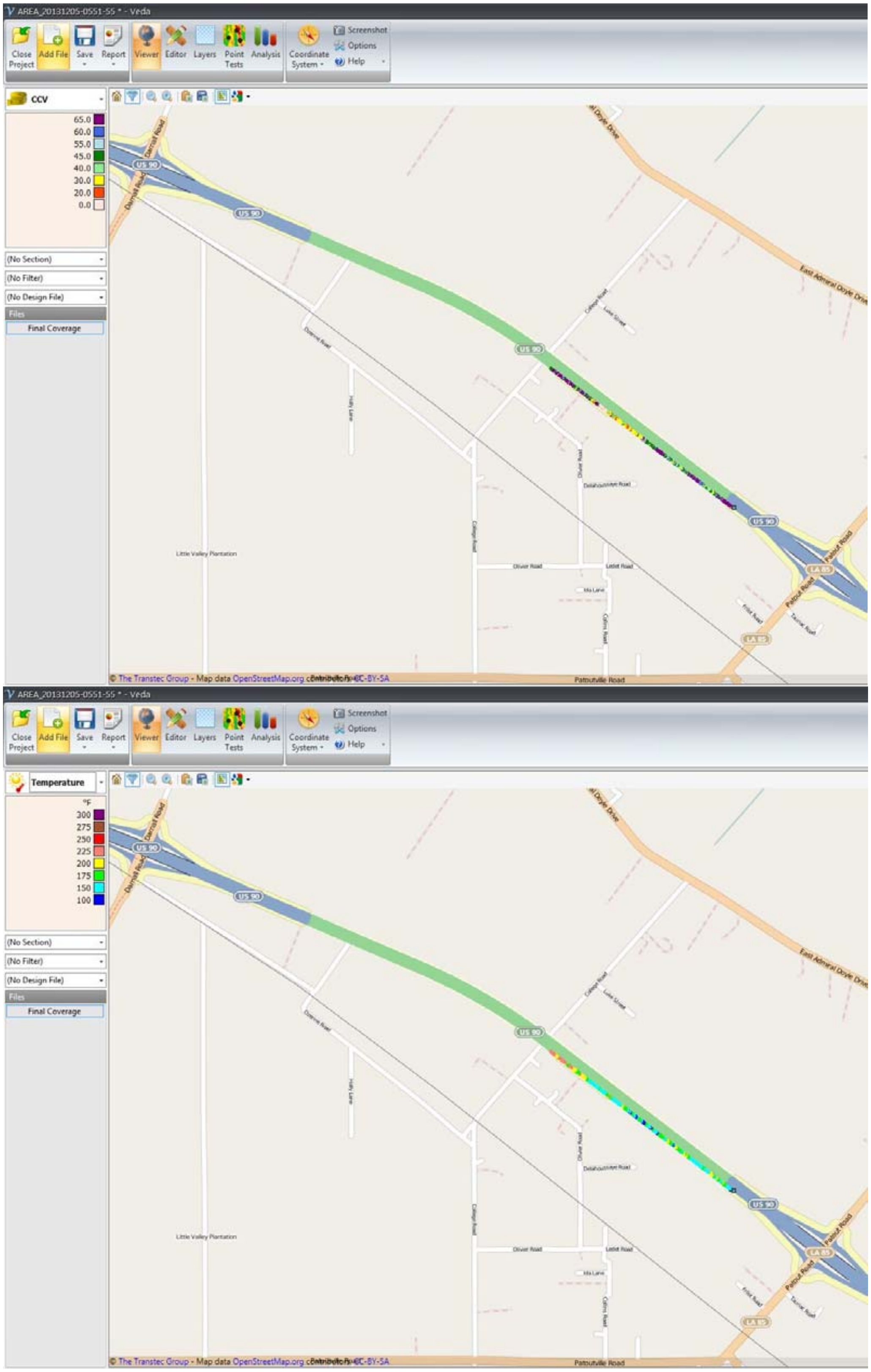


Figure 107
Wearing CCV and Temperature map from Veda – 12/05/2013-0551

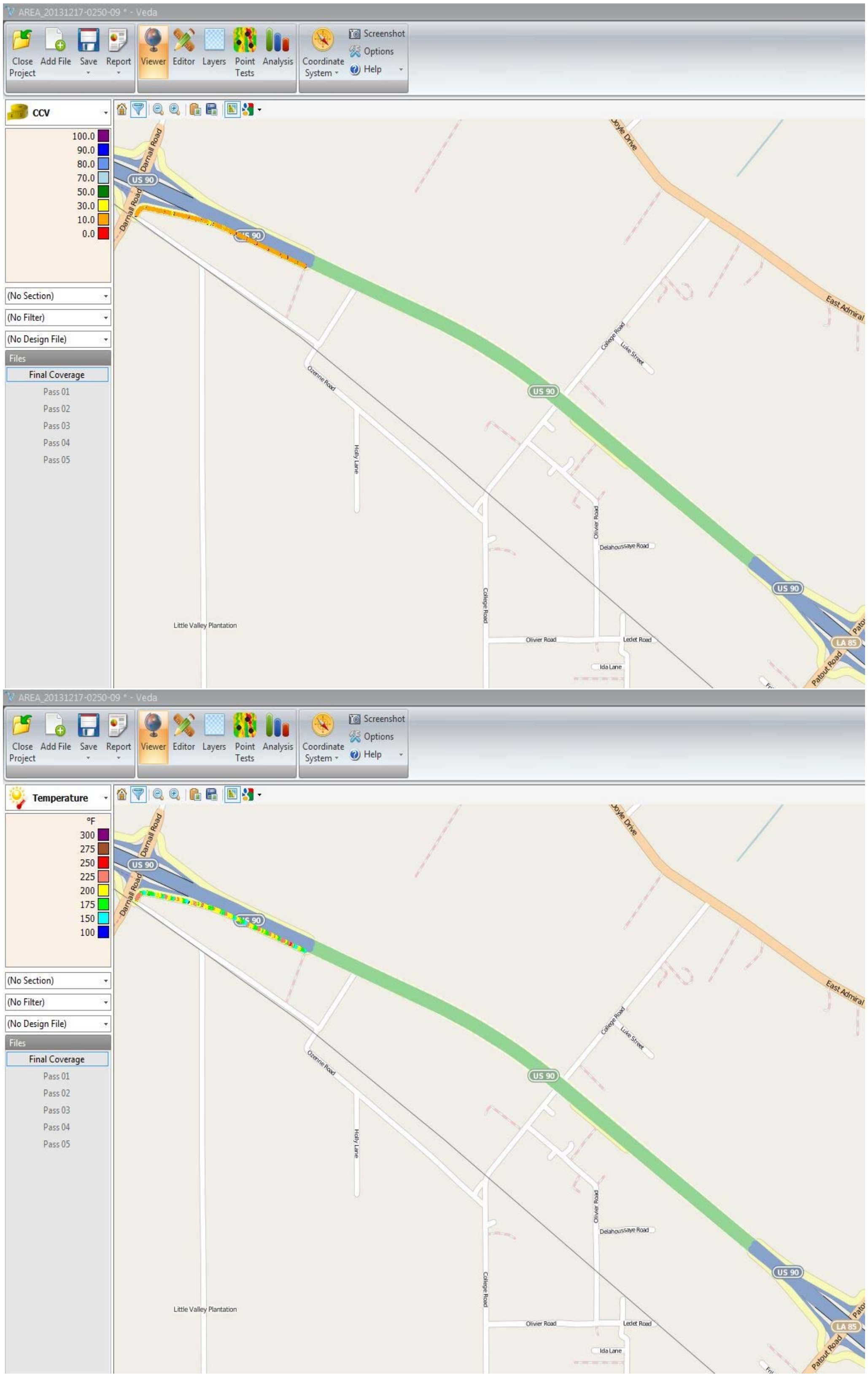


Figure 108
Wearing CCV and Temperature map from Veda – 12/17/2013-0250

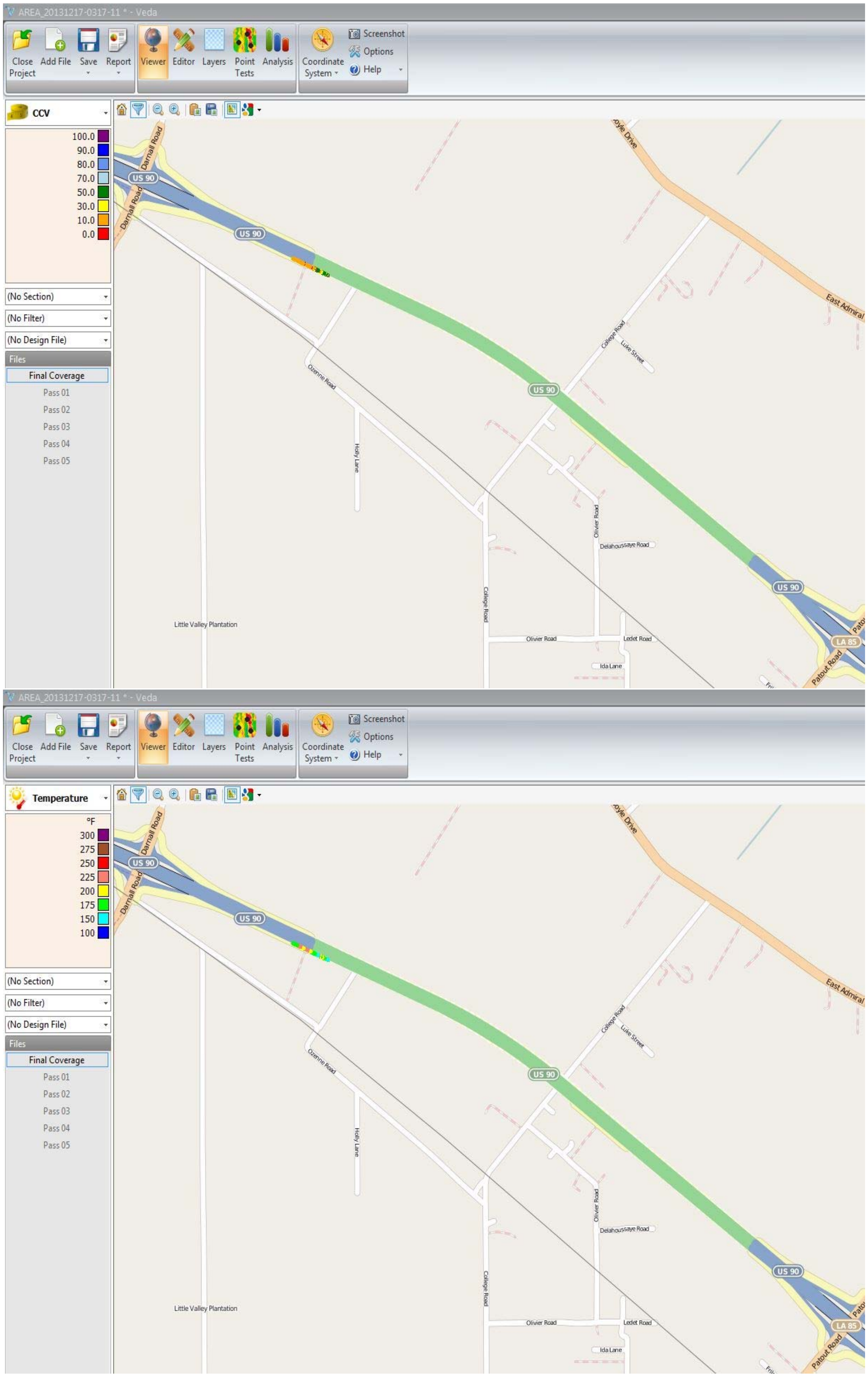


Figure 109
Wearing CCV and Temperature map from Veda – 12/17/2013-0317

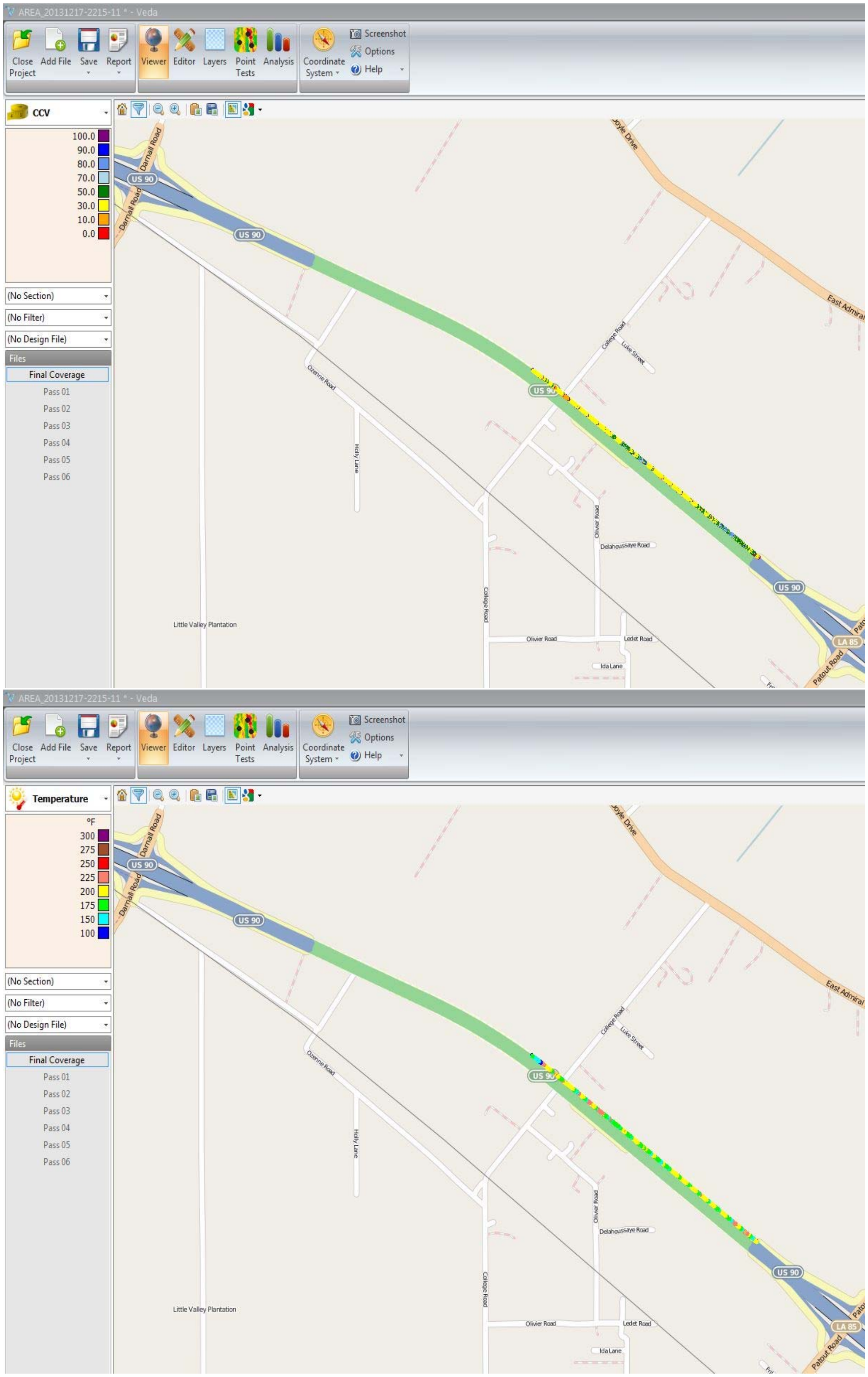


Figure 110
Wearing CCV and Temperature map from Veda – 12/17/2013-2215

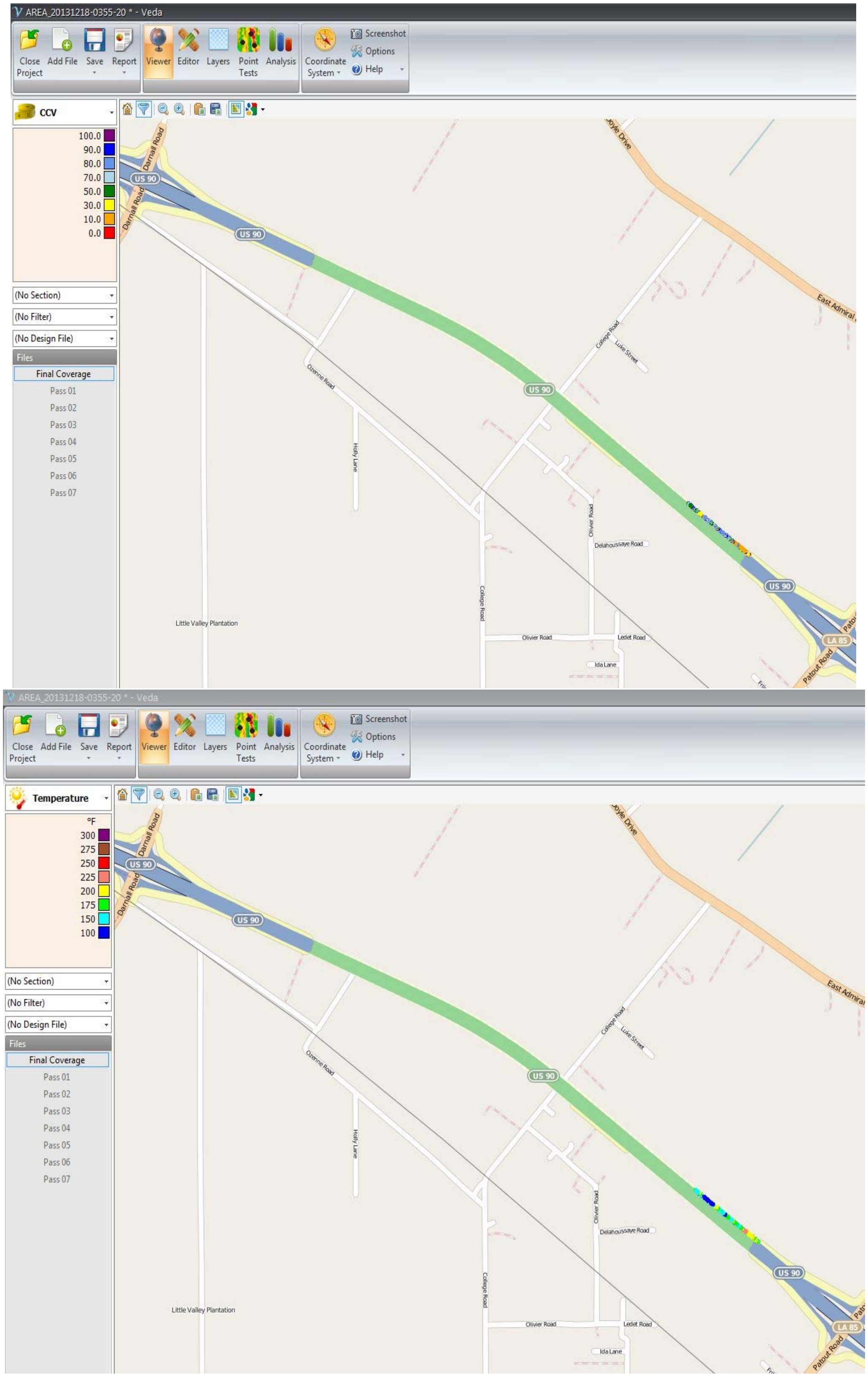


Figure 111
Wearing CCV and Temperature map from Veda – 12/18/2013-0355

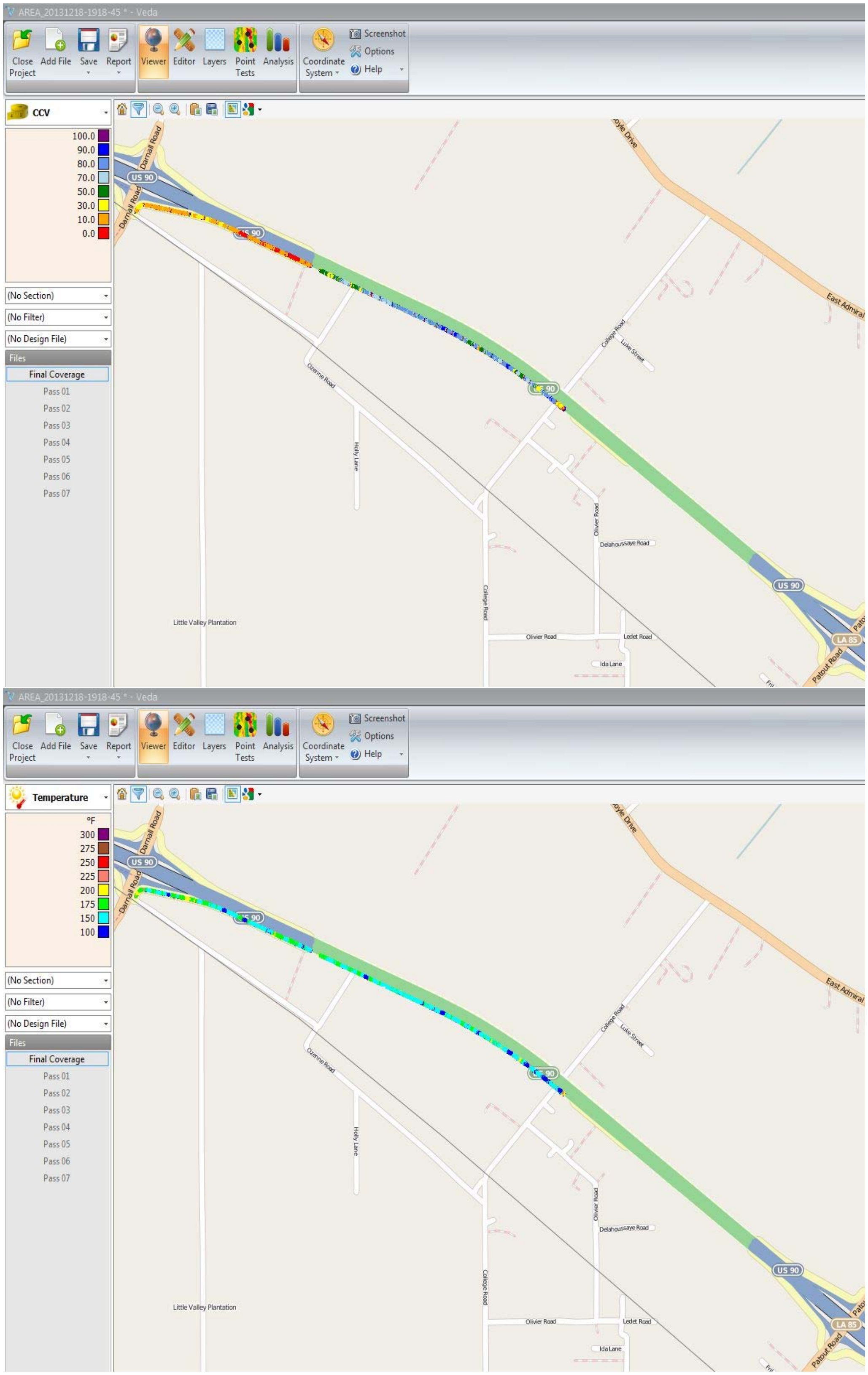


Figure 112
Wearing CCV and Temperature map from Veda – 12/18/2013-1918

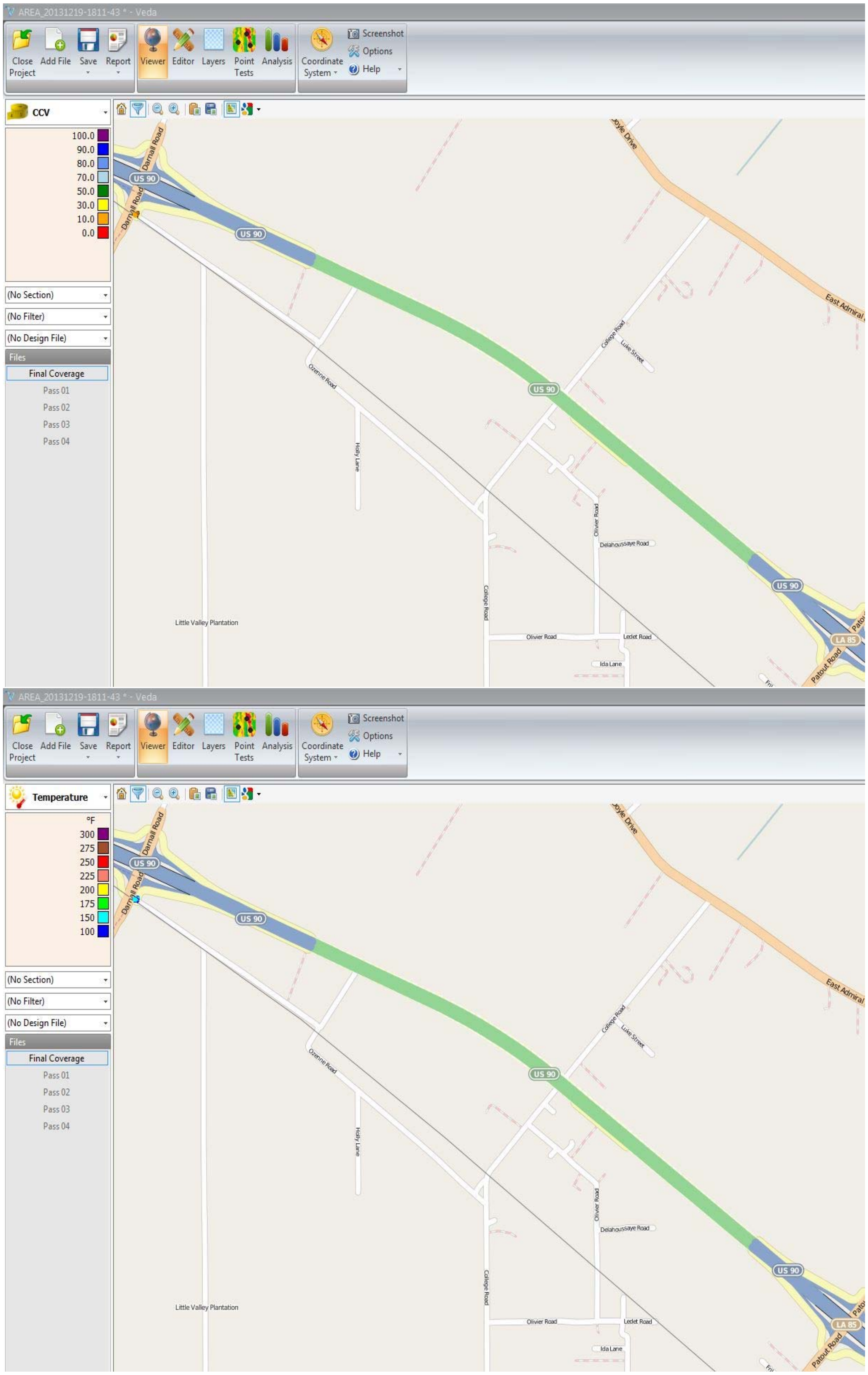


Figure 113
Wearing CCV and Temperature map from Veda – 12/19/2013-1811

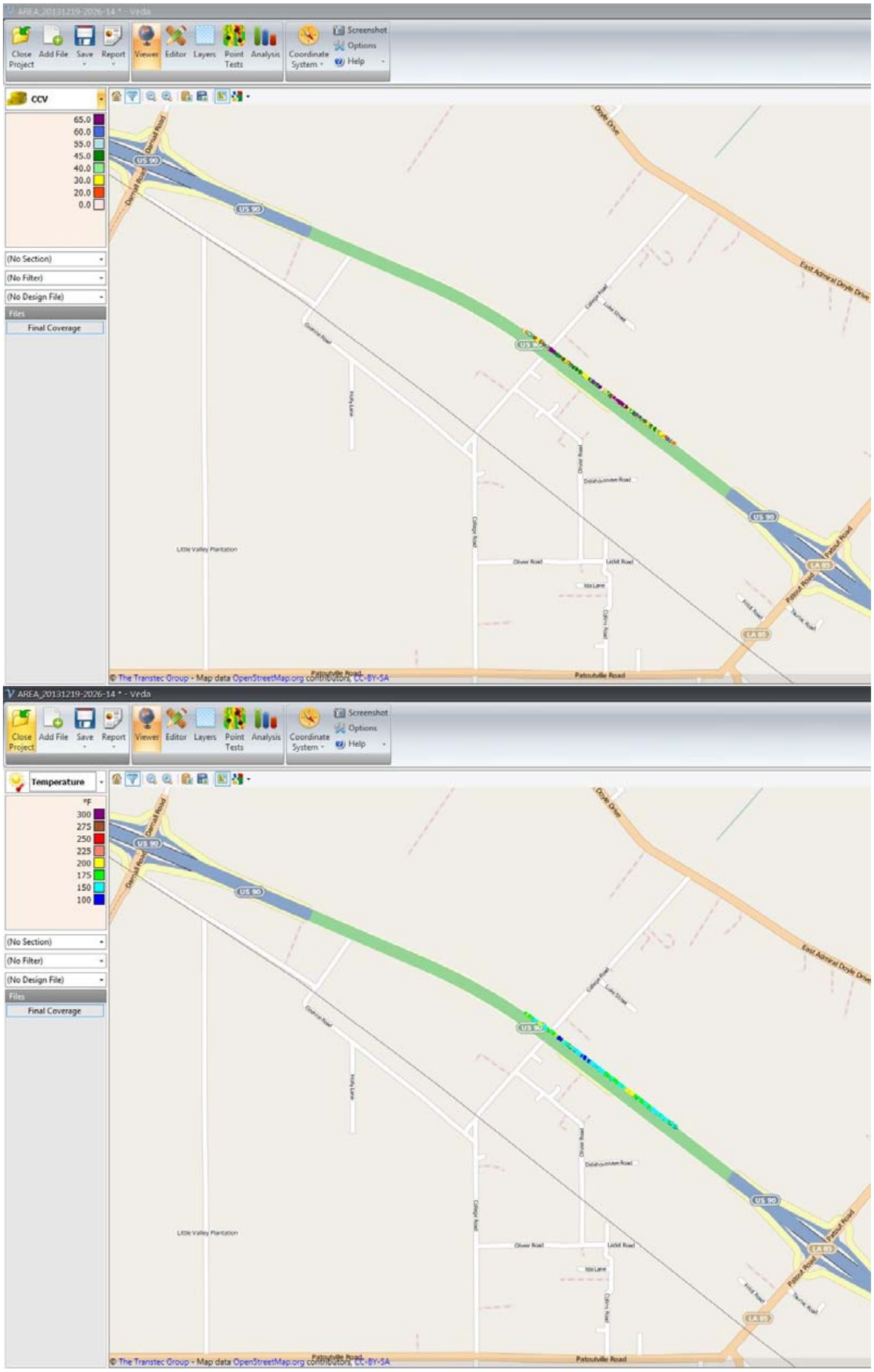


Figure 114
Wearing CCV and Temperature map from Veda – 12/19/2013-2026

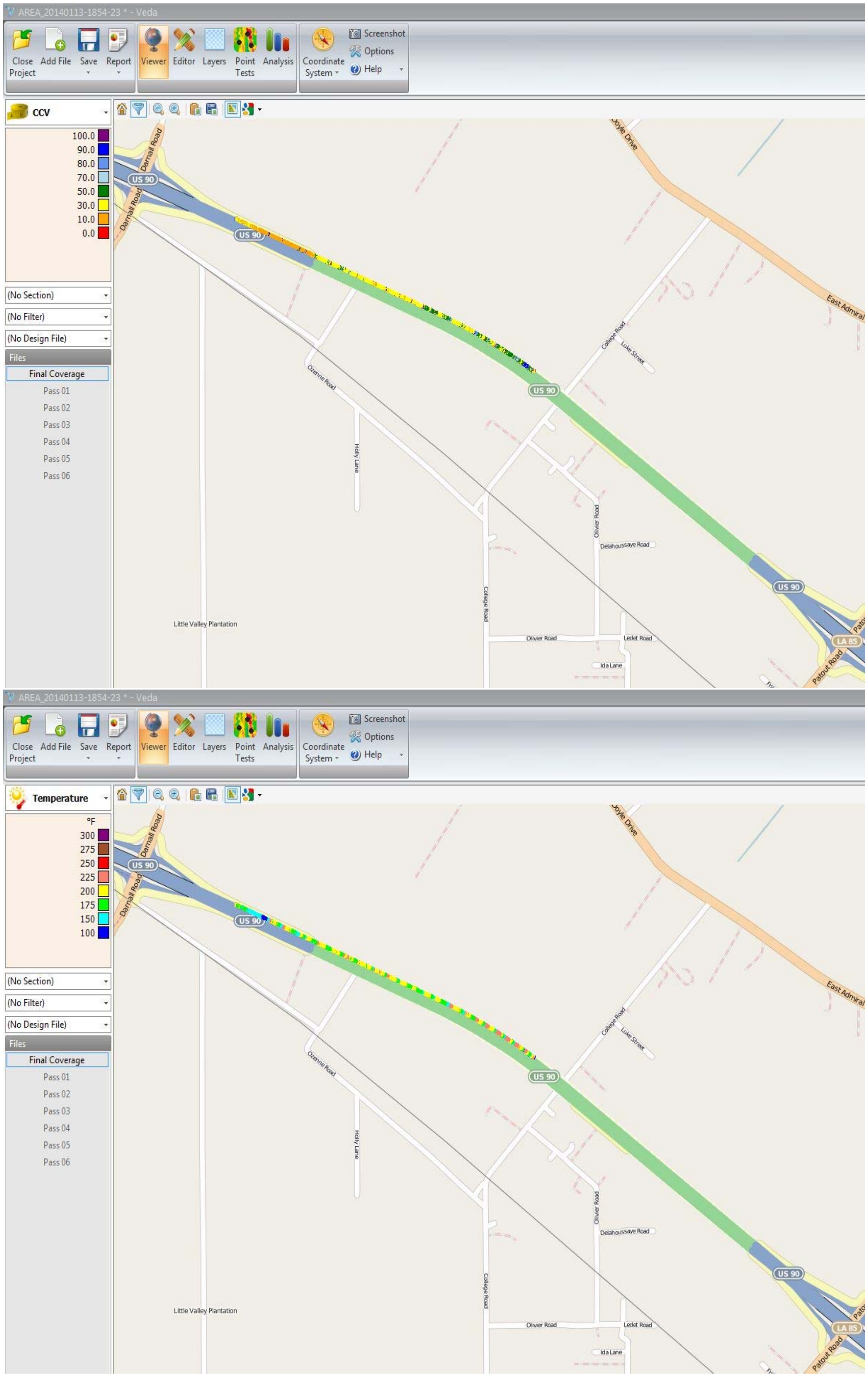


Figure 115
Wearing CCV and Temperature map from Veda – 01/13/2014-1854

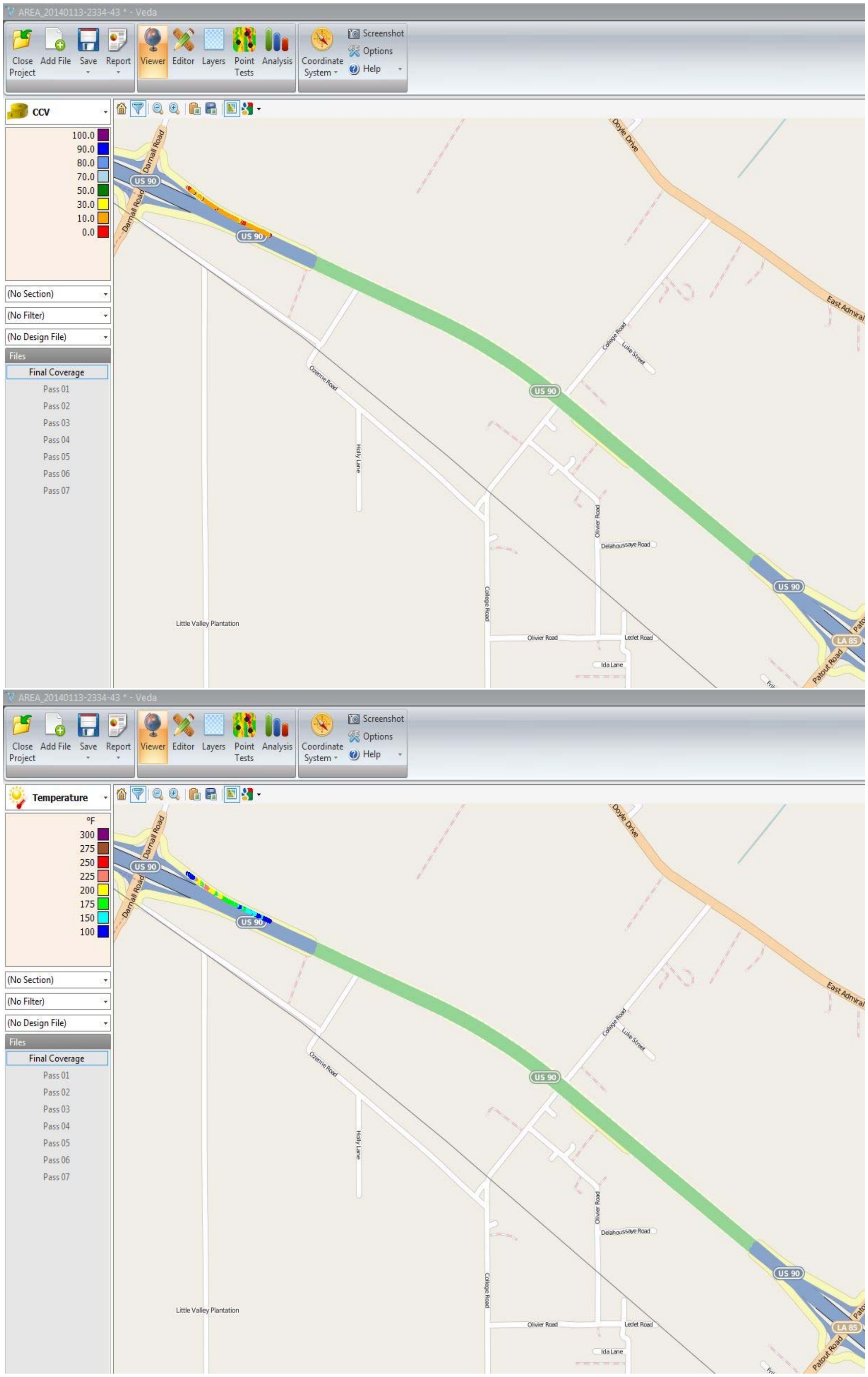


Figure 116
Wearing CCV and Temperature map from Veda – 01/13/2014-2334

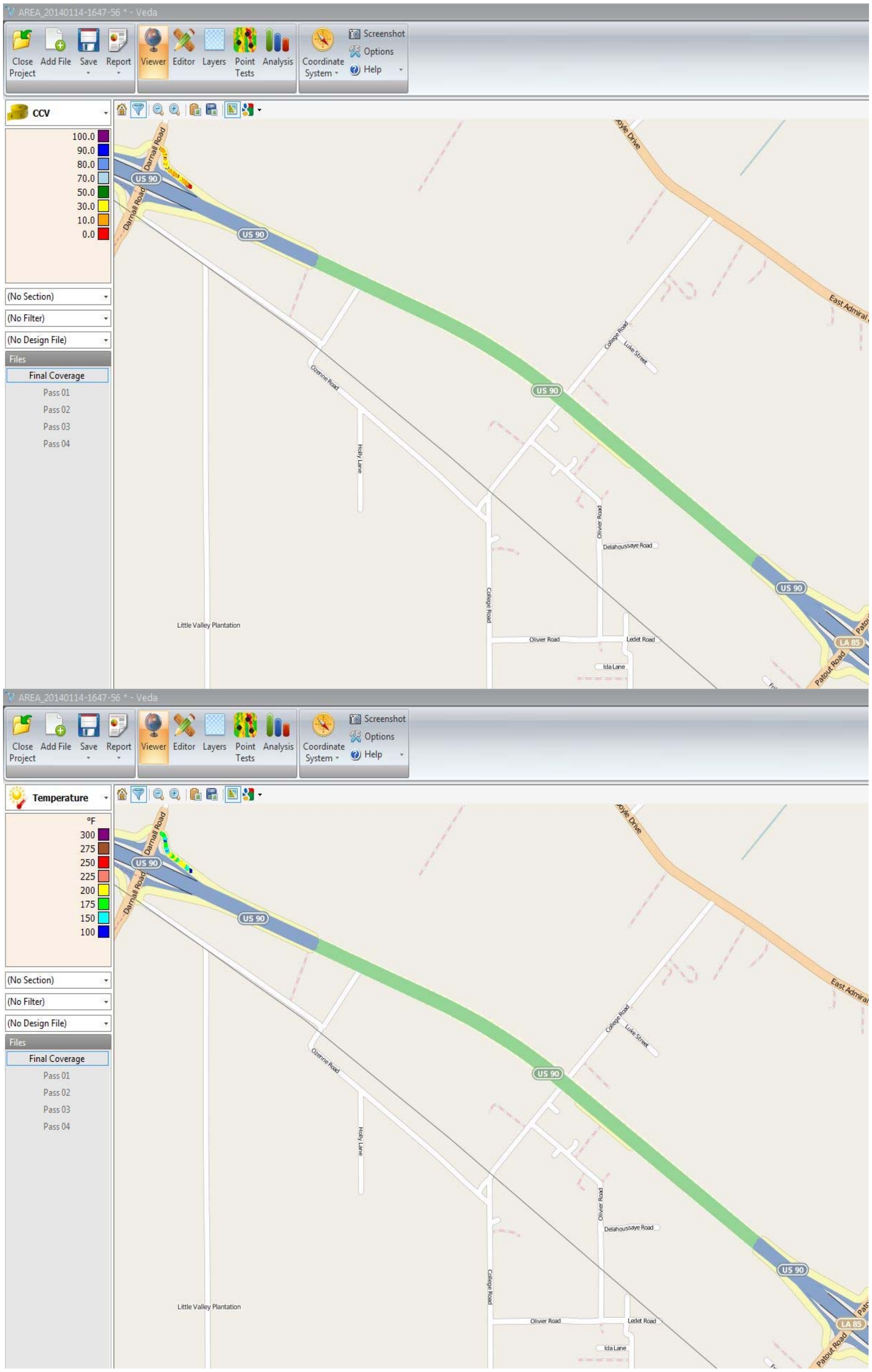


Figure 117
Wearing CCV and Temperature map from Veda – 01/14/2014-1647

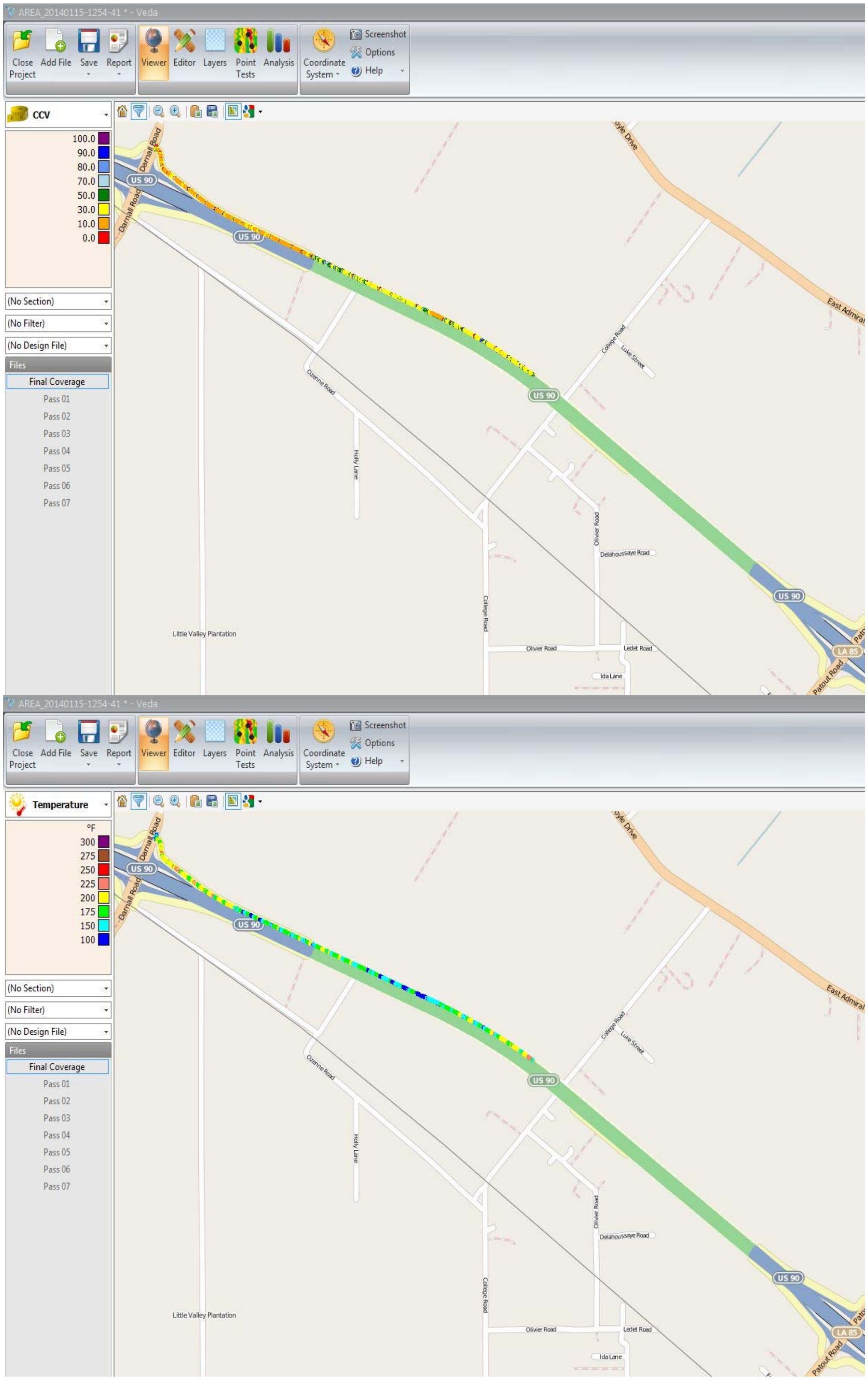


Figure 118
Wearing CCV and Temperature map from Veda – 01/15/2014-1254

APPENDIX G

APPENDIX G, VEDA analysis reports – soil layers

Pass Count 2013-05-18 to 05-20 last

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-05-18 to 05-20 last
State Plane Zone: 1702 - Louisiana South

File Information

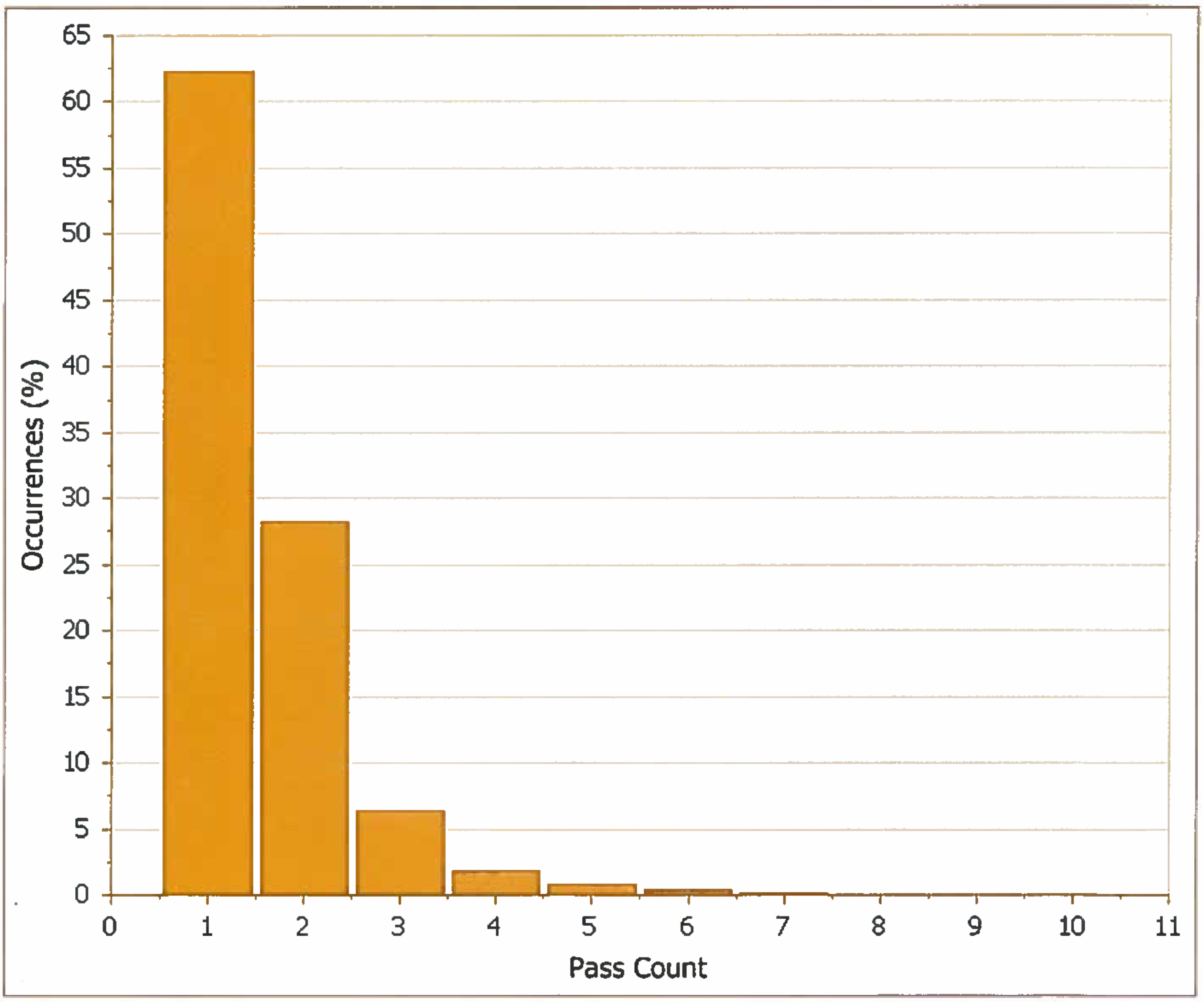
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	56
Min	1
Max	10
Sample Size	106,778
Target Status	Passed
% of Target Achieved	100.00

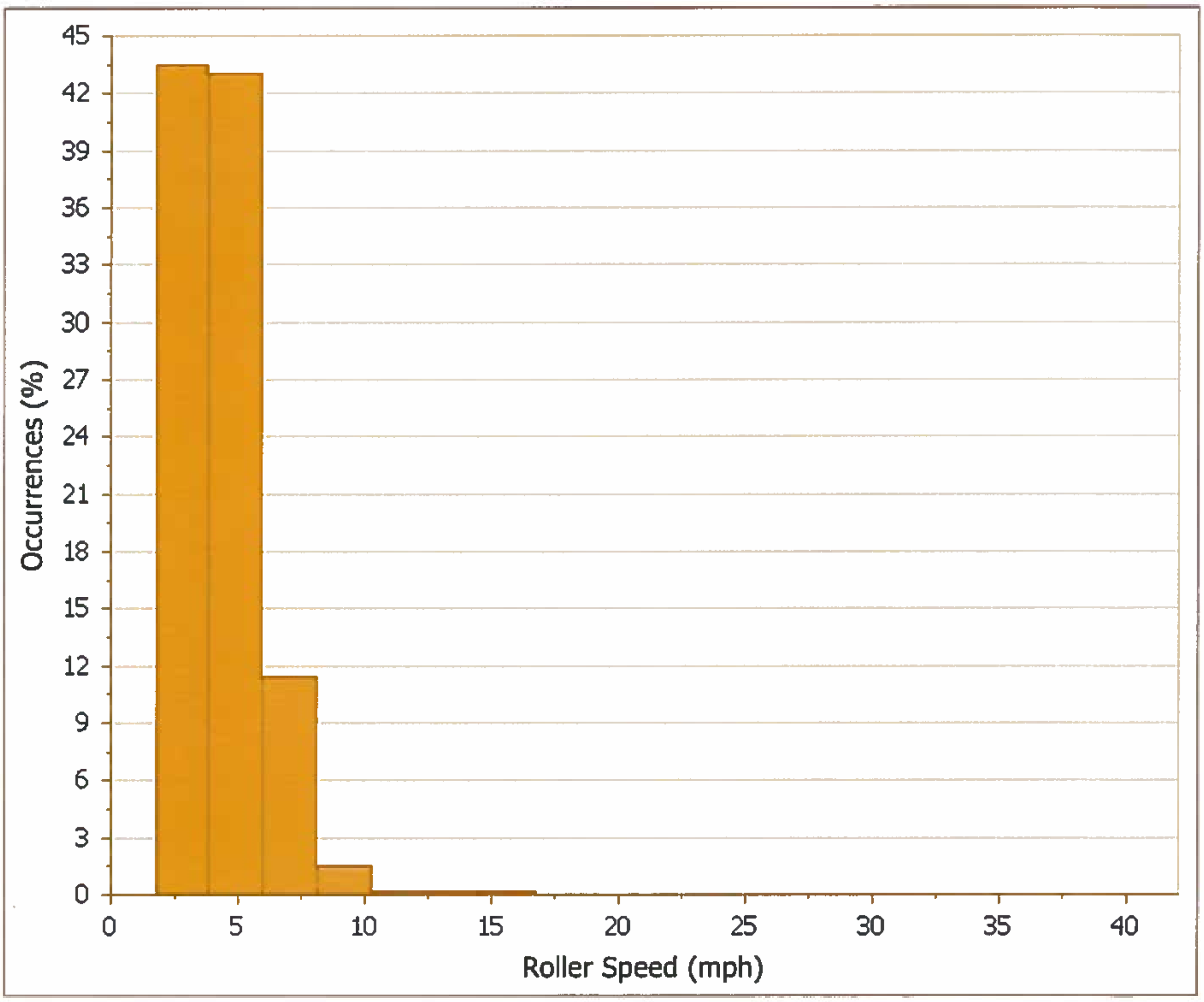


Pass Count 2013-05-18 to 05-20 last

Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	3.4
Standard Deviation (mph)	1.6
CoV (%)	46
Min (mph)	0.6
Max (mph)	43.7
Sample Size	106,778
Target Status	Passed
% of Target Achieved	100.00

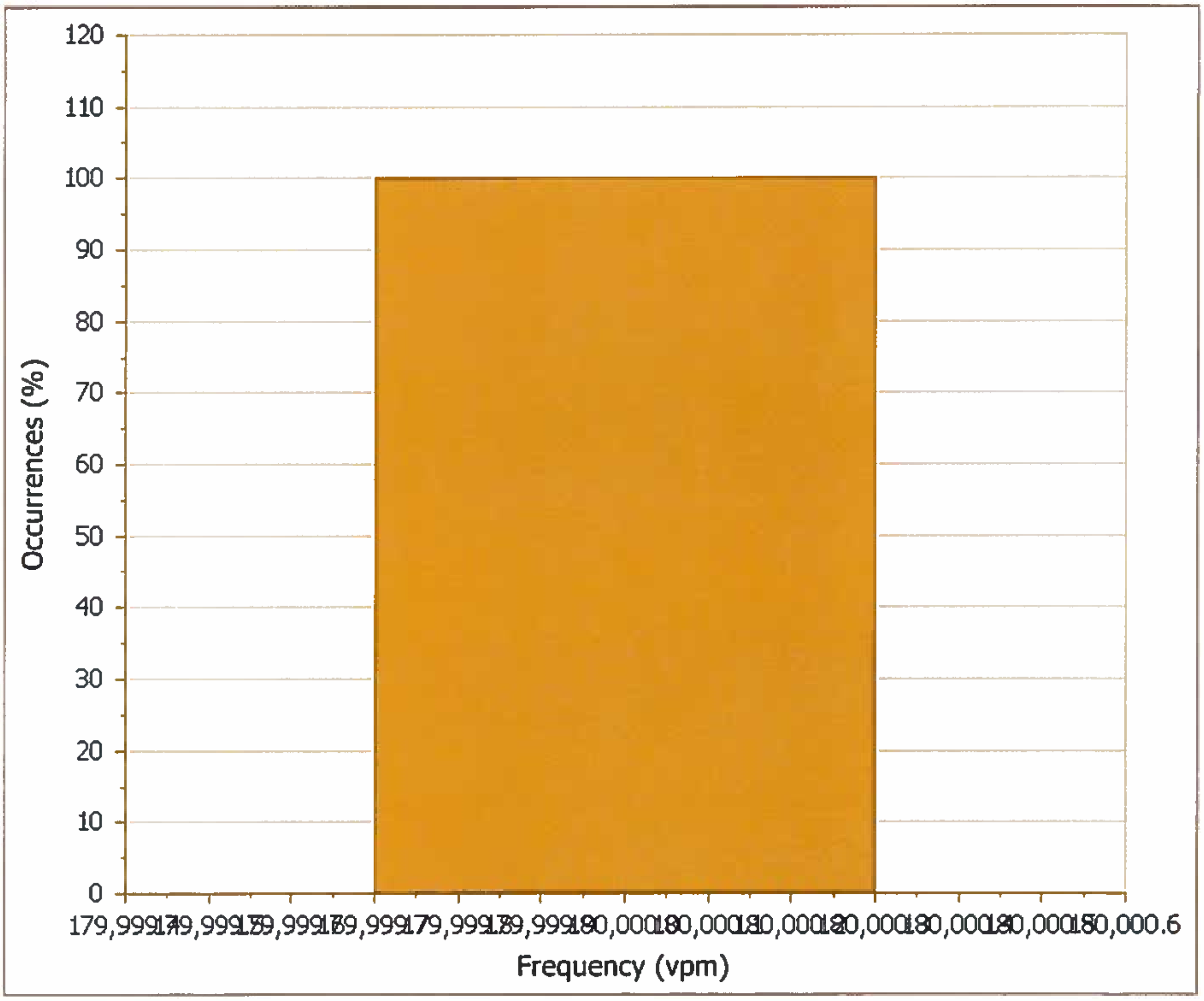


Pass Count 2013-05-18 to 05-20 last

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	90,141
Target Status	Failed
% of Target Achieved	0.00

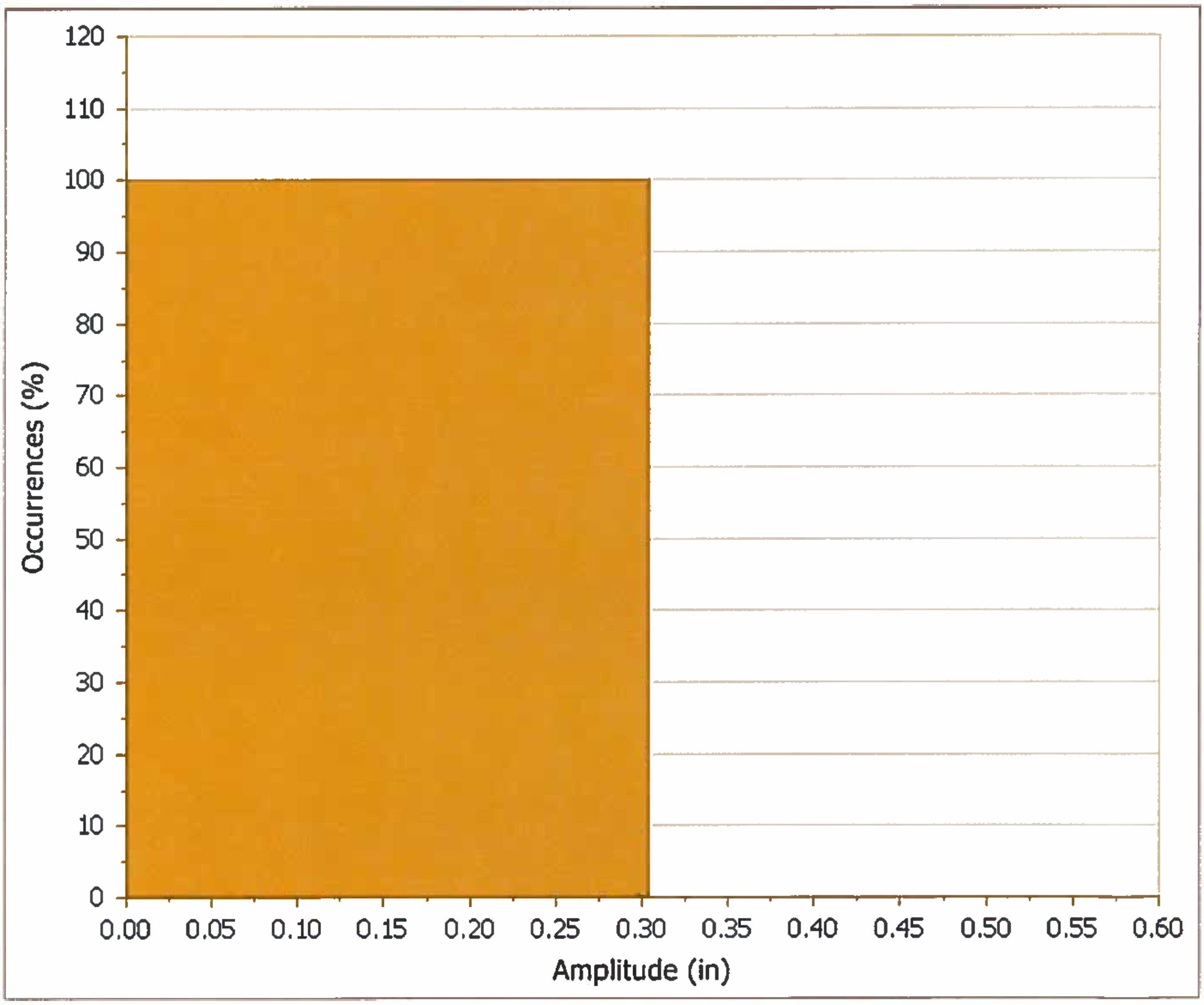


Pass Count 2013-05-18 to 05-20 last

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	90,141
Target Status	Failed
% of Target Achieved	0.00

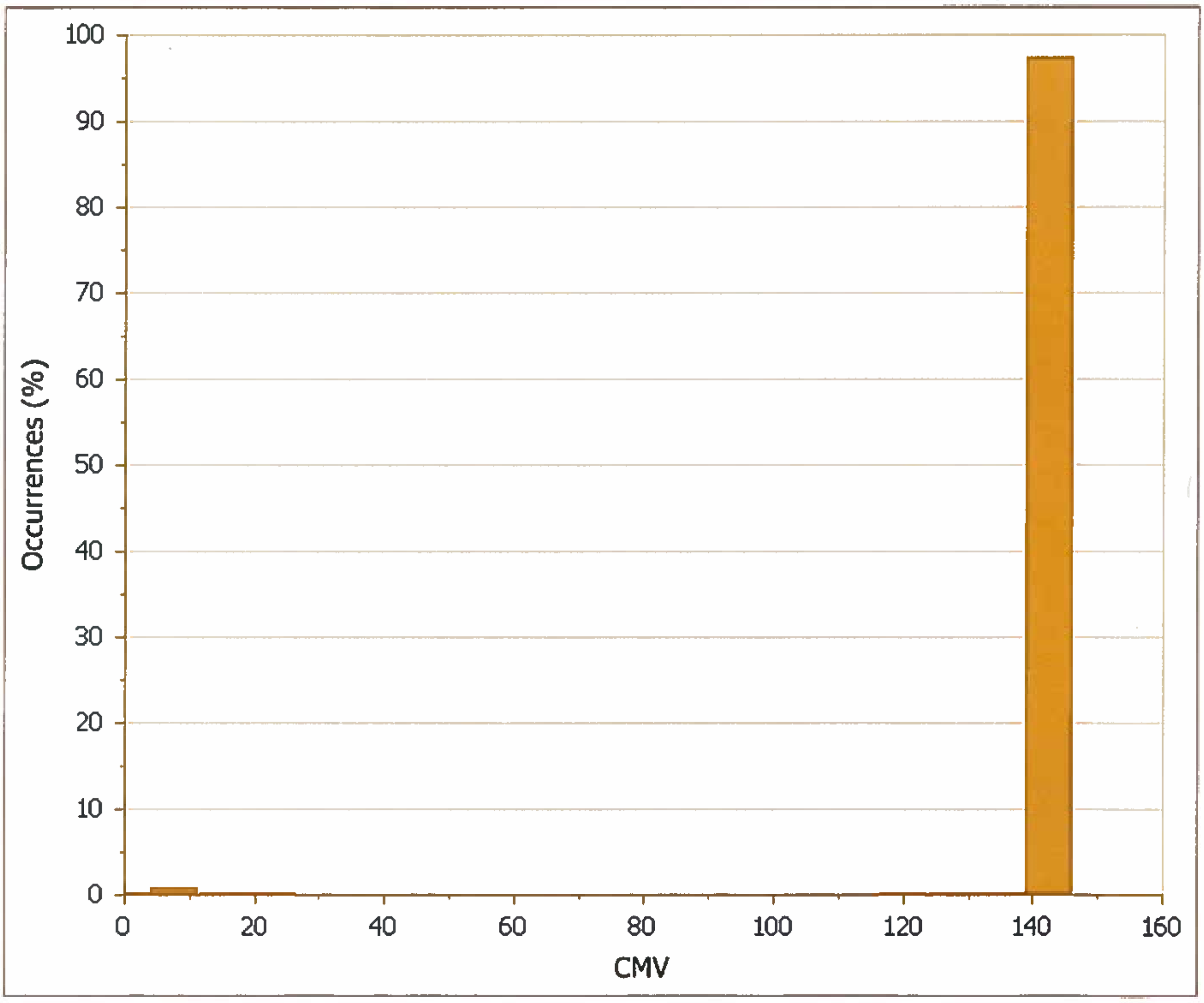


Pass Count 2013-05-18 to 05-20 last

Final Coverage: CMV

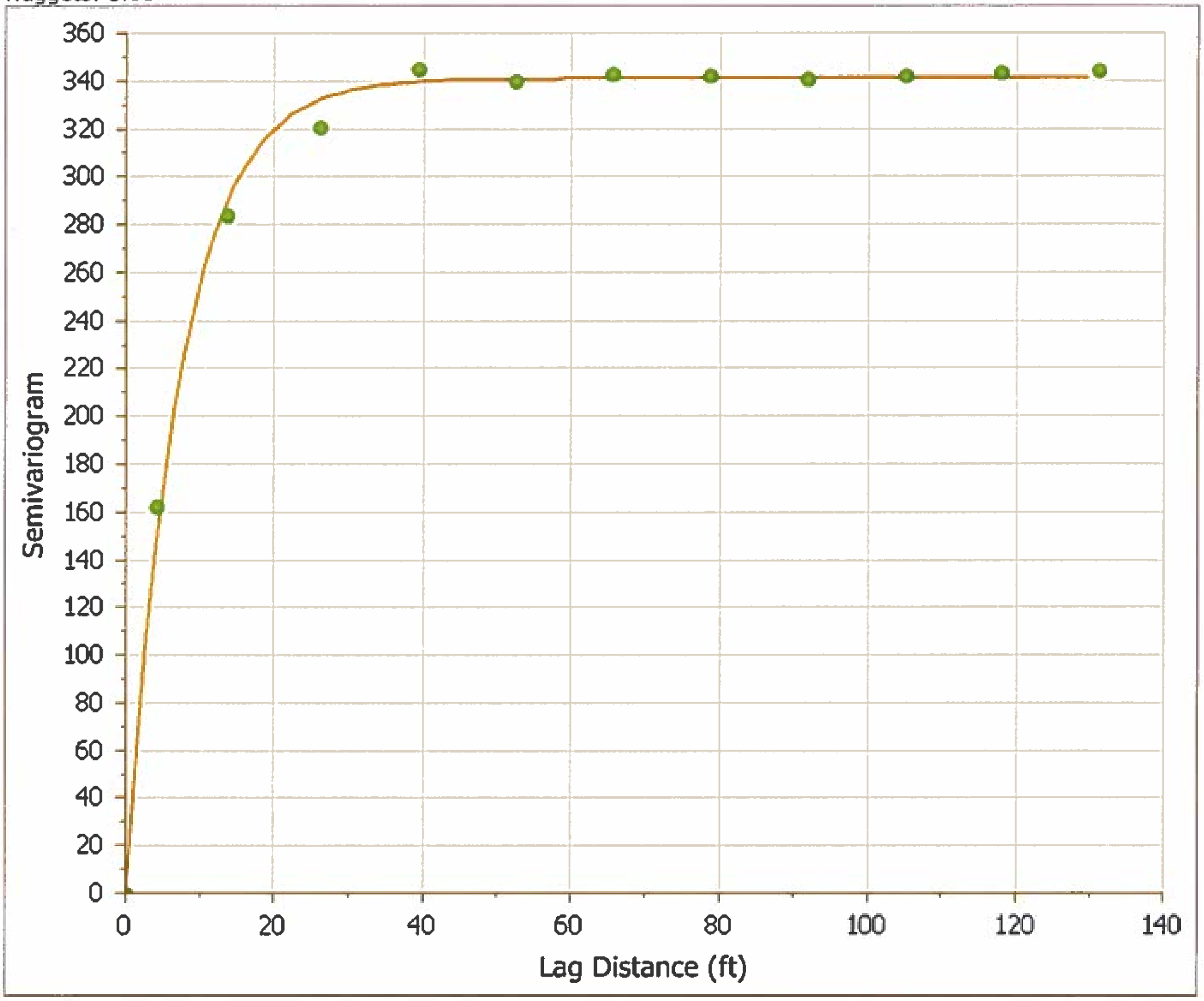
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	147.30
Standard Deviation	18.18
CoV (%)	12
Min	0.10
Max	150.00
Sample Size	90,141
Target Status	Passed
% of Target Achieved	99.73



Final Coverage: Semivariogram

Range (ft): 17.06
Sill: 309.51
Vertical Scale: 309.51
Nuggets: 0.00



Pass Count 2013-05-20 to 05-25 LAST

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-05-20 to 05-25 LAST
State Plane Zone: 1702 - Louisiana South

File Information

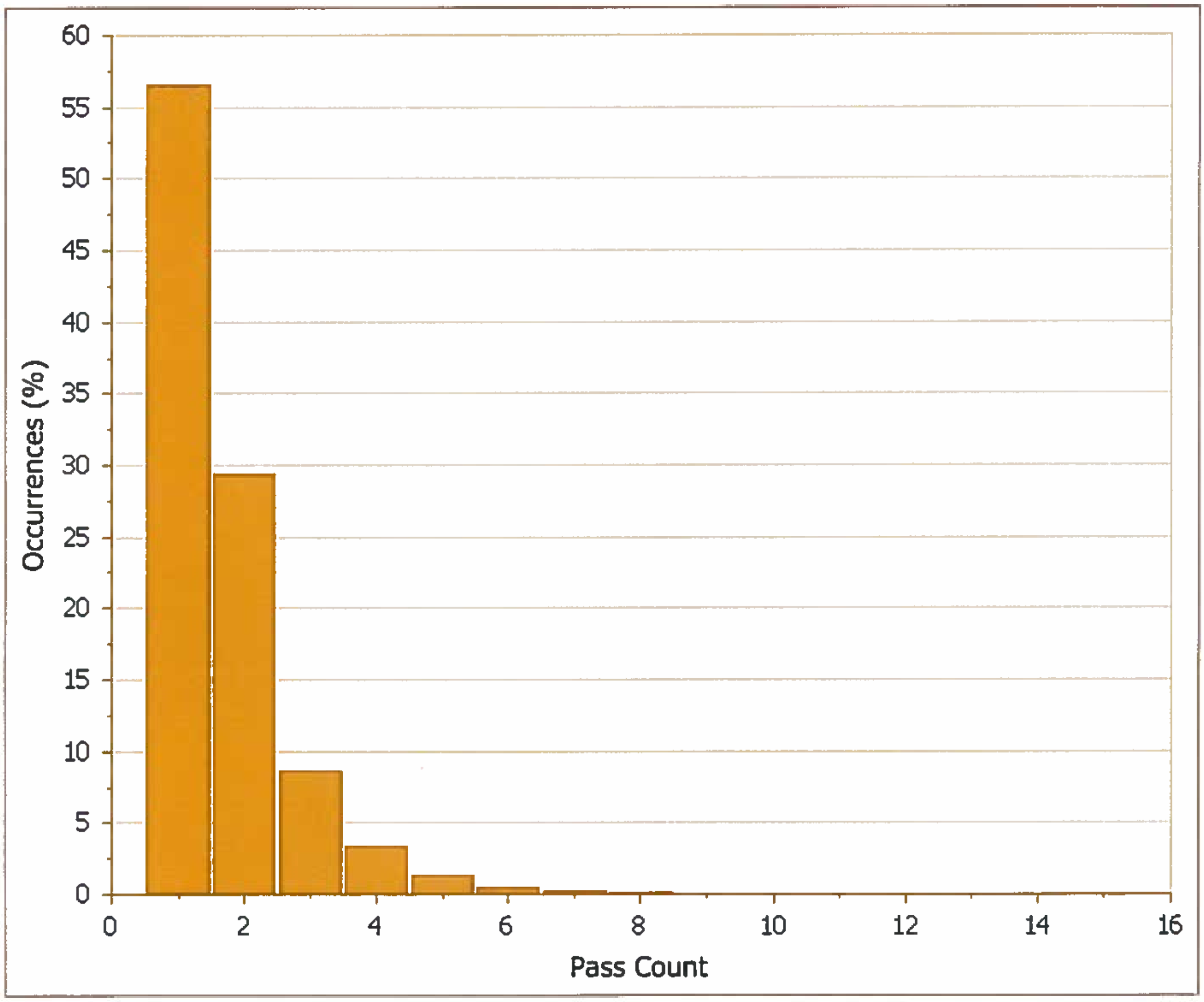
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

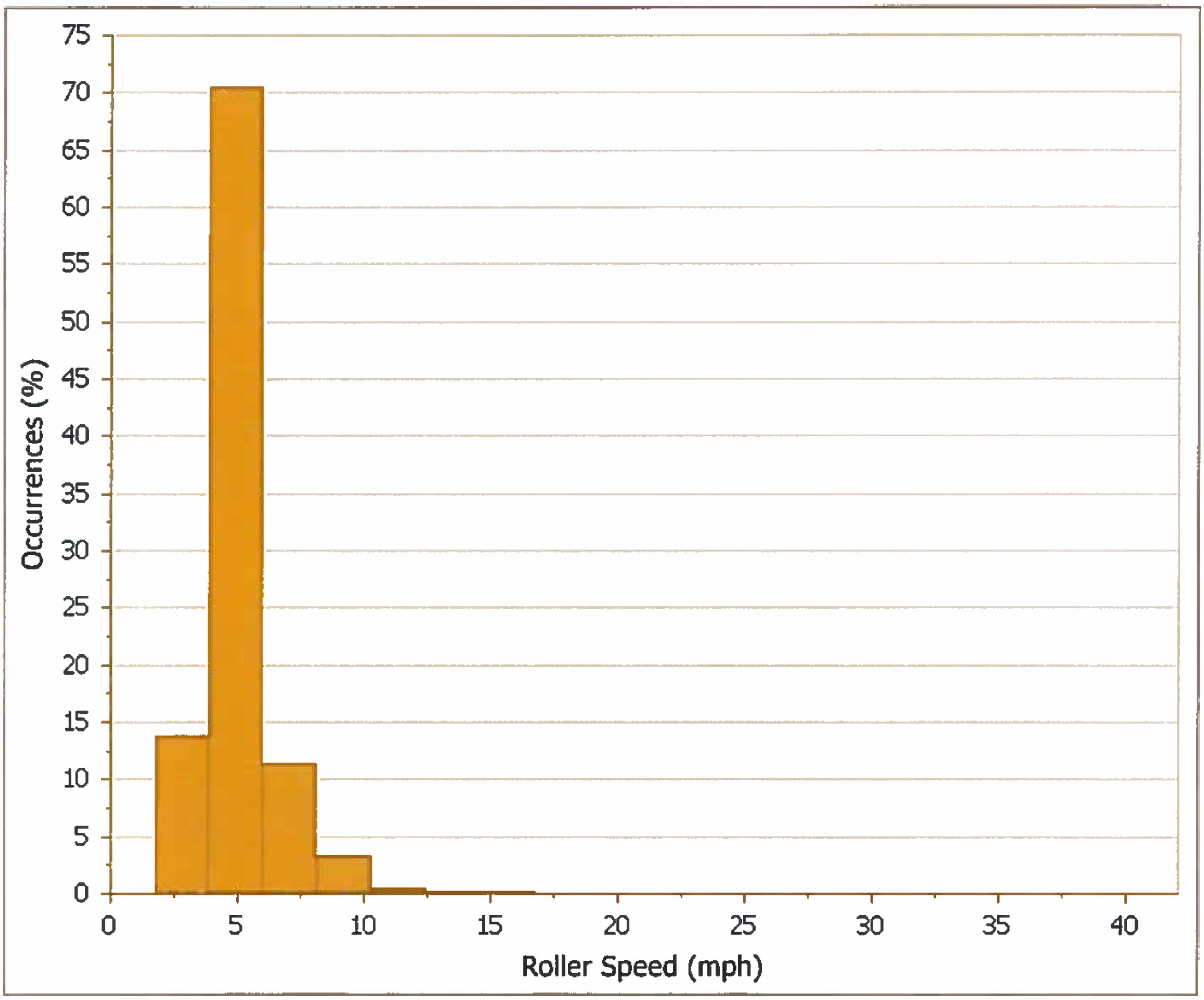
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	60
Min	1
Max	14
Sample Size	239,714
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

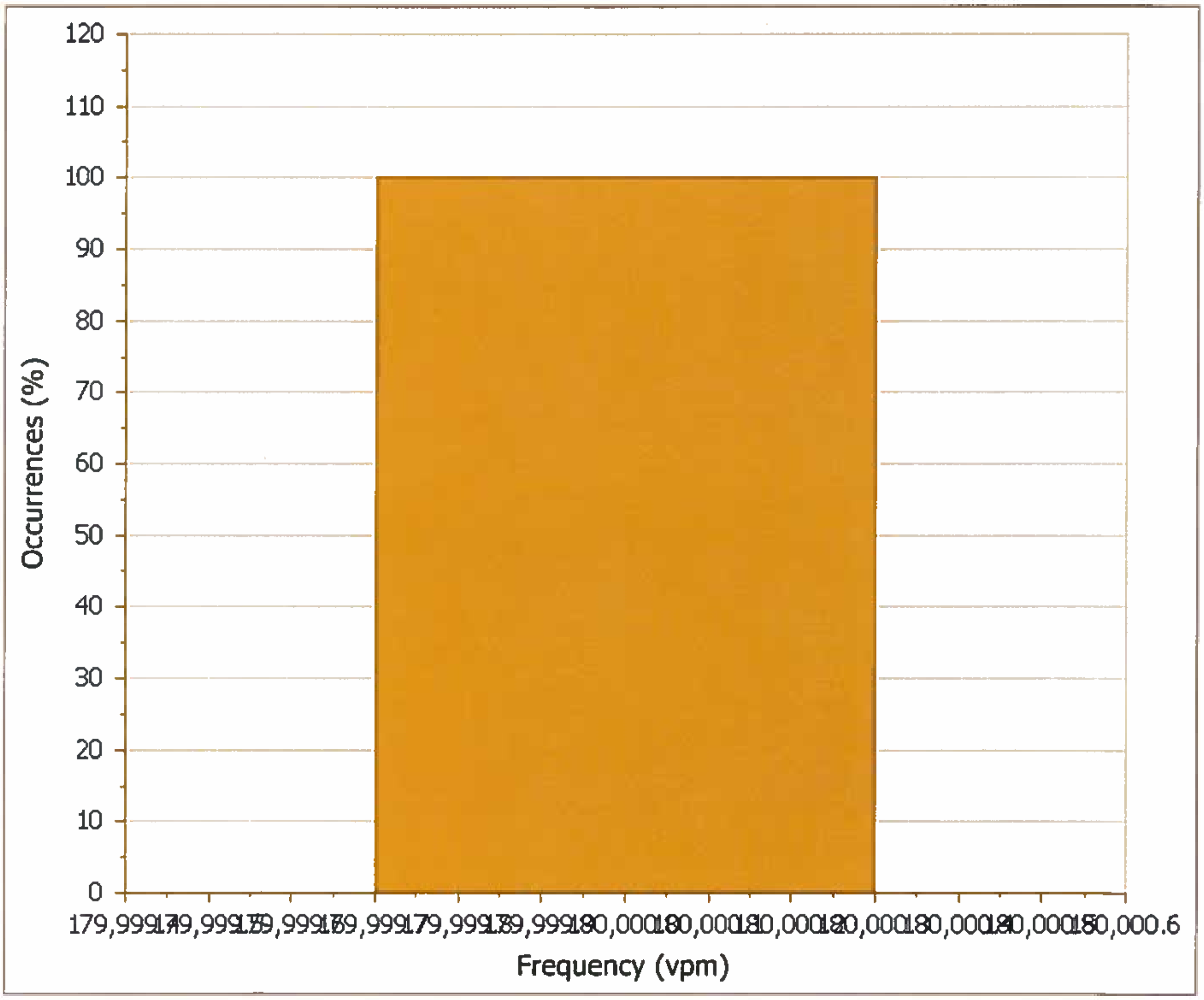
Statistic	Value
Mean (mph)	4.1
Standard Deviation (mph)	1.5
CoV (%)	37
Min (mph)	0.6
Max (mph)	43.7
Sample Size	239,714
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

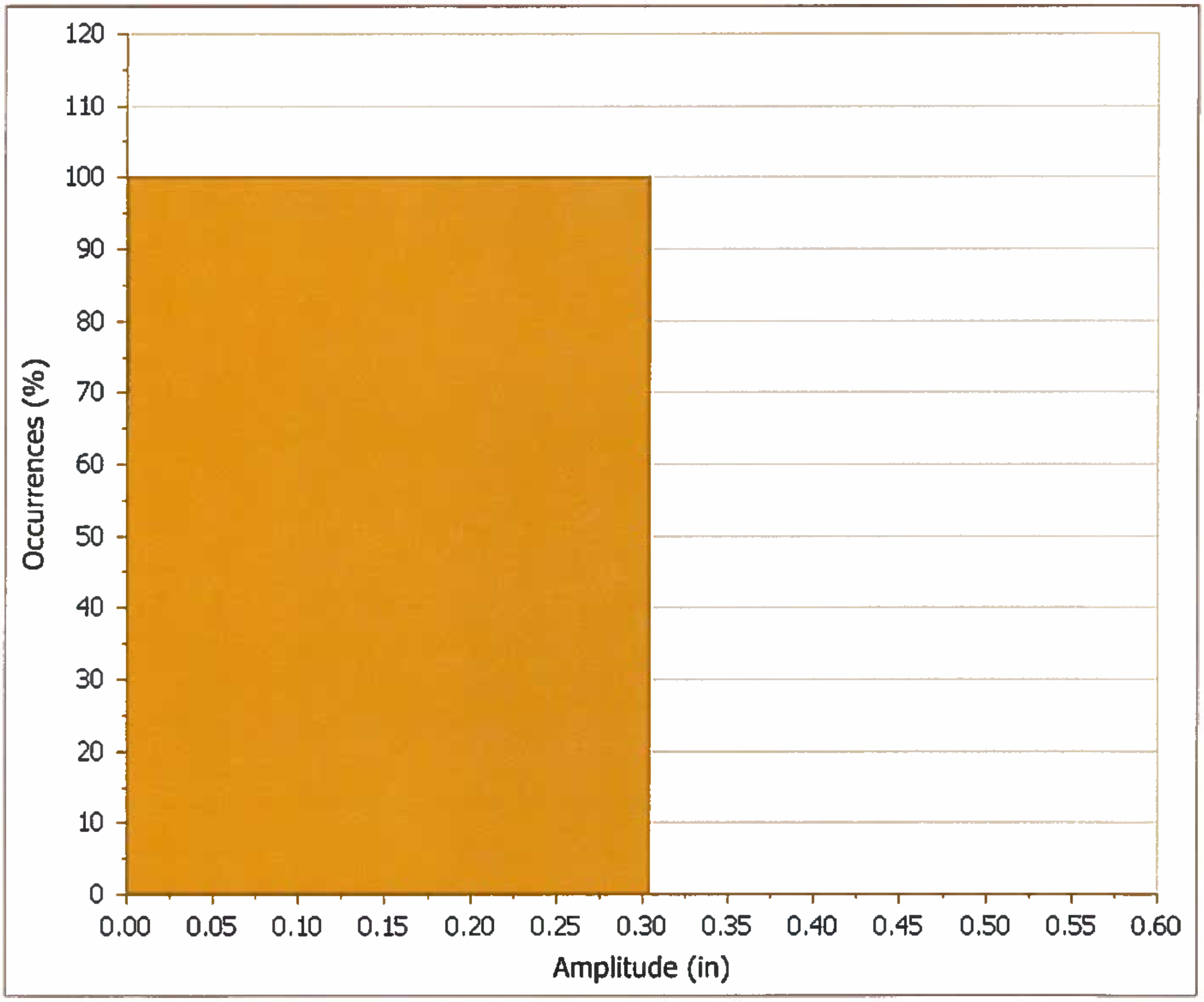
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	76,501
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	76,501
Target Status	Failed
% of Target Achieved	0.00

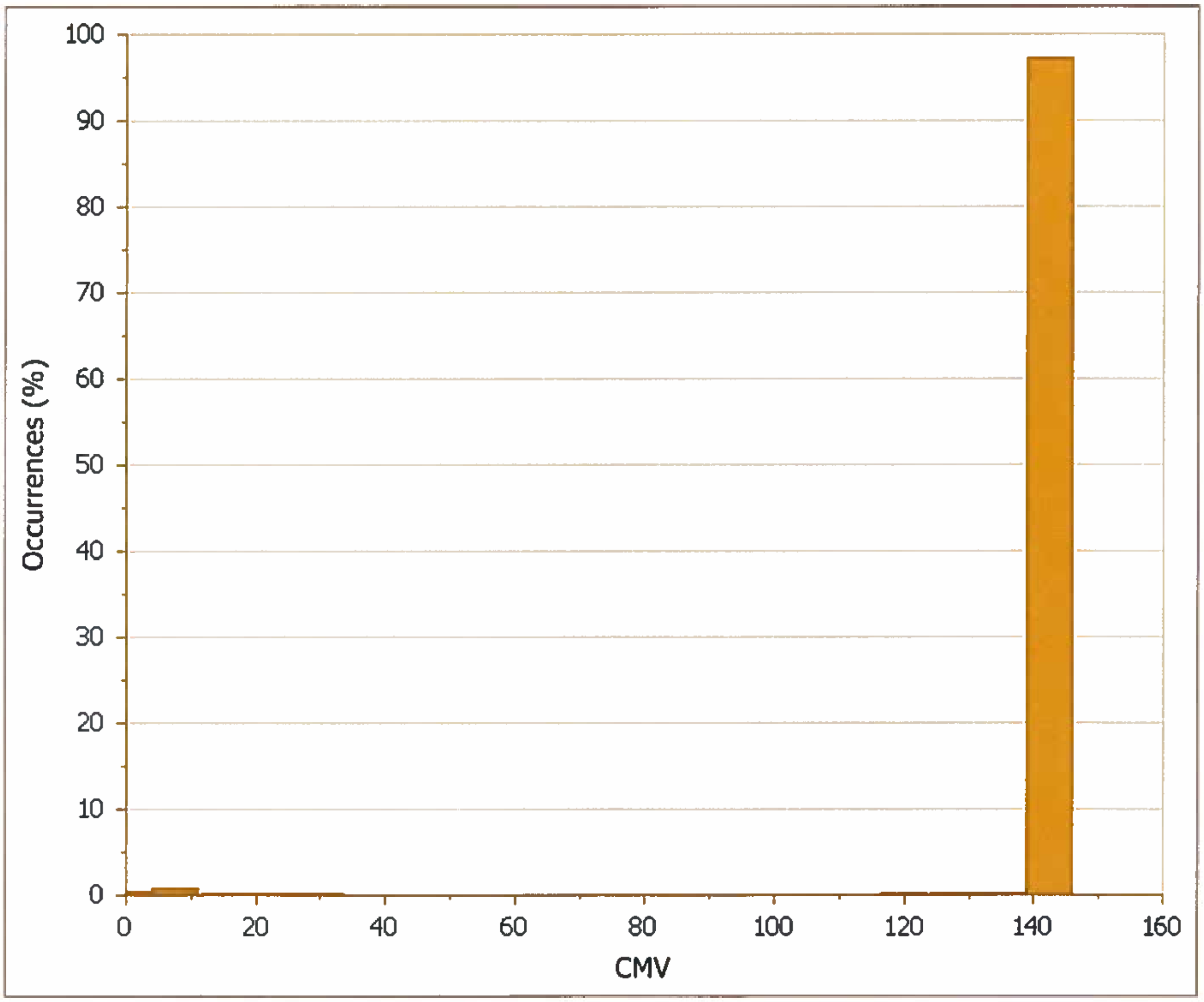


Pass Count 2013-05-20 to 05-25 LAST

Final Coverage: CMV

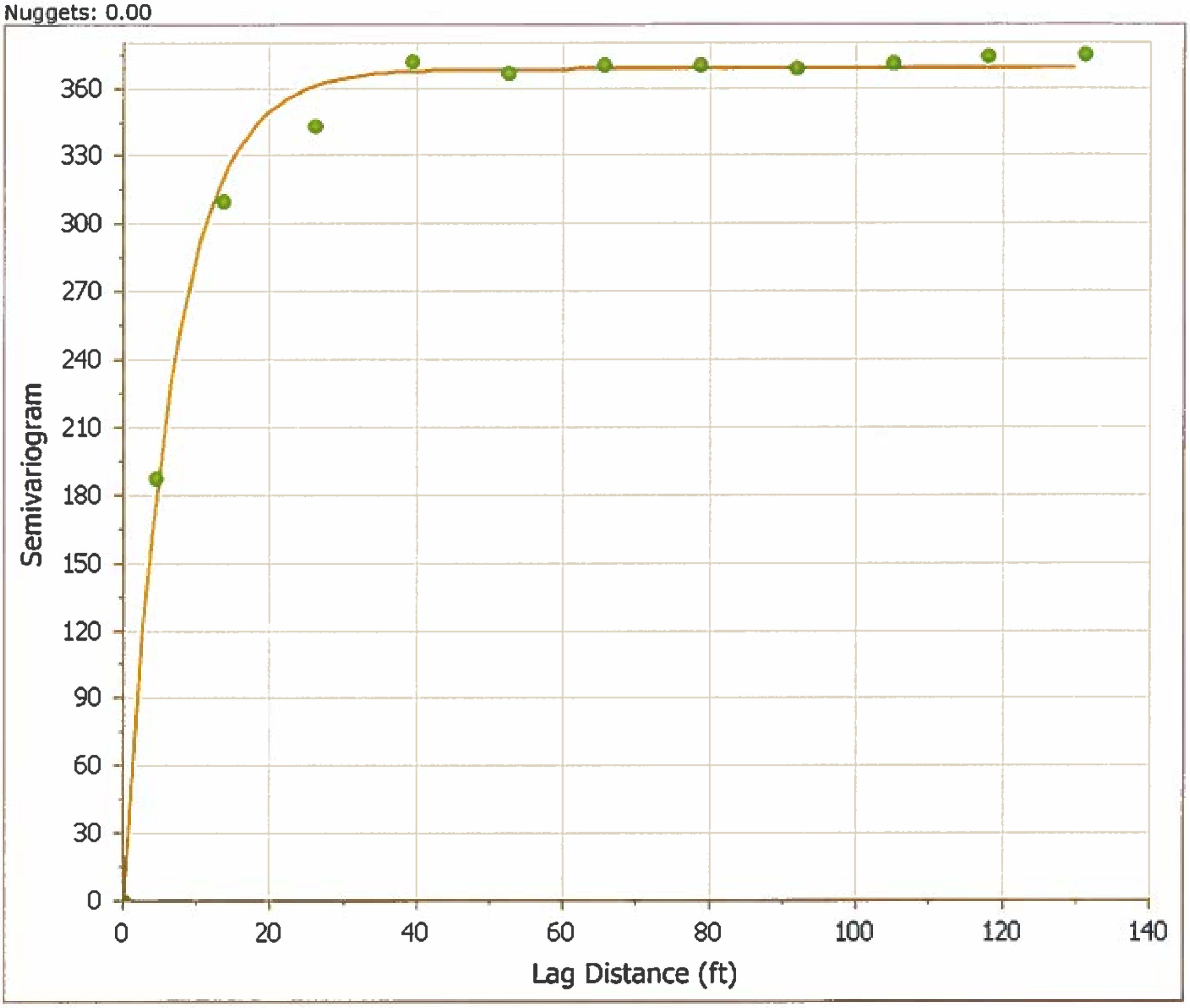
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	146.84
Standard Deviation	19.69
CoV (%)	13
Min	0.10
Max	150.00
Sample Size	76,501
Target Status	Passed
% of Target Achieved	99.68



Final Coverage: Semivariogram

Range (ft): 15.74
Sill: 333.35
Vertical Scale: 333.35
Nuggets: 0.00



Pass Count 2013-06 Last

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-06 all
State Plane Zone: 1702 - Louisiana South

File Information

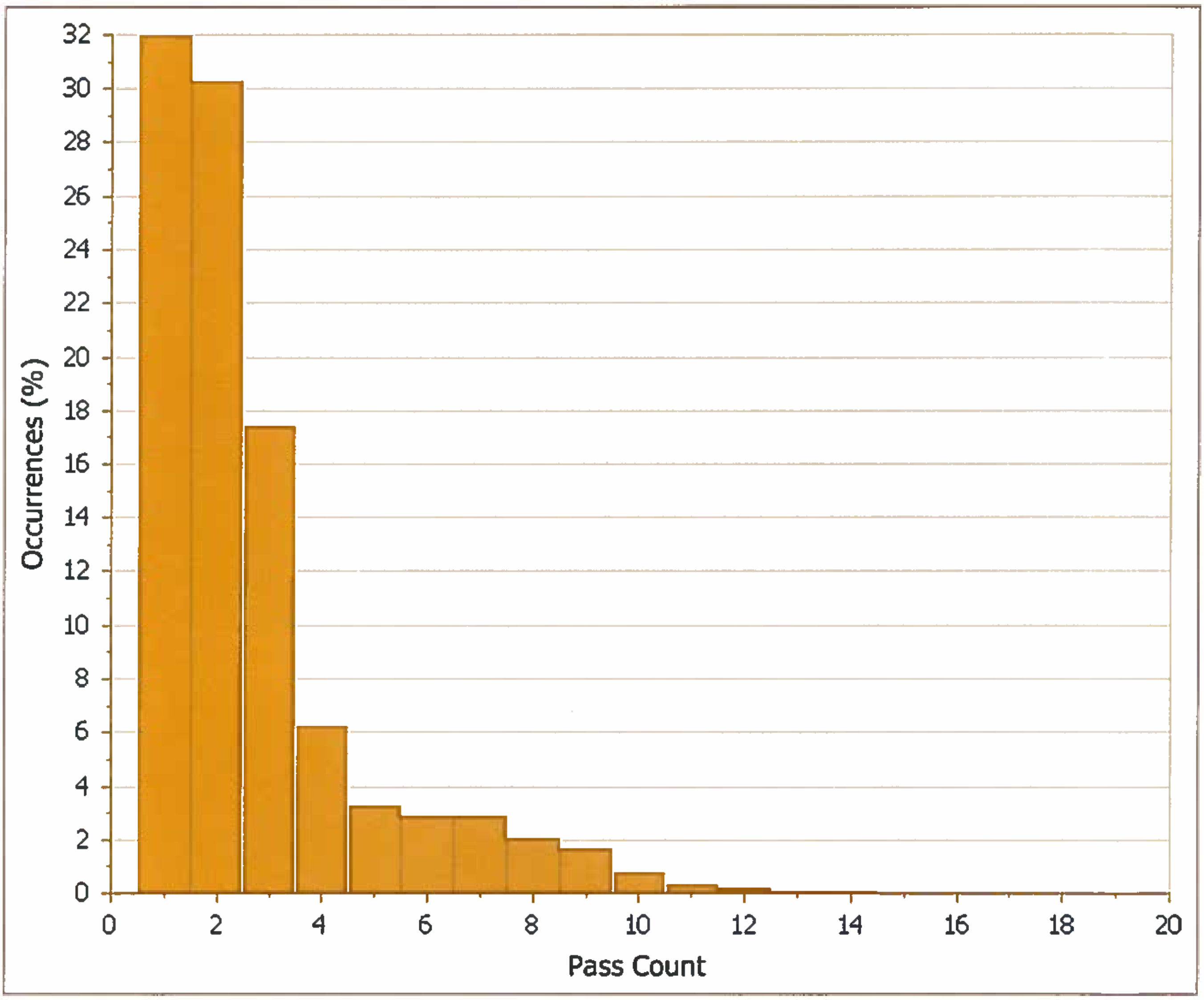
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

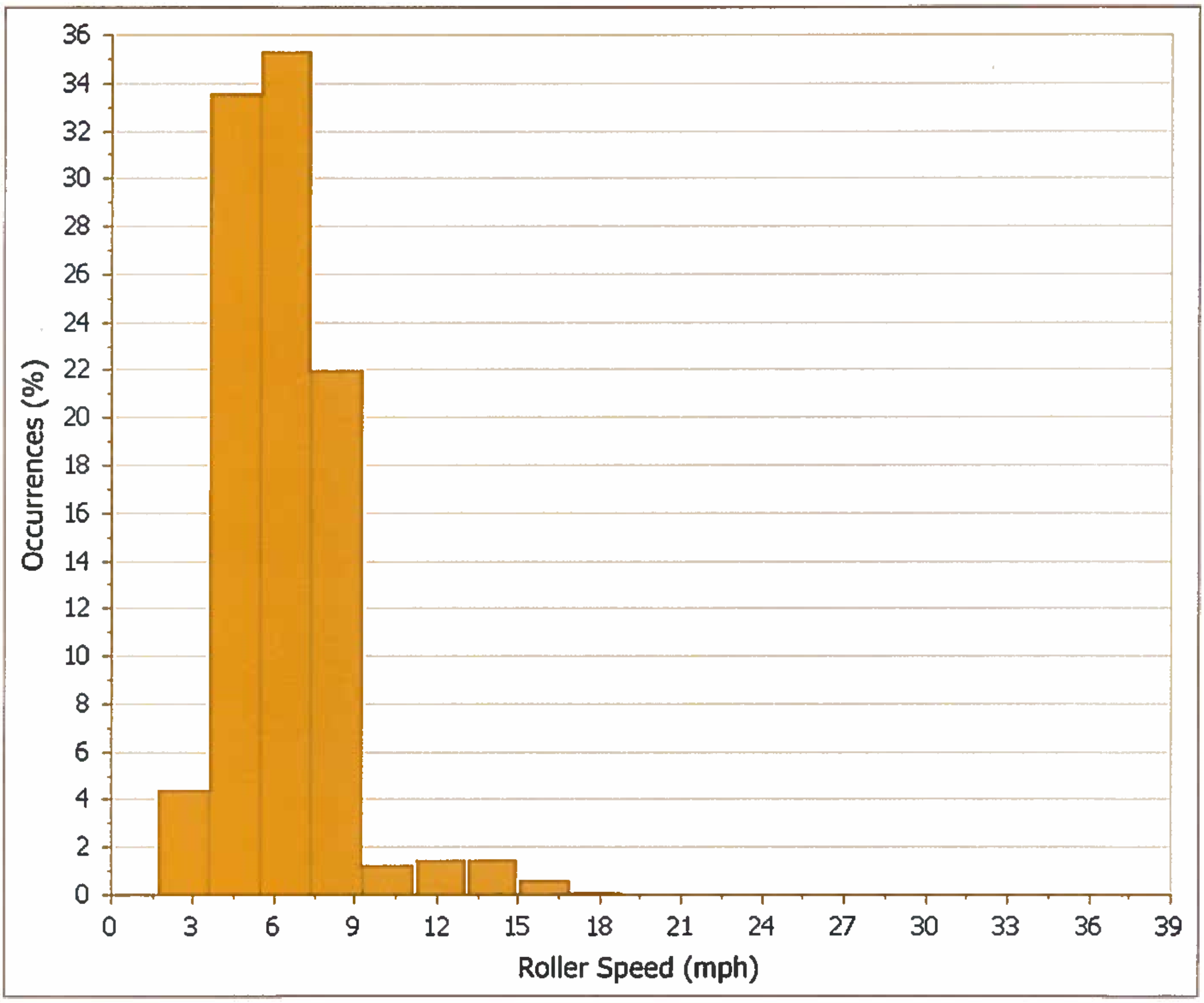
Statistic	Value
Mean	3
Standard Deviation	2
CoV (%)	78
Min	1
Max	19
Sample Size	211,630
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

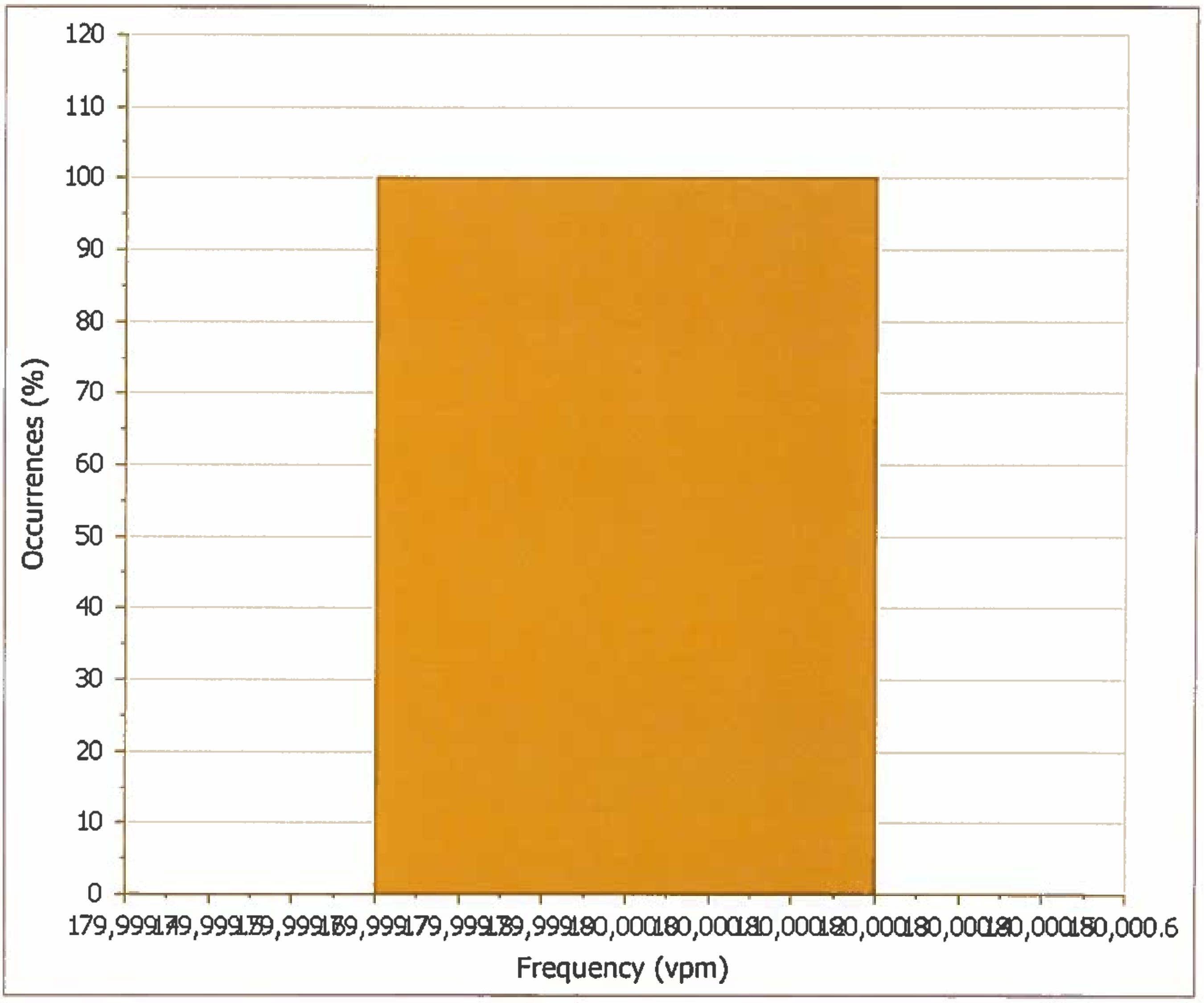
Statistic	Value
Mean (mph)	5.4
Standard Deviation (mph)	2.2
CoV (%)	42
Min (mph)	0.7
Max (mph)	38.8
Sample Size	211,630
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

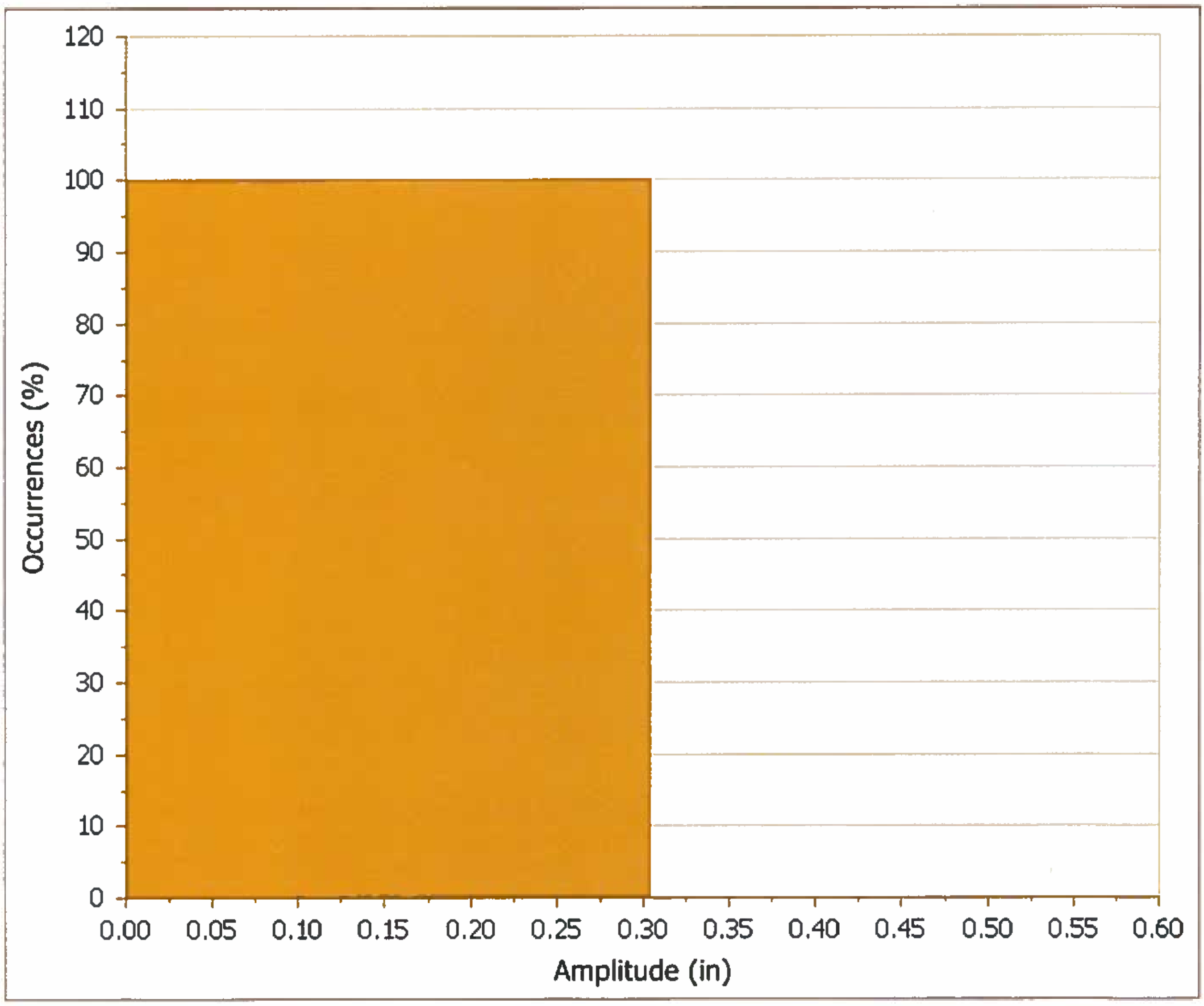
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	35,254
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	35,254
Target Status	Failed
% of Target Achieved	0.00

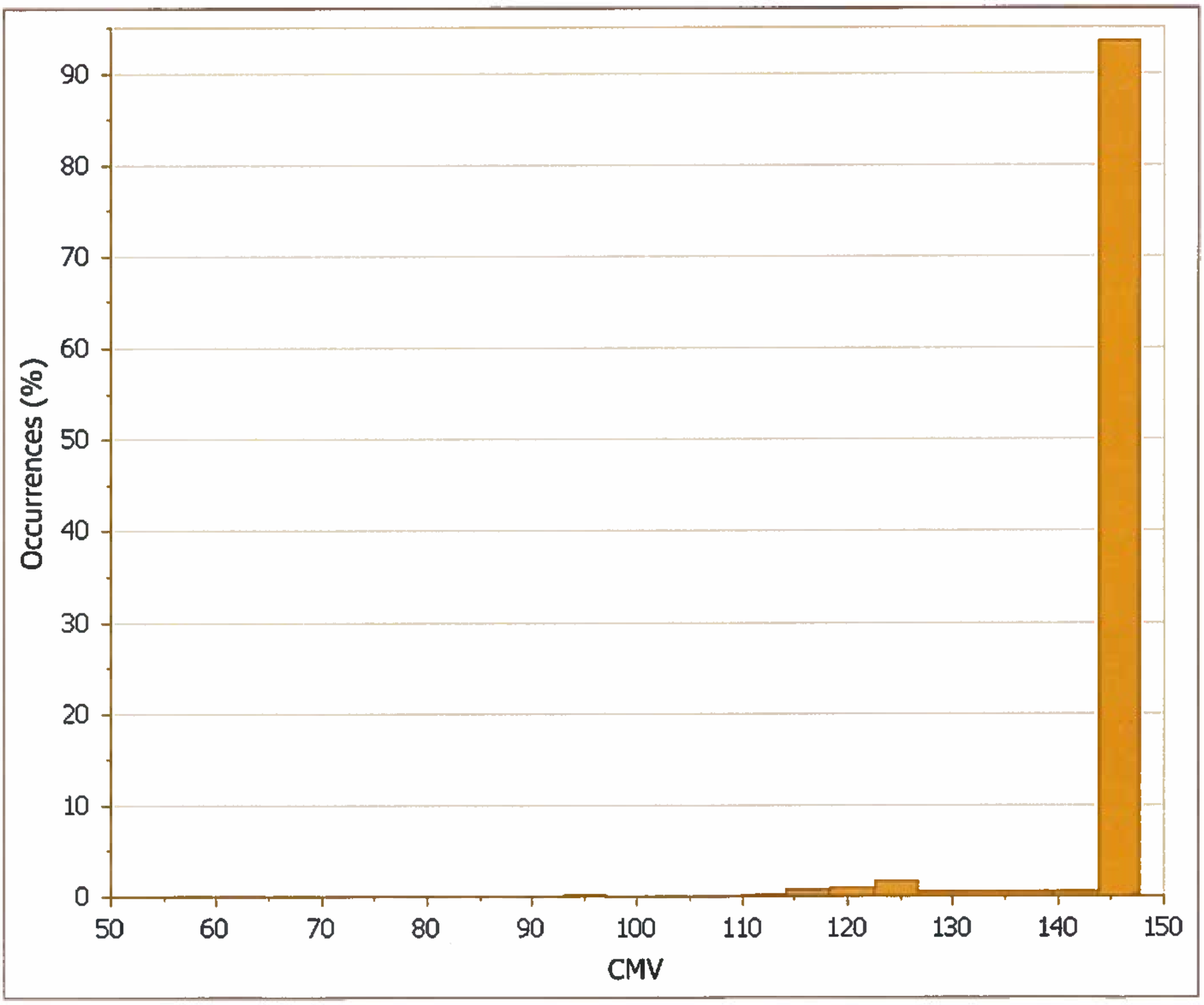


Pass Count 2013-06 Last

Final Coverage: CMV

Target Percentage (%): 0.00
Target Value: 0.00

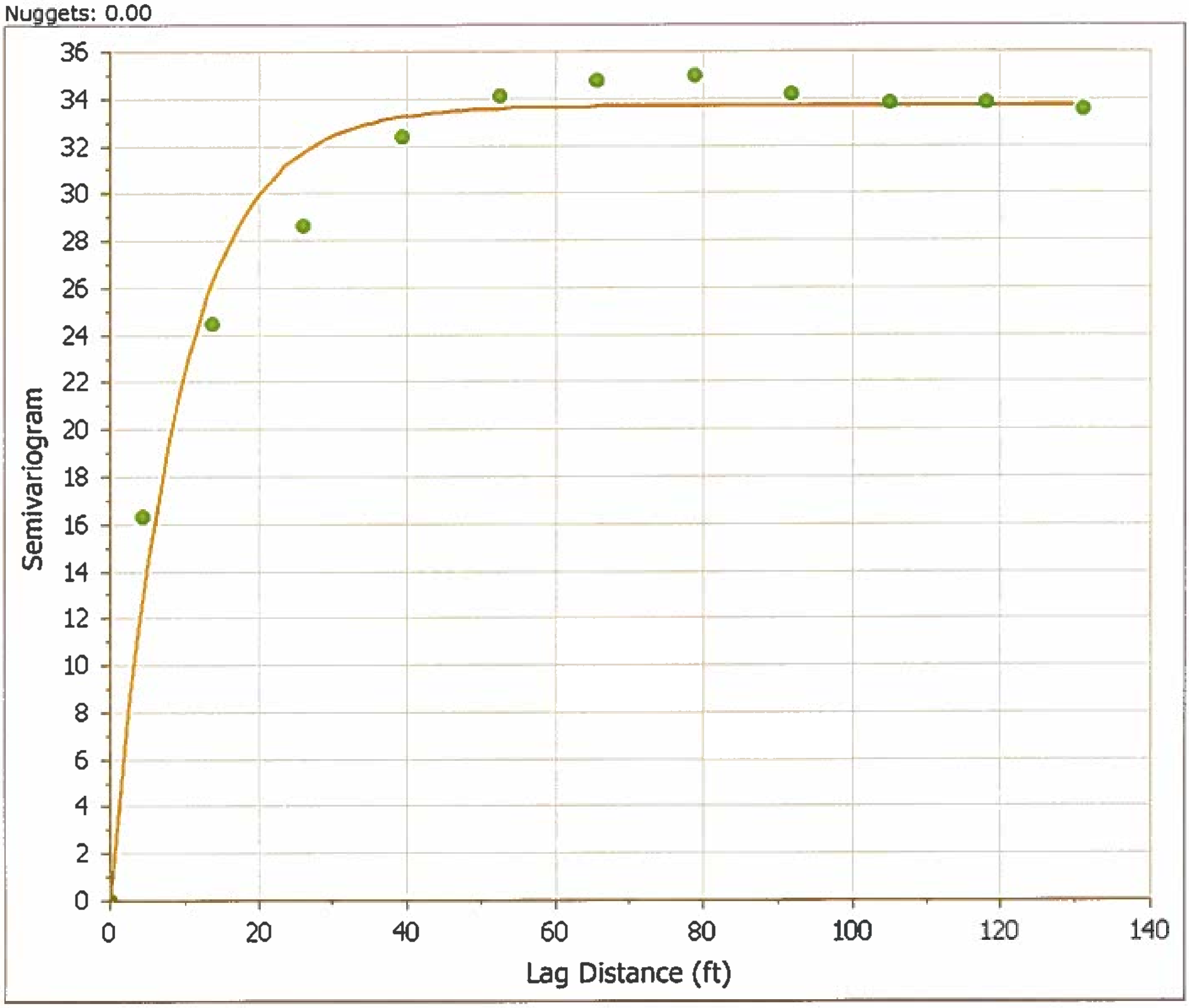
Statistic	Value
Mean	148.01
Standard Deviation	7.67
CoV (%)	5
Min	65.40
Max	150.00
Sample Size	35,254
Target Status	Passed
% of Target Achieved	99.99



Pass Count 2013-06 Last

Final Coverage: Semivariogram

Range (ft): 19.68
Sill: 29.78
Vertical Scale: 29.78
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-07-31 Last PASS
State Plane Zone: 1702 - Louisiana South

File Information

Final Coverage
Final Coverage: True

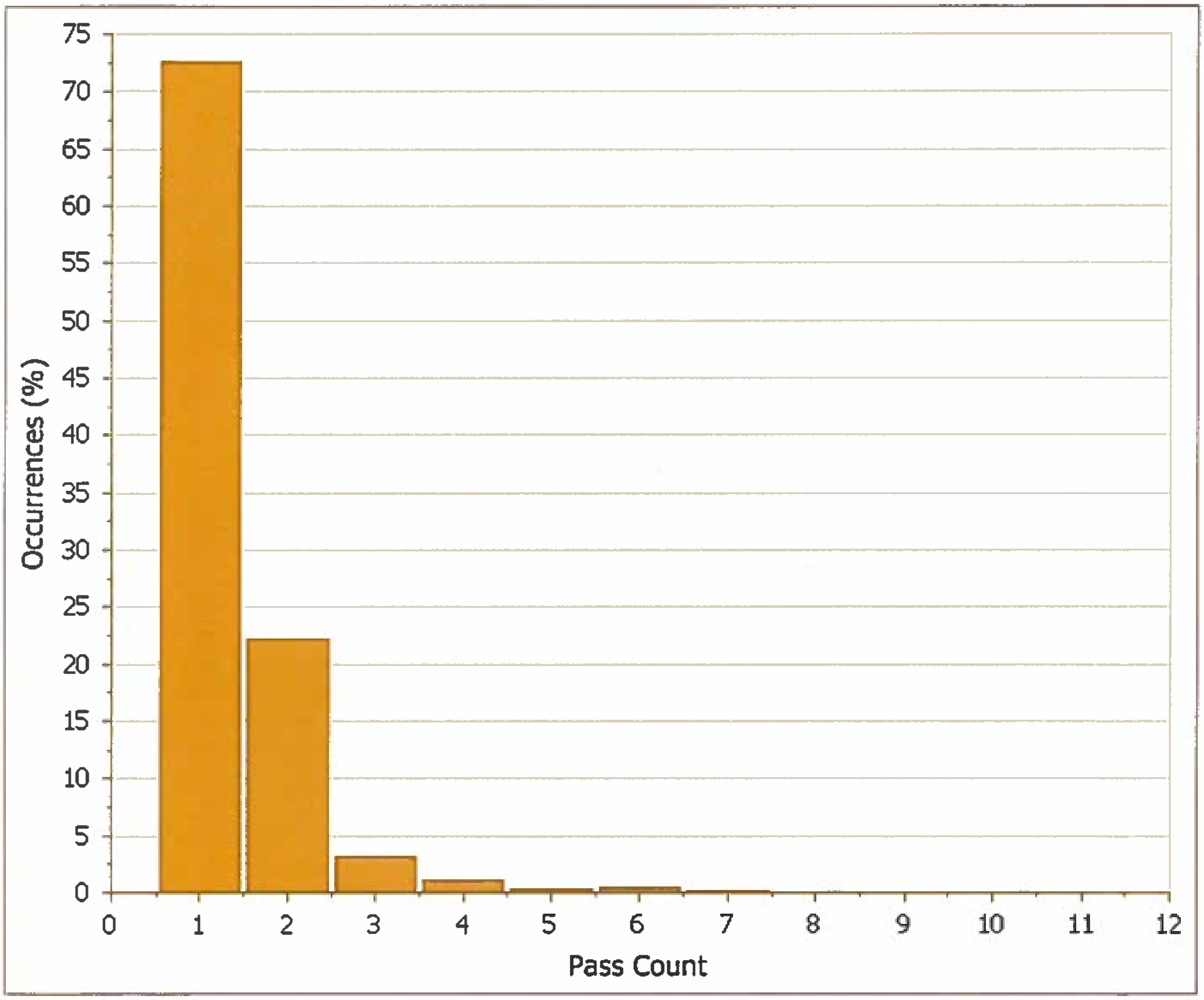
Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Pass Count 2013-07-31 Last PASS

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

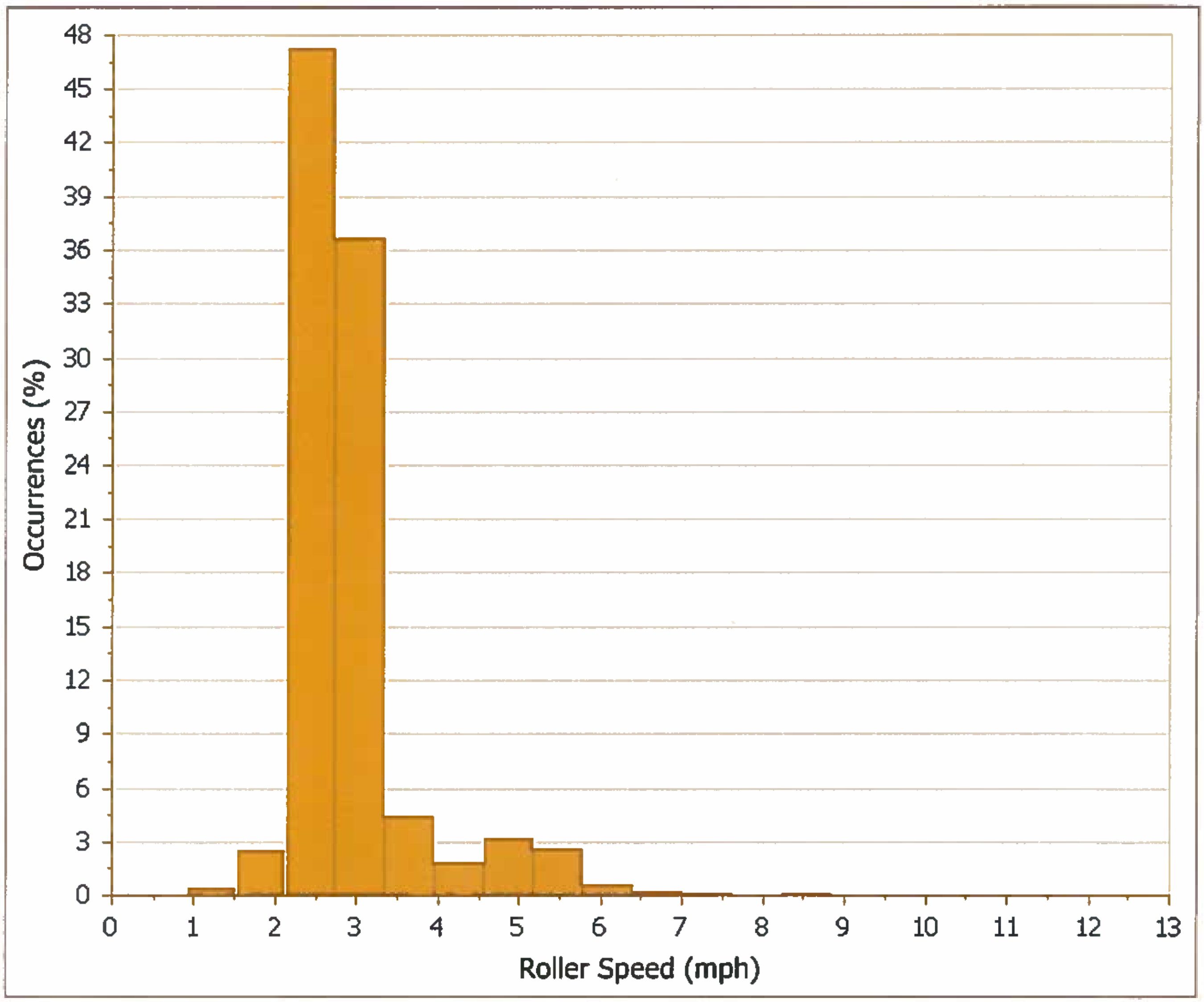
Statistic	Value
Mean	1
Standard Deviation	1
CoV (%)	53
Min	1
Max	11
Sample Size	38,477
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	2.7
Standard Deviation (mph)	0.8
CoV (%)	30
Min (mph)	0.6
Max (mph)	12.8
Sample Size	38,477
Target Status	Passed
% of Target Achieved	99.99

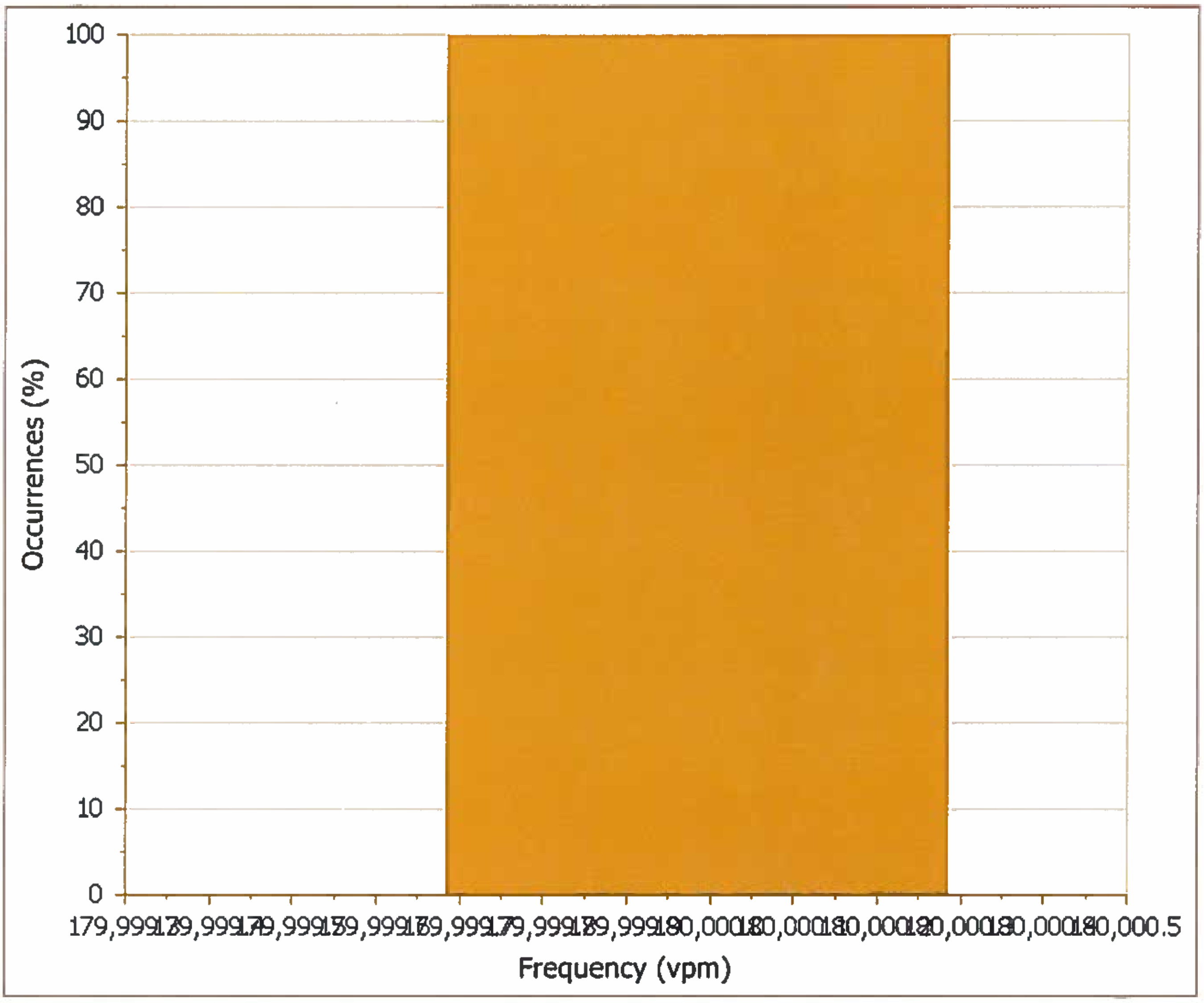


Pass Count 2013-07-31 Last PASS

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	38,457
Target Status	Passed
% of Target Achieved	99.98

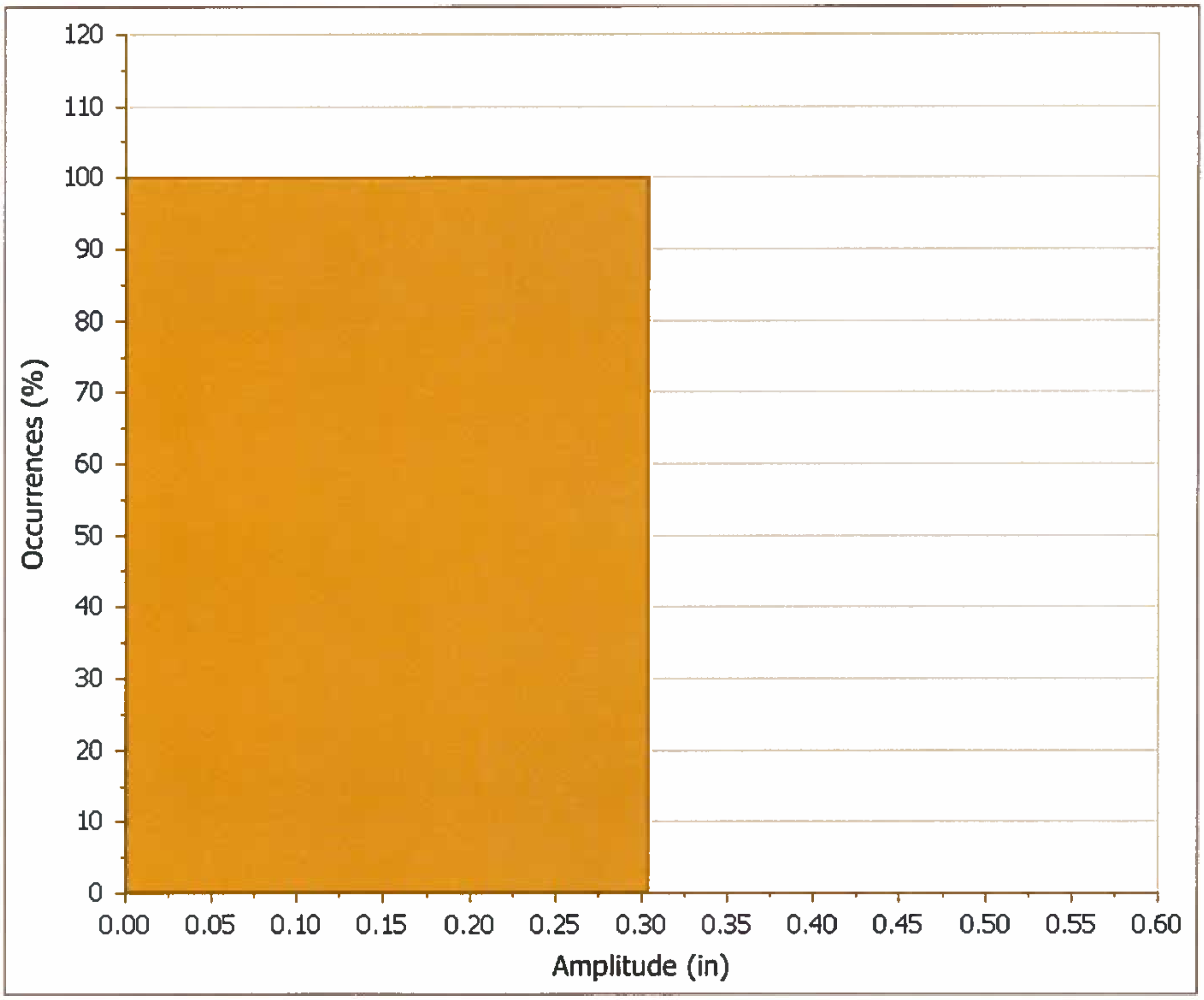


Pass Count 2013-07-31 Last PASS

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	38,457
Target Status	Failed
% of Target Achieved	0.00

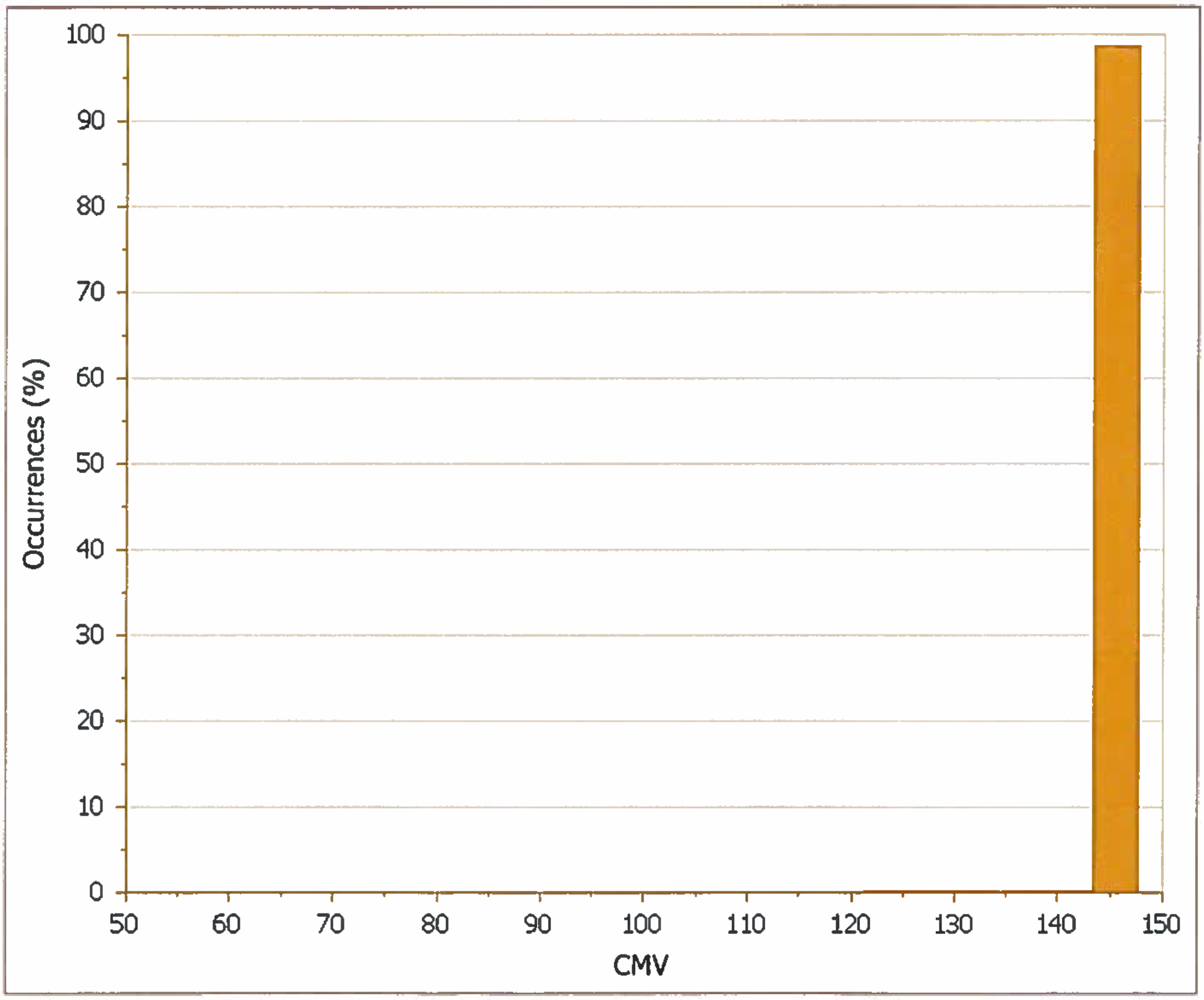


Pass Count 2013-07-31 Last PASS

Final Coverage: CMV

Target Percentage (%): 0.00
Target Value: 0.00

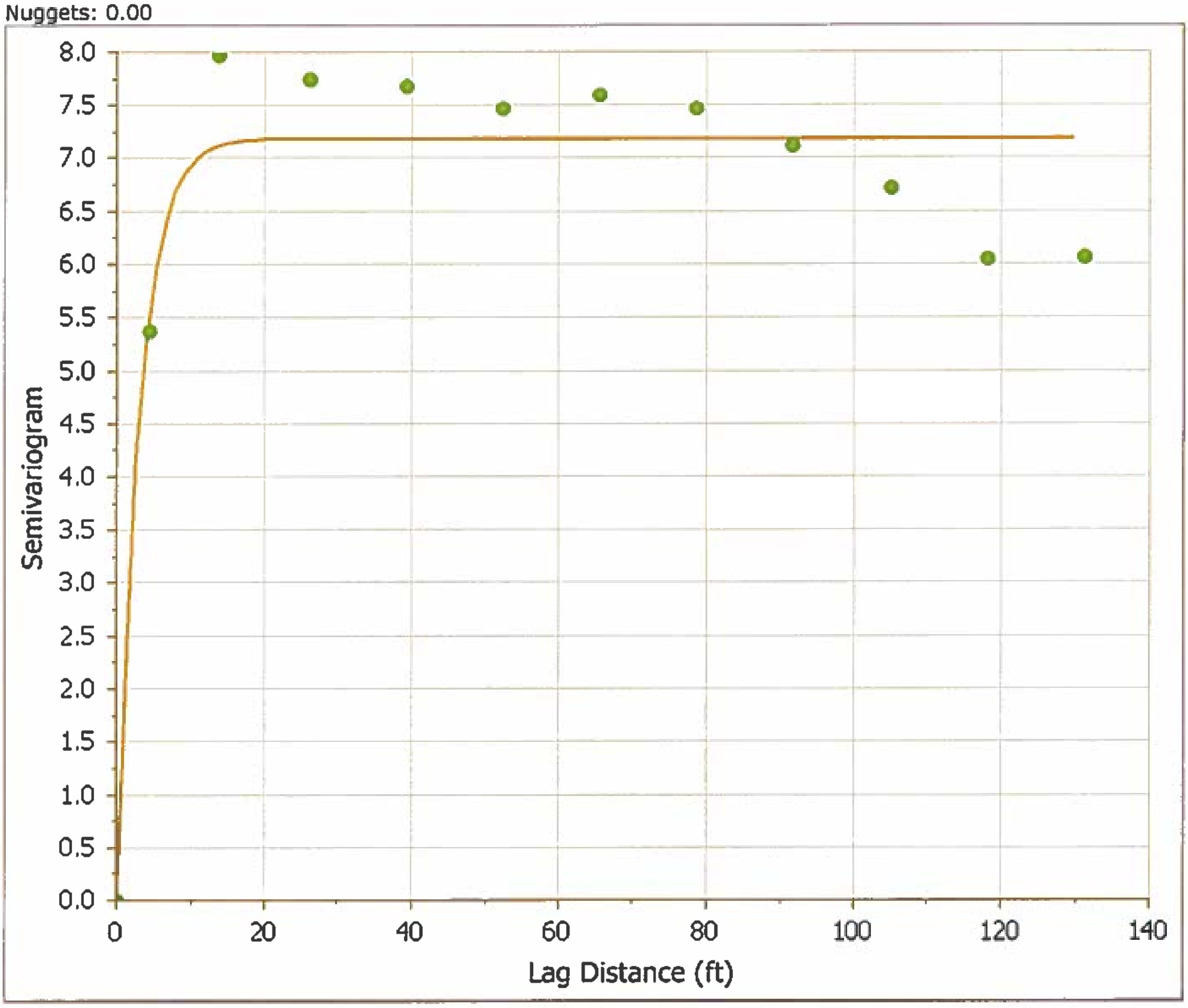
Statistic	Value
Mean	149.58
Standard Deviation	3.77
CoV (%)	3
Min	61.20
Max	150.00
Sample Size	38,457
Target Status	Passed
% of Target Achieved	99.99



Pass Count 2013-07-31 Last PASS

Final Coverage: Semivariogram

Range (ft): 9.18
Sill: 6.86
Vertical Scale: 6.86
Nuggets: 0.00



Pass Count 2013-07-31 to 08-08 LAST

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-07-31 to 08-08 LAST
State Plane Zone: 1702 - Louisiana South

File Information

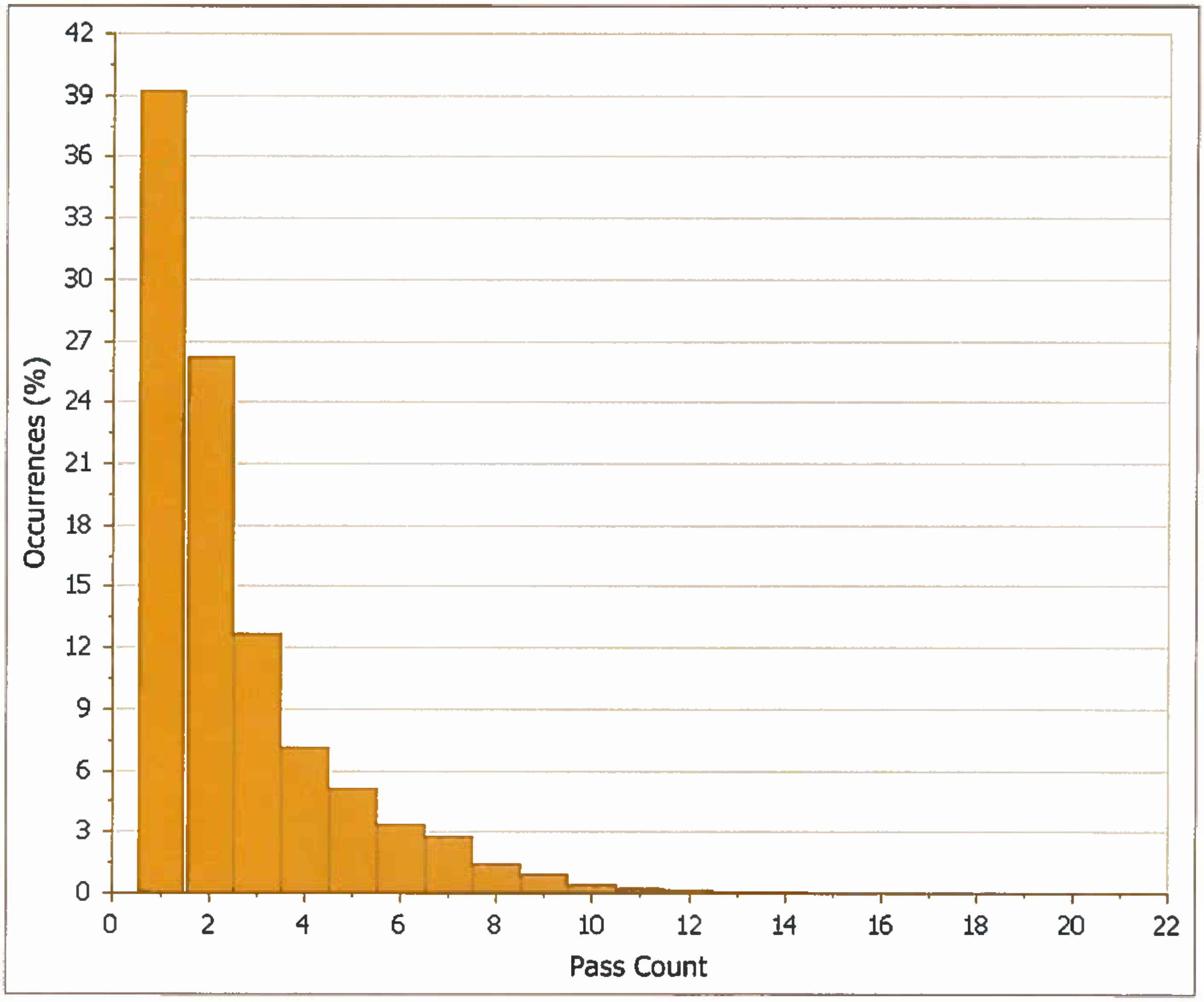
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

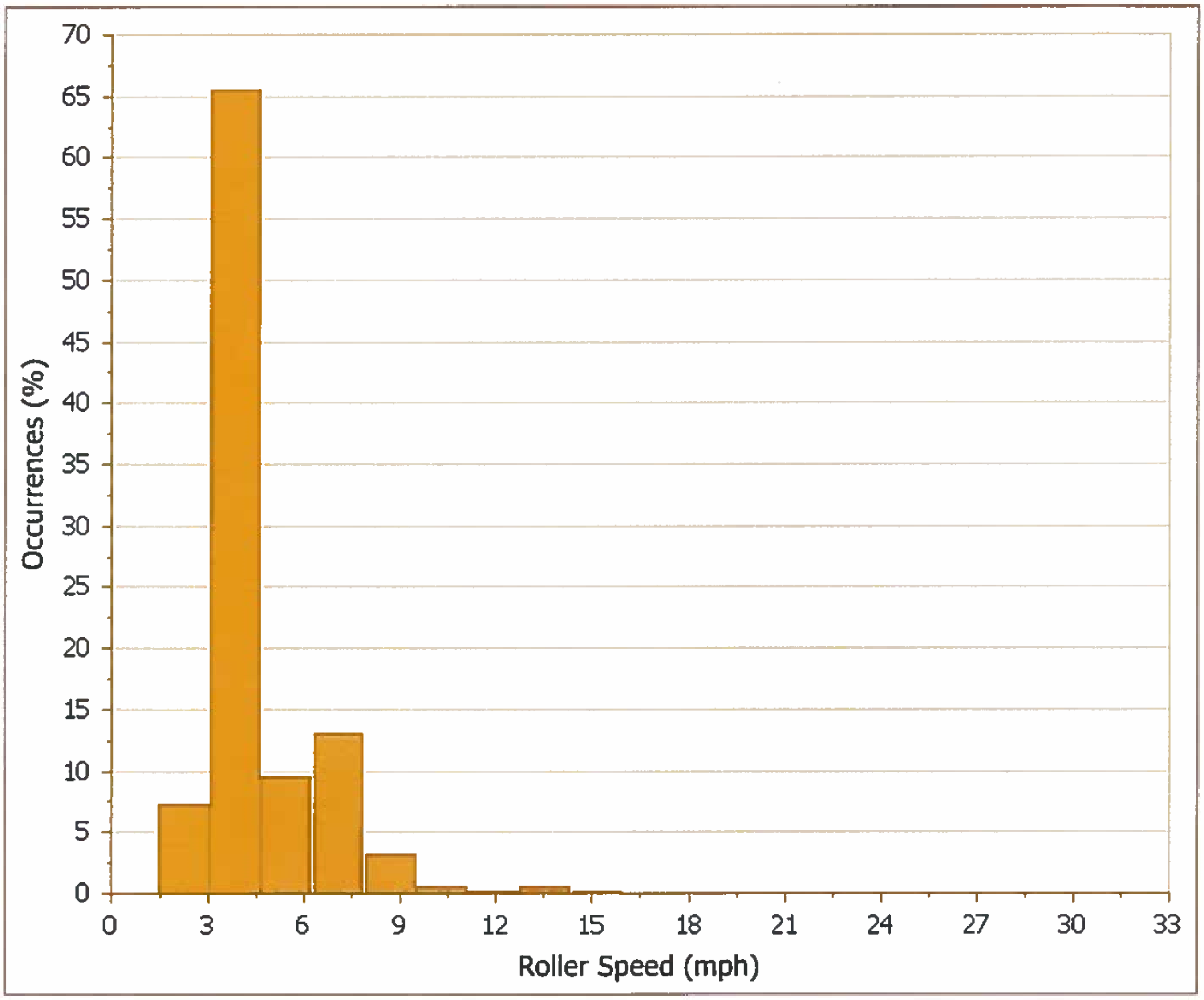
Statistic	Value
Mean	3
Standard Deviation	2
CoV (%)	80
Min	1
Max	21
Sample Size	209,771
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	3.8
Standard Deviation (mph)	1.8
CoV (%)	48
Min (mph)	0.6
Max (mph)	32.9
Sample Size	209,771
Target Status	Passed
% of Target Achieved	100.00

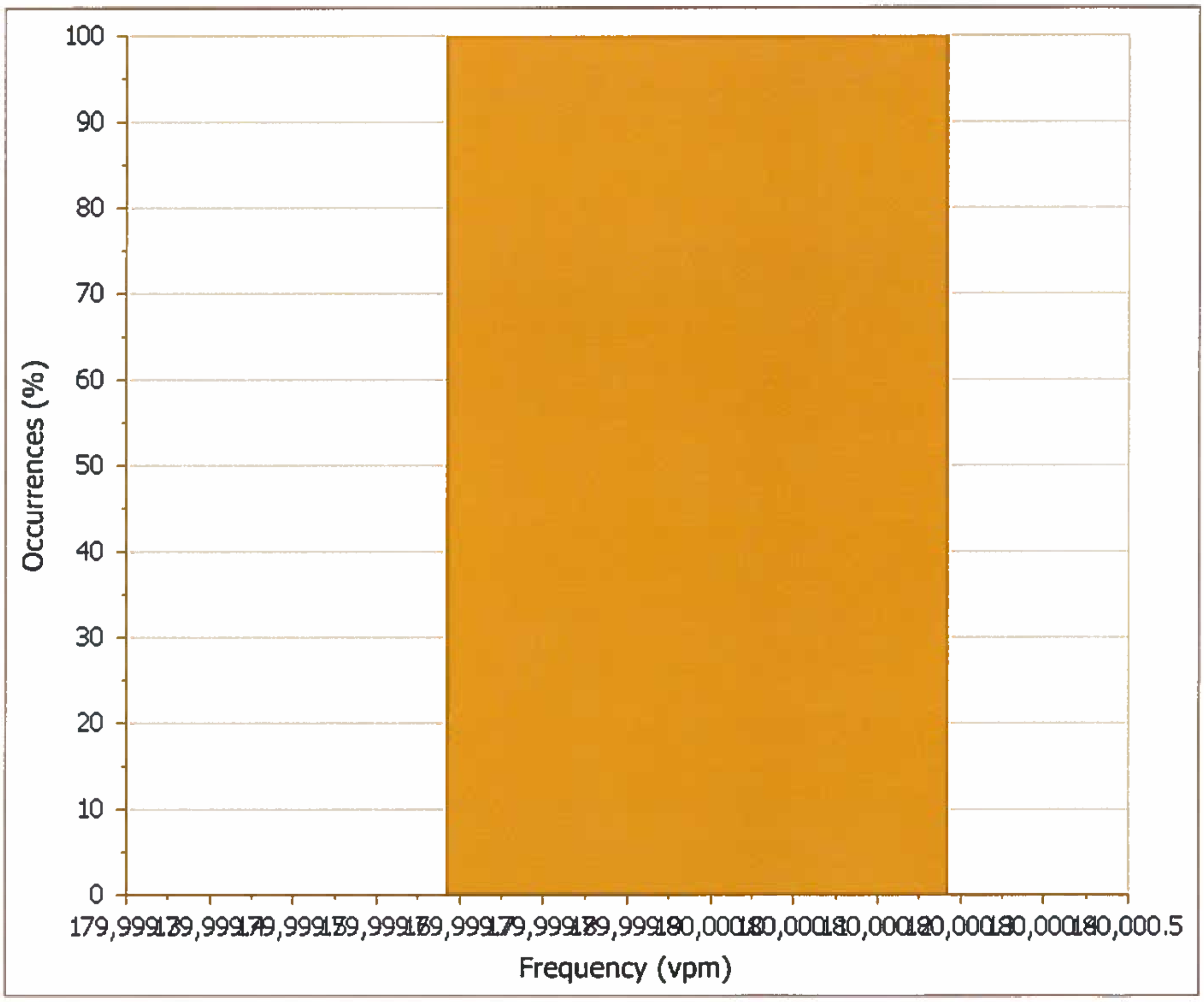


Pass Count 2013-07-31 to 08-08 LAST

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

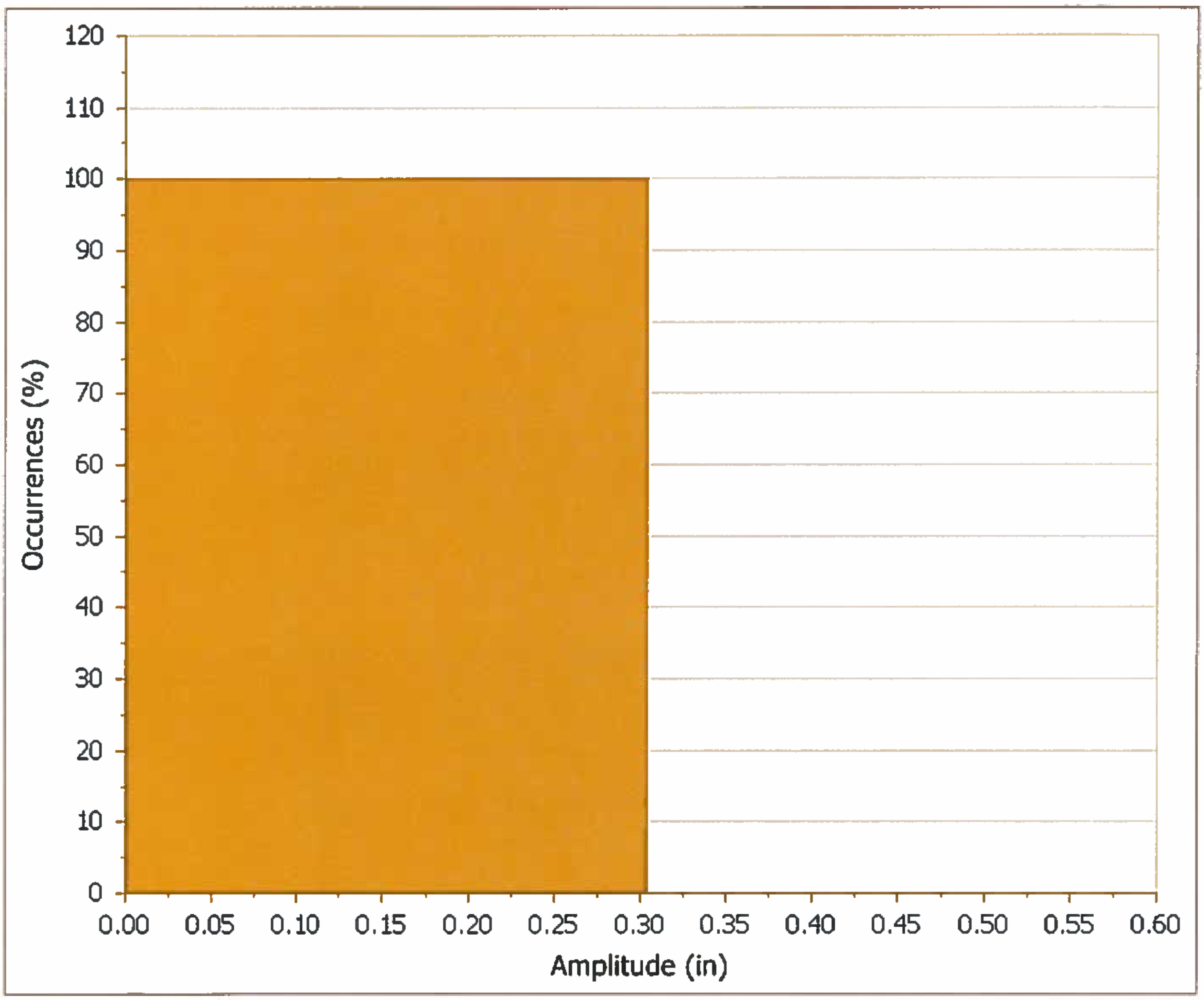
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	197,679
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Amplitude

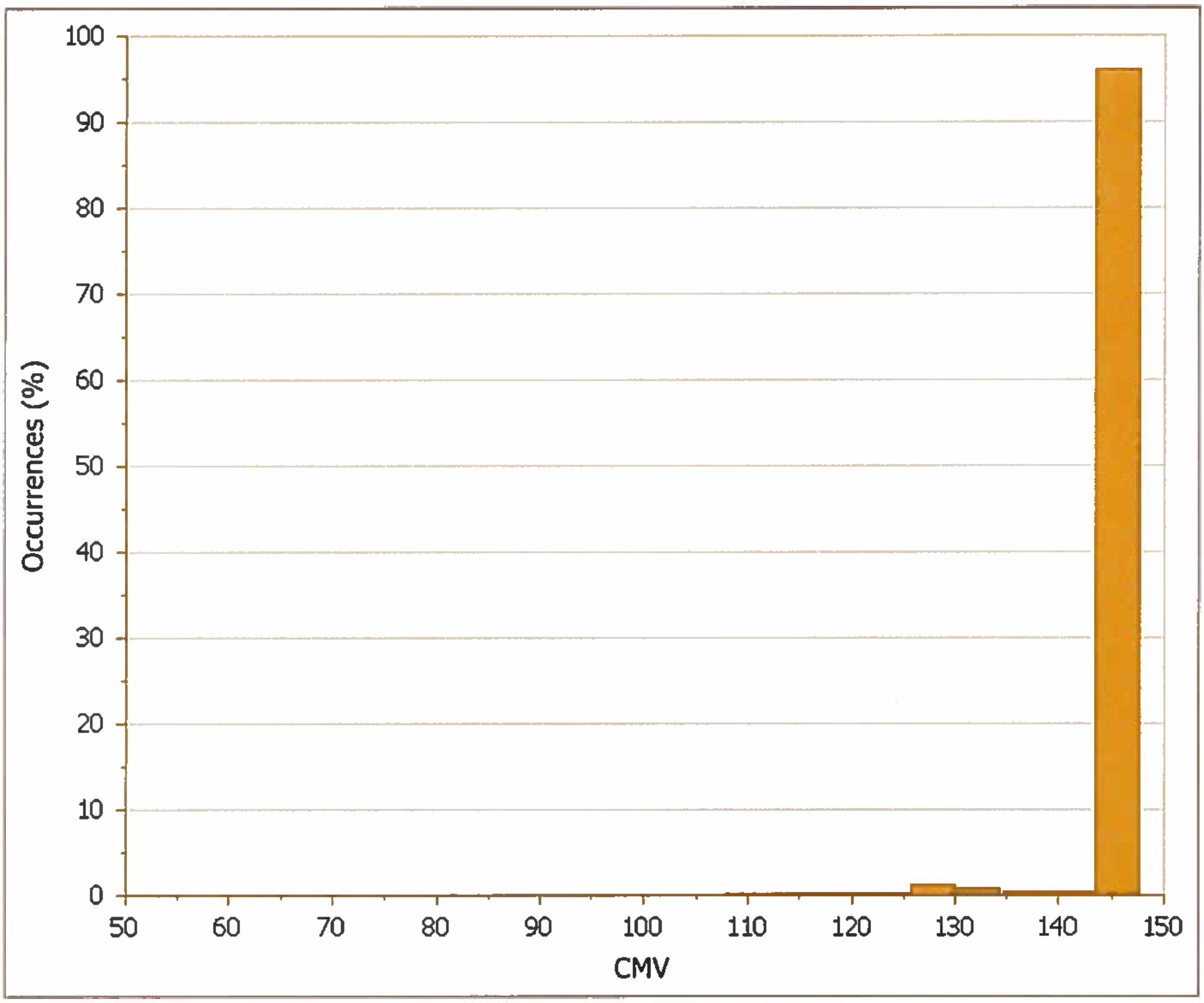
Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	197,679
Target Status	Failed
% of Target Achieved	0.00



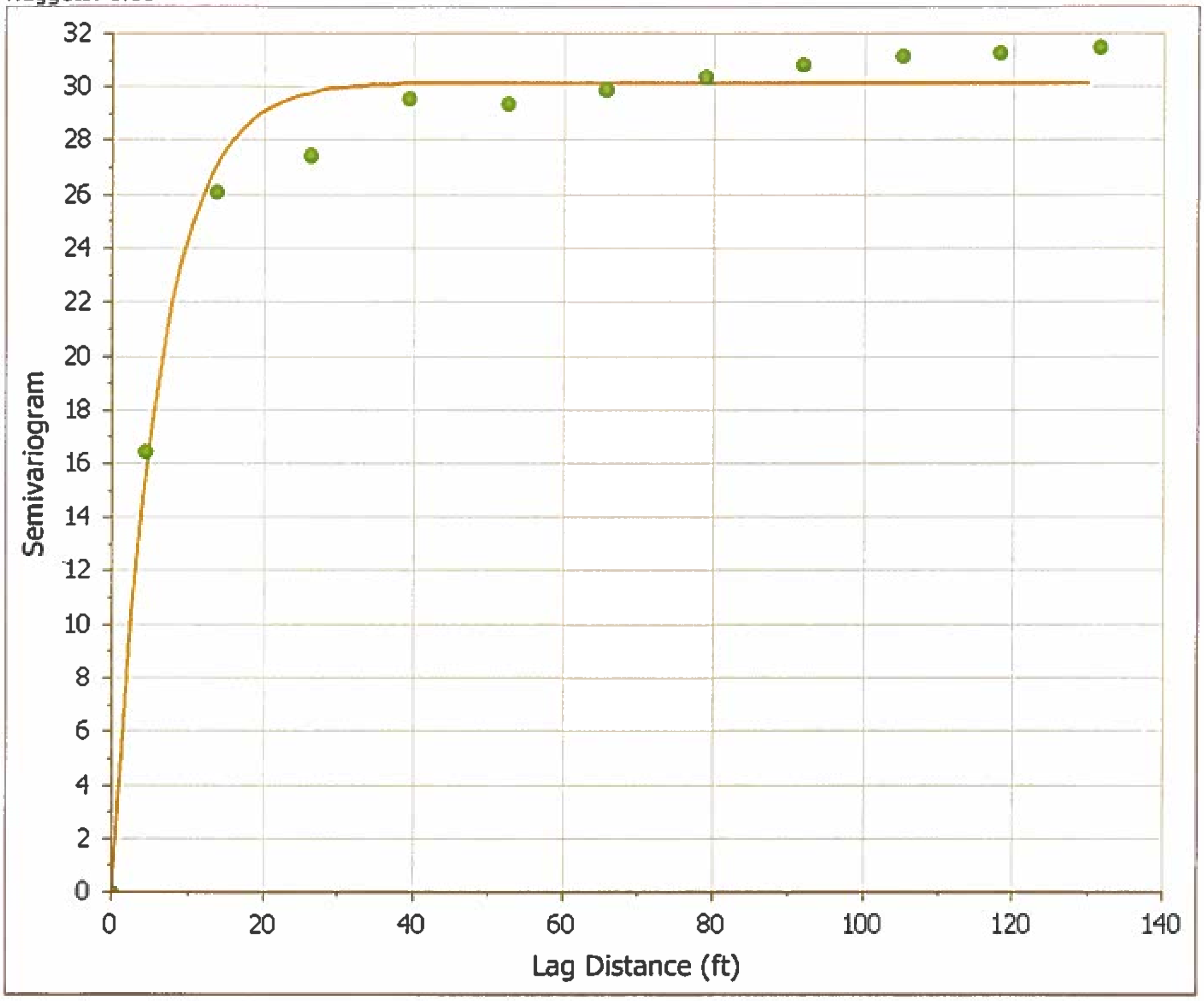
Final Coverage: CMV
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	148.88
Standard Deviation	5.68
CoV (%)	4
Min	61.20
Max	150.00
Sample Size	197,679
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Semivariogram

Range (ft): 15.75
Sill: 27.98
Vertical Scale: 27.98
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-08-08 Final Coverage
State Plane Zone: 1702 - Louisiana South

File Information

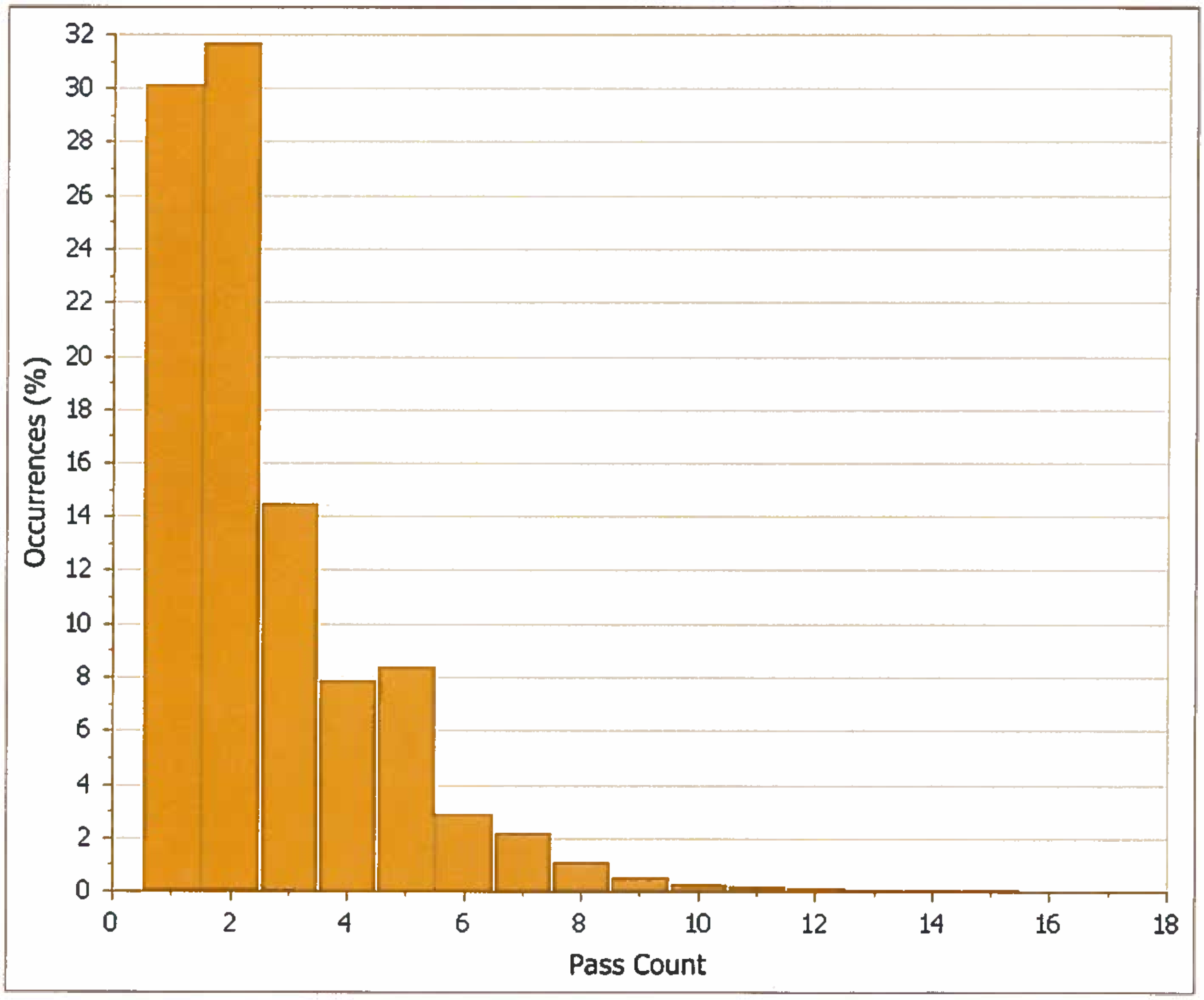
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

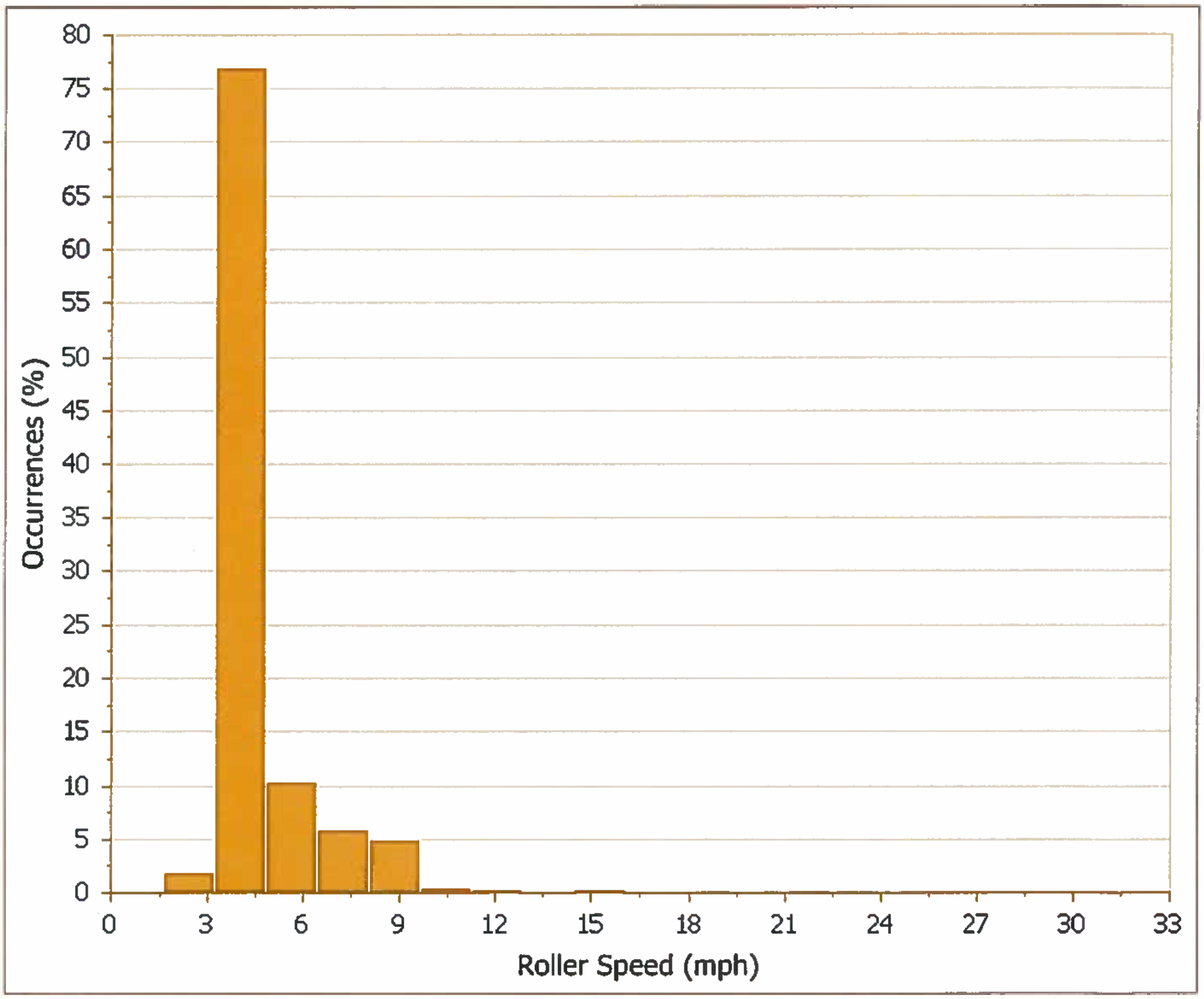
Statistic	Value
Mean	3
Standard Deviation	2
CoV (%)	70
Min	1
Max	17
Sample Size	70,167
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

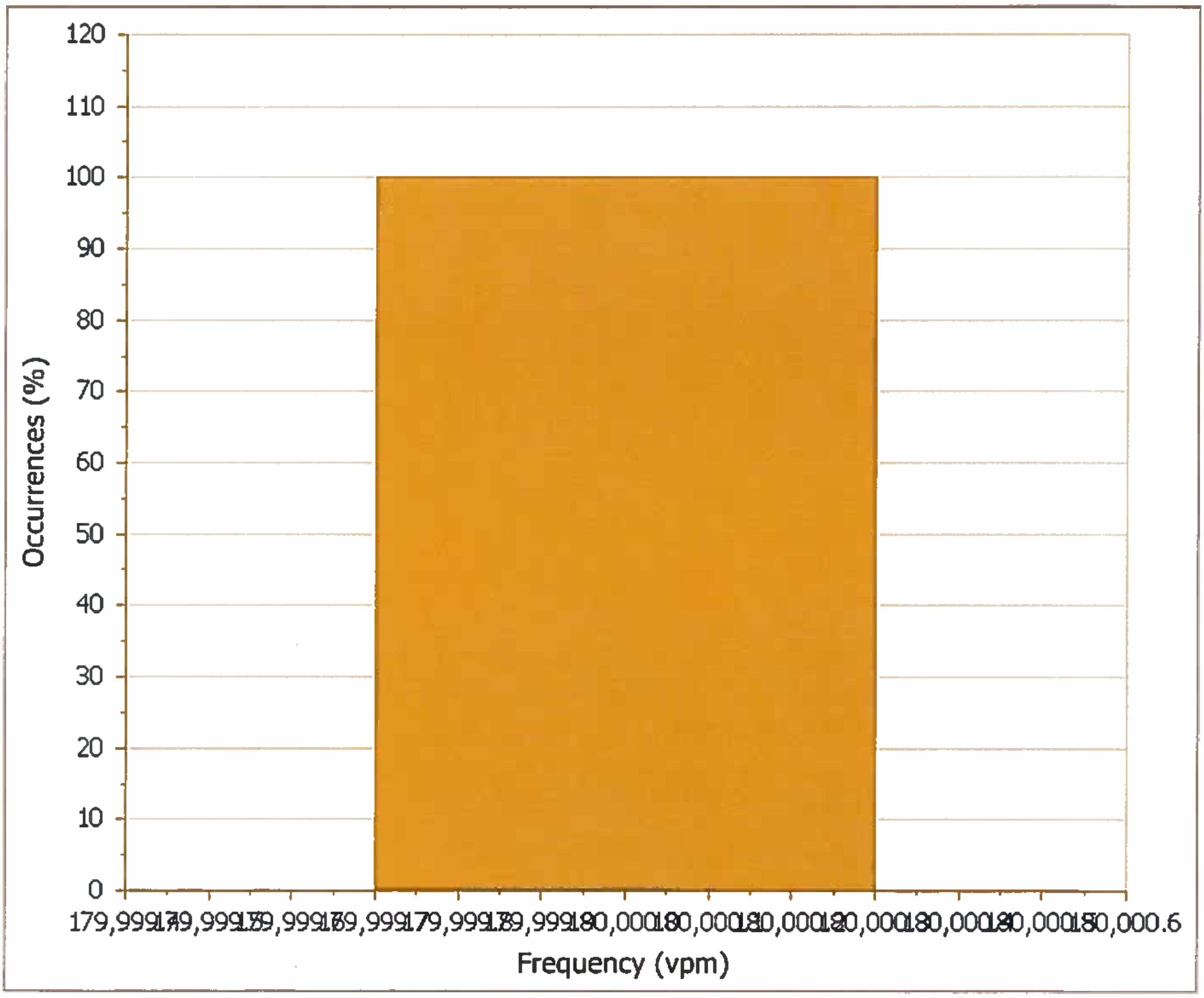
Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	4.1
Standard Deviation (mph)	1.5
CoV (%)	36
Min (mph)	0.8
Max (mph)	32.9
Sample Size	70,167
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency
Target Percentage (%): 0.00
Target Value (vpm): 0

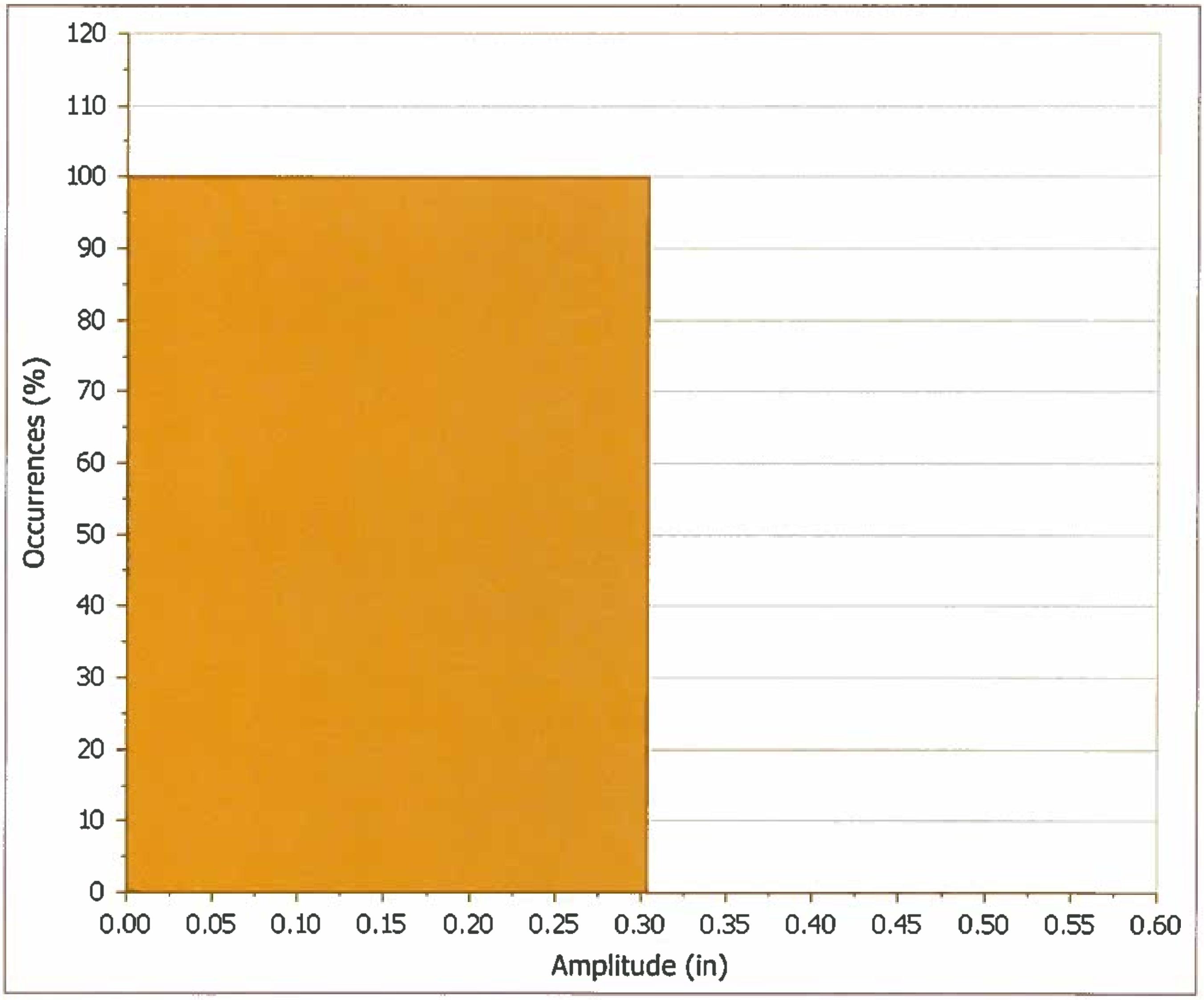
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	66,997
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

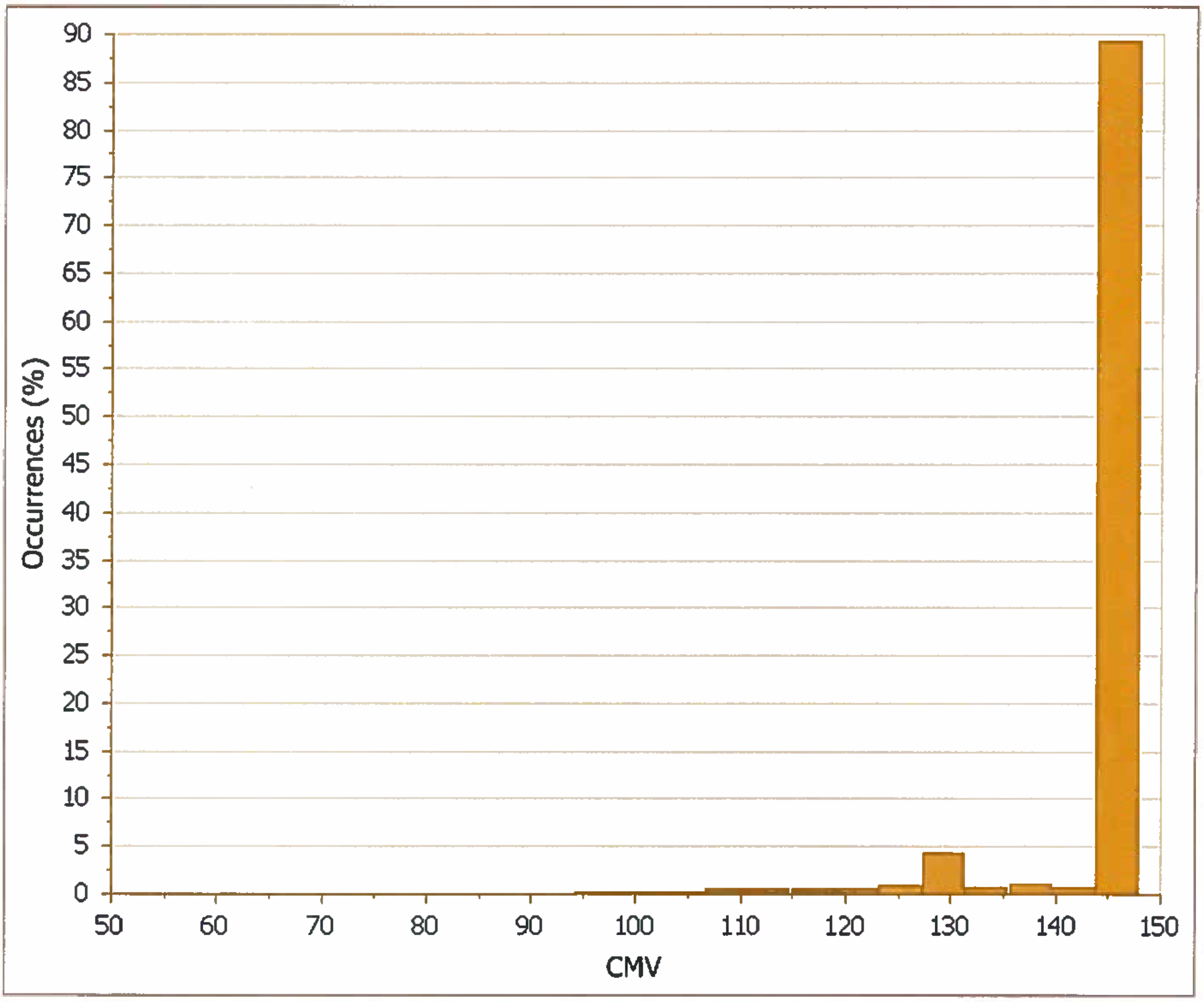
Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	66,997
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: CMV

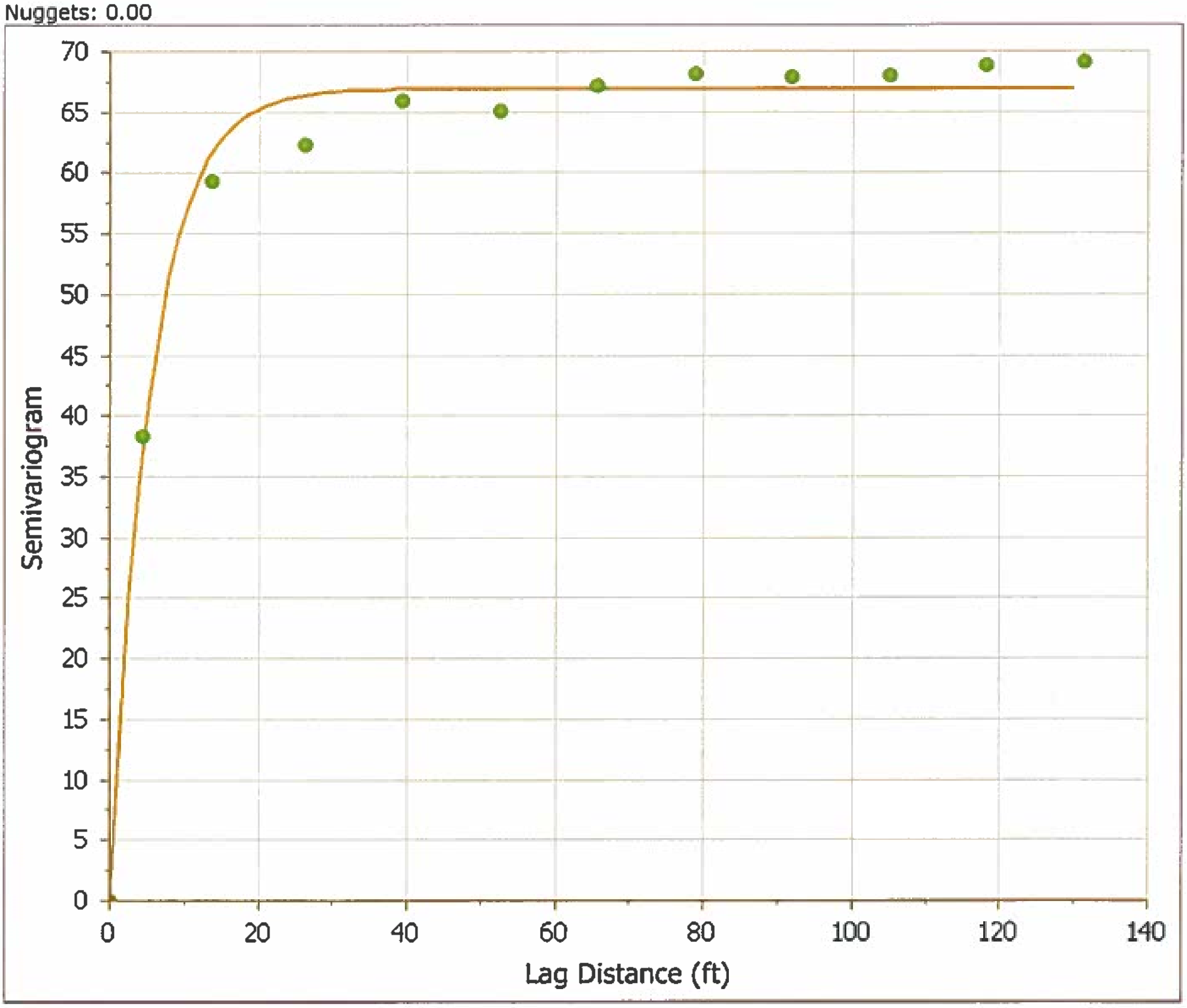
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	147.04
Standard Deviation	8.97
CoV (%)	6
Min	67.10
Max	150.00
Sample Size	66,997
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Semivariogram

Range (ft): 14.43
Sill: 62.28
Vertical Scale: 62.28
Nuggets: 0.00



Pass Count 2012-11-09 LAST

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2012-11-09 LAST
State Plane Zone: 1702 - Louisiana South

File Information

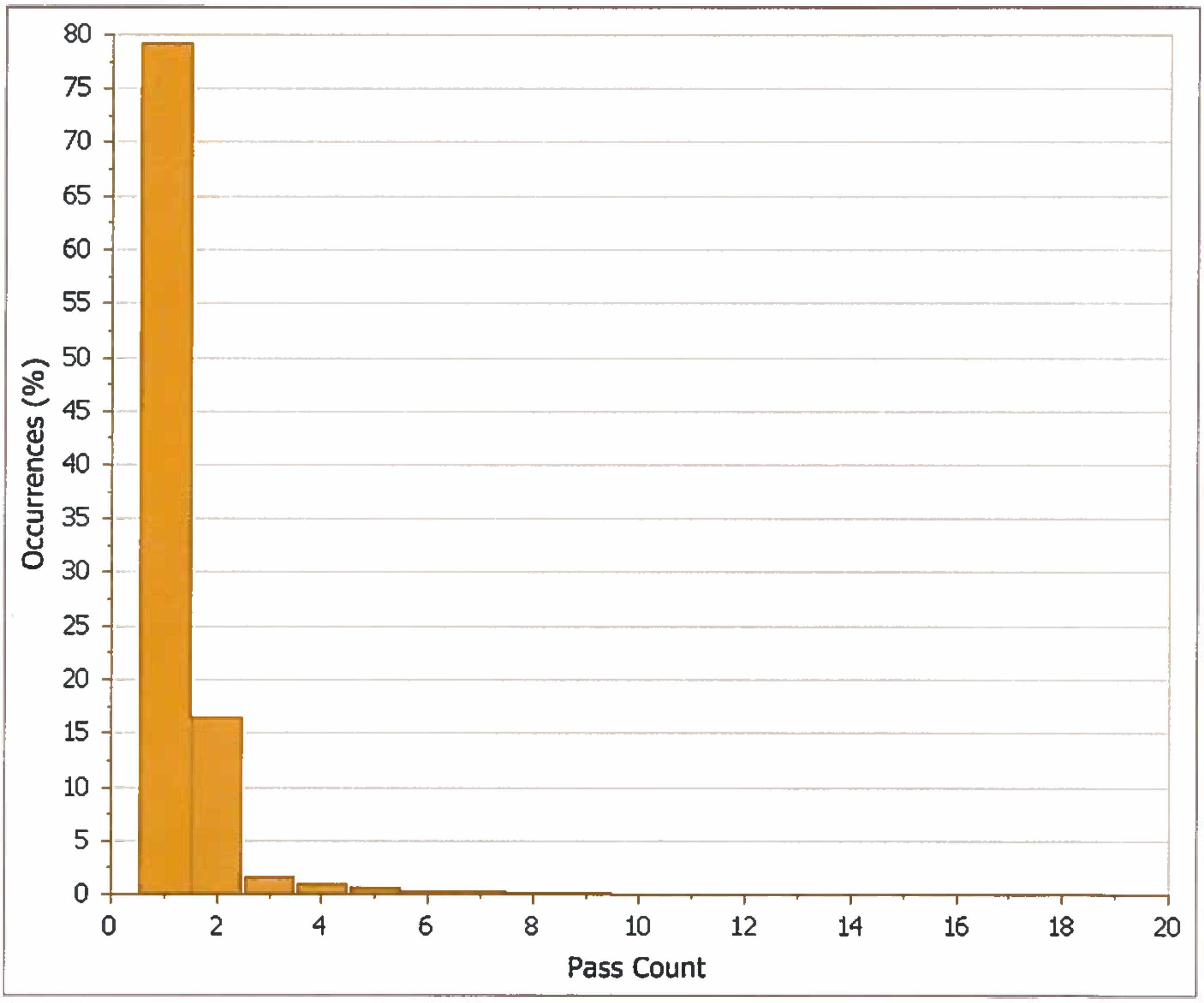
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

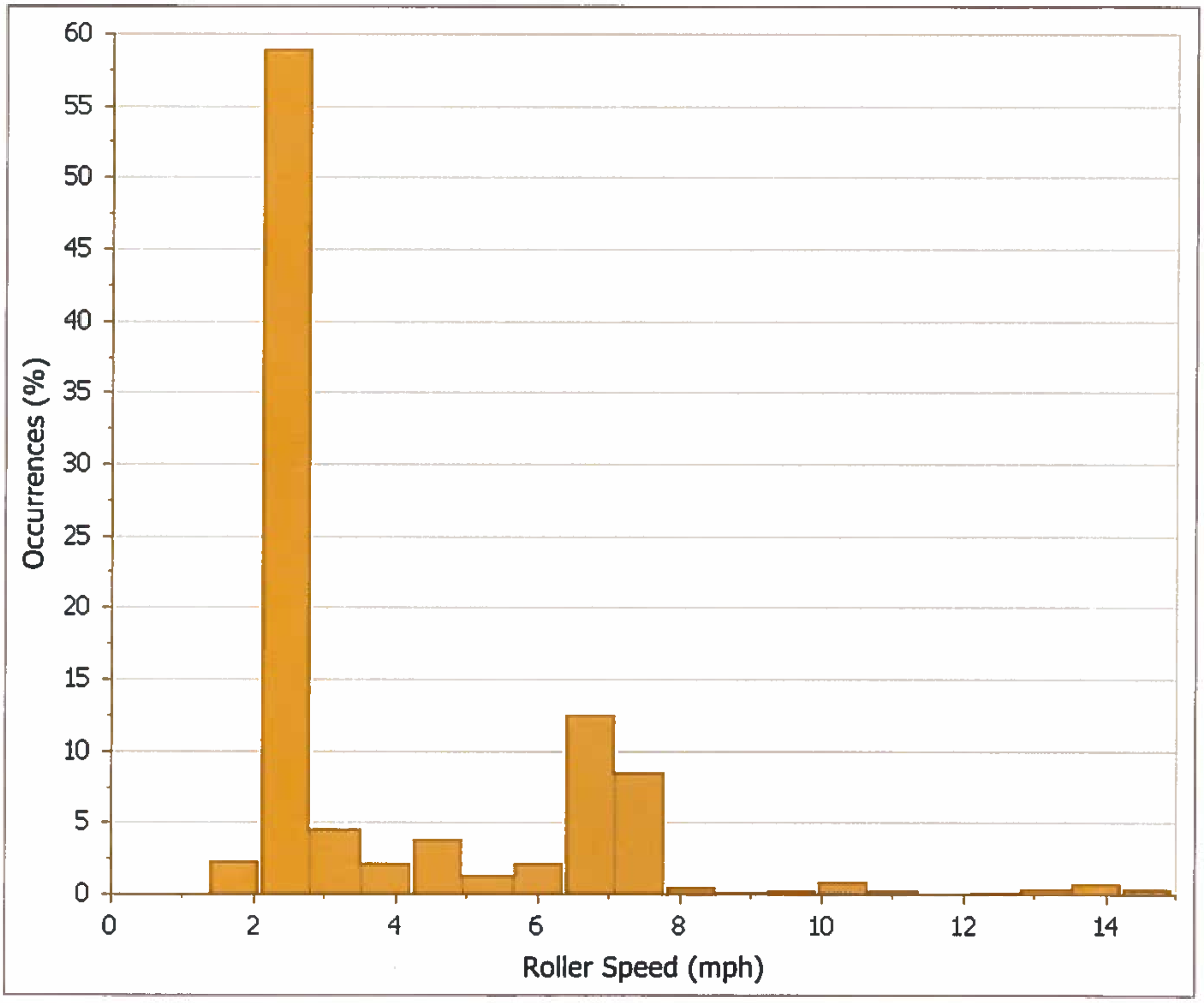
Statistic	Value
Mean	1
Standard Deviation	1
CoV (%)	68
Min	1
Max	19
Sample Size	57,130
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

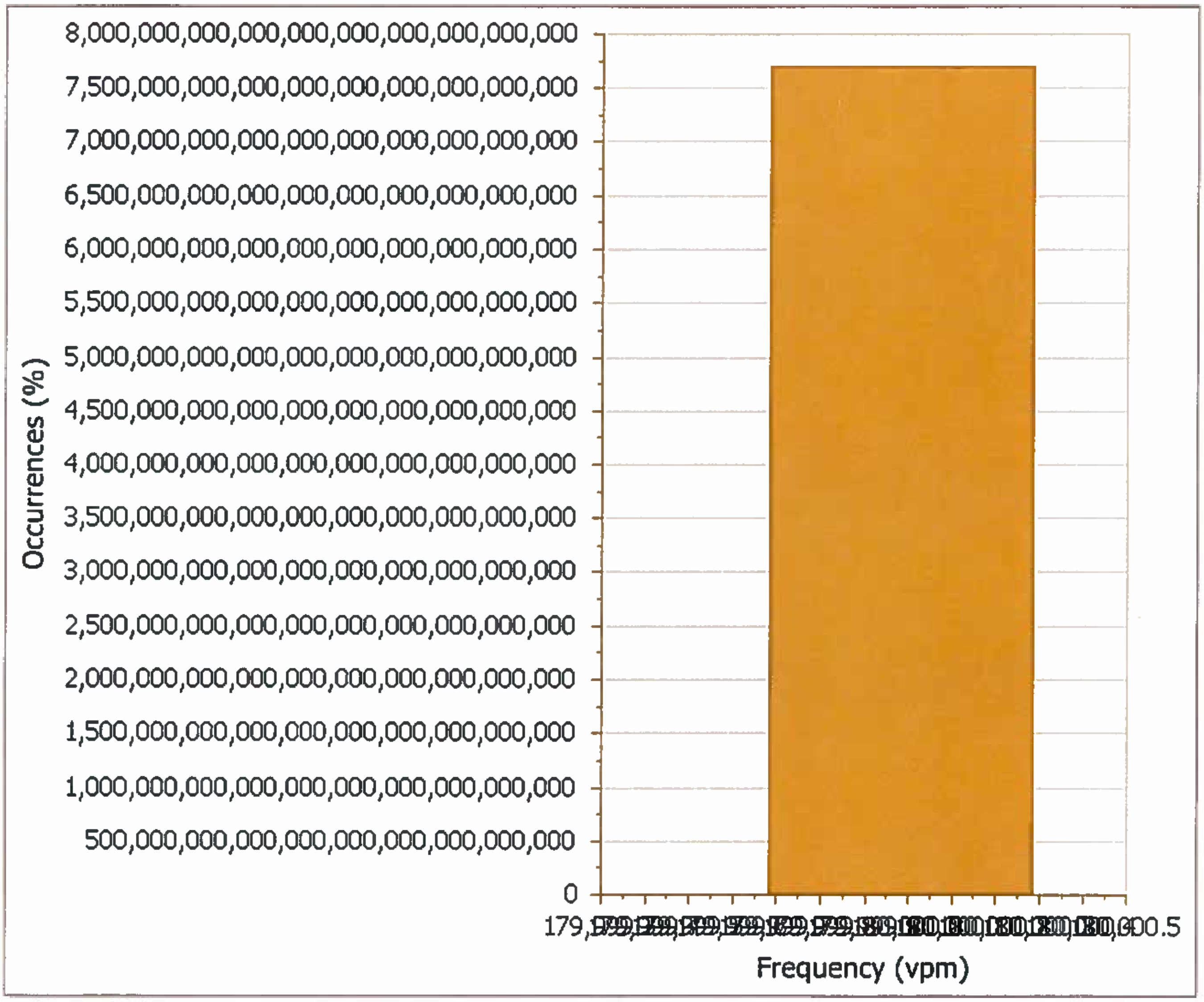
Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	3.6
Standard Deviation (mph)	2.4
CoV (%)	68
Min (mph)	1.0
Max (mph)	15.3
Sample Size	57,130
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency
Target Percentage (%): 0.00
Target Value (vpm): 0

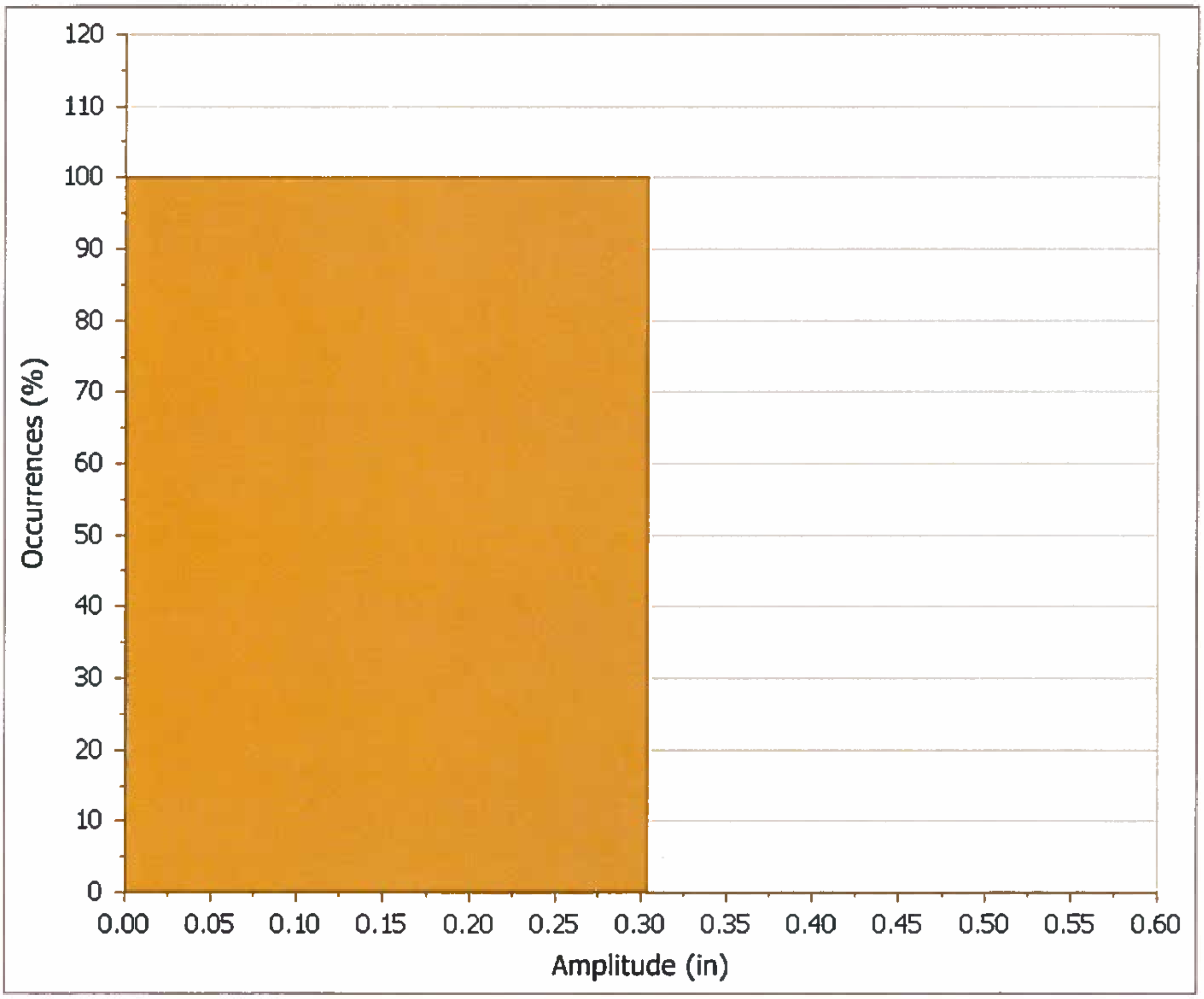
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	41,225
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

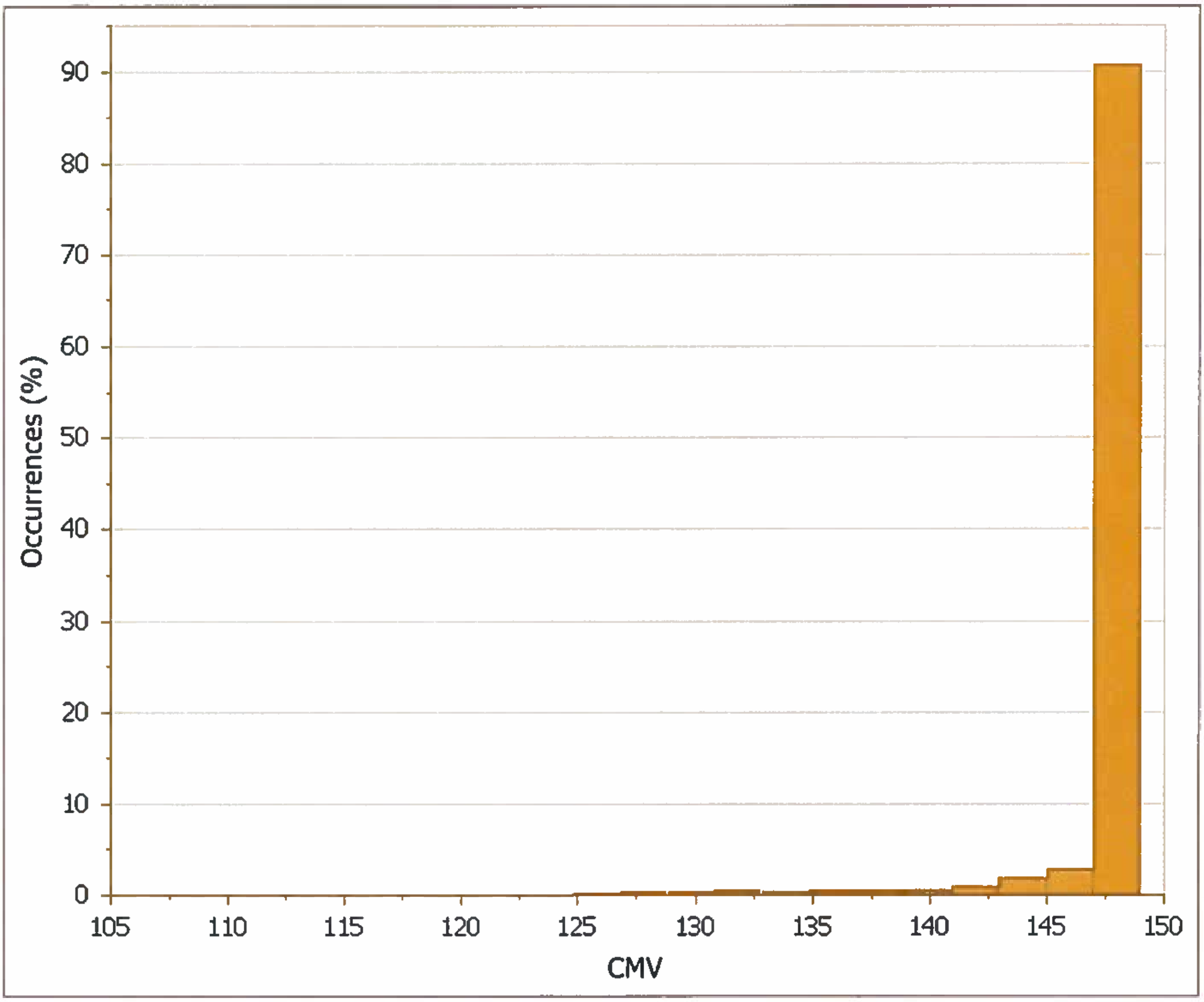
Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	41,225
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: CMV

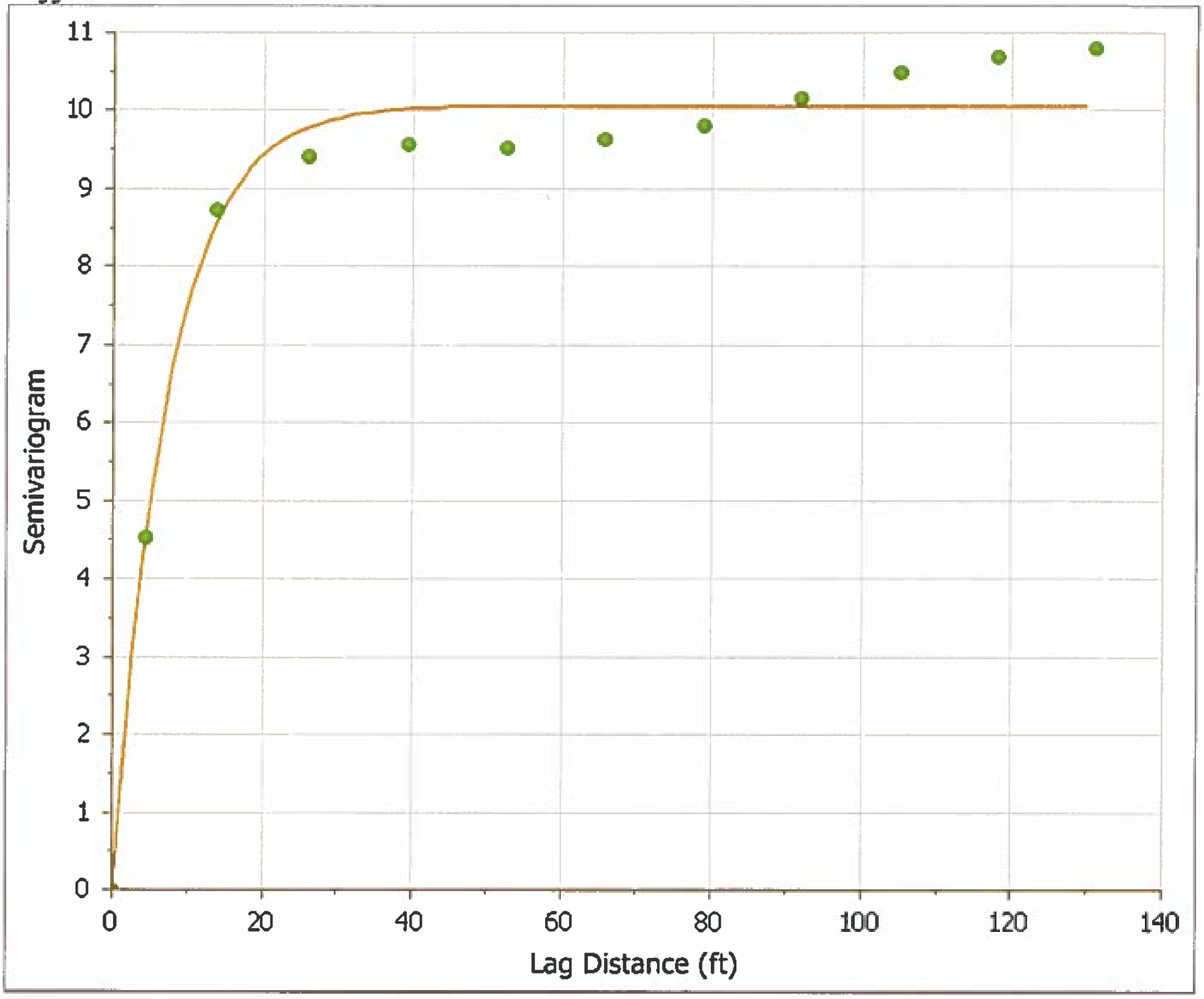
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	148.82
Standard Deviation	3.81
CoV (%)	3
Min	109.60
Max	150.00
Sample Size	41,225
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Semivariogram

Range (ft): 17.06
Sill: 9.12
Vertical Scale: 9.12
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2012-11-13 Last
State Plane Zone: 1702 - Louisiana South

File Information

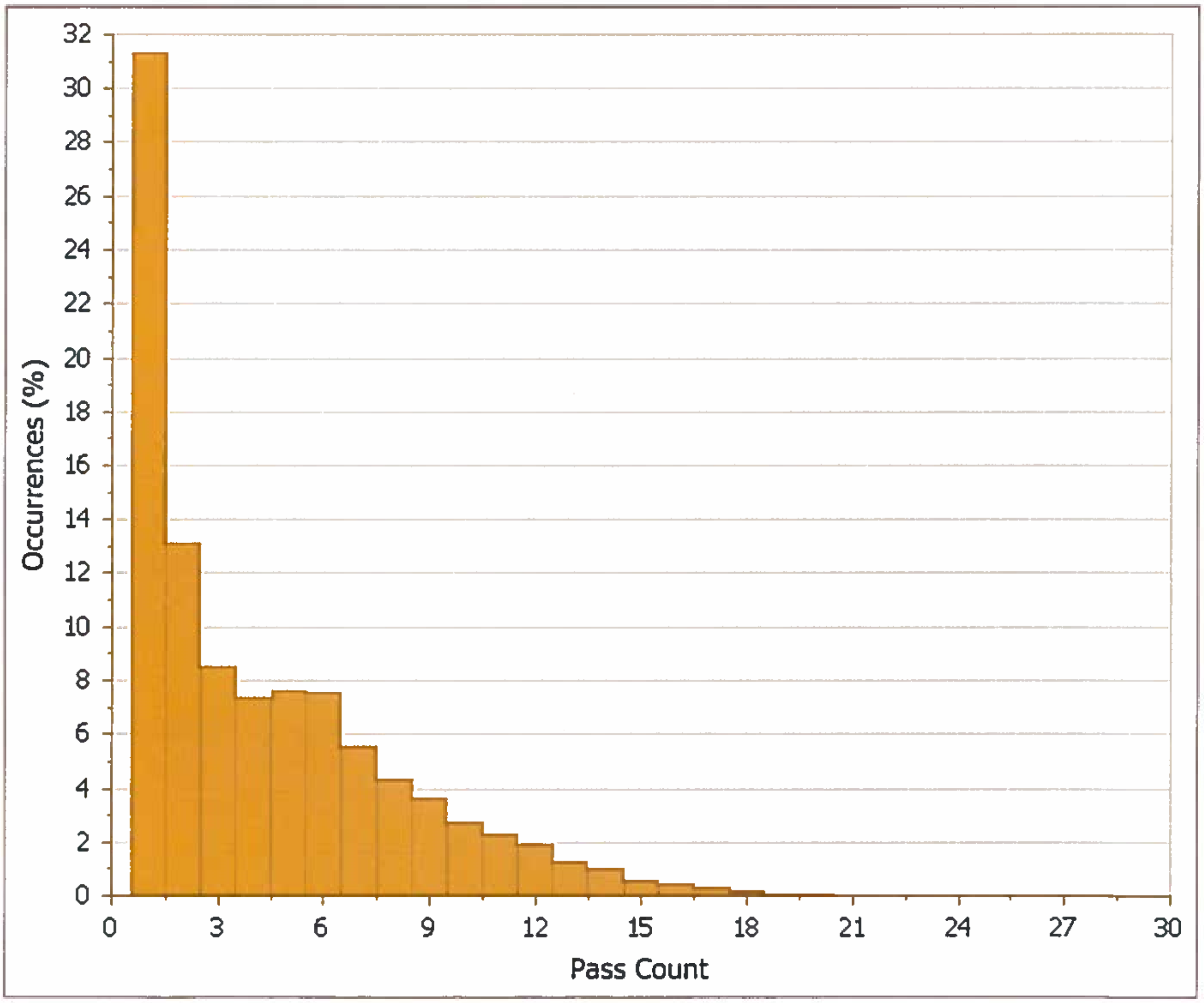
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

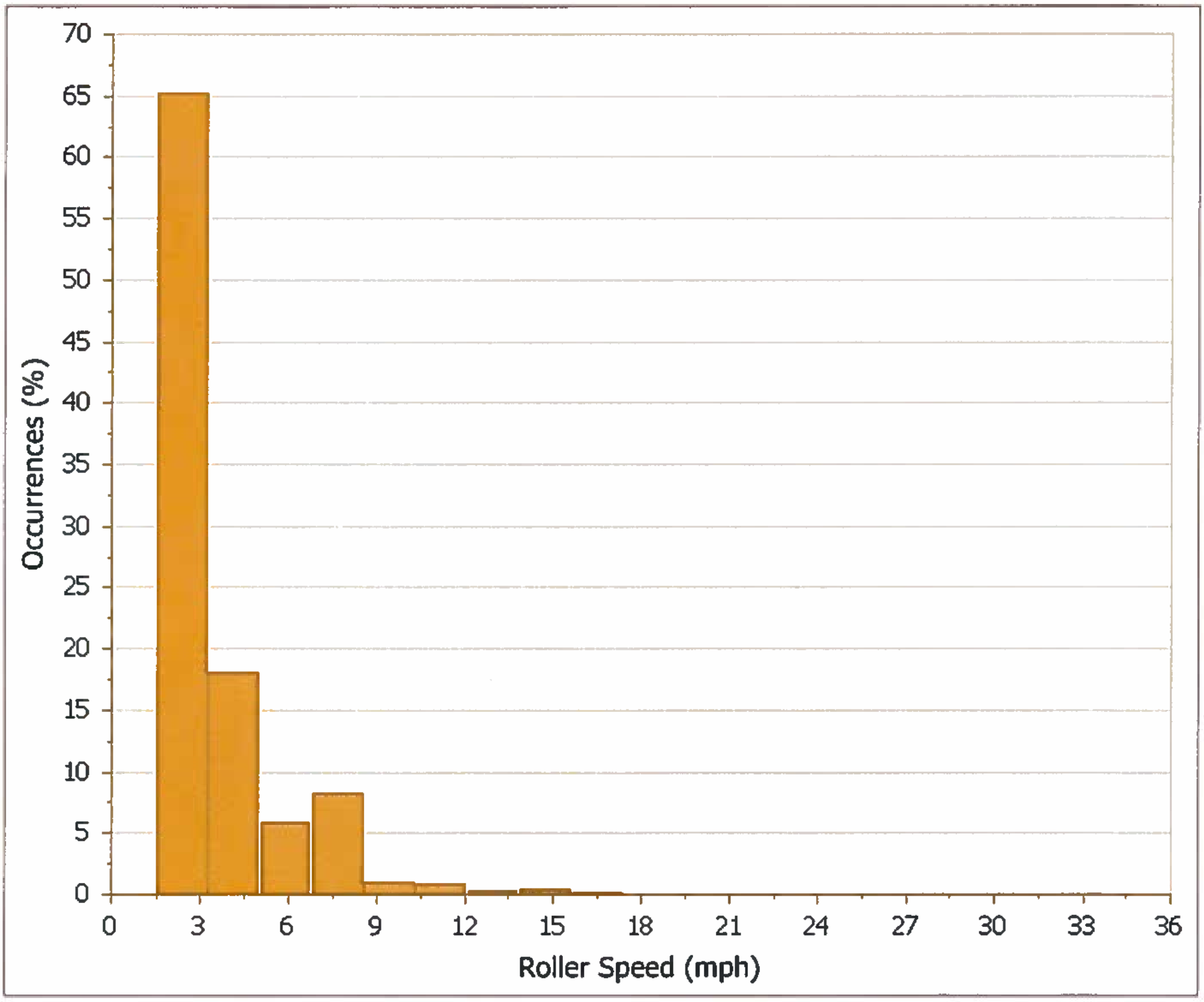
Statistic	Value
Mean	4
Standard Deviation	4
CoV (%)	85
Min	1
Max	28
Sample Size	88,808
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	2.9
Standard Deviation (mph)	2.0
CoV (%)	68
Min (mph)	0.6
Max (mph)	35.9
Sample Size	88,808
Target Status	Passed
% of Target Achieved	100.00

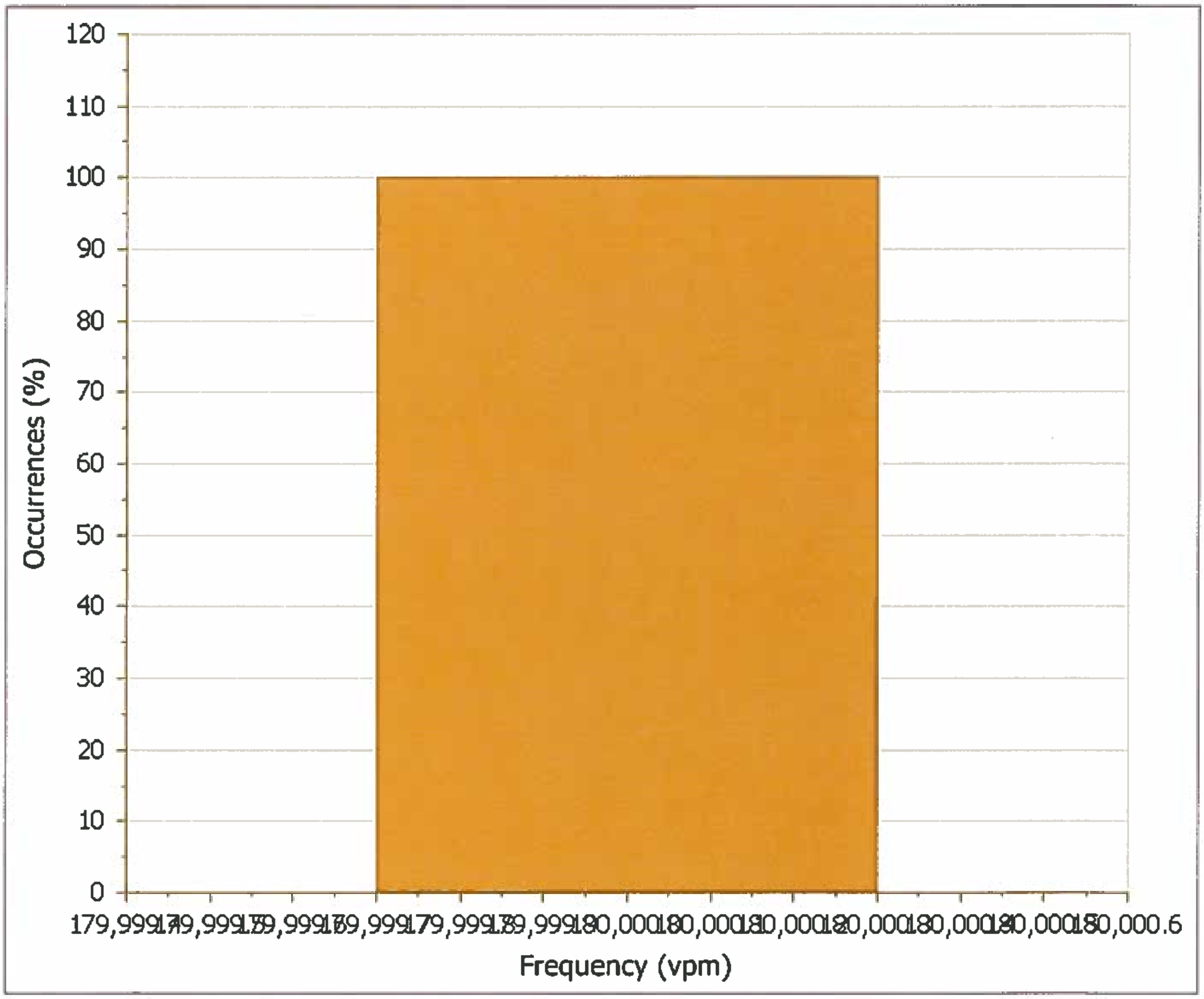


Pass Count 2012-11-13 Last

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	79,417
Target Status	Failed
% of Target Achieved	0.00

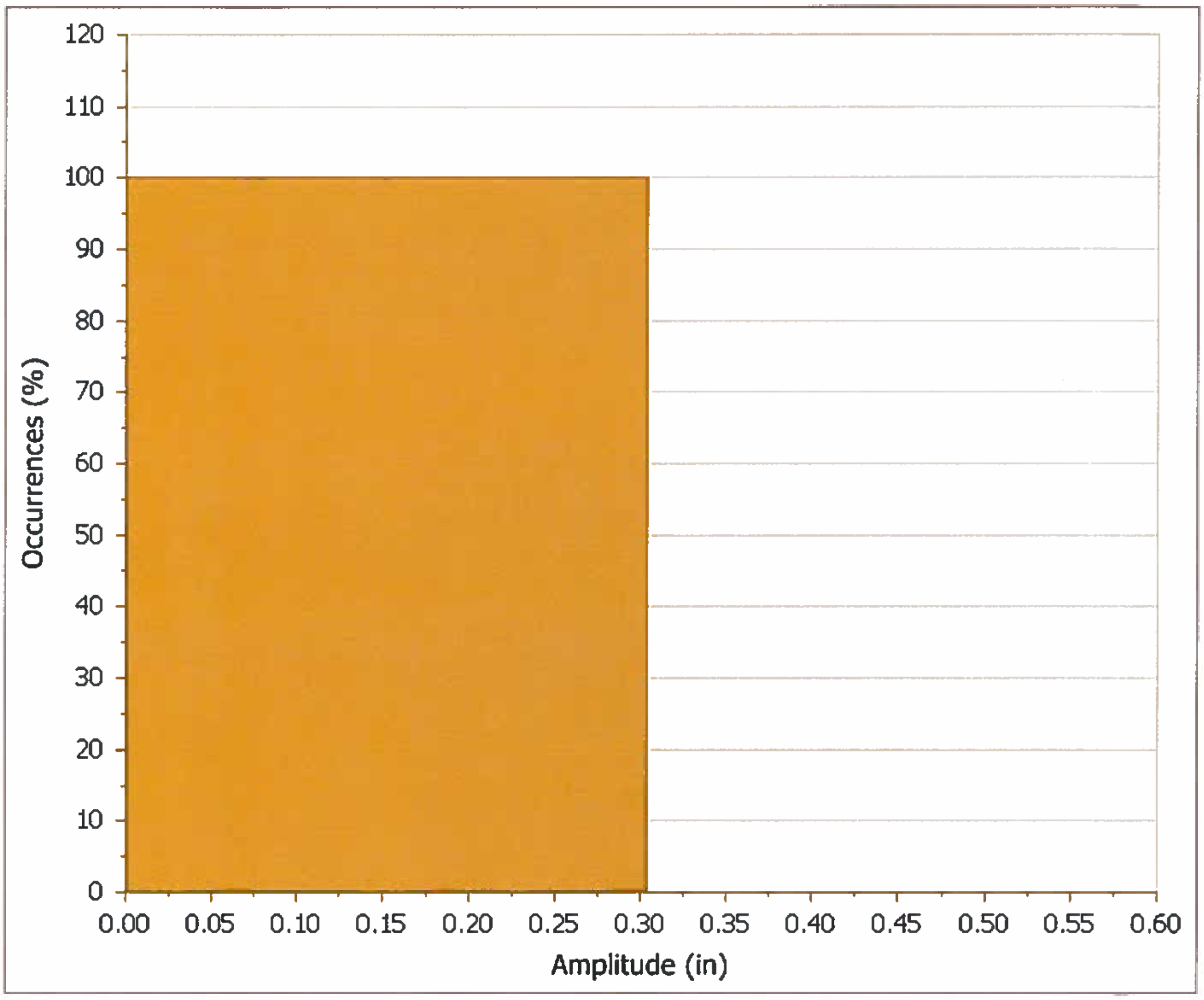


Pass Count 2012-11-13 Last

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	79,417
Target Status	Failed
% of Target Achieved	0.00

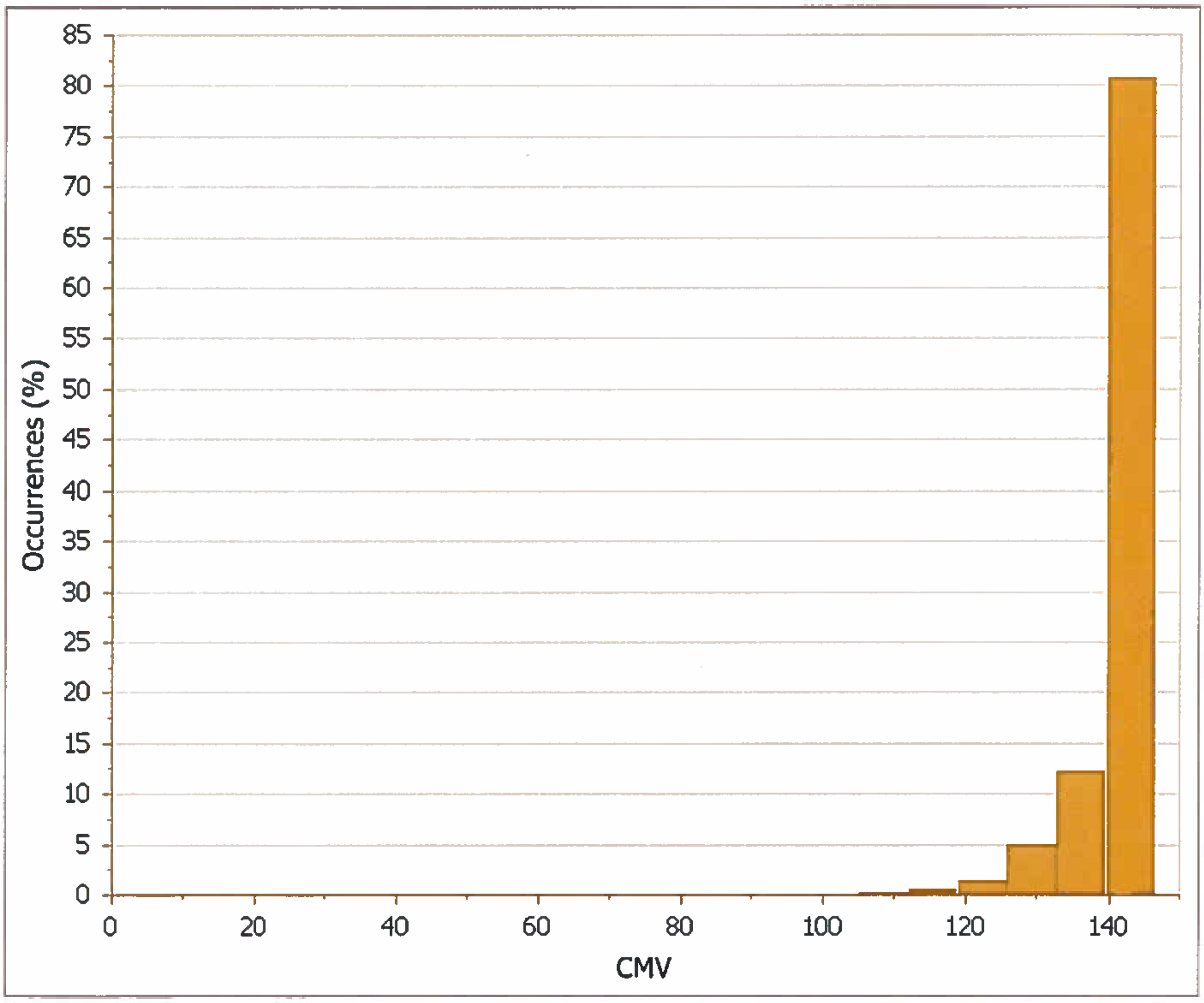


Pass Count 2012-11-13 Last

Final Coverage: CMV

Target Percentage (%): 0.00
Target Value: 0.00

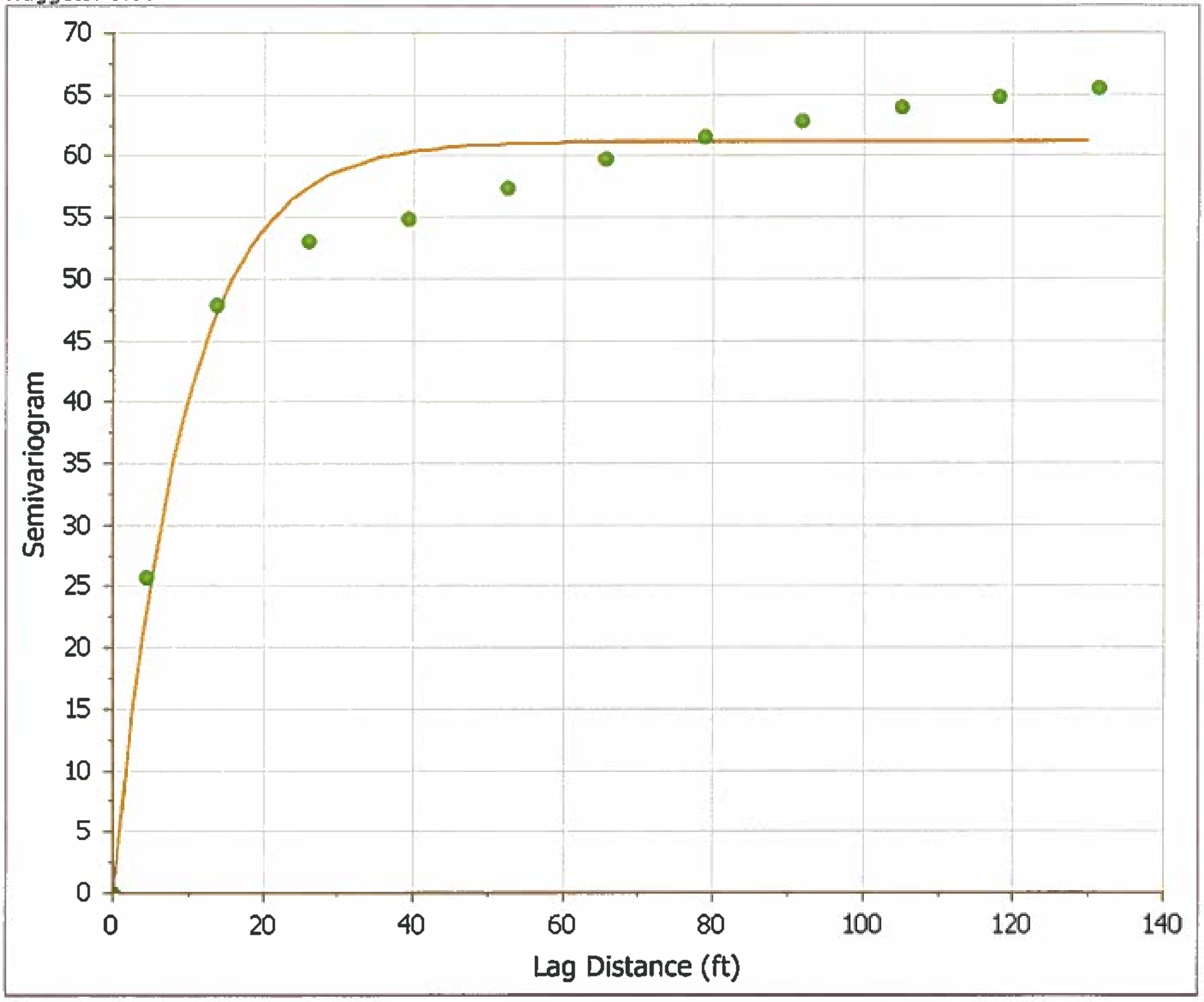
Statistic	Value
Mean	142.97
Standard Deviation	8.76
CoV (%)	6
Min	11.80
Max	150.00
Sample Size	79,417
Target Status	Passed
% of Target Achieved	100.00



Pass Count 2012-11-13 Last

Final Coverage: Semivariogram

Range (ft): 19.68
Sill: 53.81
Vertical Scale: 53.81
Nuggets: 0.00



Pass Count 2012-11-14 LAST

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2012-11-14 LAST
State Plane Zone: 1702 - Louisiana South

File Information

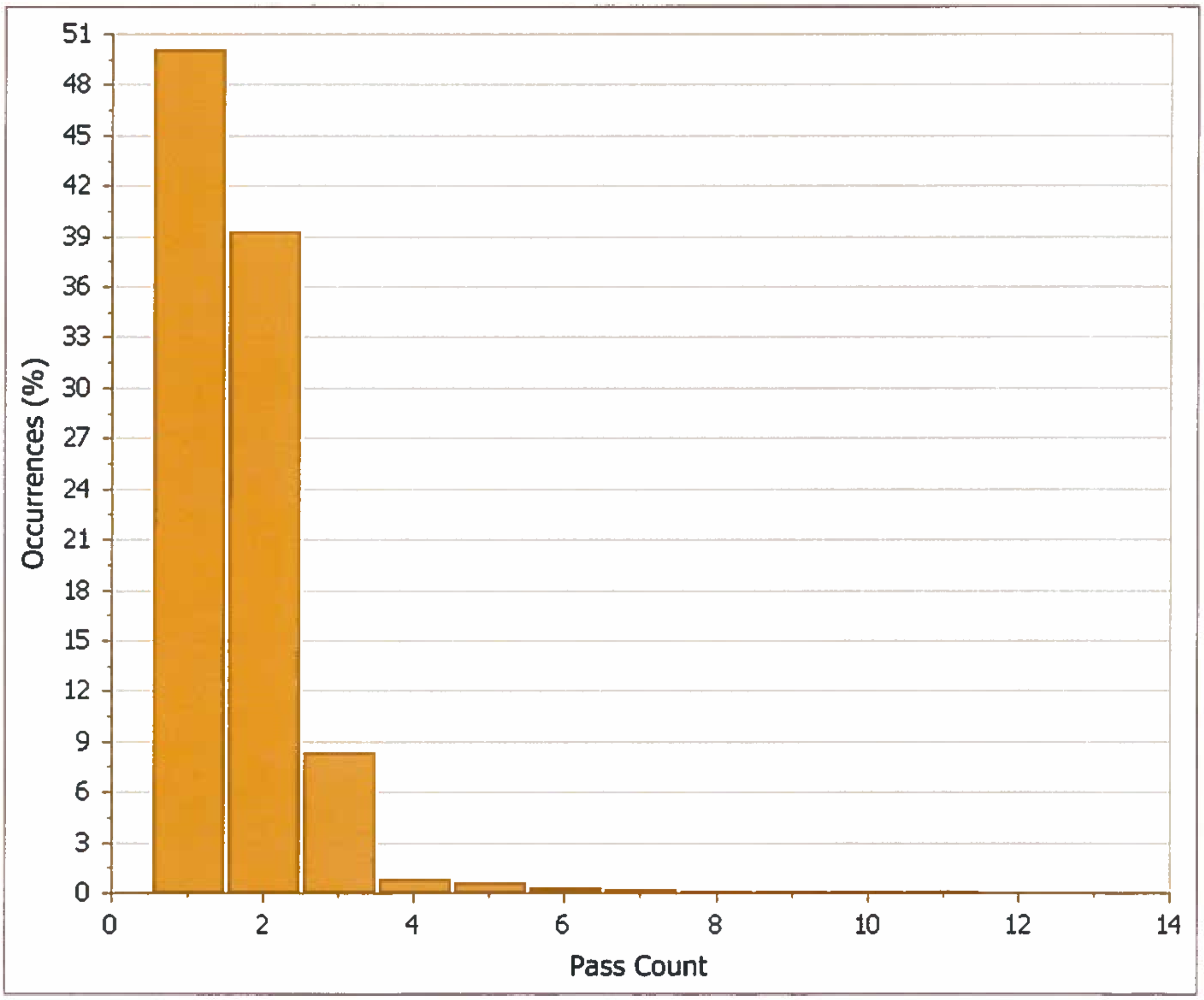
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

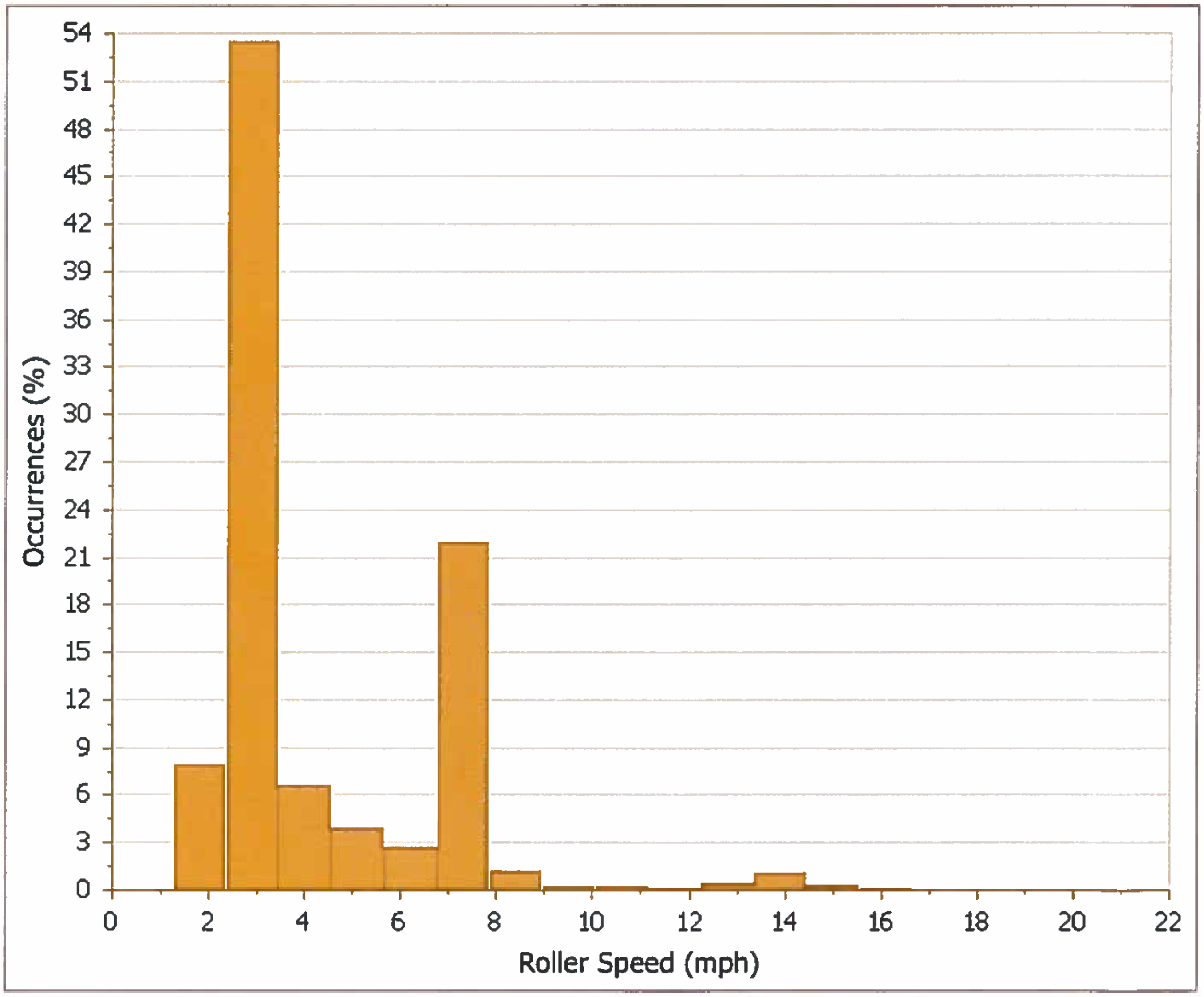
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	56
Min	1
Max	13
Sample Size	26,939
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

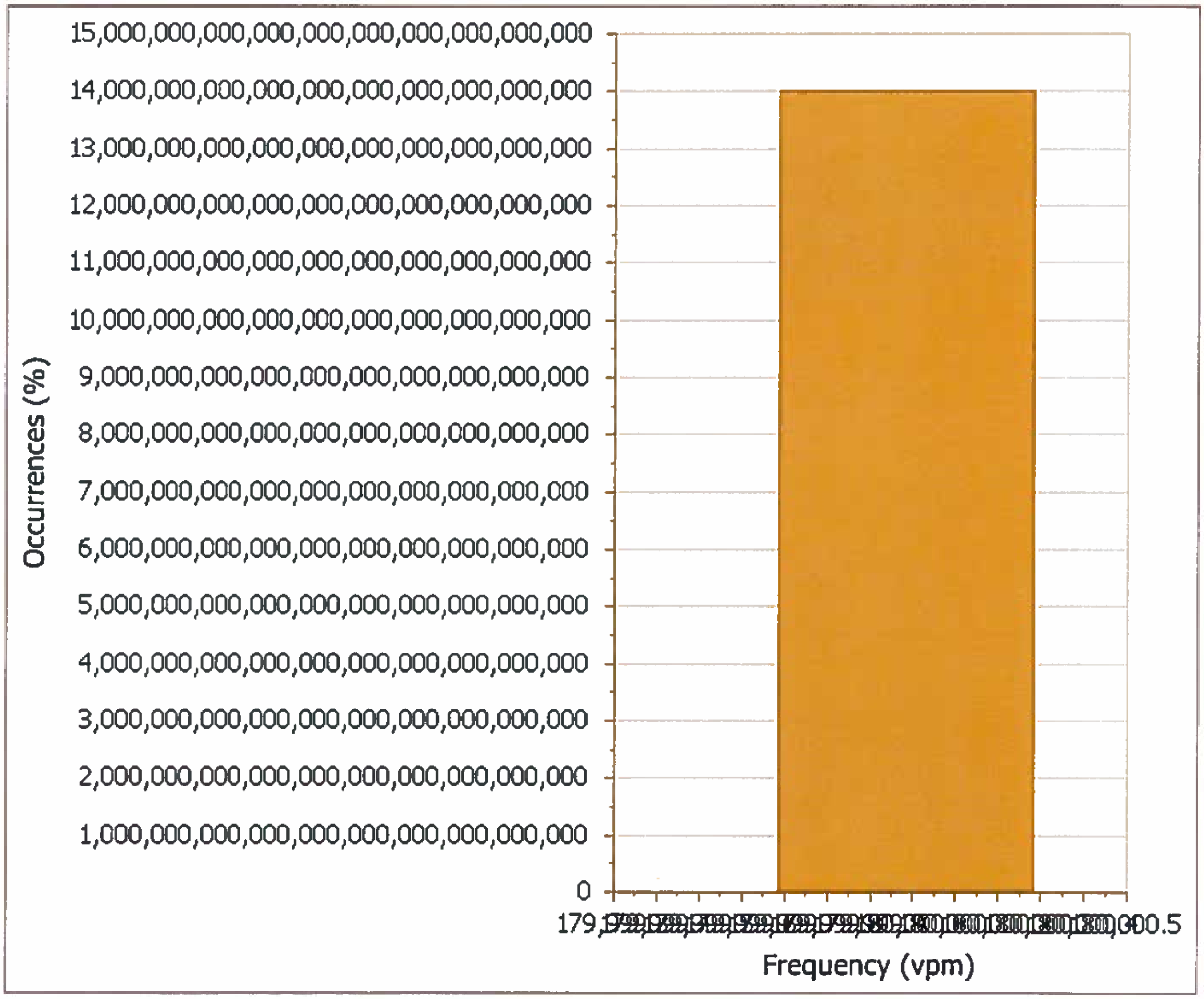
Statistic	Value
Mean (mph)	3.7
Standard Deviation (mph)	2.5
CoV (%)	67
Min (mph)	0.7
Max (mph)	22.7
Sample Size	26,939
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Frequency

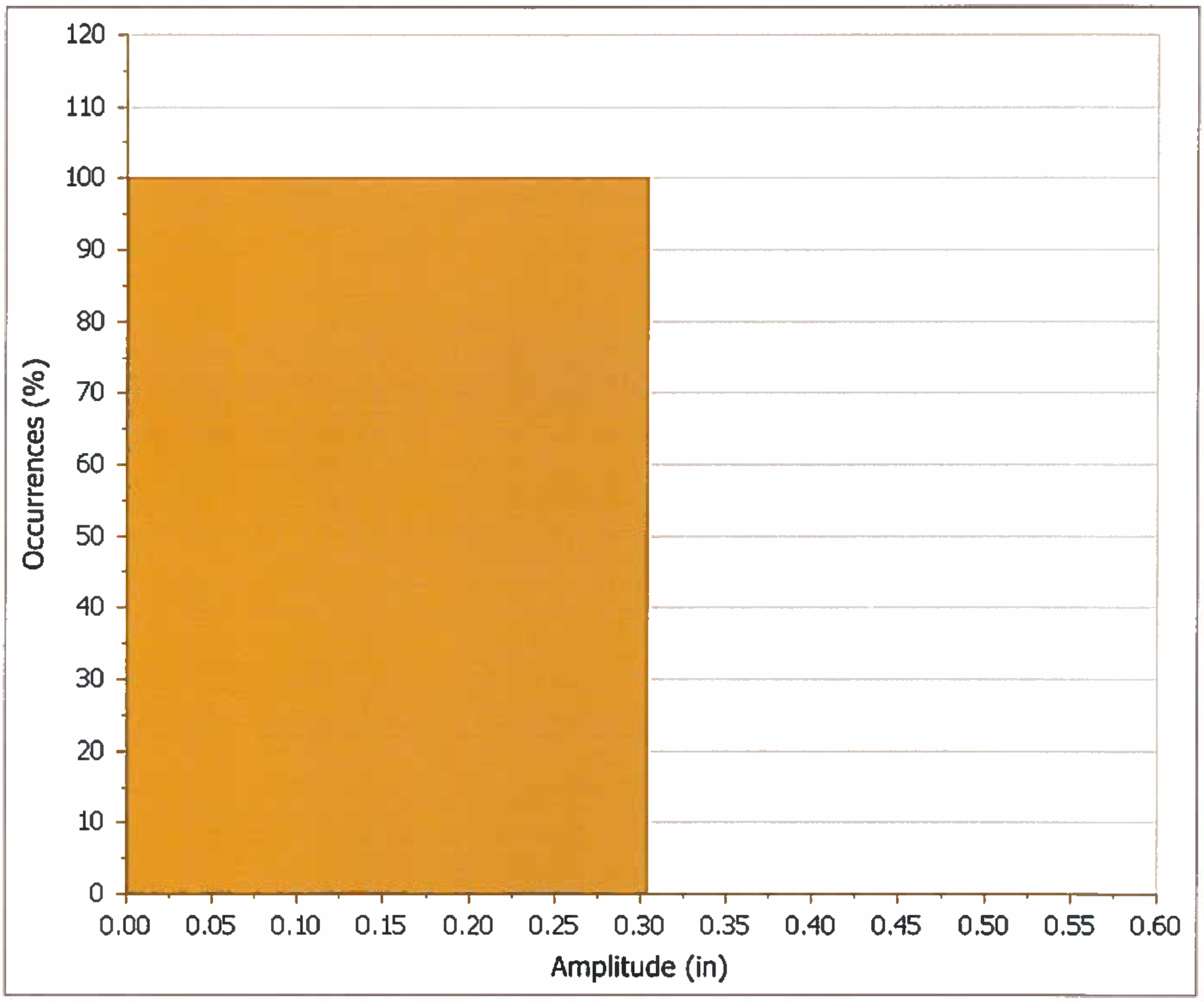
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	22,652
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Amplitude
Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	22,652
Target Status	Failed
% of Target Achieved	0.00

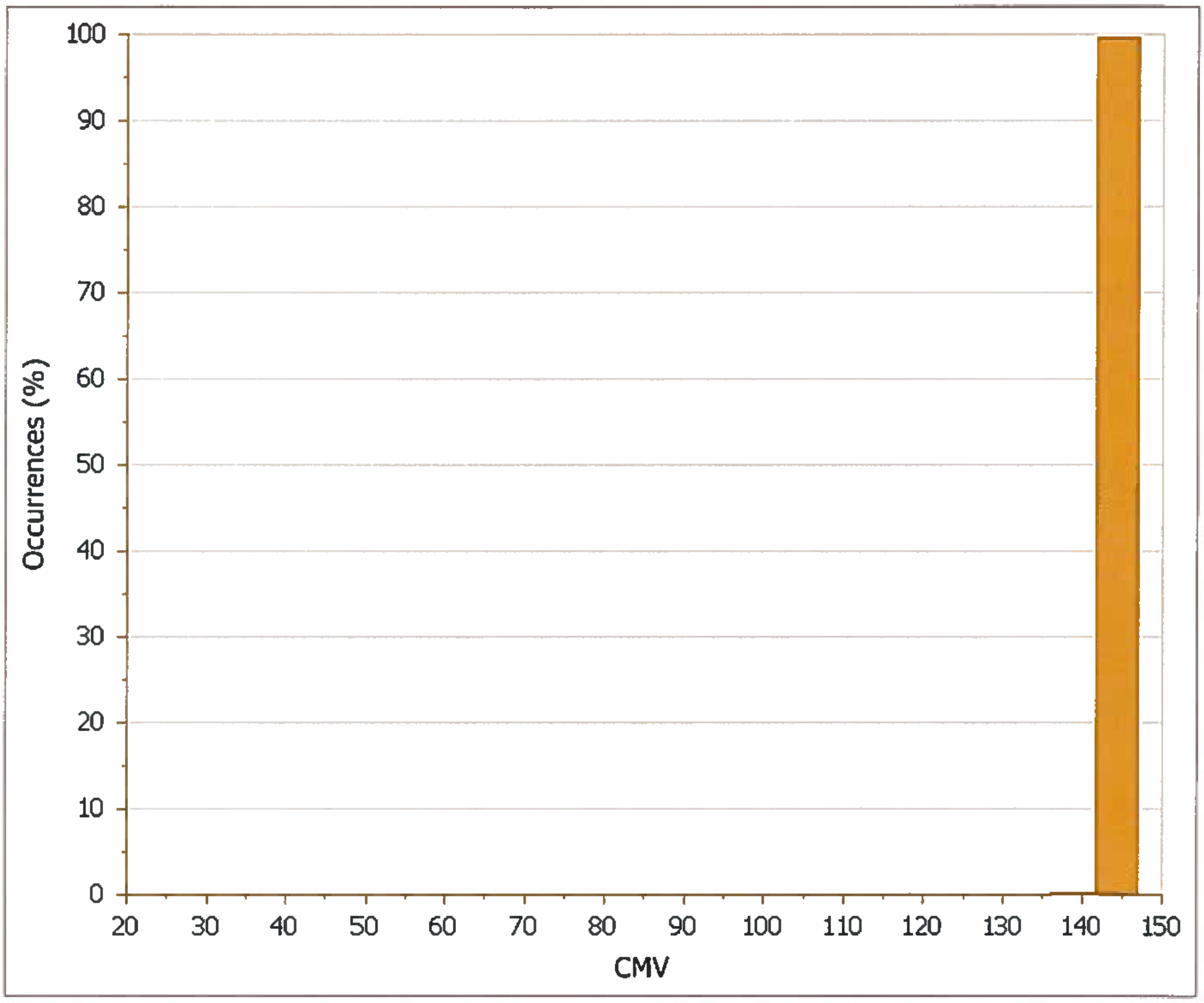


Pass Count 2012-11-14 LAST

Final Coverage: CMV

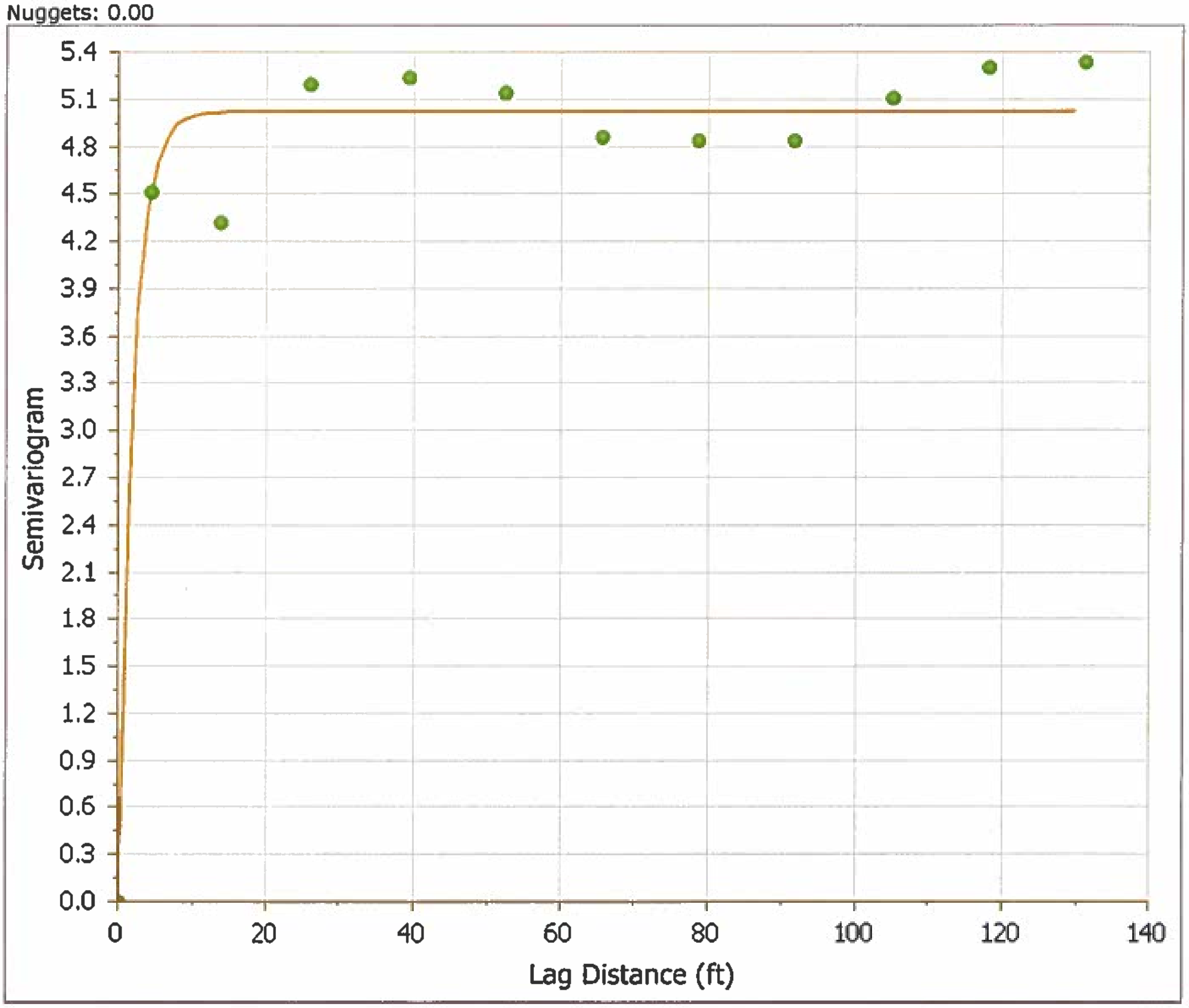
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	149.68
Standard Deviation	2.84
CoV (%)	2
Min	37.60
Max	150.00
Sample Size	22,652
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Semivariogram

Range (ft): 6.56
Sill: 4.86
Vertical Scale: 4.86
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2012-11-14 to 11-29 LAST
State Plane Zone: 1702 - Louisiana South

File Information

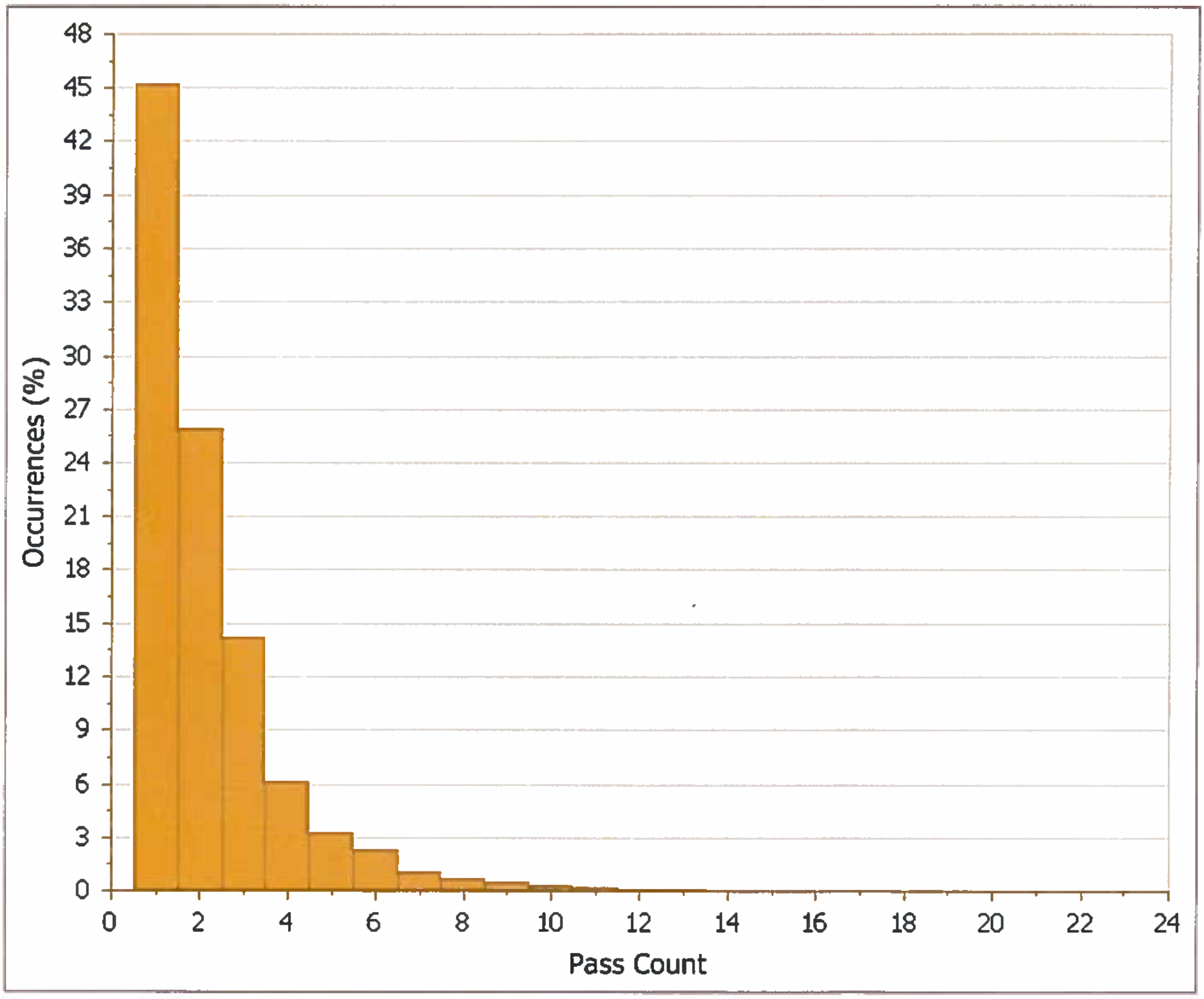
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	2
Standard Deviation	2
CoV (%)	78
Min	1
Max	22
Sample Size	192,164
Target Status	Passed
% of Target Achieved	100.00

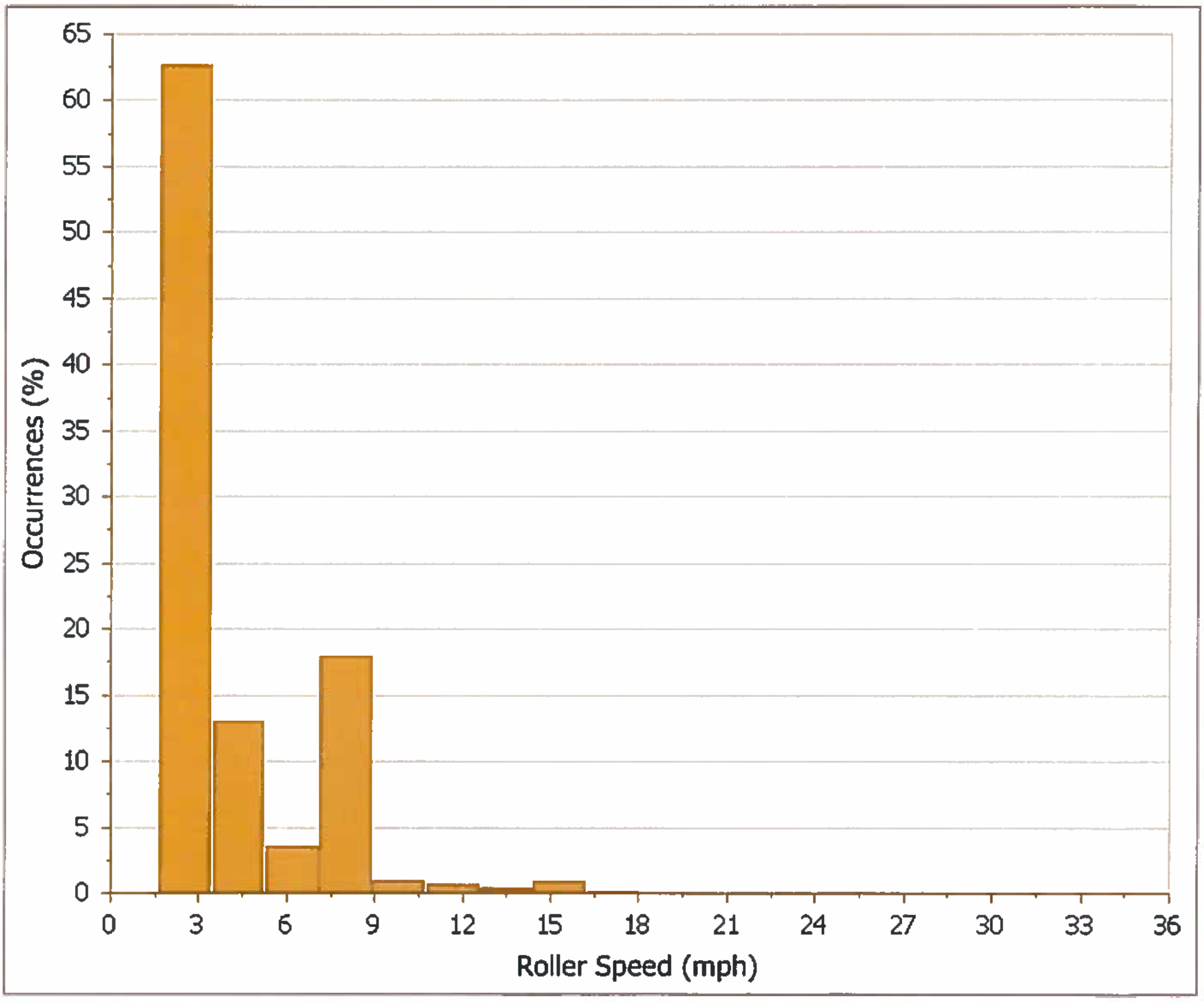


Pass Count 2012-11-14 to 11-29 LAST

Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

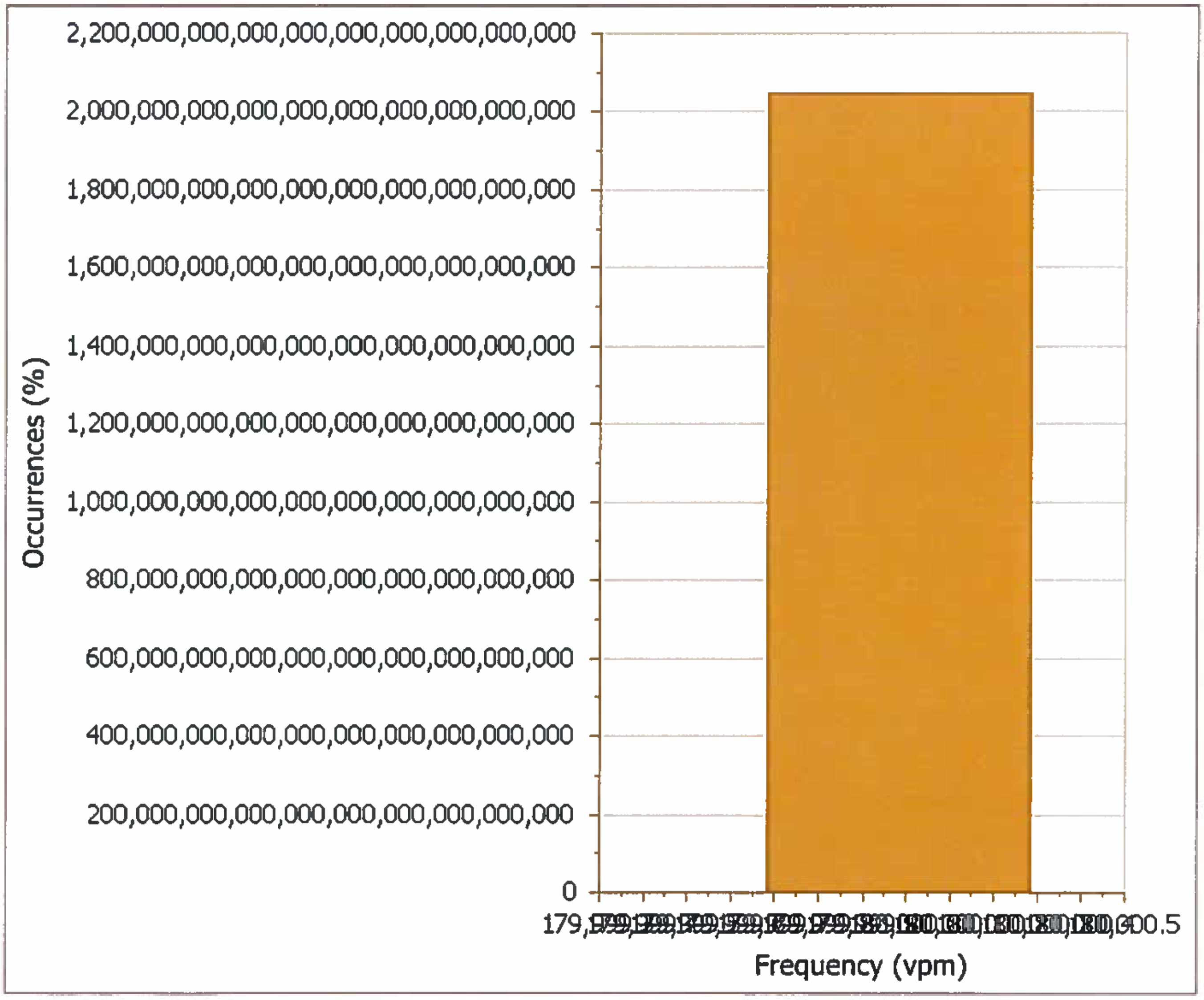
Statistic	Value
Mean (mph)	3.5
Standard Deviation (mph)	2.4
CoV (%)	69
Min (mph)	0.7
Max (mph)	37.2
Sample Size	192,164
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

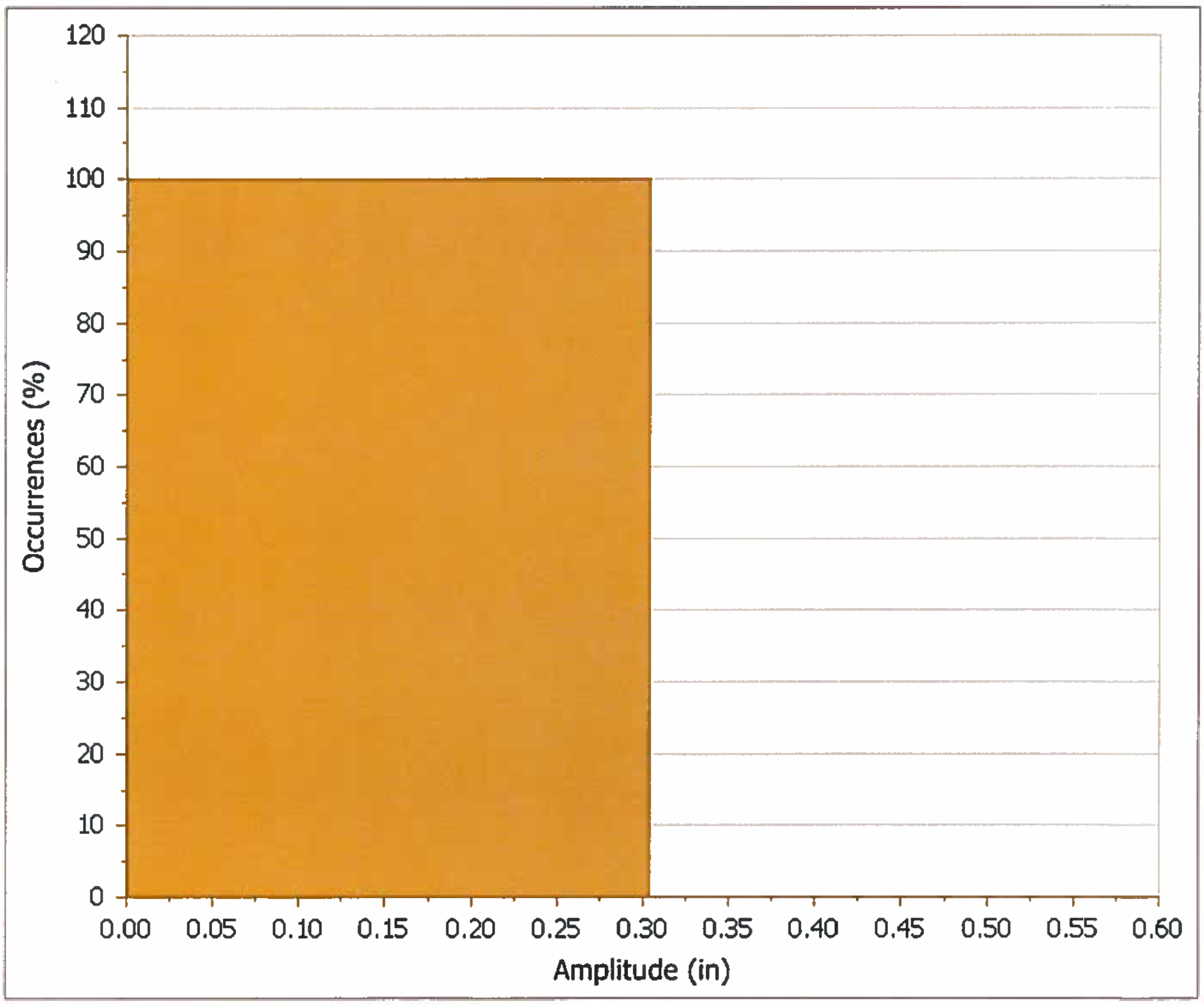
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	154,847
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	154,847
Target Status	Failed
% of Target Achieved	0.00

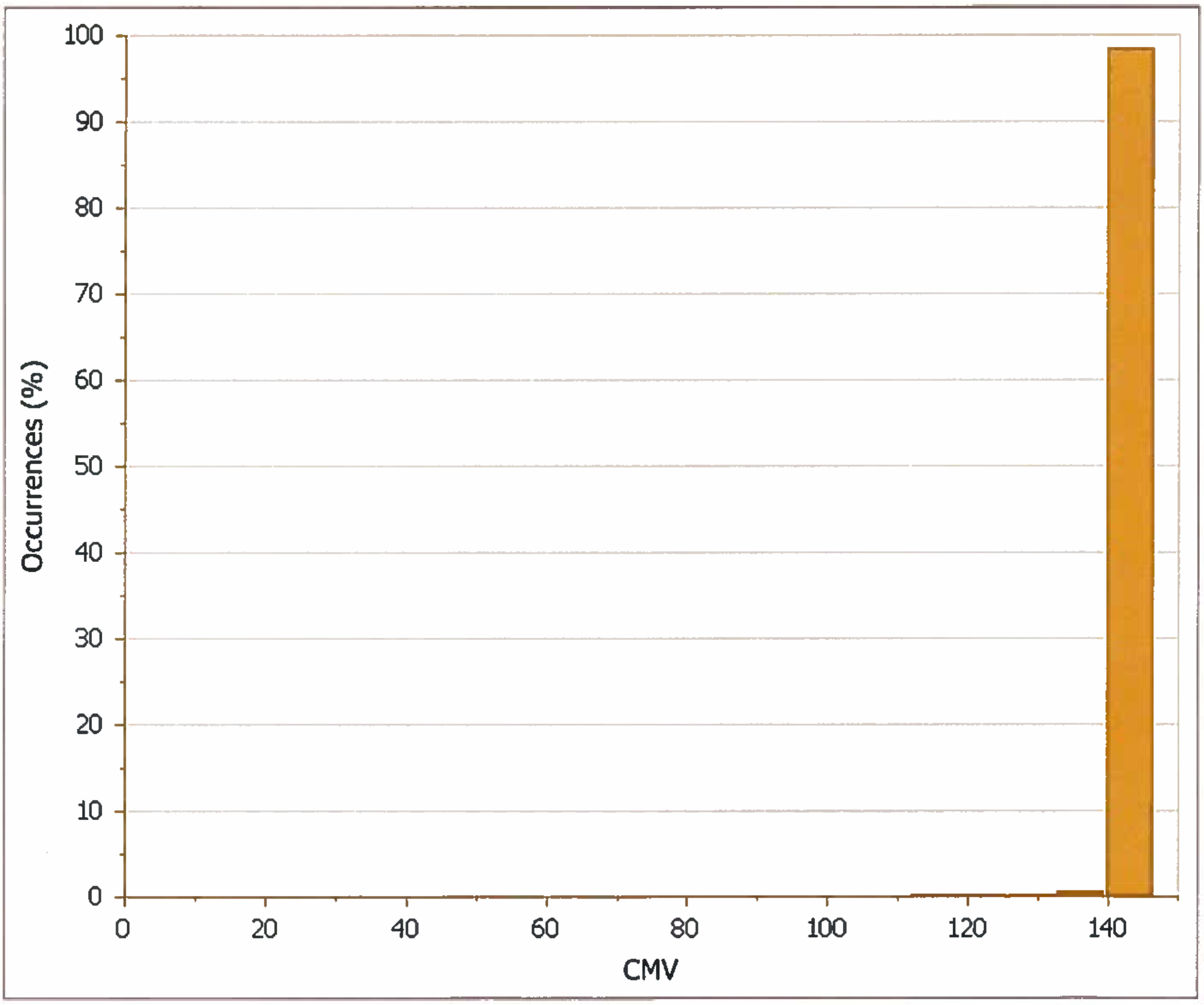


Pass Count 2012-11-14 to 11-29 LAST

Final Coverage: CMV

Target Percentage (%): 0.00
Target Value: 0.00

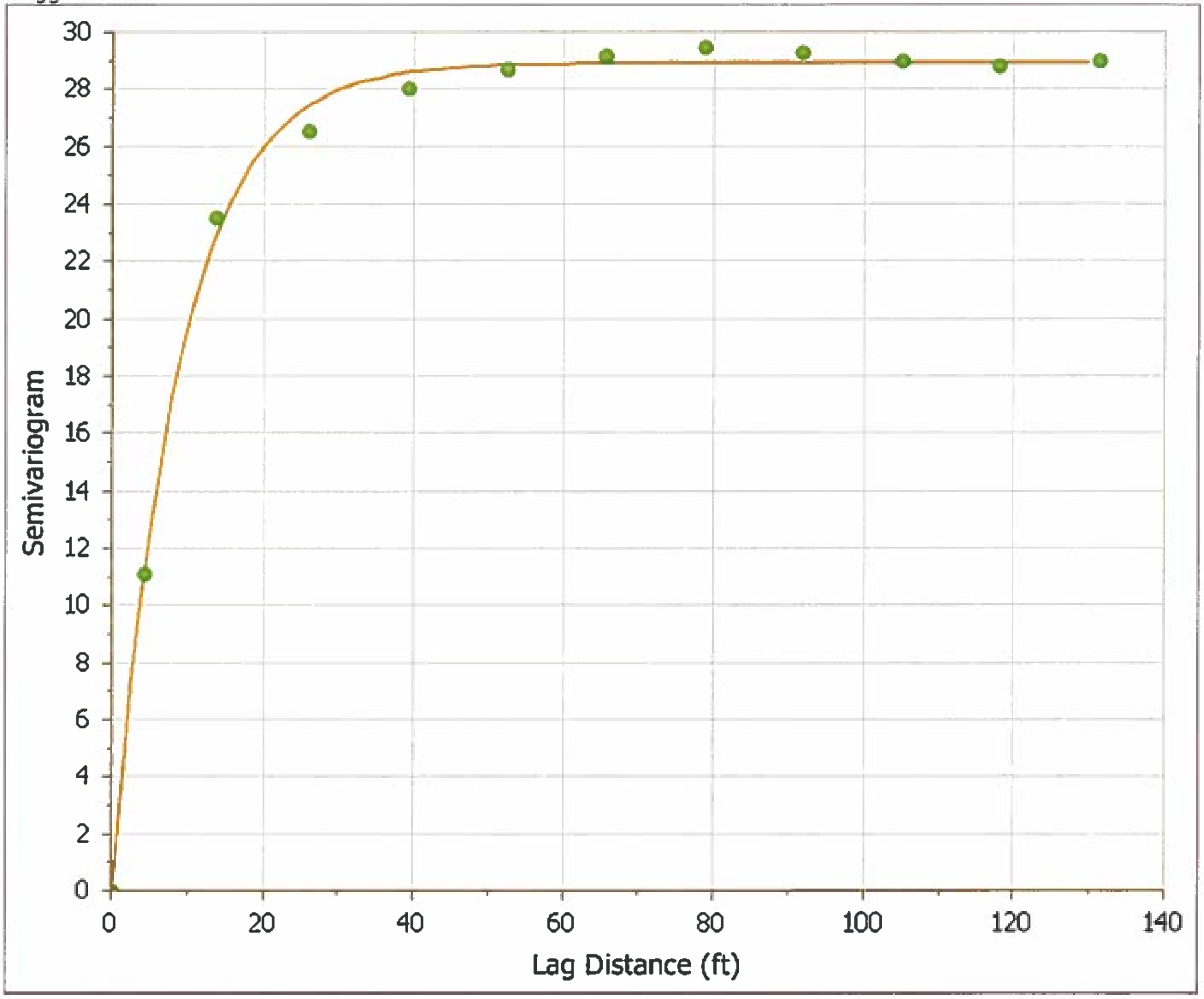
Statistic	Value
Mean	149.14
Standard Deviation	6.03
CoV (%)	4
Min	10.40
Max	150.00
Sample Size	154,847
Target Status	Passed
% of Target Achieved	100.00



Pass Count 2012-11-14 to 11-29 LAST

Final Coverage: Semivariogram

Range (ft): 18.37
Sill: 25.36
Vertical Scale: 25.36
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2012-12-01 to 12-12 Last
State Plane Zone: 1702 - Louisiana South

File Information

Final Coverage
Final Coverage: True

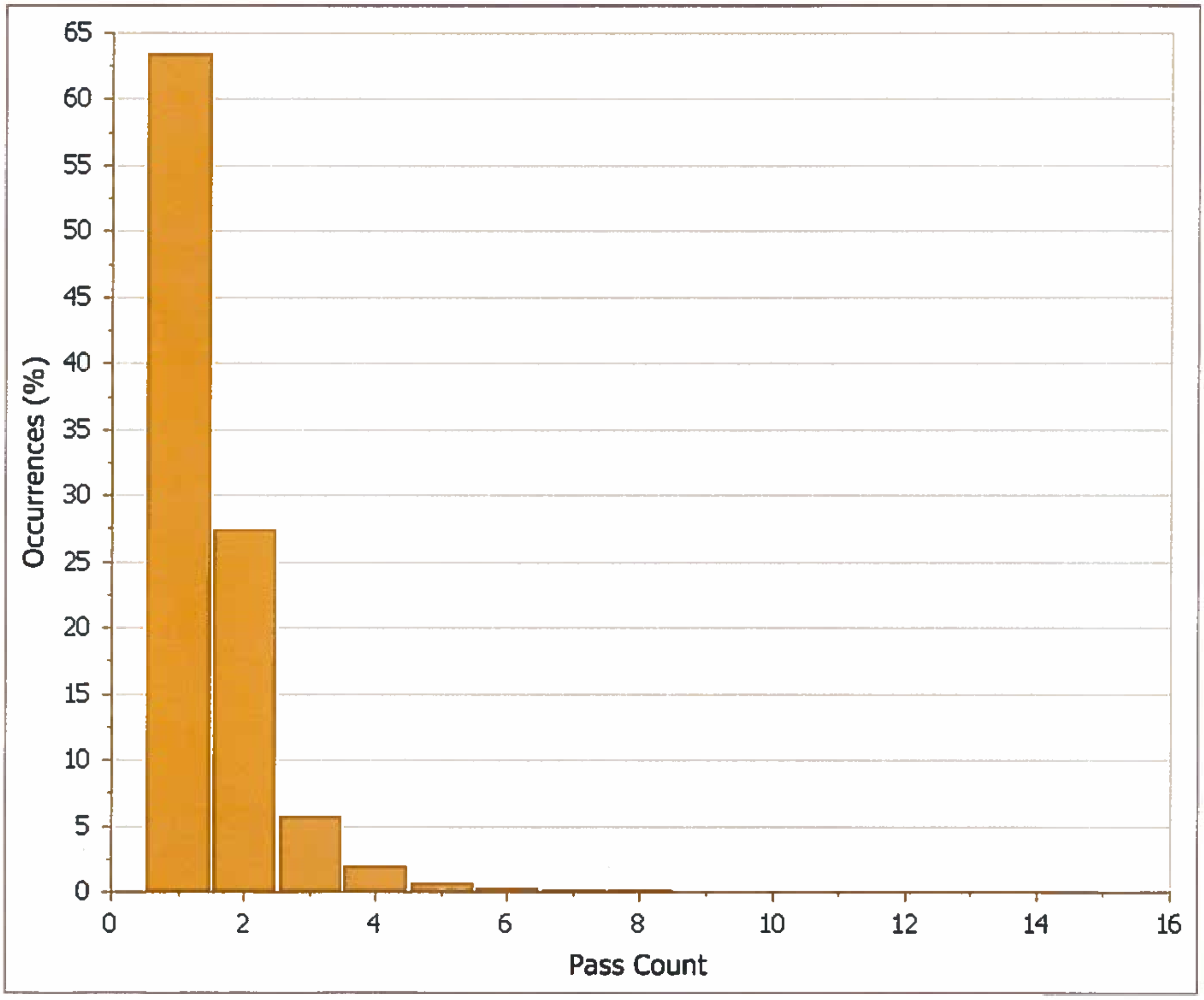
Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Pass Count 2012-12-01 to 12-12 Last

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

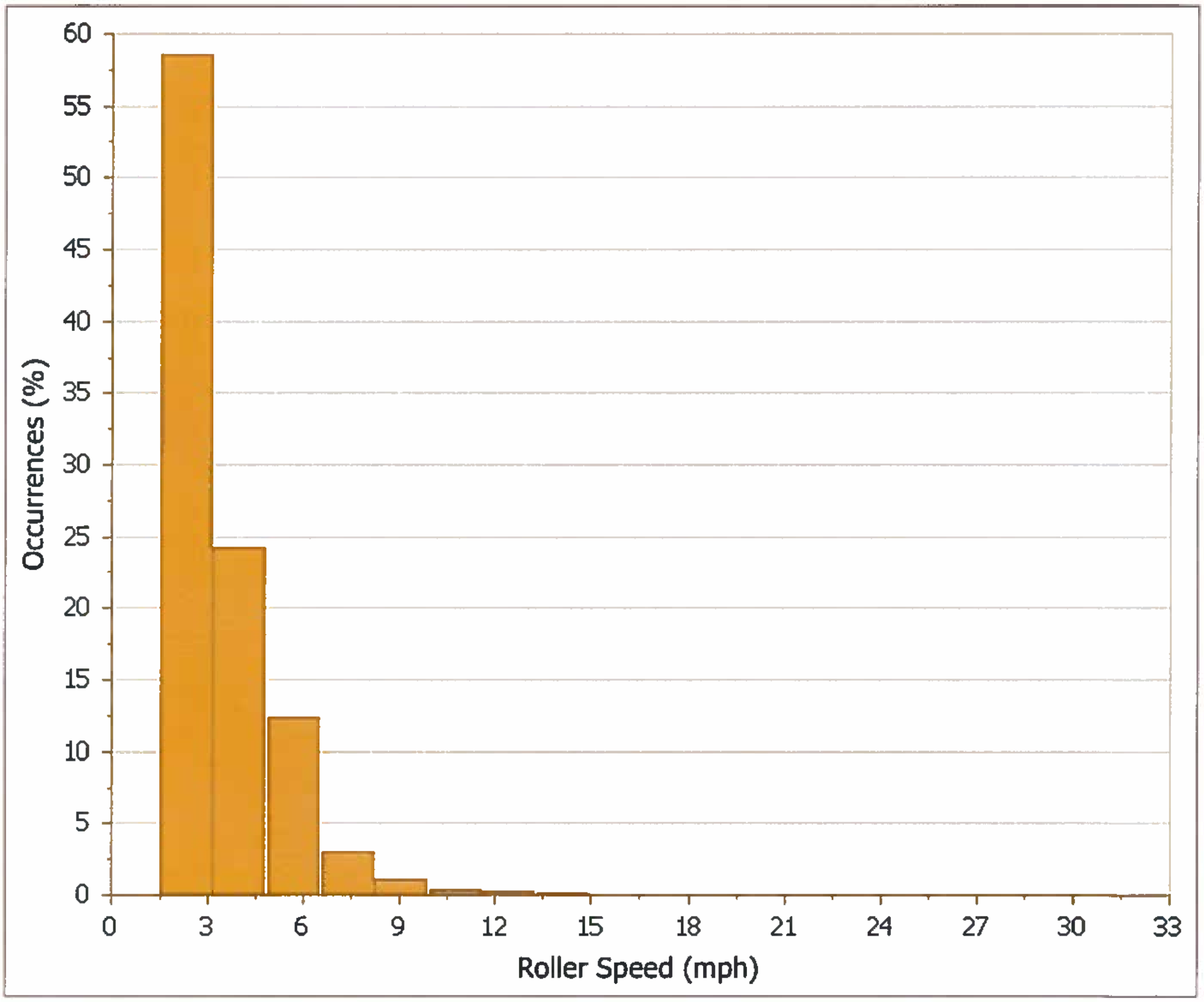
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	57
Min	1
Max	14
Sample Size	146,680
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	2.8
Standard Deviation (mph)	1.5
CoV (%)	54
Min (mph)	0.6
Max (mph)	34.4
Sample Size	146,680
Target Status	Passed
% of Target Achieved	100.00

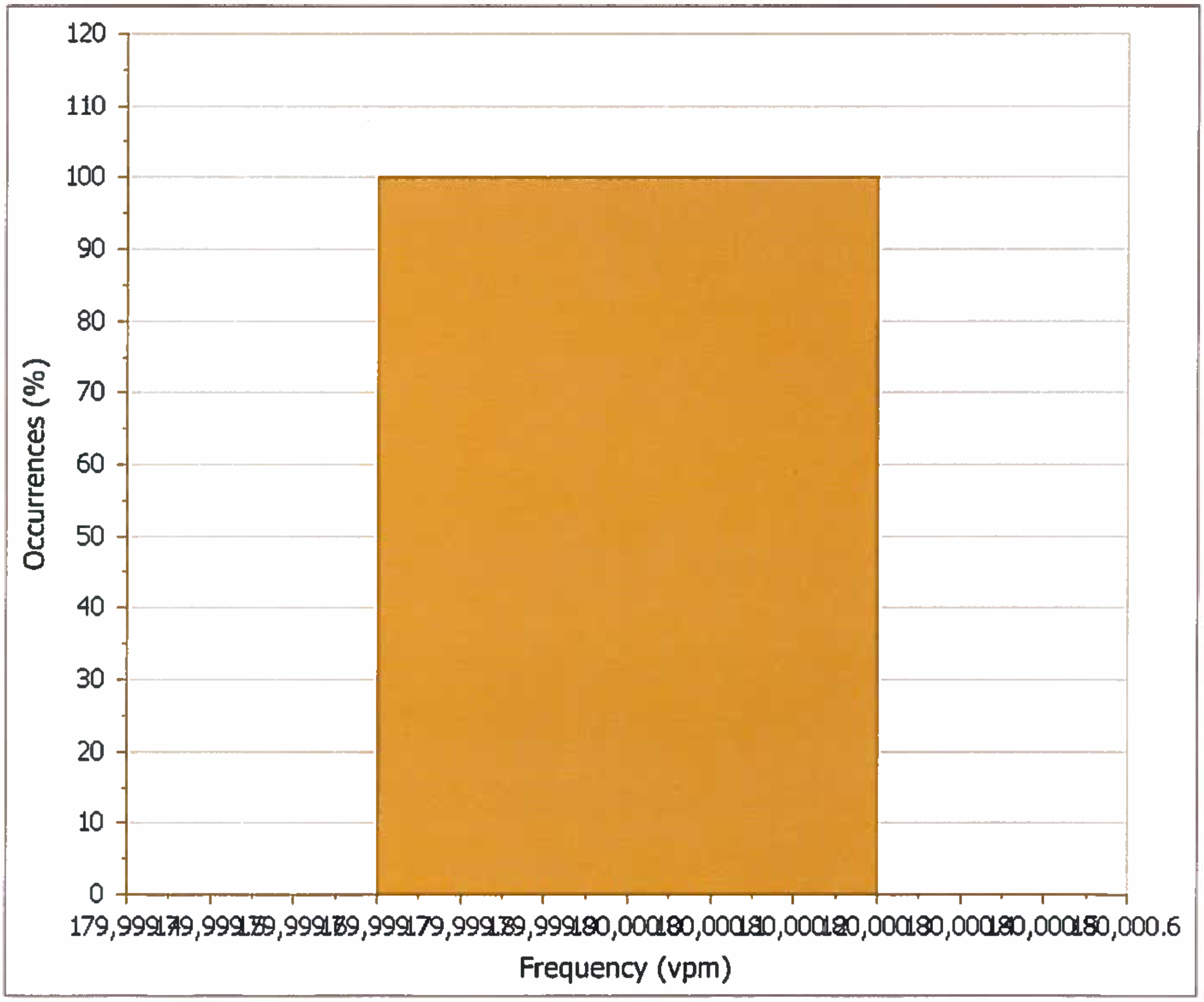


Pass Count 2012-12-01 to 12-12 Last

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	128,962
Target Status	Failed
% of Target Achieved	0.00

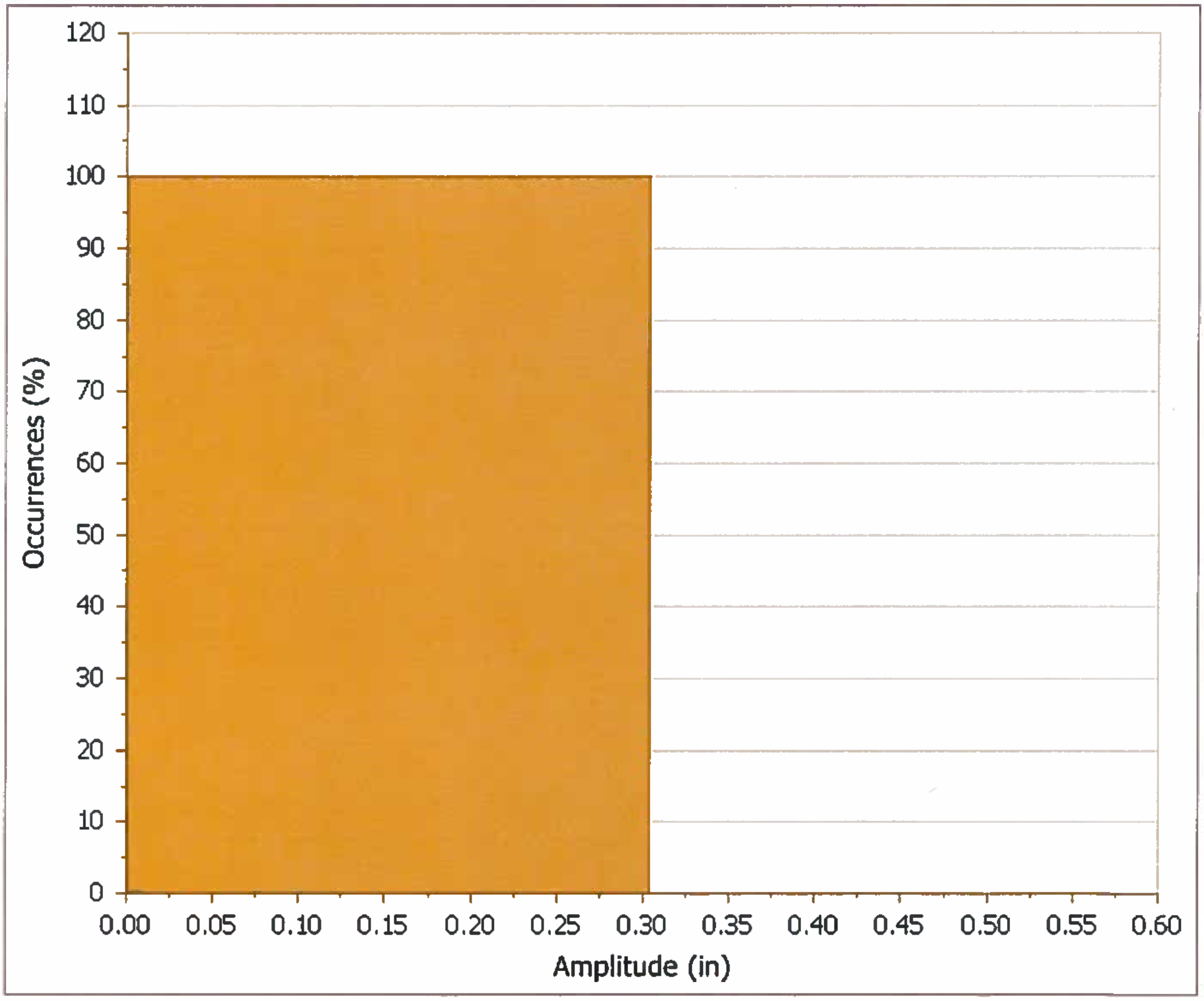


Pass Count 2012-12-01 to 12-12 Last

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	128,962
Target Status	Failed
% of Target Achieved	0.00

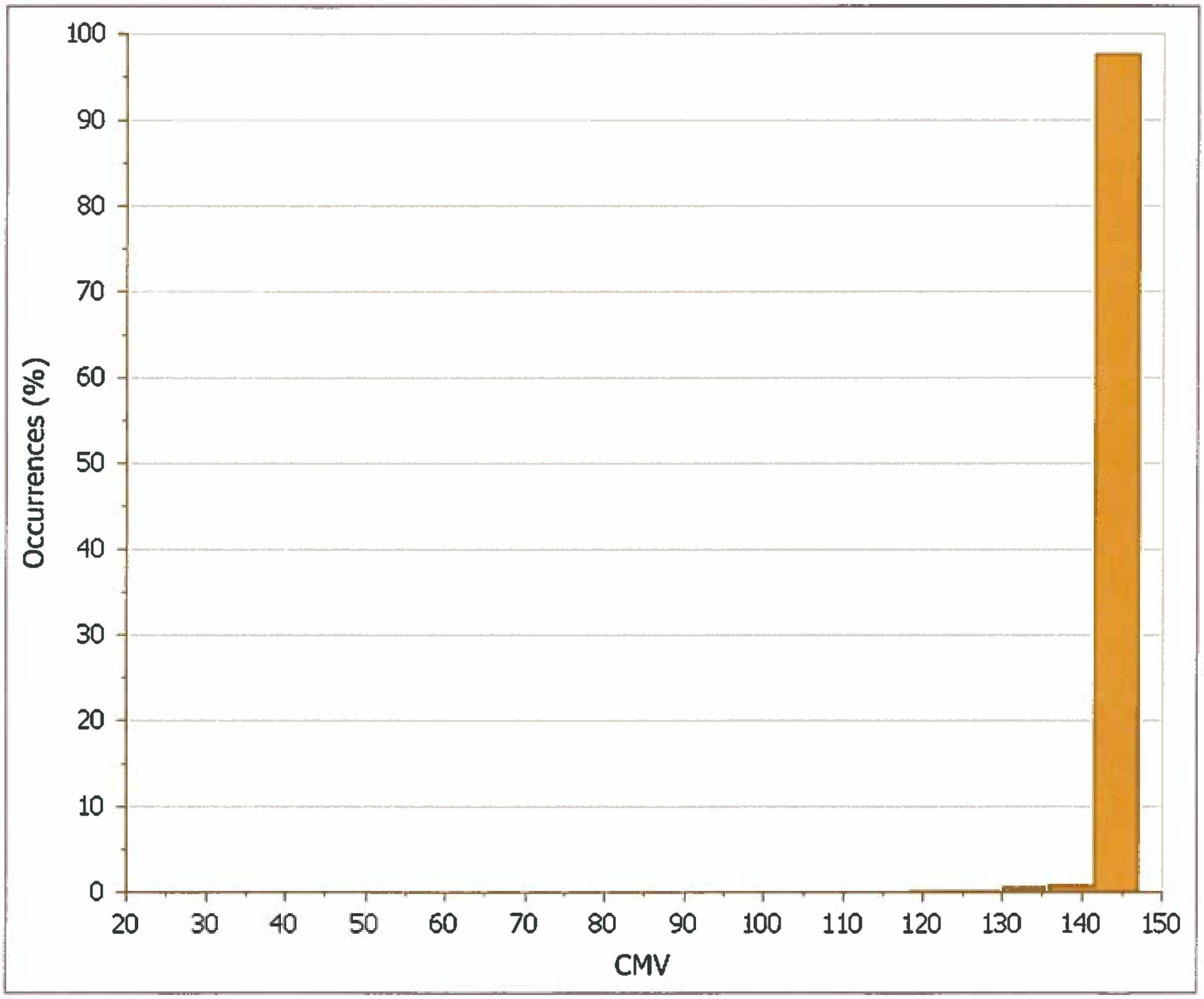


Pass Count 2012-12-01 to 12-12 Last

Final Coverage: CMV

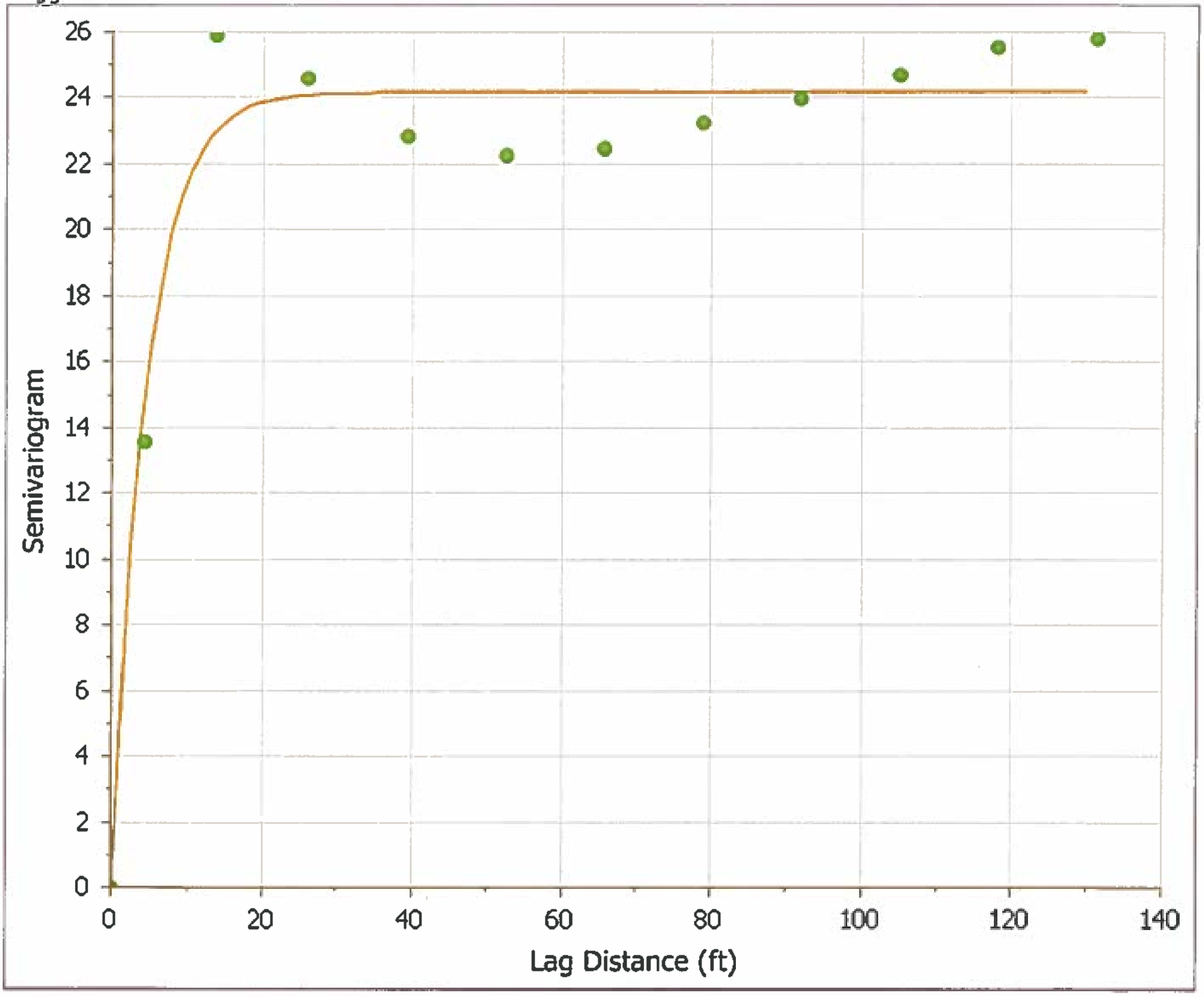
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	149.01
Standard Deviation	5.72
CoV (%)	4
Min	34.70
Max	150.00
Sample Size	128,962
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Semivariogram

Range (ft): 13.12
Sill: 22.83
Vertical Scale: 22.83
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2012-12-20 LAST
State Plane Zone: 1702 - Louisiana South

File Information

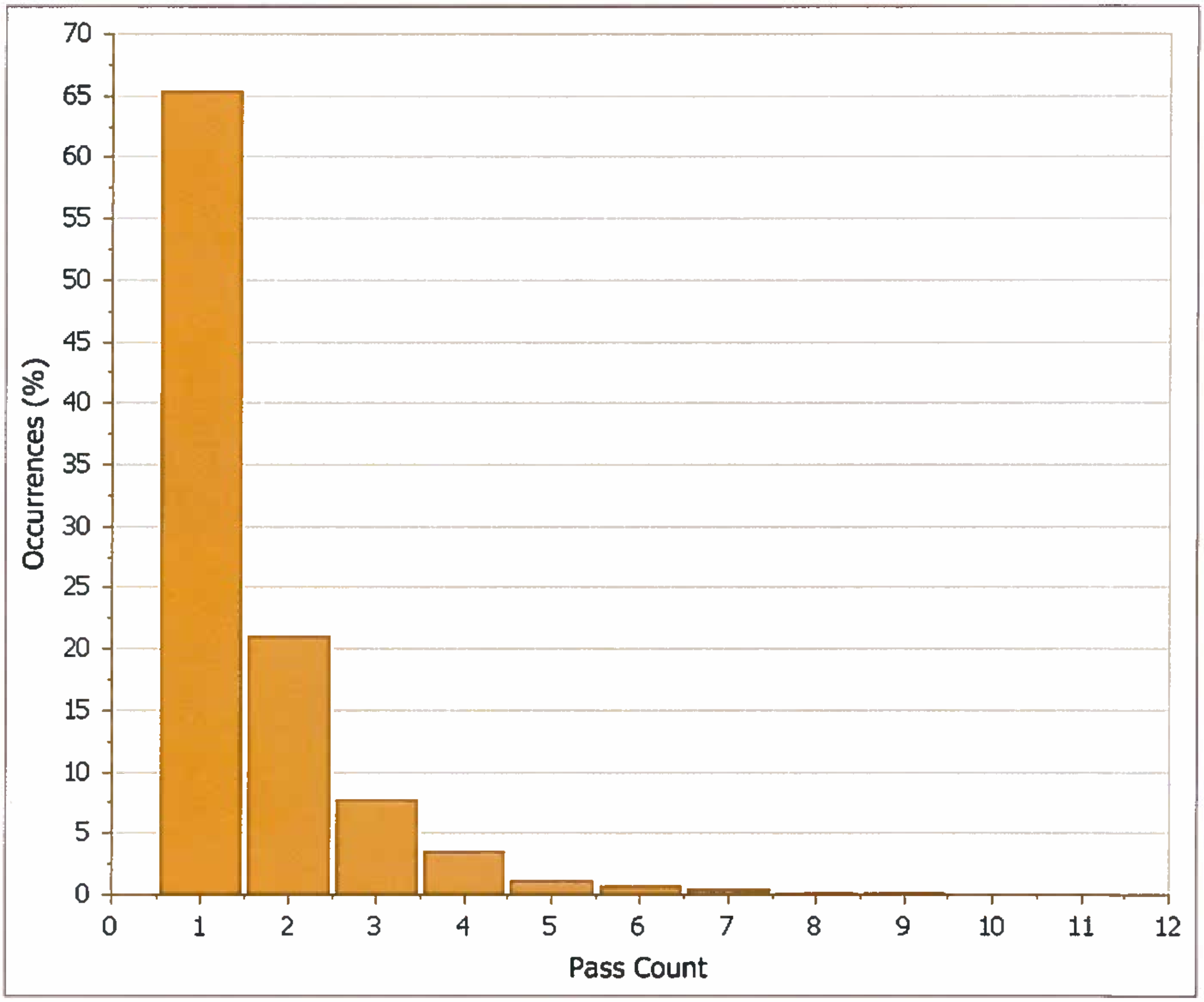
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

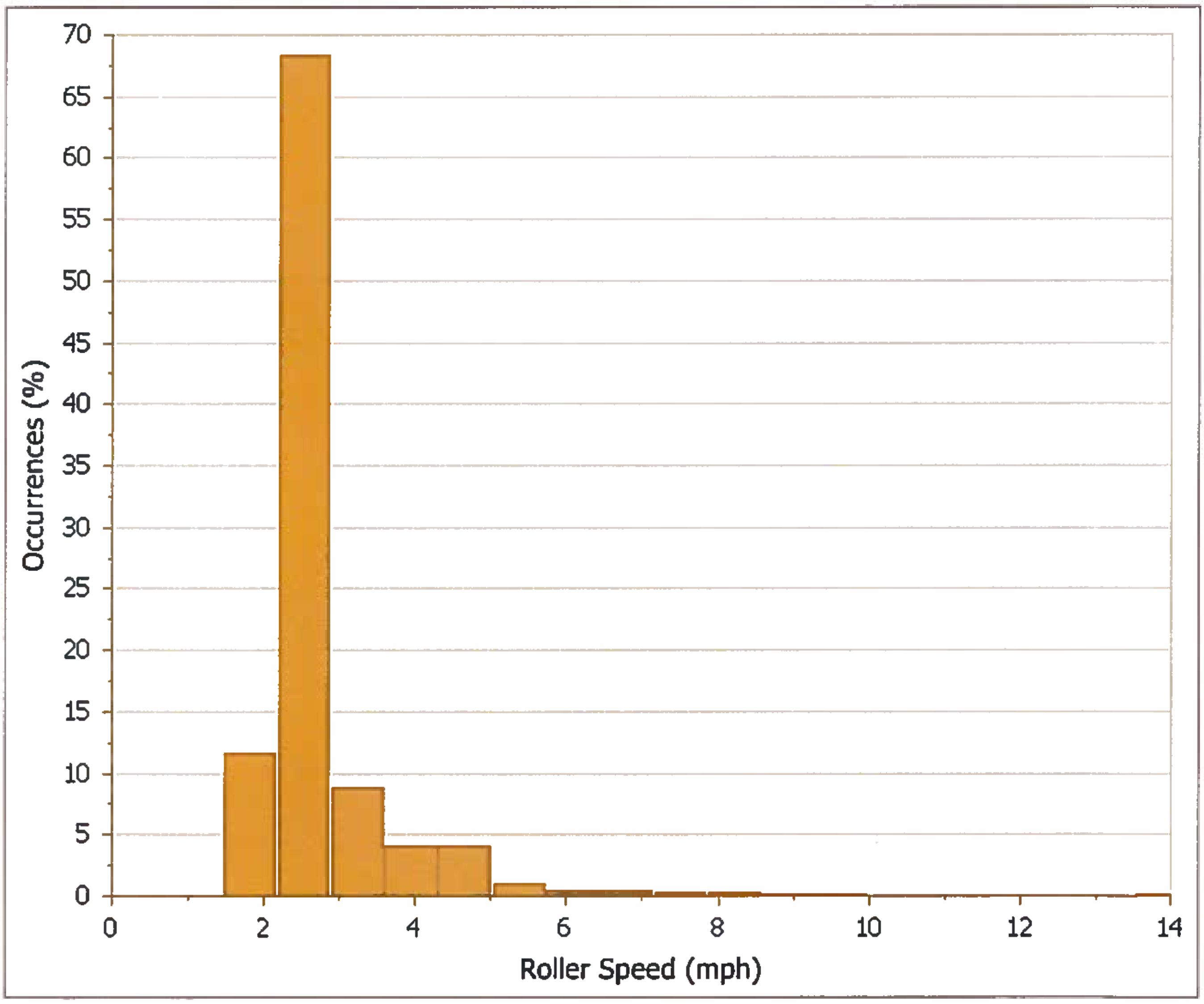
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	67
Min	1
Max	11
Sample Size	9,034
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	2.4
Standard Deviation (mph)	1.1
CoV (%)	45
Min (mph)	0.4
Max (mph)	14.6
Sample Size	9,034
Target Status	Passed
% of Target Achieved	99.99

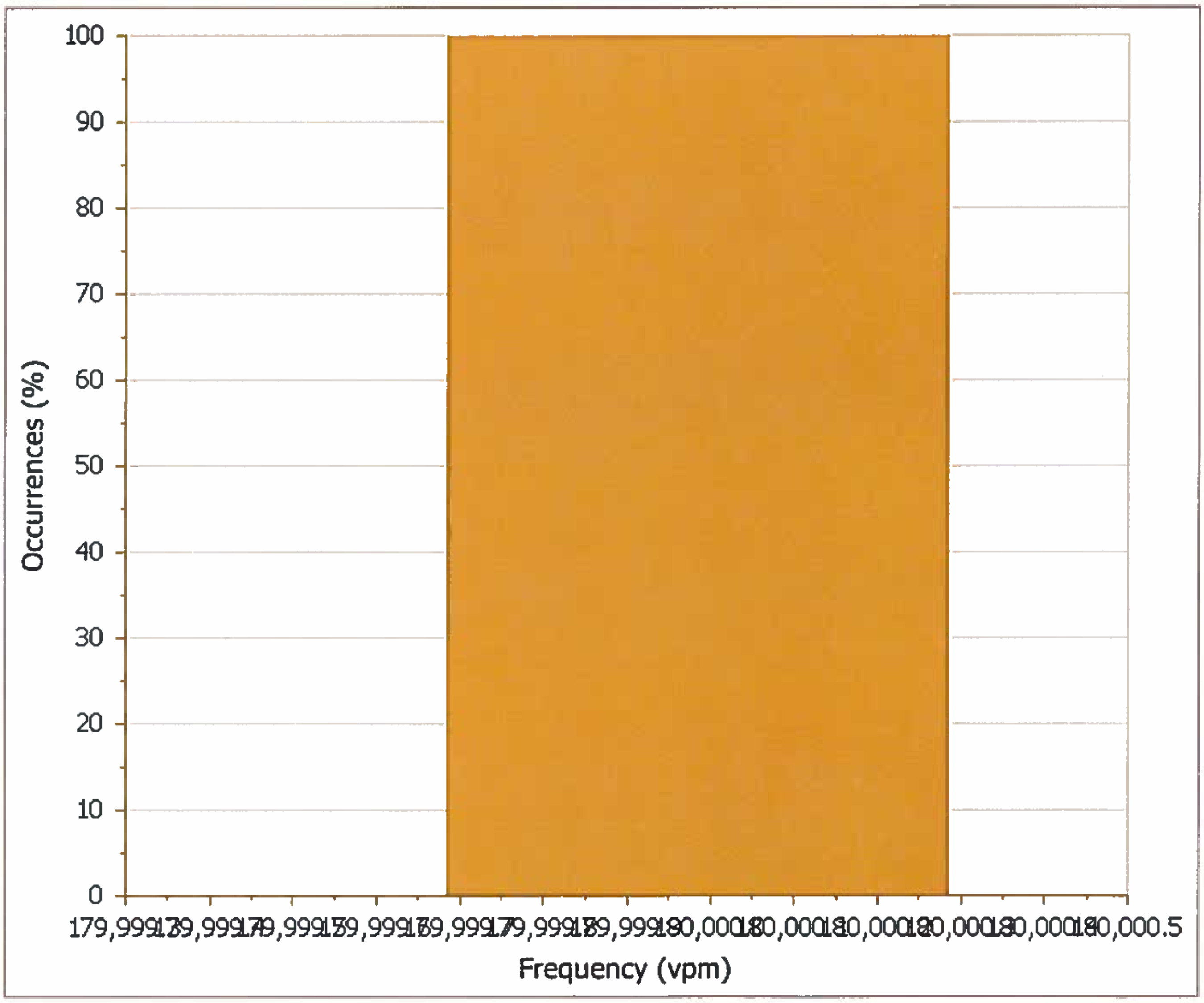


Pass Count 2012-12-20 LAST

Final Coverage: Frequency

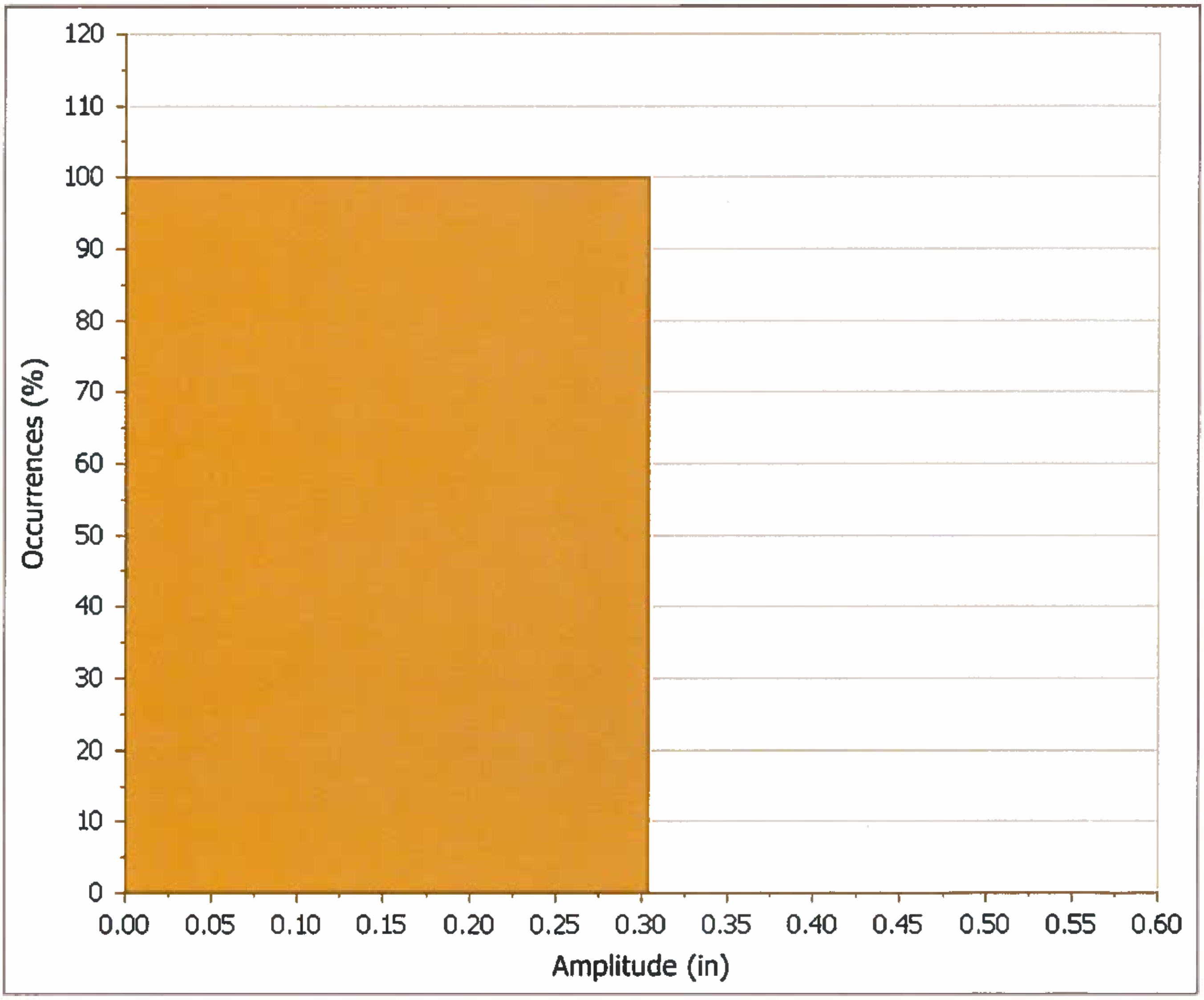
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	8,918
Target Status	Passed
% of Target Achieved	99.97



Final Coverage: Amplitude
Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	8,918
Target Status	Failed
% of Target Achieved	0.00

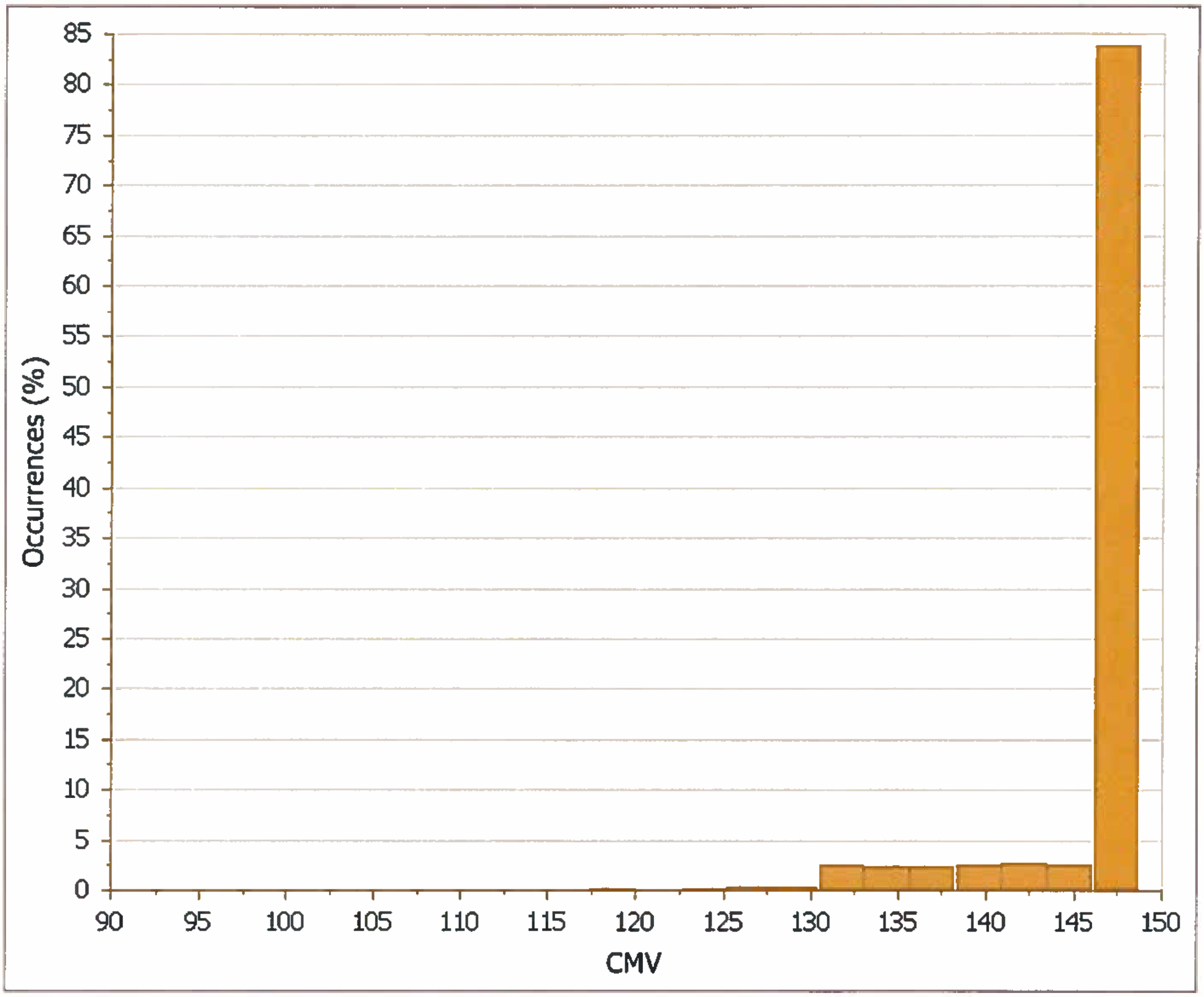


Pass Count 2012-12-20 LAST

Final Coverage: CMV

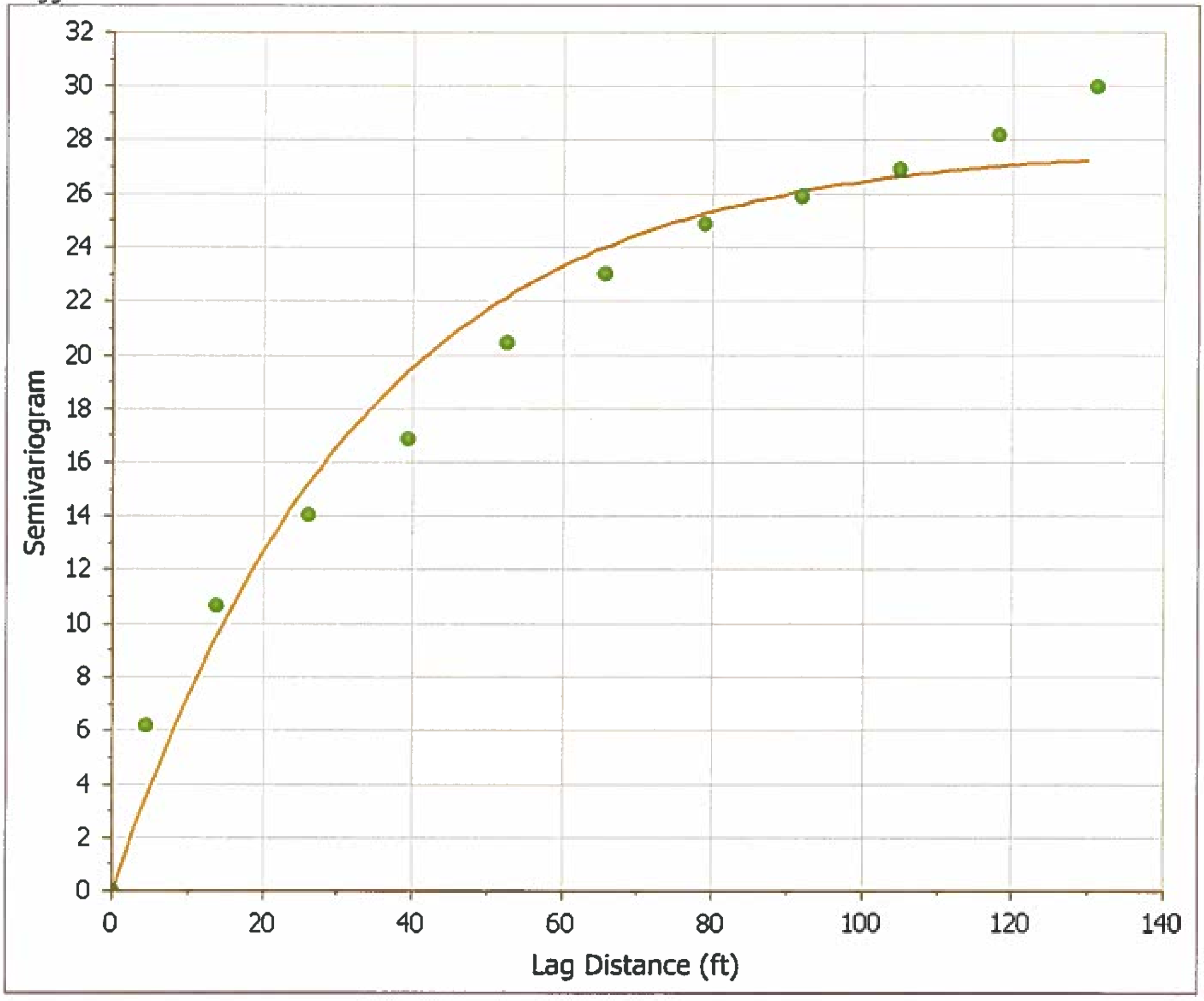
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	147.48
Standard Deviation	5.68
CoV (%)	4
Min	97.80
Max	150.00
Sample Size	8,918
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Semivariogram

Range (ft): 27.55
Sill: 15.77
Vertical Scale: 15.77
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-01-05 Last
State Plane Zone: 1702 - Louisiana South

File Information

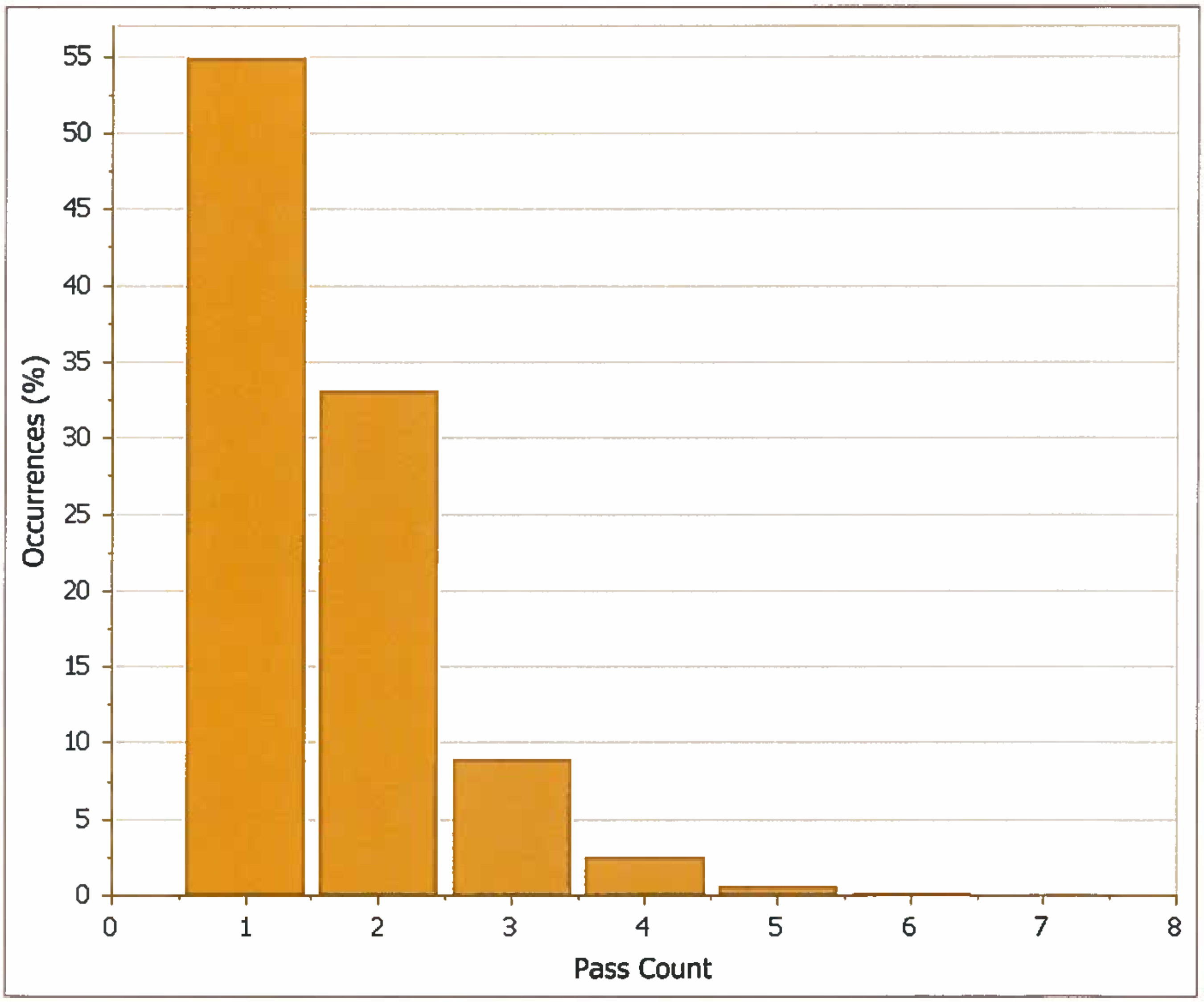
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	50
Min	1
Max	7
Sample Size	71,865
Target Status	Passed
% of Target Achieved	100.00

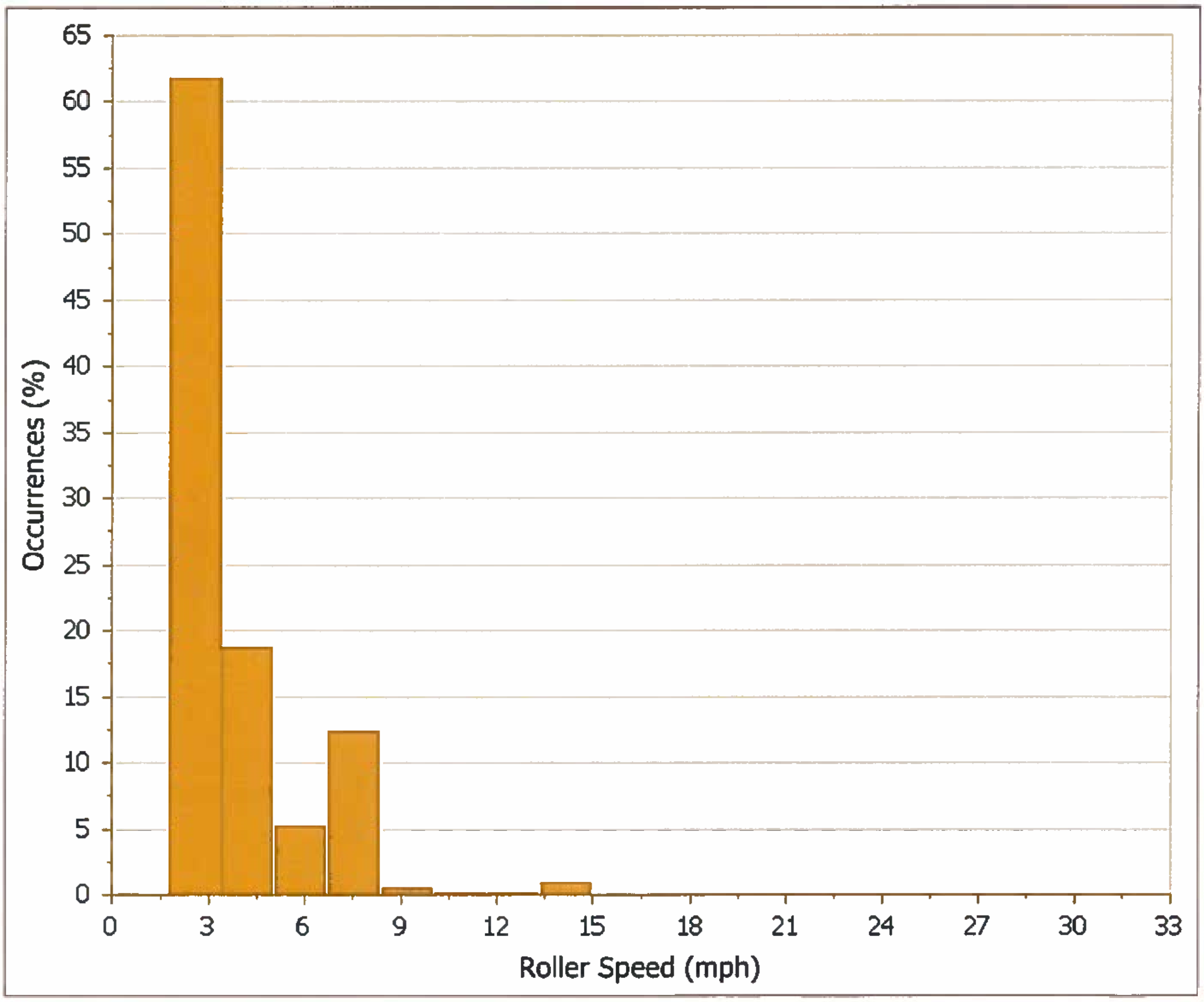


Pass Count 2013-01-05 Last

Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

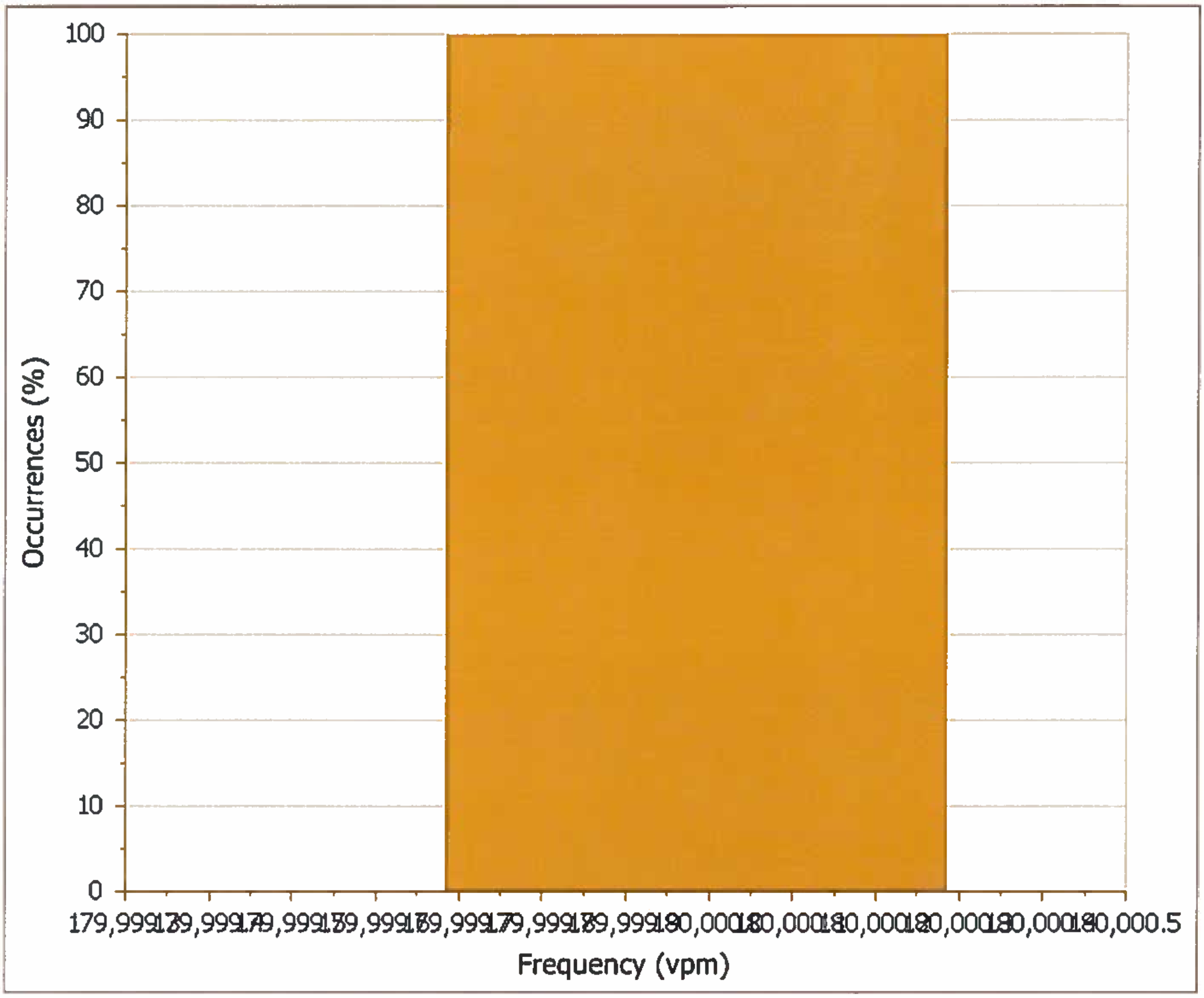
Statistic	Value
Mean (mph)	3.2
Standard Deviation (mph)	2.1
CoV (%)	66
Min (mph)	0.9
Max (mph)	34.0
Sample Size	71,865
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	68,410
Target Status	Passed
% of Target Achieved	100.00

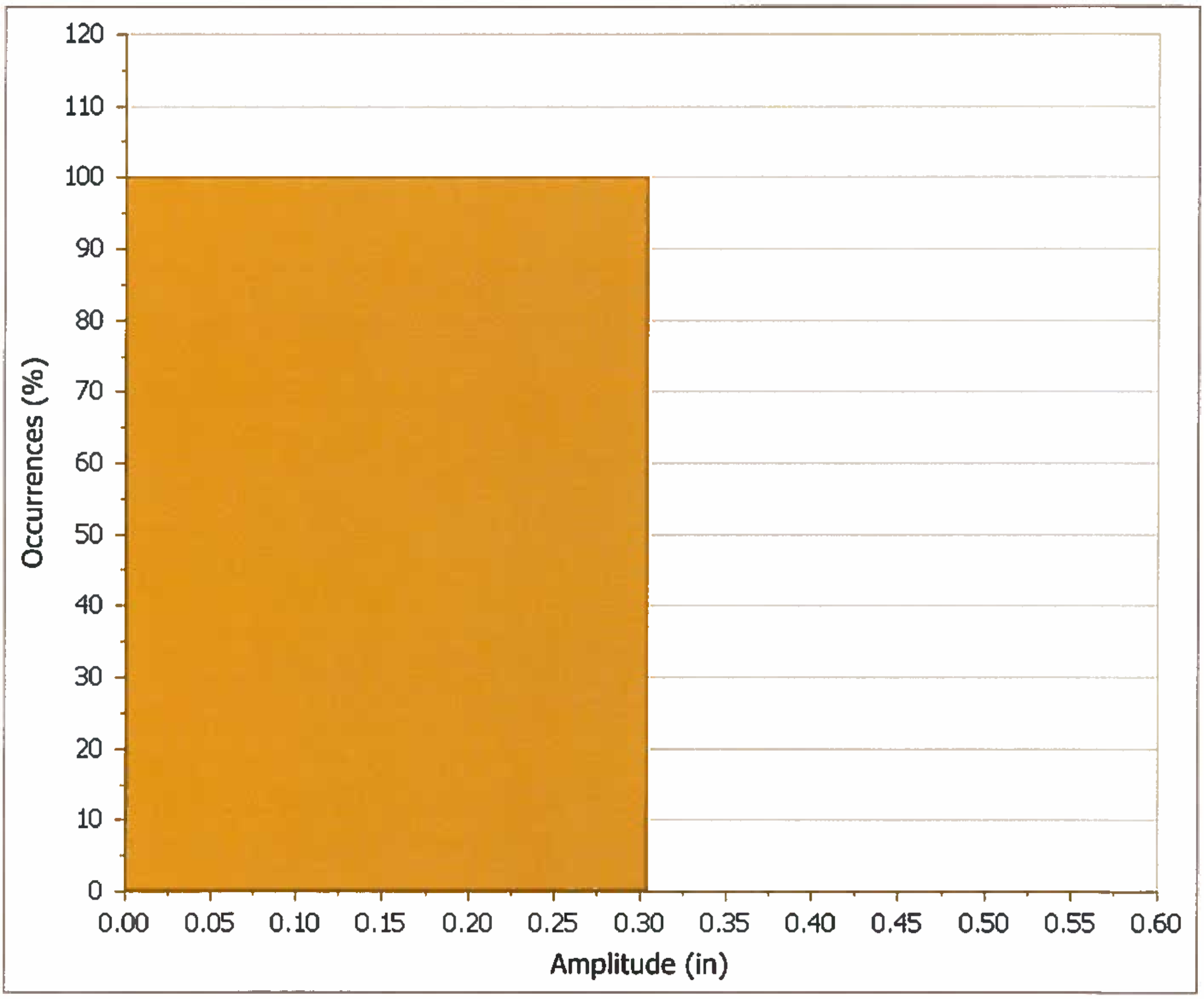


Pass Count 2013-01-05 Last

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	68,410
Target Status	Failed
% of Target Achieved	0.00

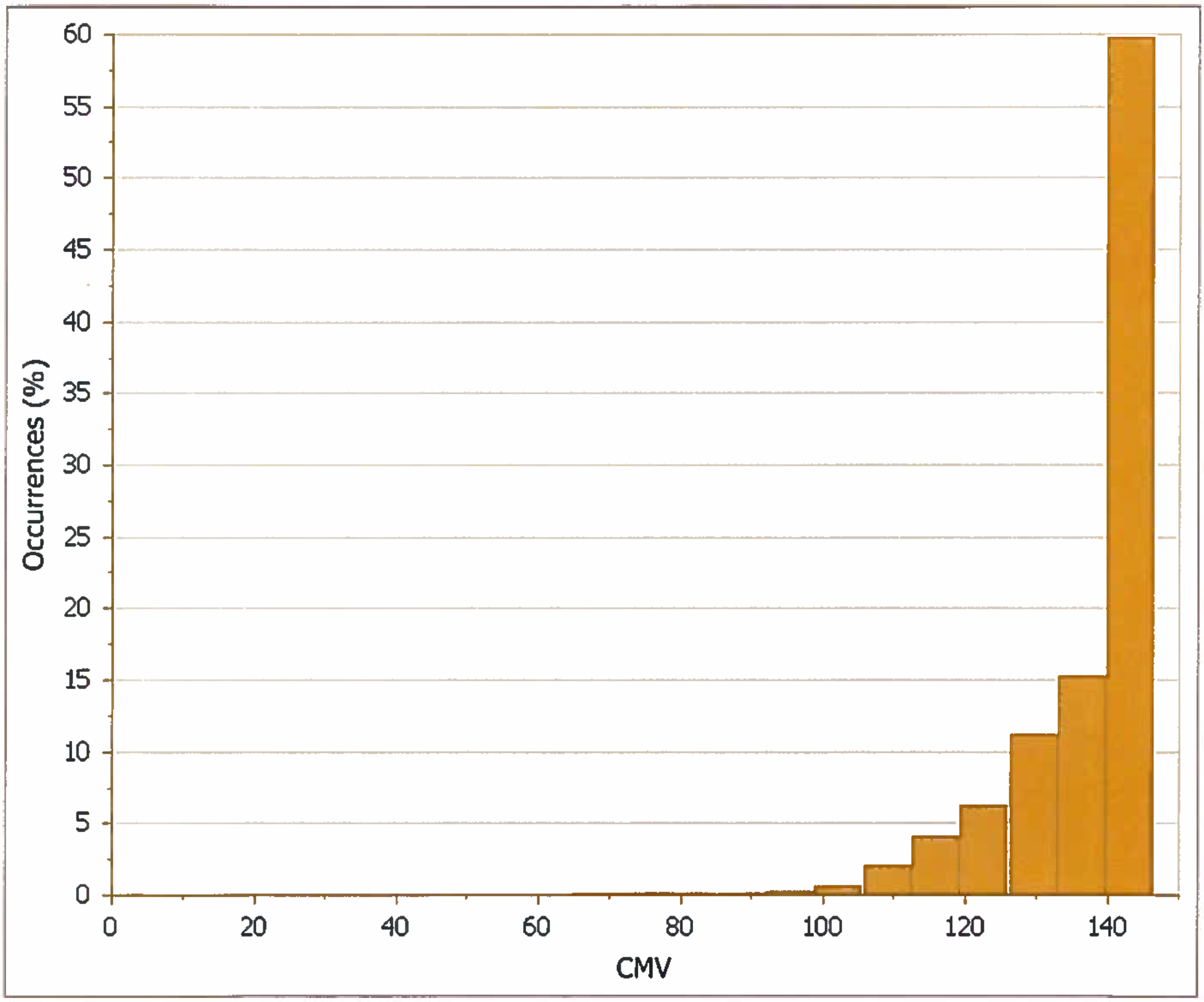


Pass Count 2013-01-05 Last

Final Coverage: CMV

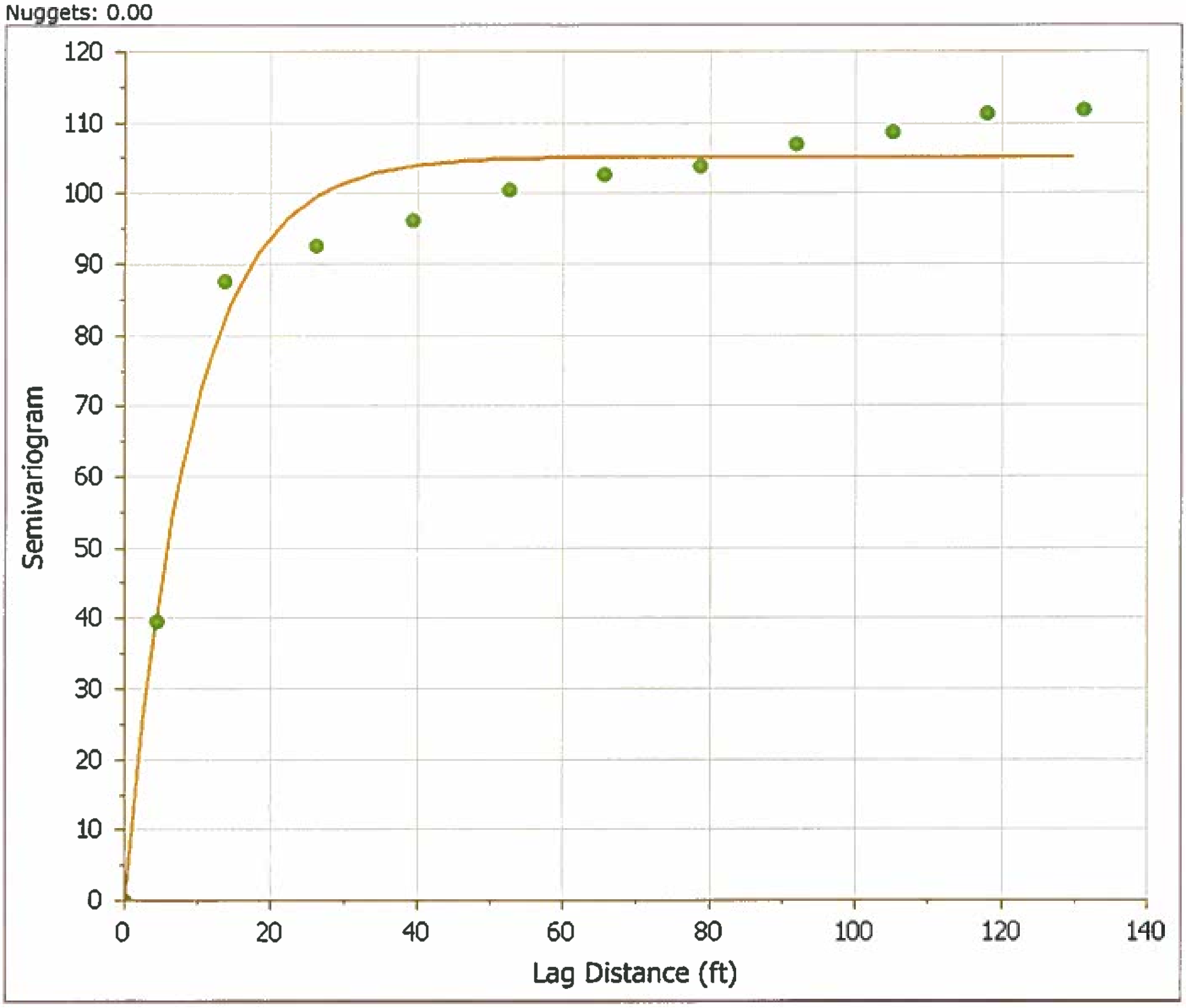
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	135.38
Standard Deviation	12.73
CoV (%)	9
Min	13.40
Max	150.00
Sample Size	68,410
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Semivariogram

Range (ft): 19.68
Sill: 93.45
Vertical Scale: 93.45
Nuggets: 0.00



Pass Count 2013-01-22 to 1-23 last

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-01-22 to 1-23 last
State Plane Zone: 1702 - Louisiana South

File Information

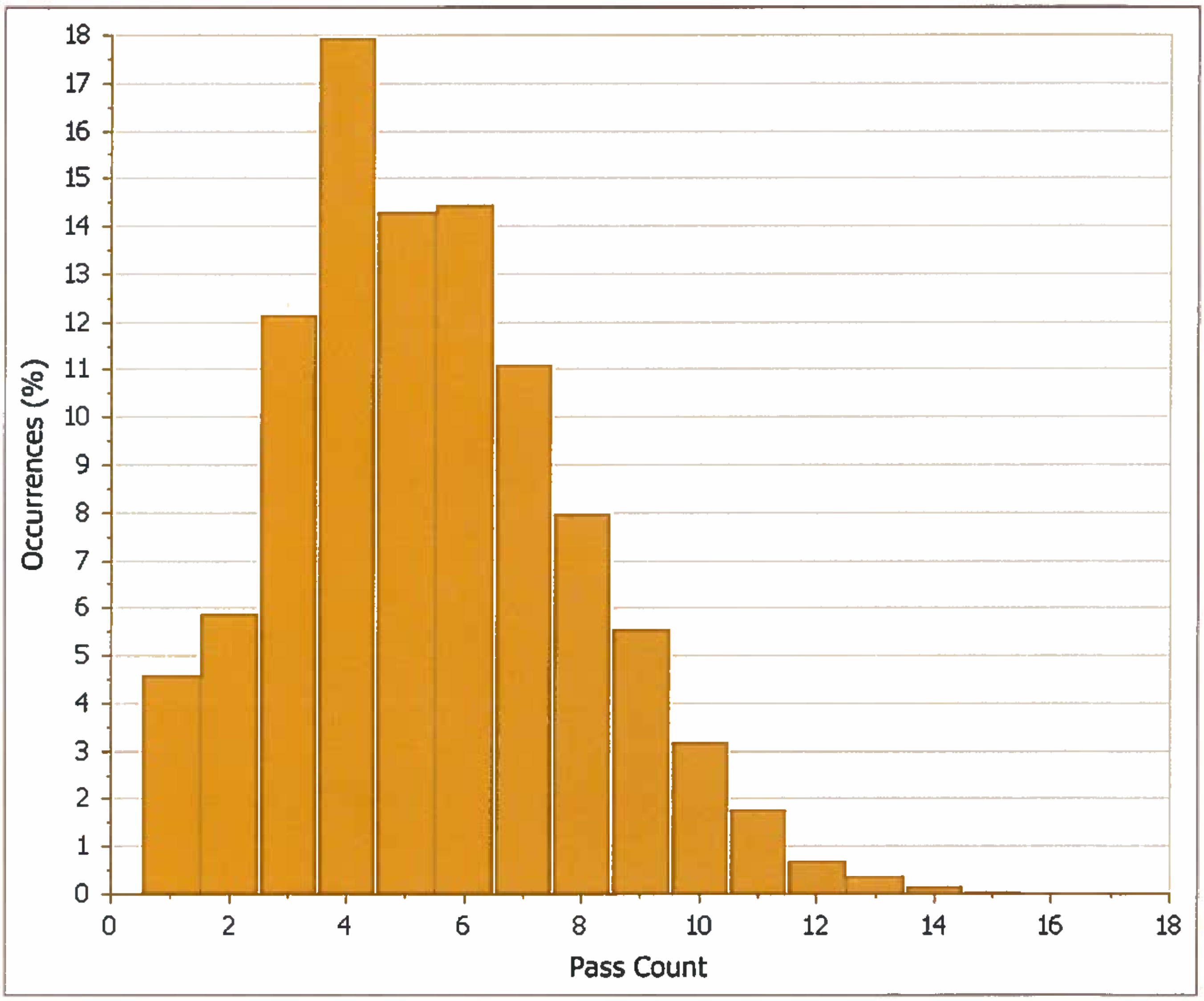
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

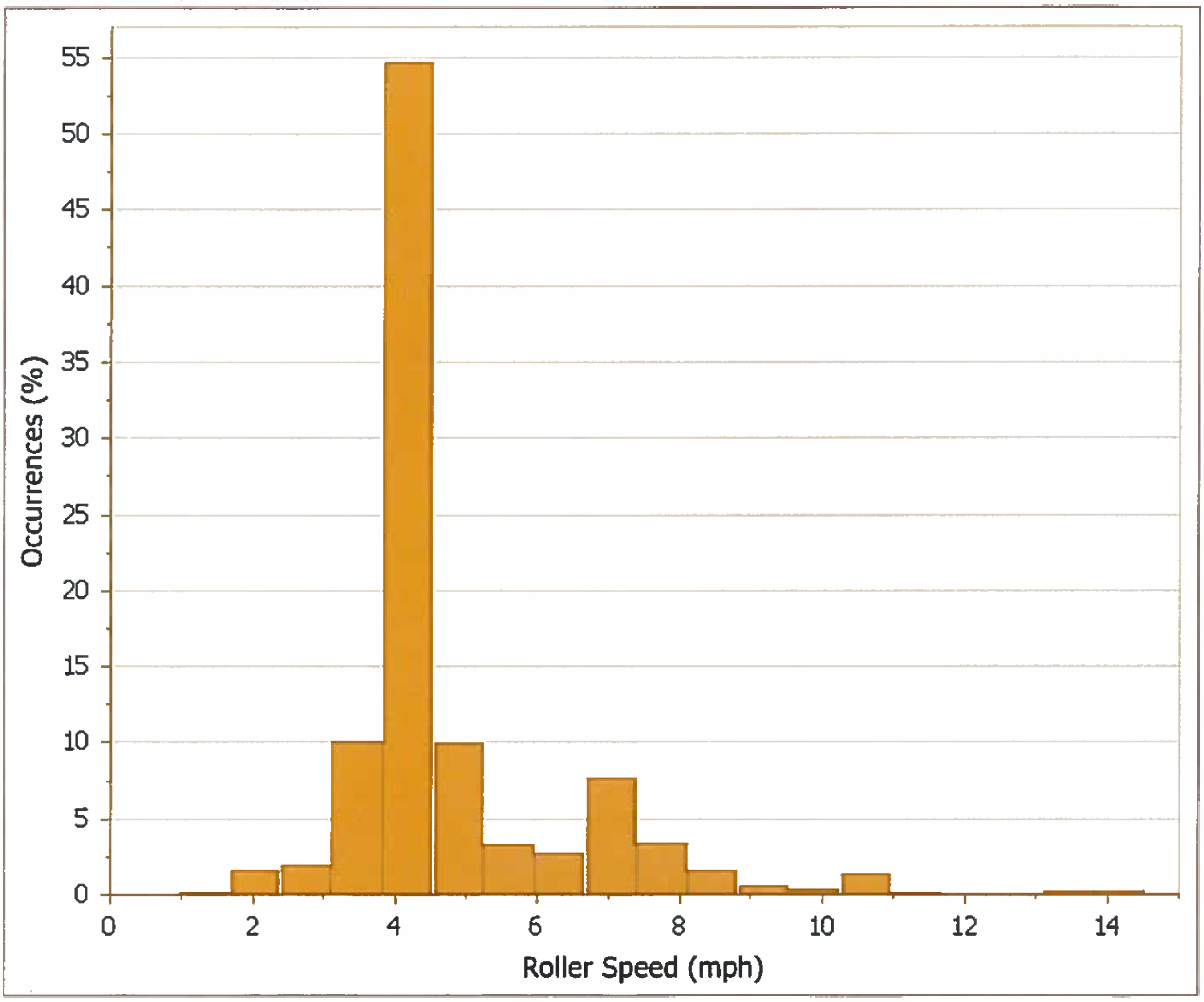
Statistic	Value
Mean	5
Standard Deviation	2
CoV (%)	46
Min	1
Max	17
Sample Size	42,618
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	4.5
Standard Deviation (mph)	1.7
CoV (%)	38
Min (mph)	0.6
Max (mph)	14.9
Sample Size	42,618
Target Status	Passed
% of Target Achieved	100.00

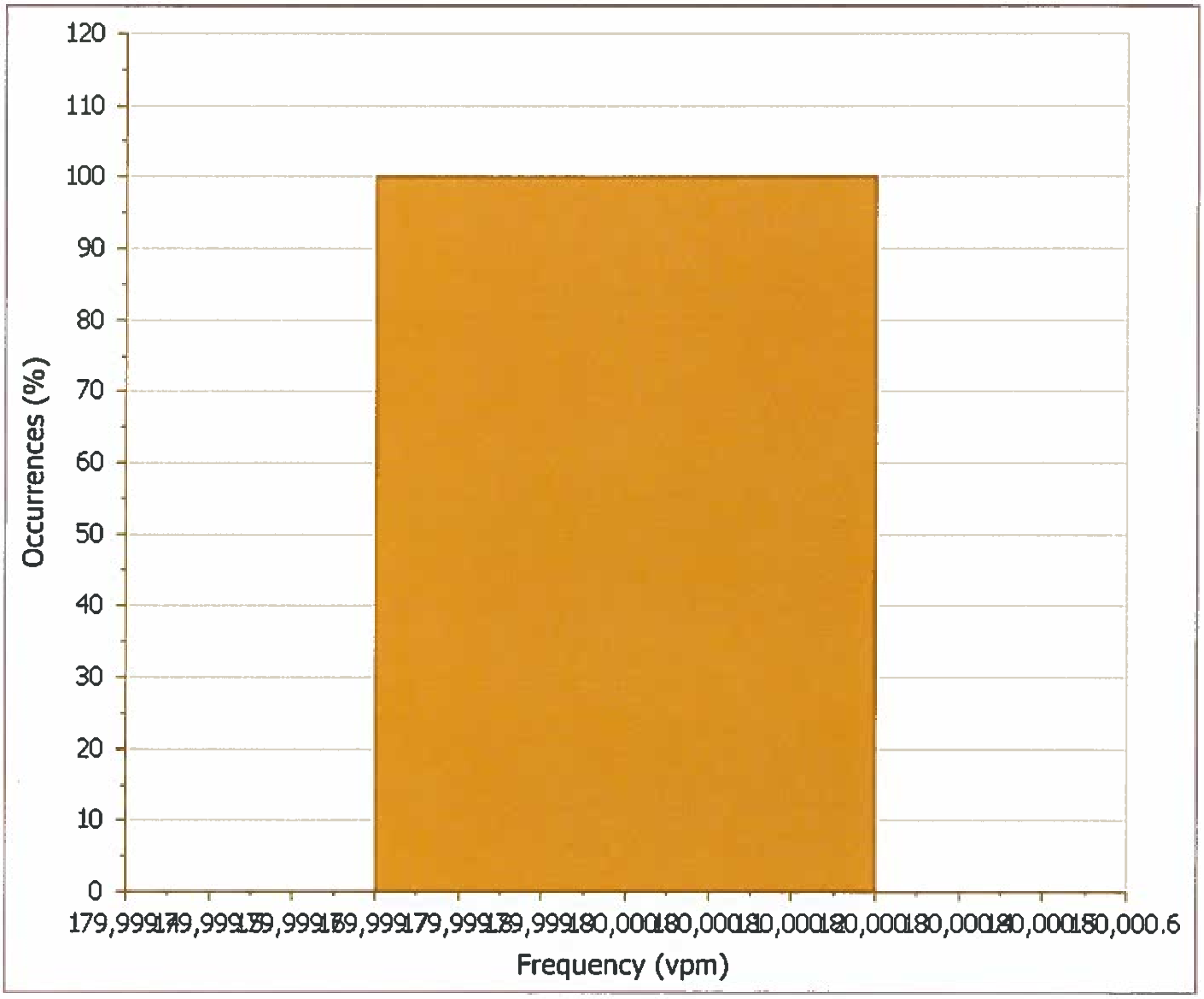


Pass Count 2013-01-22 to 1-23 last

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

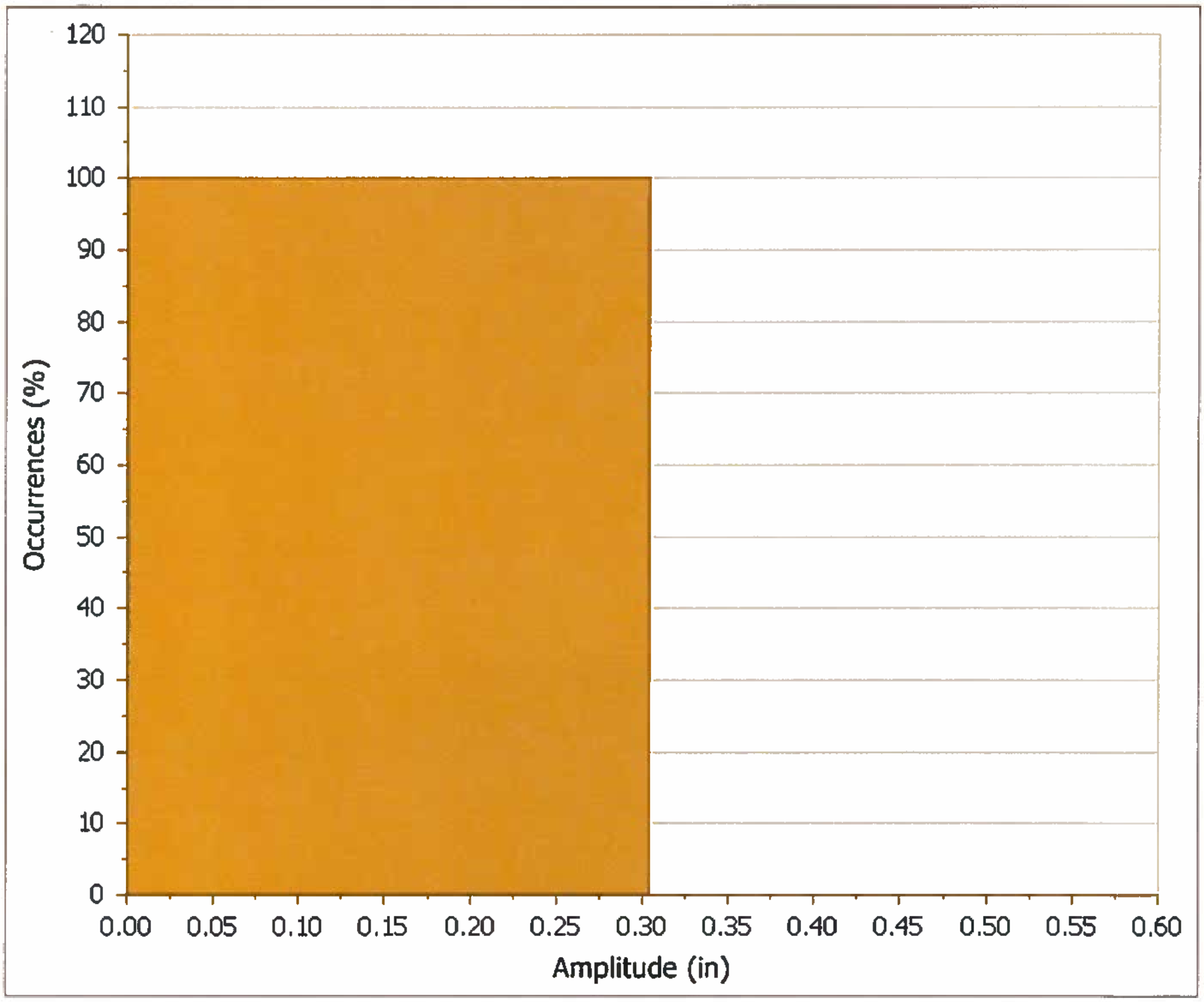
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	4,203
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	4,203
Target Status	Failed
% of Target Achieved	0.00

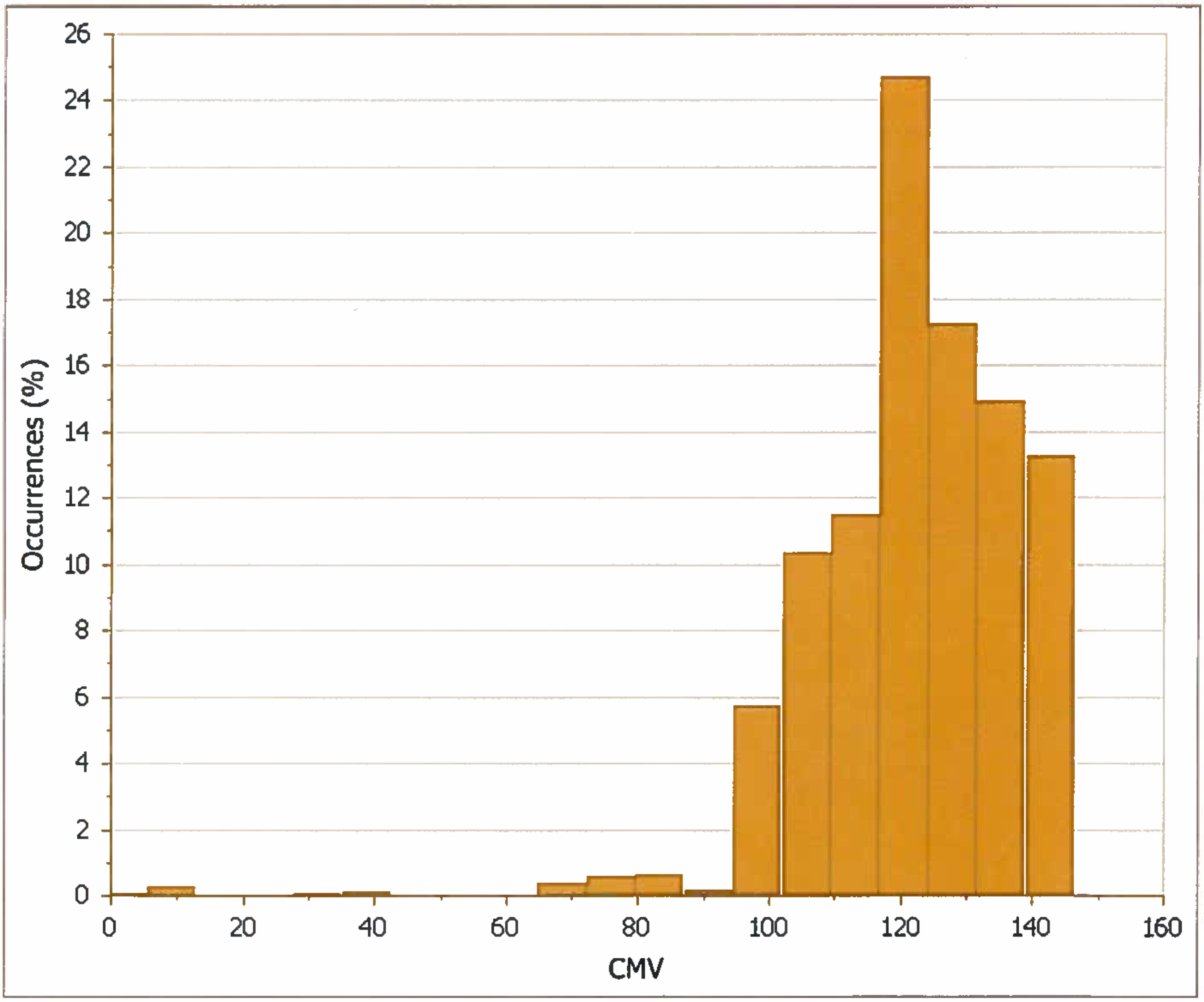


Pass Count 2013-01-22 to 1-23 last

Final Coverage: CMV

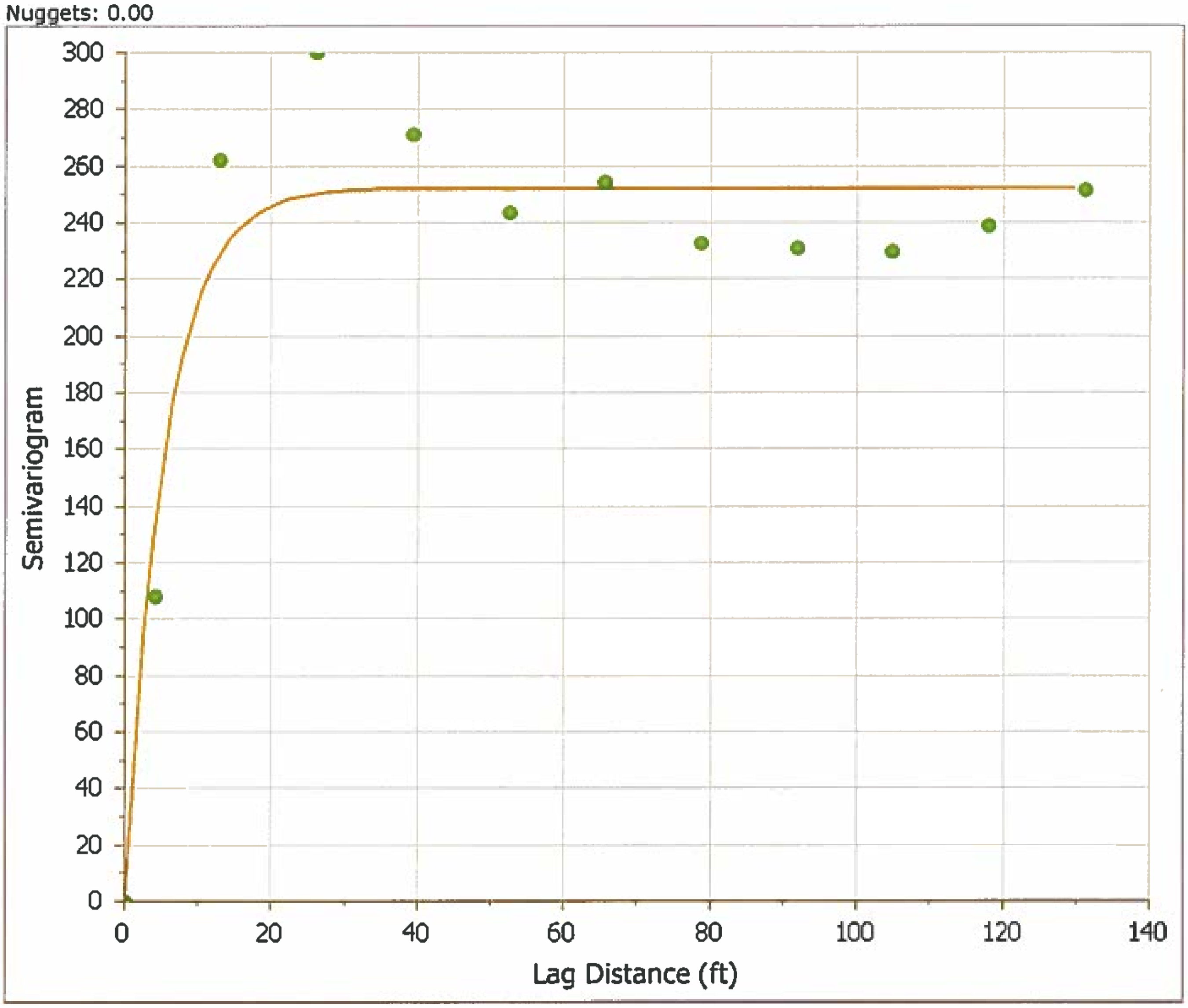
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	118.82
Standard Deviation	16.87
CoV (%)	14
Min	1.60
Max	150.00
Sample Size	4,203
Target Status	Passed
% of Target Achieved	99.95



Final Coverage: Semivariogram

Range (ft): 14.43
Sill: 234.52
Vertical Scale: 234.52
Nuggets: 0.00



Pass Count 2013-03-02 to 03-06- last

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-03-02 to 03-06- last
State Plane Zone: 1702 - Louisiana South

File Information

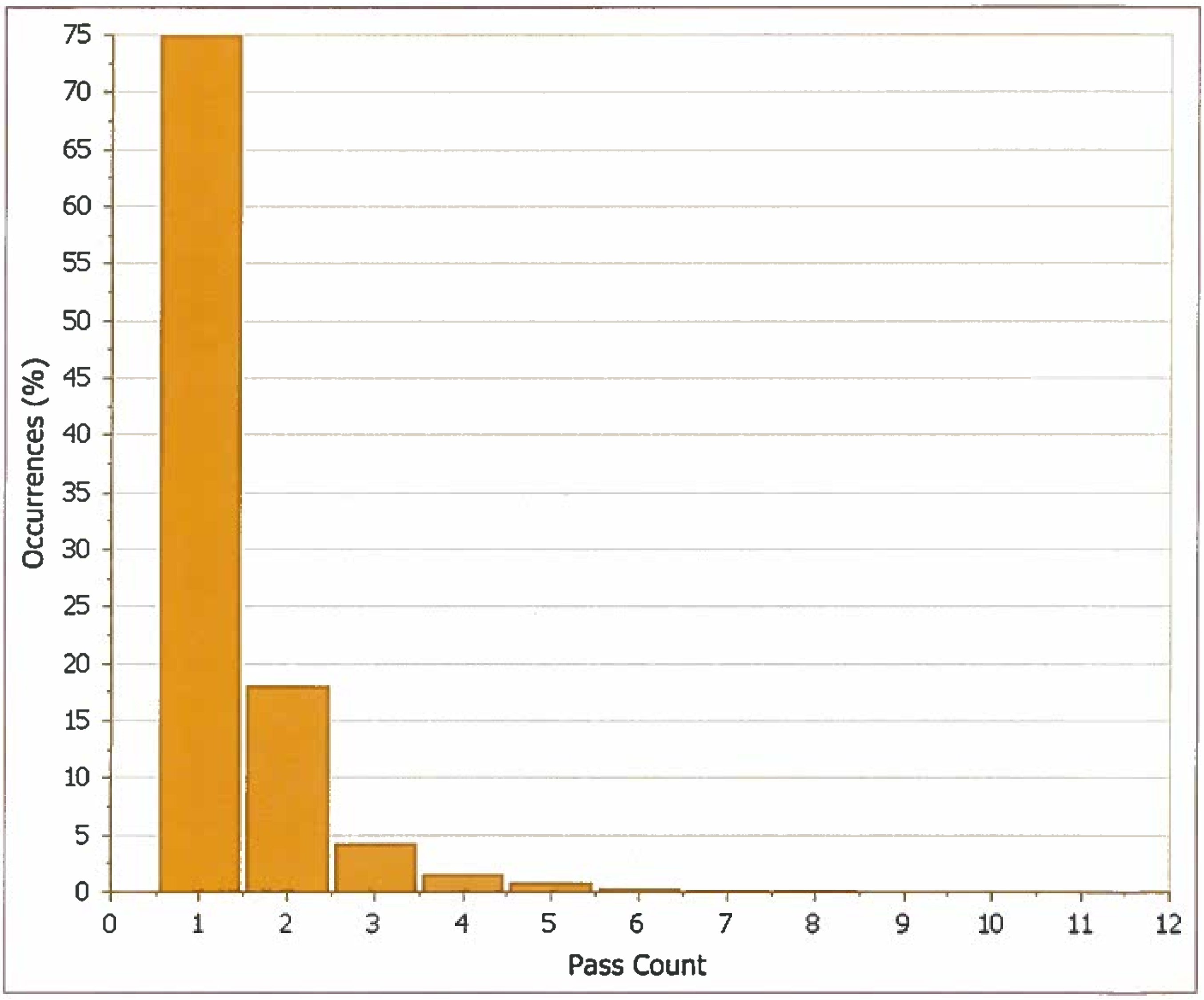
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

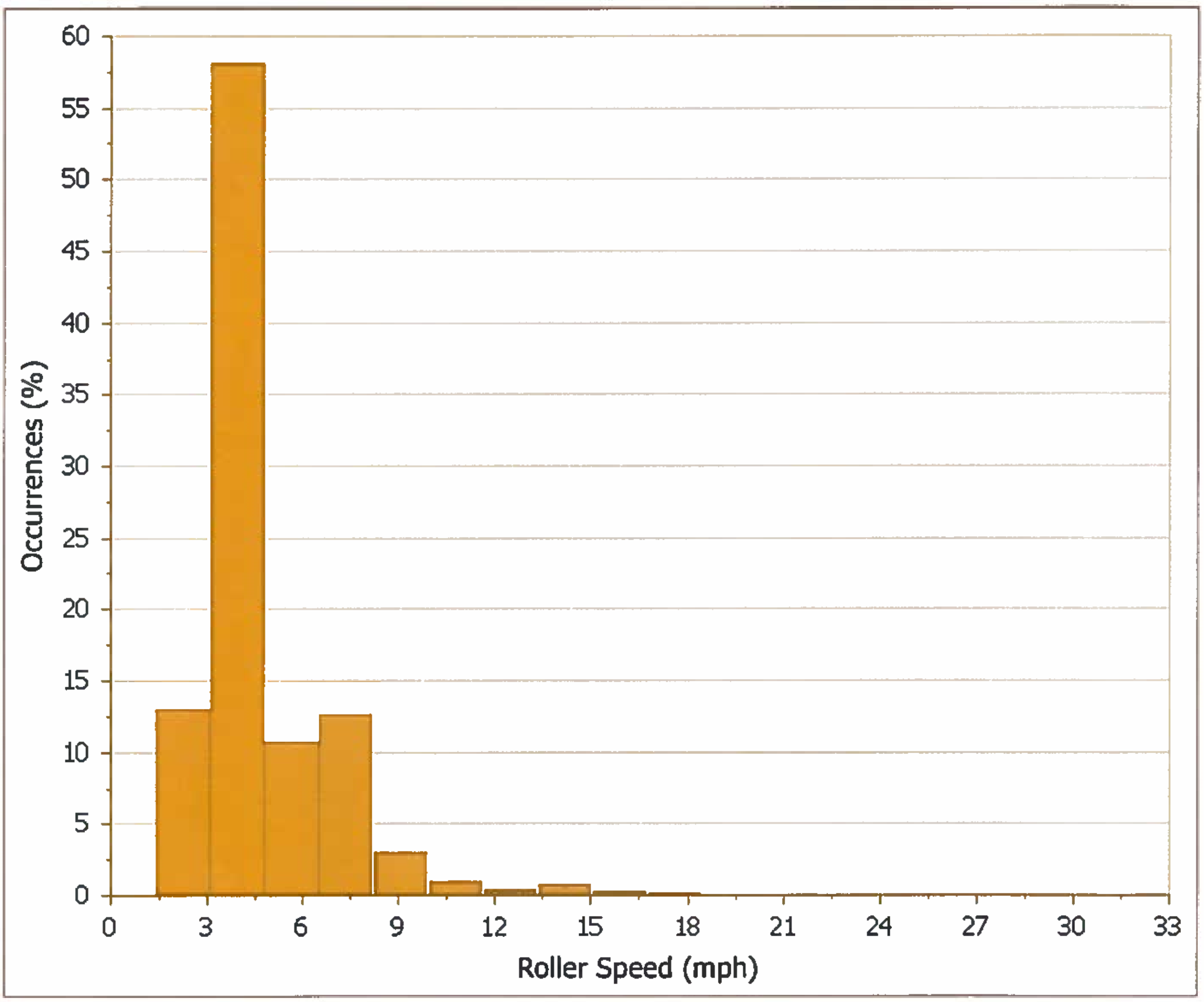
Statistic	Value
Mean	1
Standard Deviation	1
CoV (%)	59
Min	1
Max	11
Sample Size	150,301
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

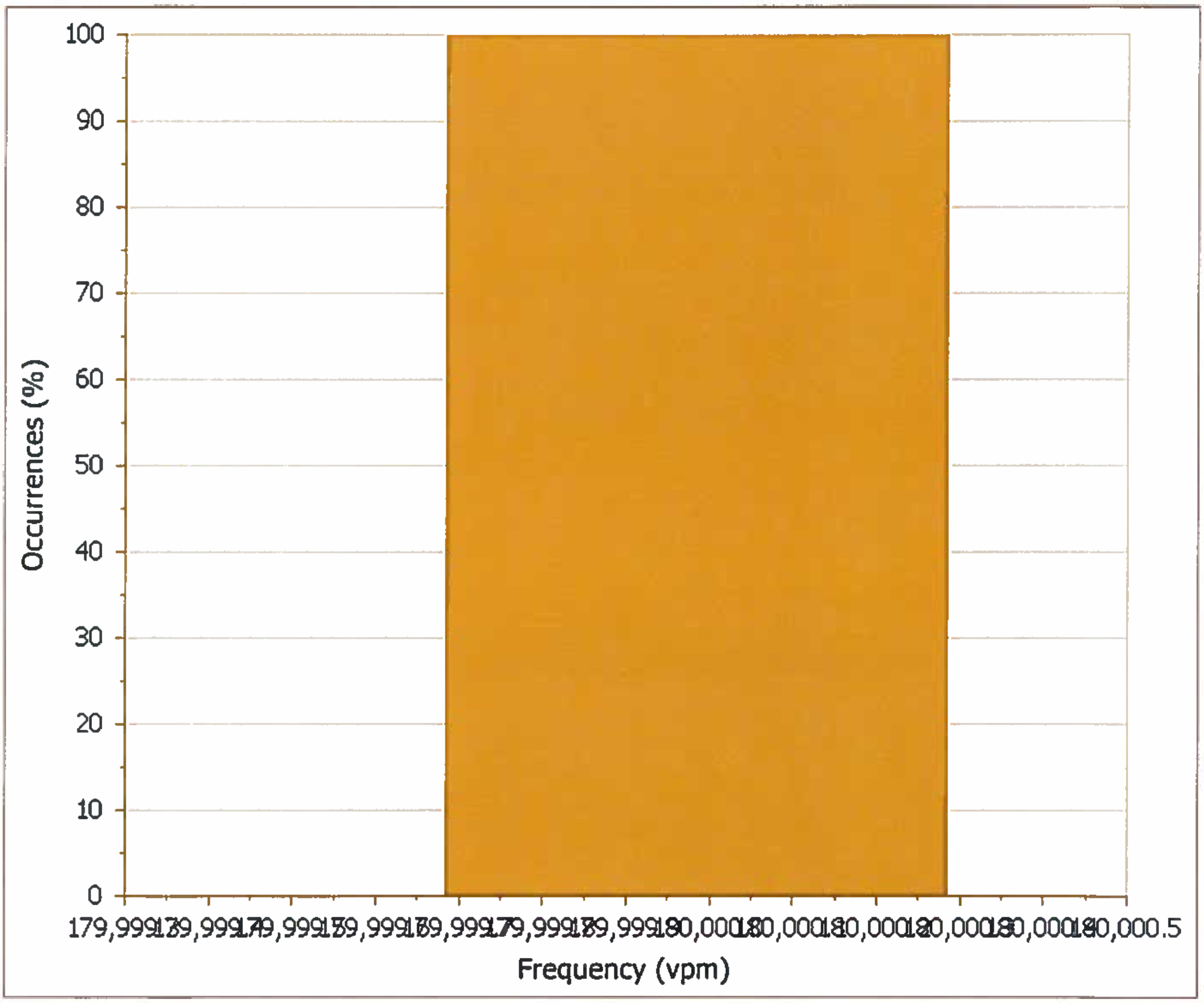
Statistic	Value
Mean (mph)	3.8
Standard Deviation (mph)	2.3
CoV (%)	60
Min (mph)	0.5
Max (mph)	34.7
Sample Size	150,301
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

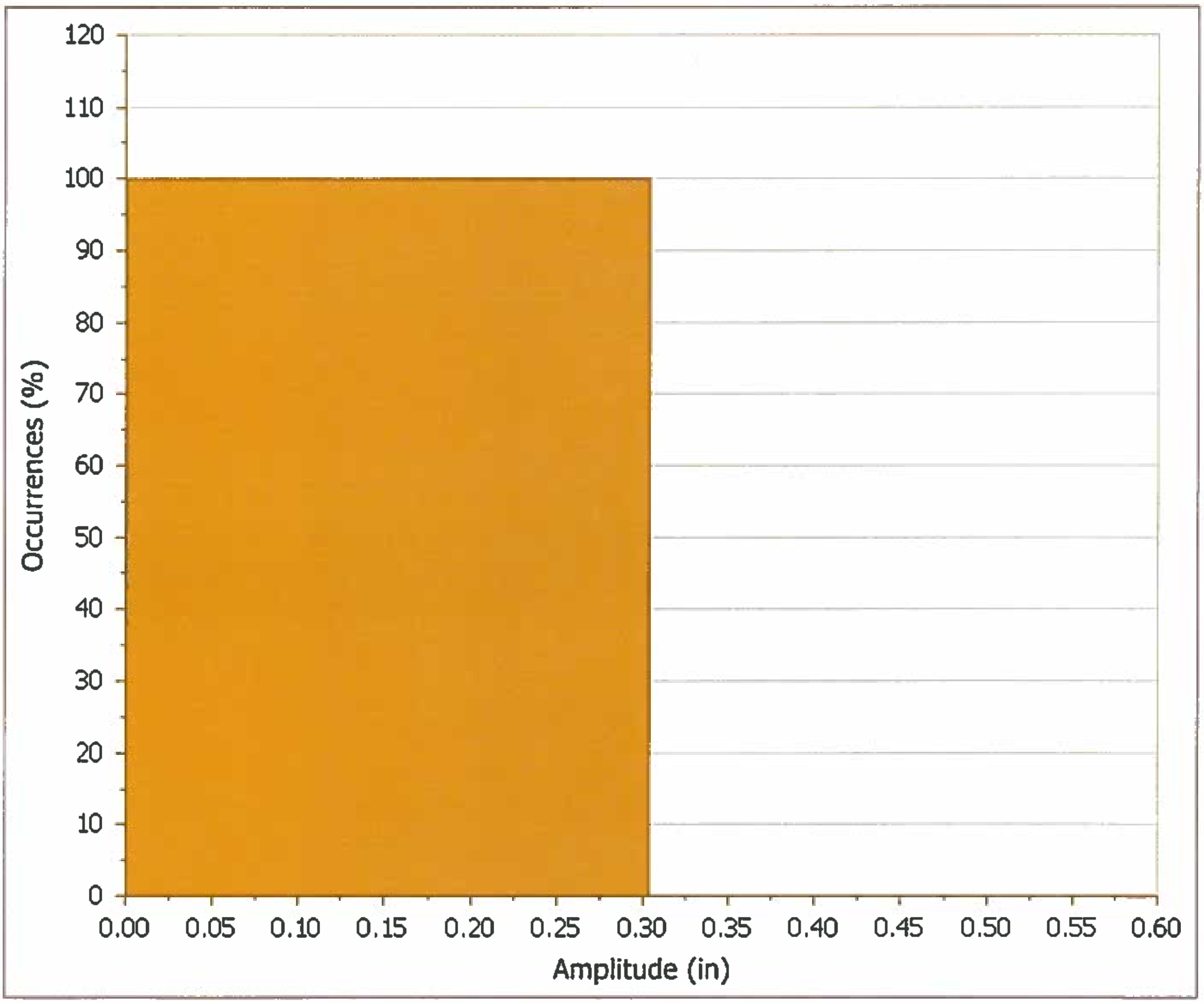
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	57,834
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	57,834
Target Status	Failed
% of Target Achieved	0.00

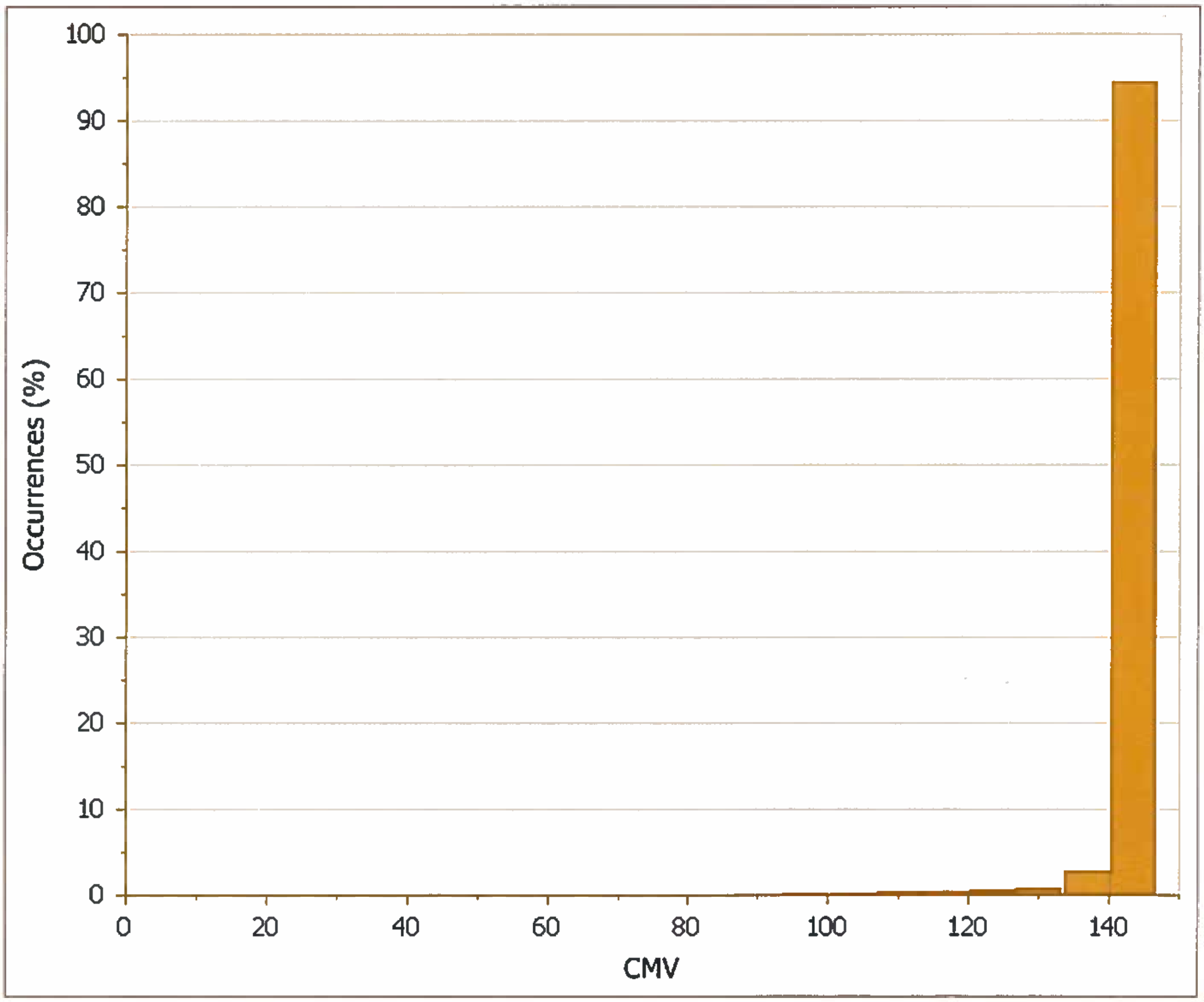


Pass Count 2013-03-02 to 03-06- last

Final Coverage: CMV

Target Percentage (%): 0.00
Target Value: 0.00

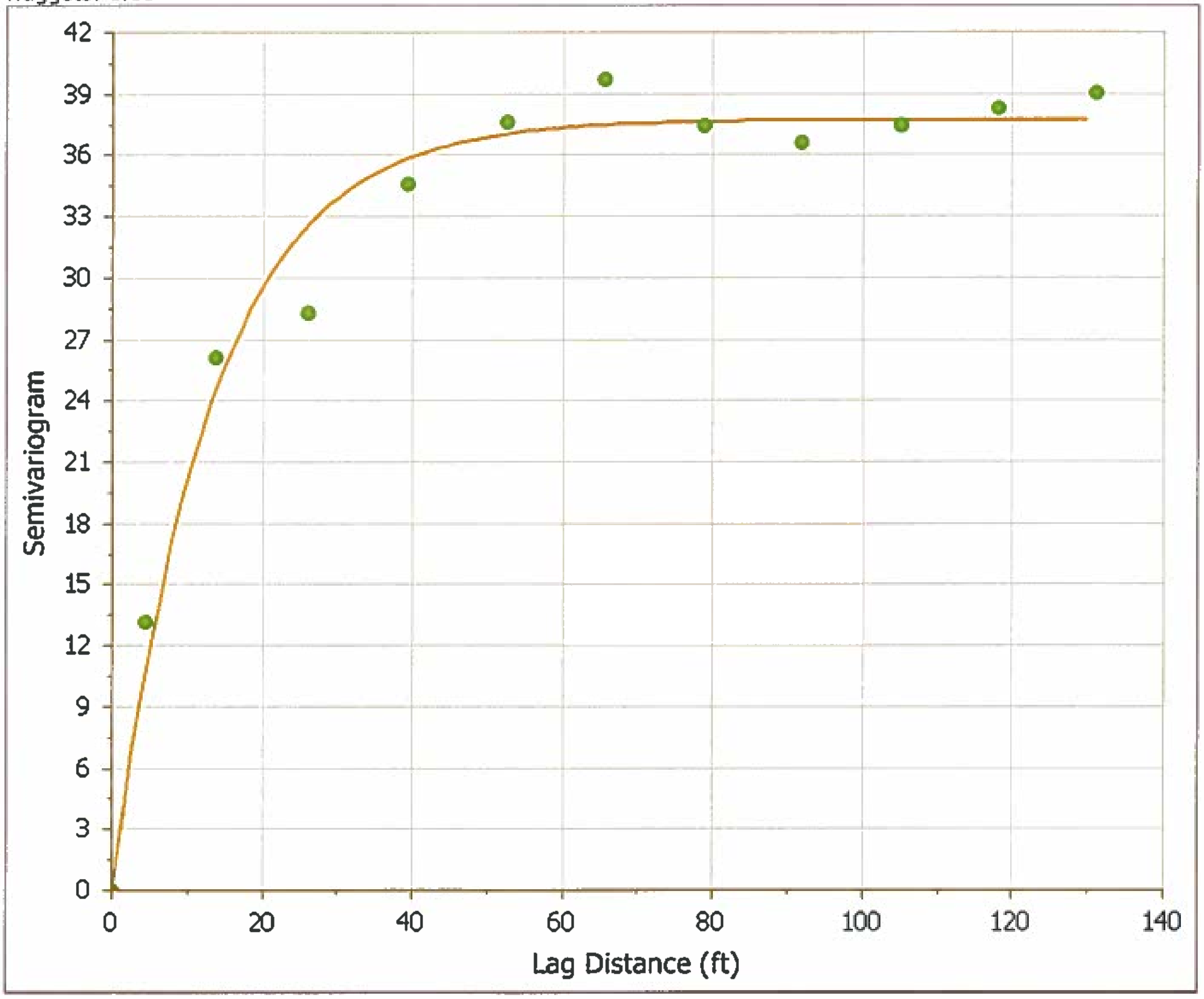
Statistic	Value
Mean	148.01
Standard Deviation	8.00
CoV (%)	5
Min	17.10
Max	150.00
Sample Size	57,834
Target Status	Passed
% of Target Achieved	99.98



Pass Count 2013-03-02 to 03-06- last

Final Coverage: Semivariogram

Range (ft): 22.30
Sill: 30.87
Vertical Scale: 30.87
Nuggets: 0.00



Pass Count 2013-03-07 Last

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-03-07 Last
State Plane Zone: 1702 - Louisiana South

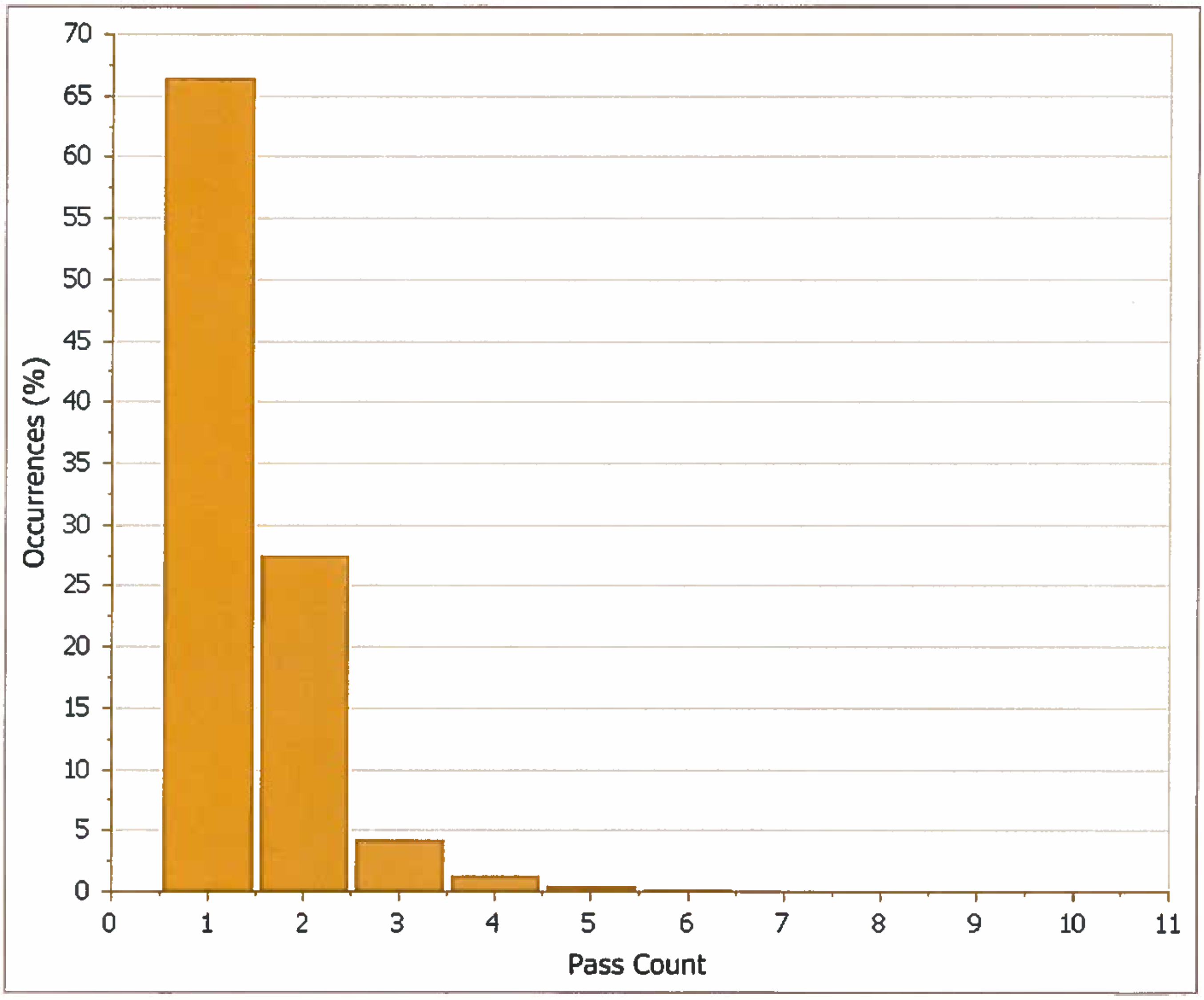
File Information

Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count
Target Percentage (%): 0.00
Target Value: 0.00

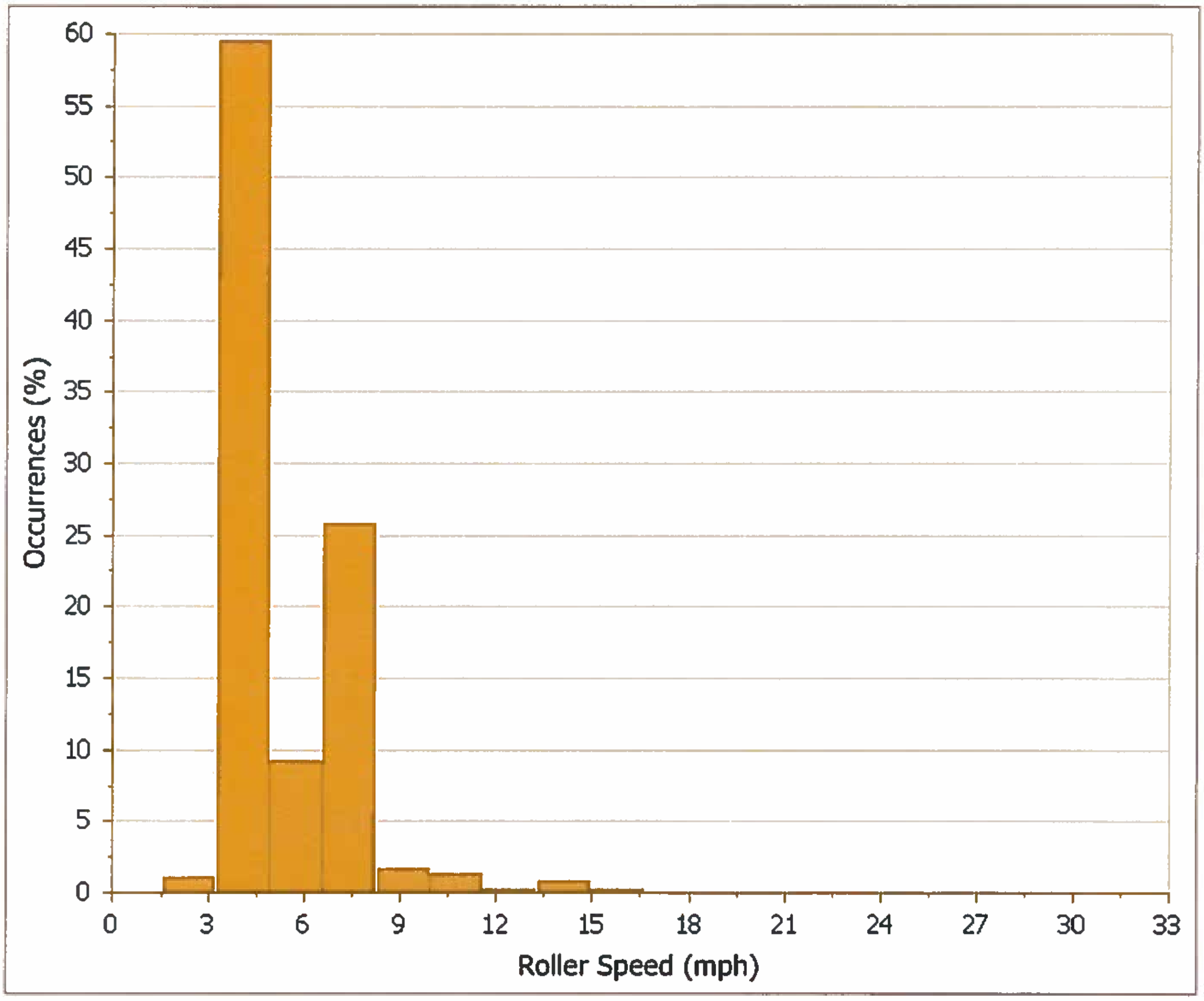
Statistic	Value
Mean	1
Standard Deviation	1
CoV (%)	51
Min	1
Max	10
Sample Size	64,594
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	4.4
Standard Deviation (mph)	2.2
CoV (%)	51
Min (mph)	0.7
Max (mph)	34.2
Sample Size	64,594
Target Status	Passed
% of Target Achieved	100.00

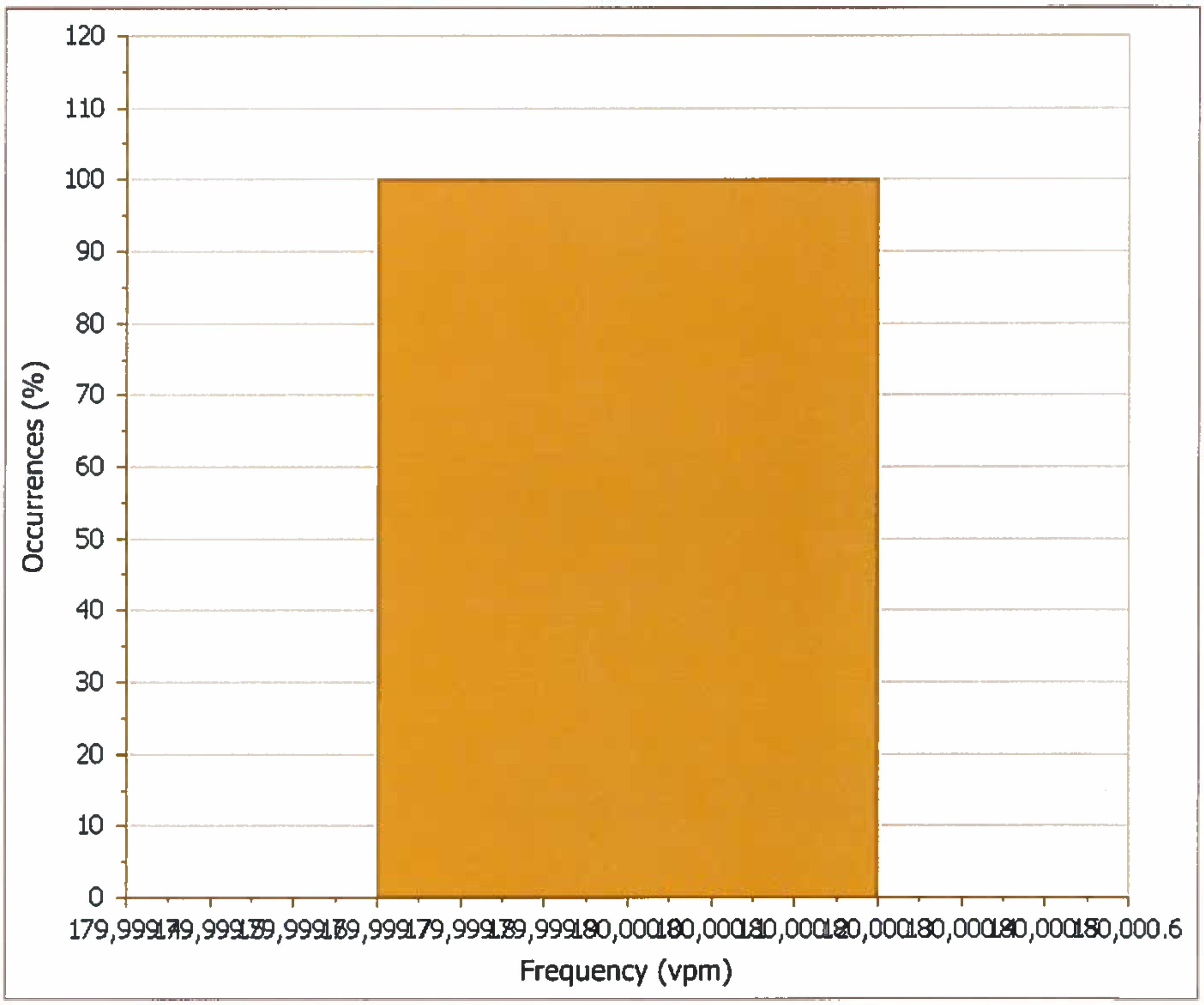


Pass Count 2013-03-07 Last

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	42,075
Target Status	Failed
% of Target Achieved	0.00

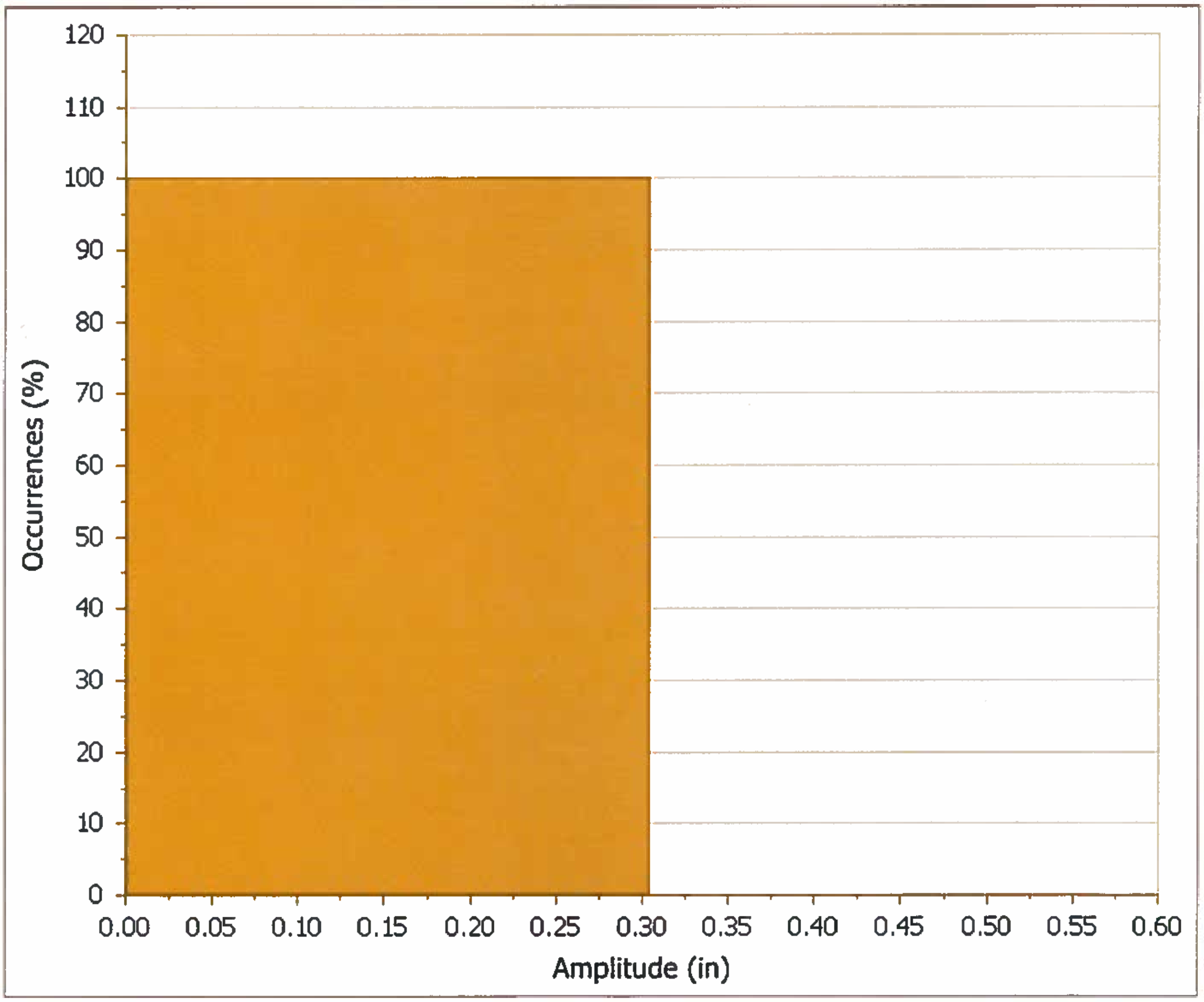


Pass Count 2013-03-07 Last

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	42,075
Target Status	Failed
% of Target Achieved	0.00

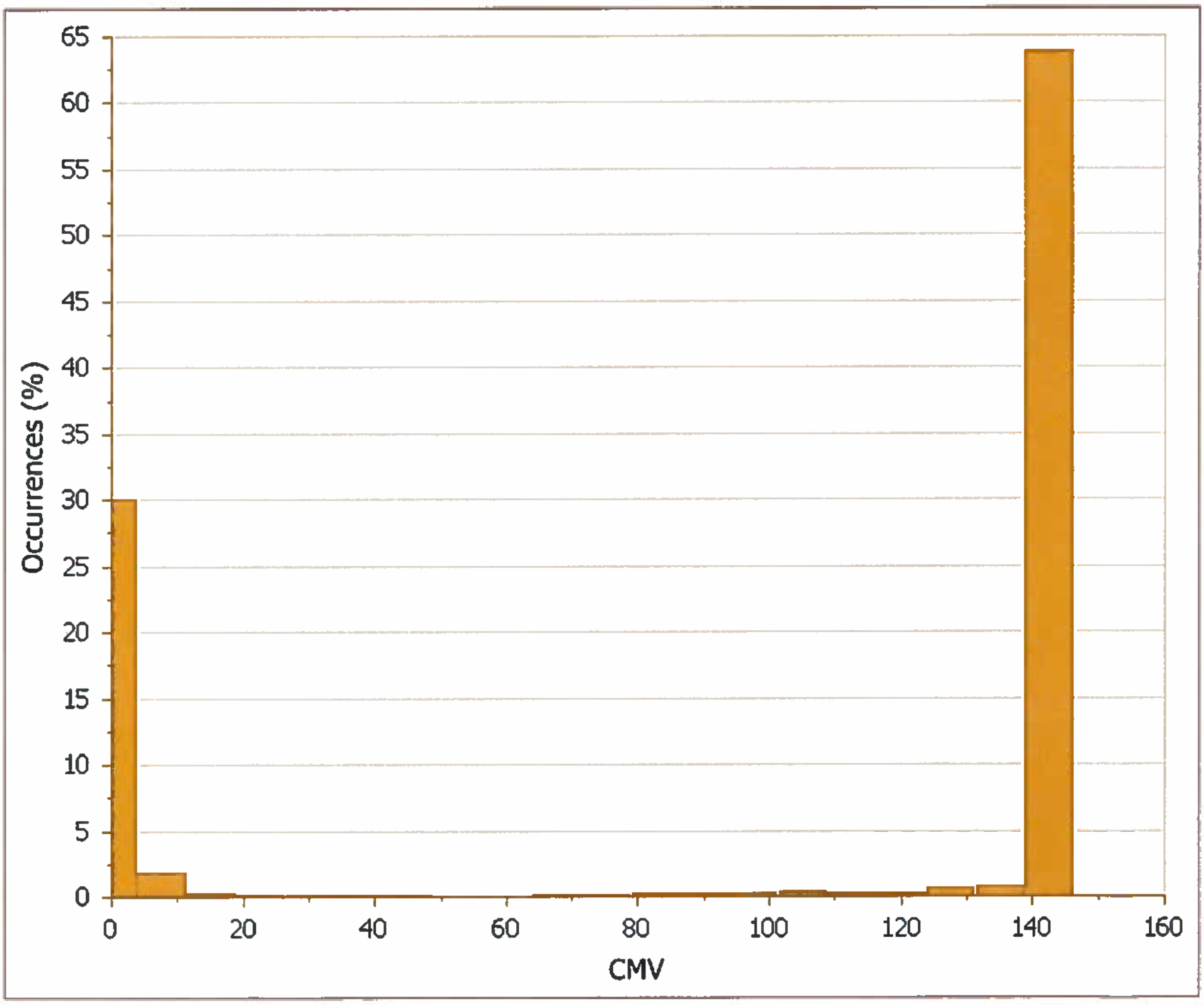


Pass Count 2013-03-07 Last

Final Coverage: CMV

Target Percentage (%): 0.00
Target Value: 0.00

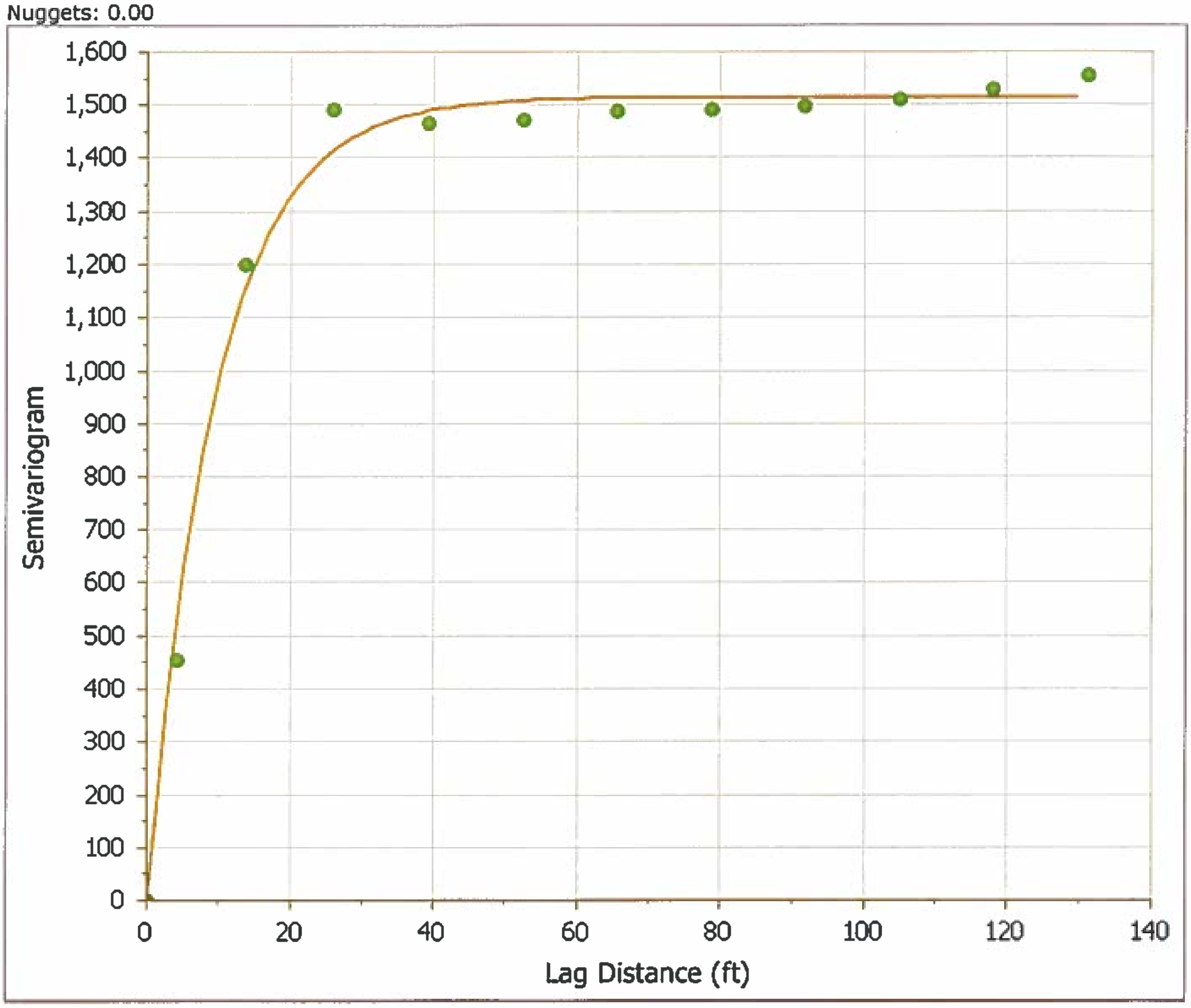
Statistic	Value
Mean	99.63
Standard Deviation	69.33
CoV (%)	70
Min	0.10
Max	150.00
Sample Size	42,075
Target Status	Passed
% of Target Achieved	69.98



Pass Count 2013-03-07 Last

Final Coverage: Semivariogram

Range (ft): 19.68
Sill: 1,320.88
Vertical Scale: 1,320.88
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-03-08 to 03-15- Last
State Plane Zone: 1702 - Louisiana South

File Information

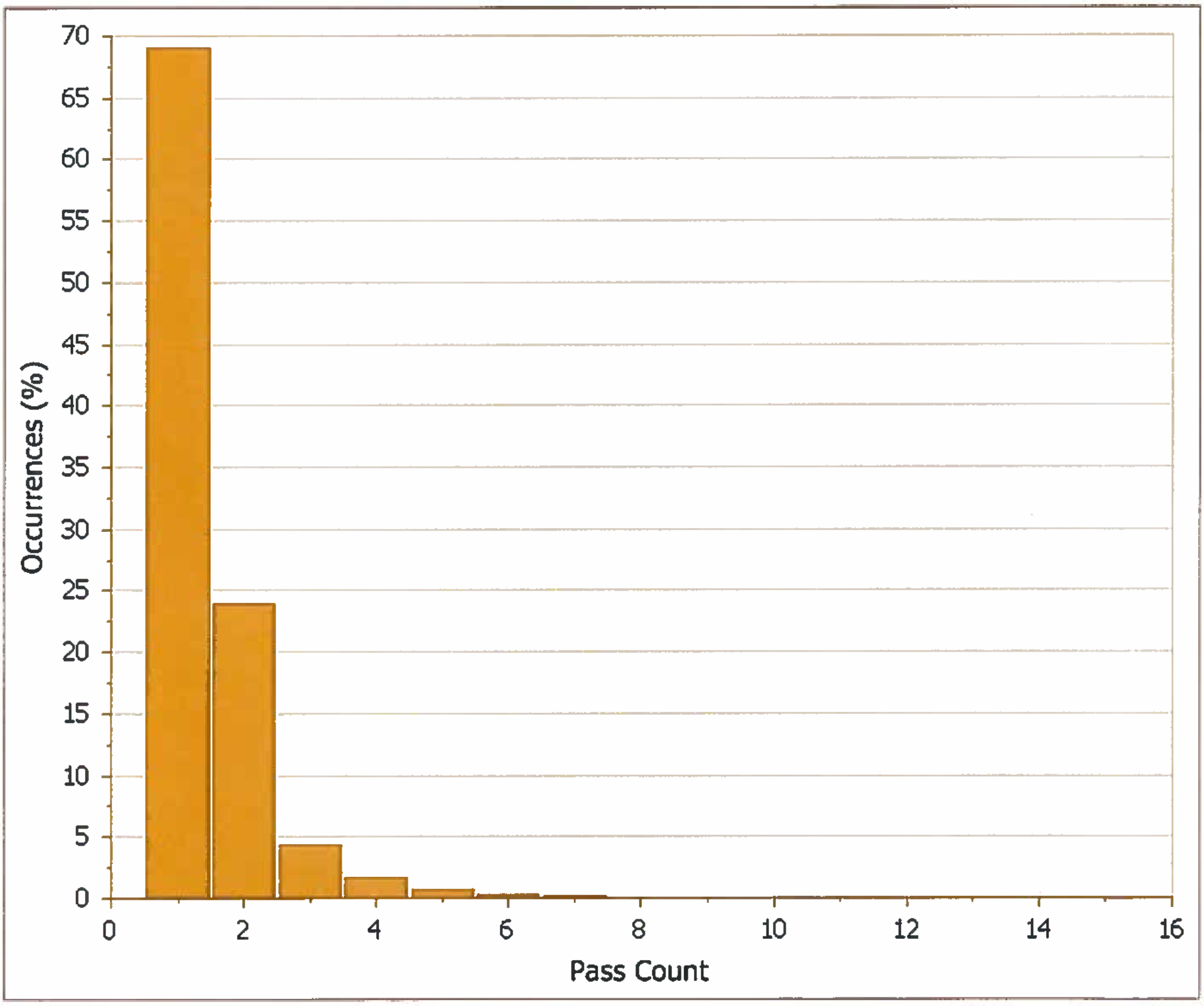
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

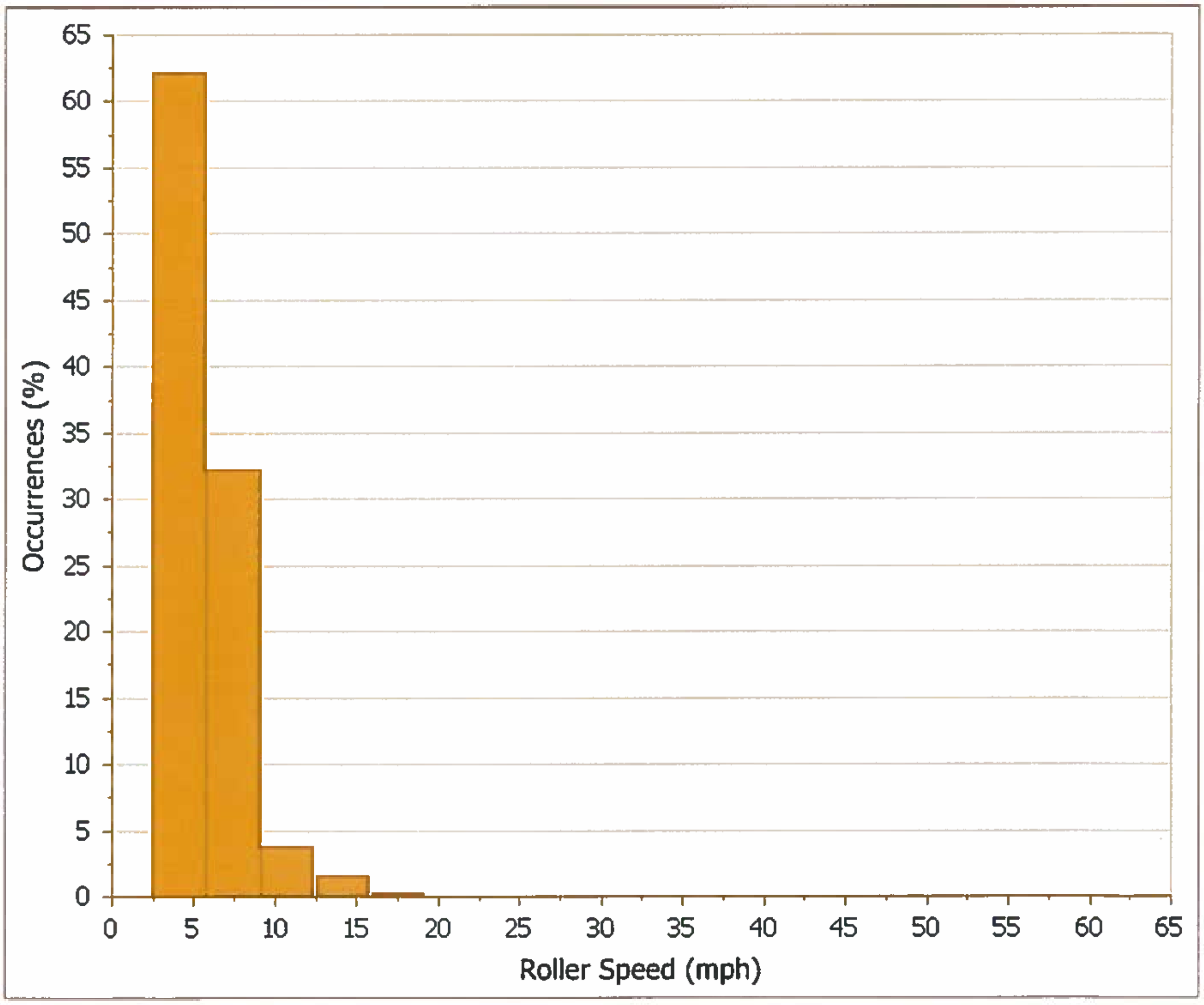
Statistic	Value
Mean	1
Standard Deviation	1
CoV (%)	56
Min	1
Max	14
Sample Size	166,622
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	4.3
Standard Deviation (mph)	2.5
CoV (%)	57
Min (mph)	0.7
Max (mph)	67.8
Sample Size	166,622
Target Status	Passed
% of Target Achieved	100.00

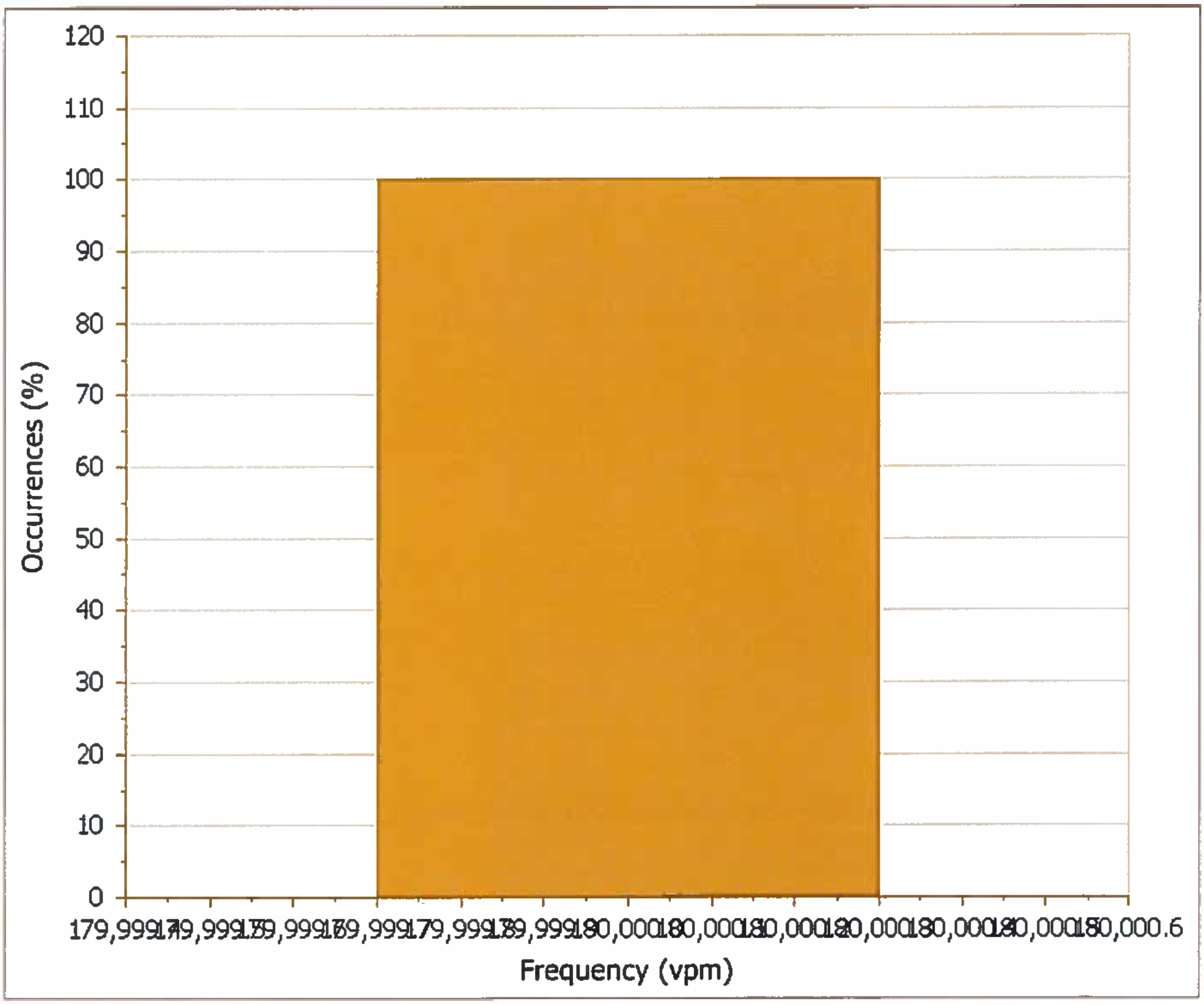


Pass Count 2013-03-08 to 03-15- Last

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	88,105
Target Status	Failed
% of Target Achieved	0.00

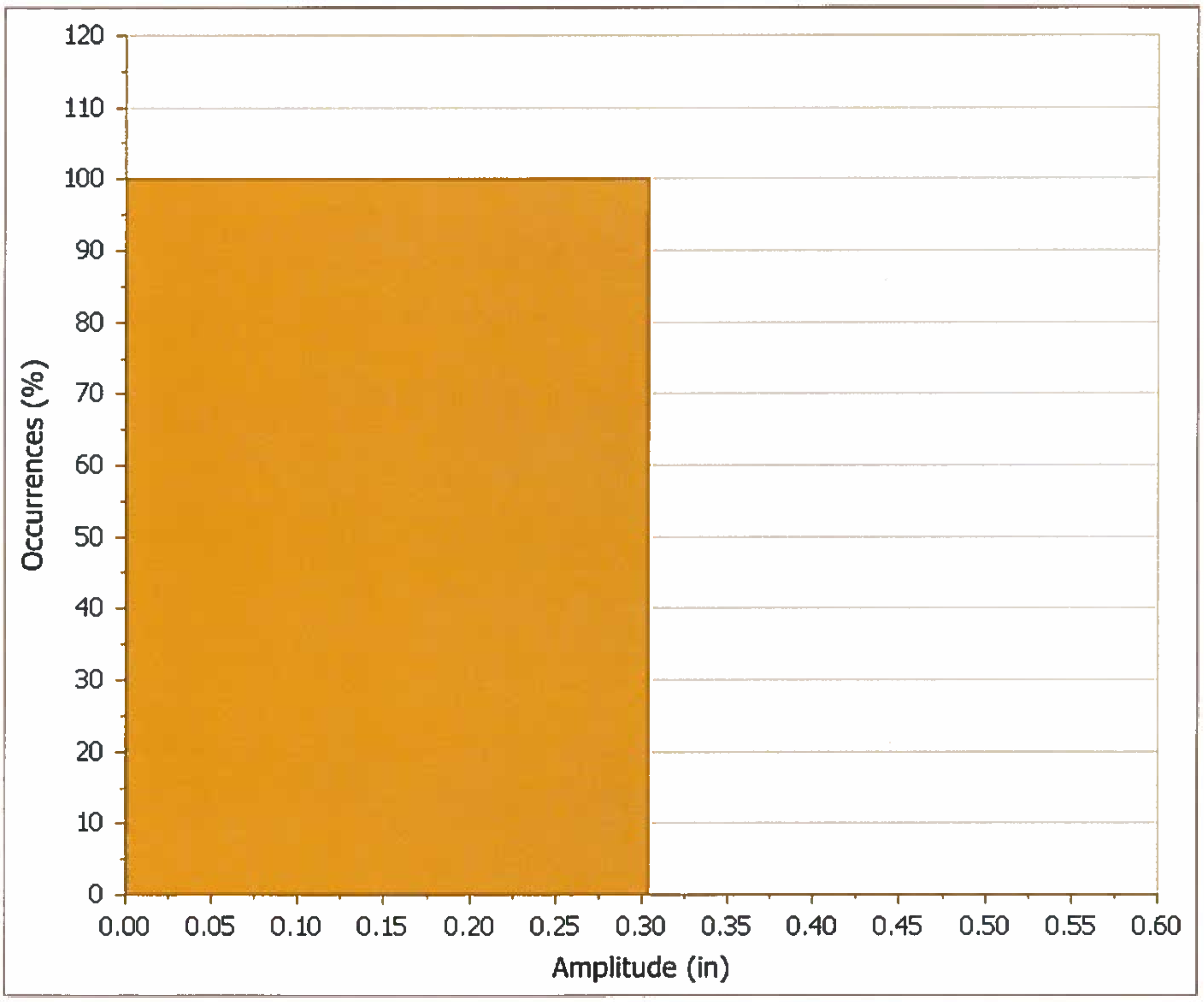


Pass Count 2013-03-08 to 03-15- Last

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	88,105
Target Status	Failed
% of Target Achieved	0.00

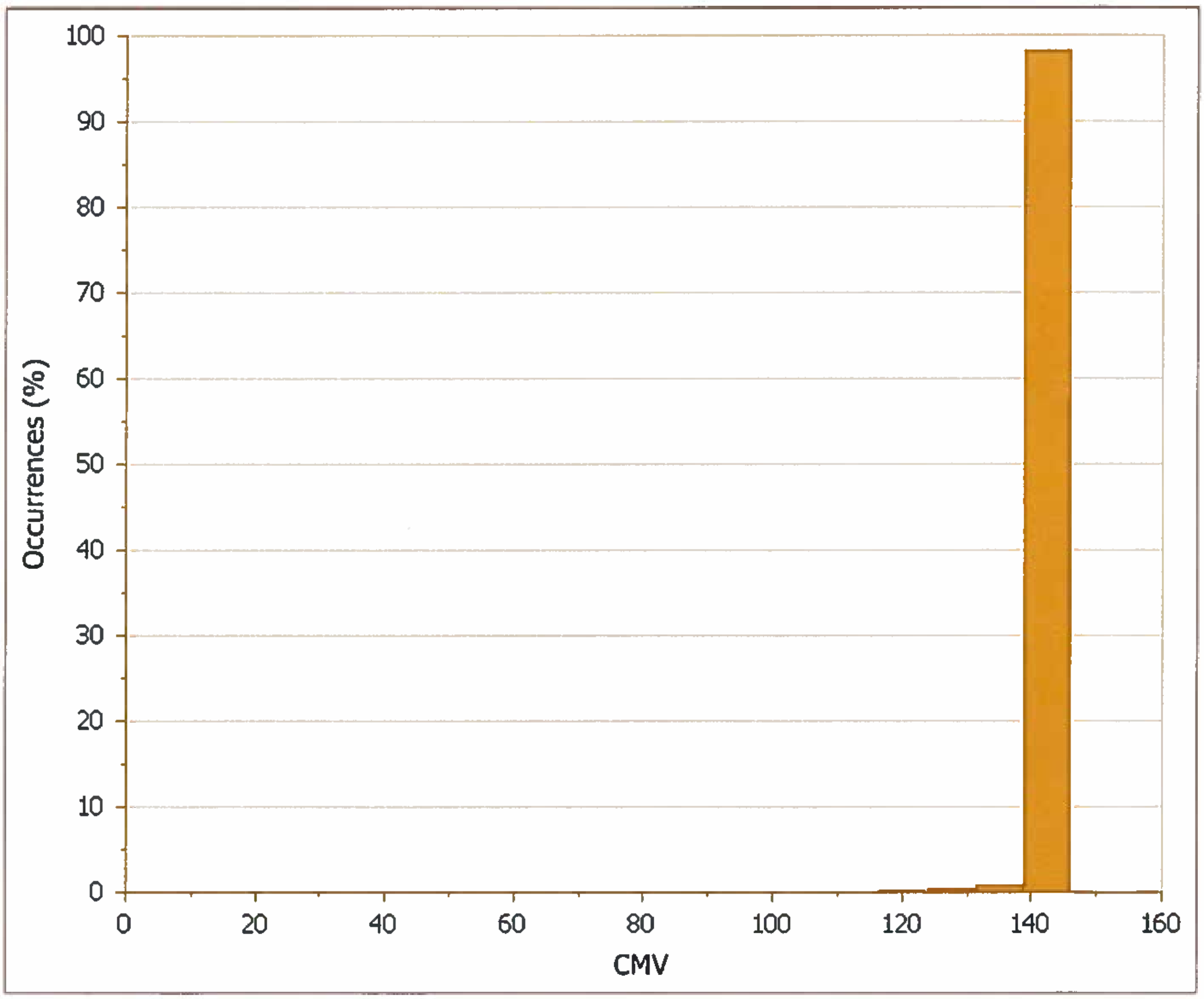


Pass Count 2013-03-08 to 03-15- Last

Final Coverage: CMV

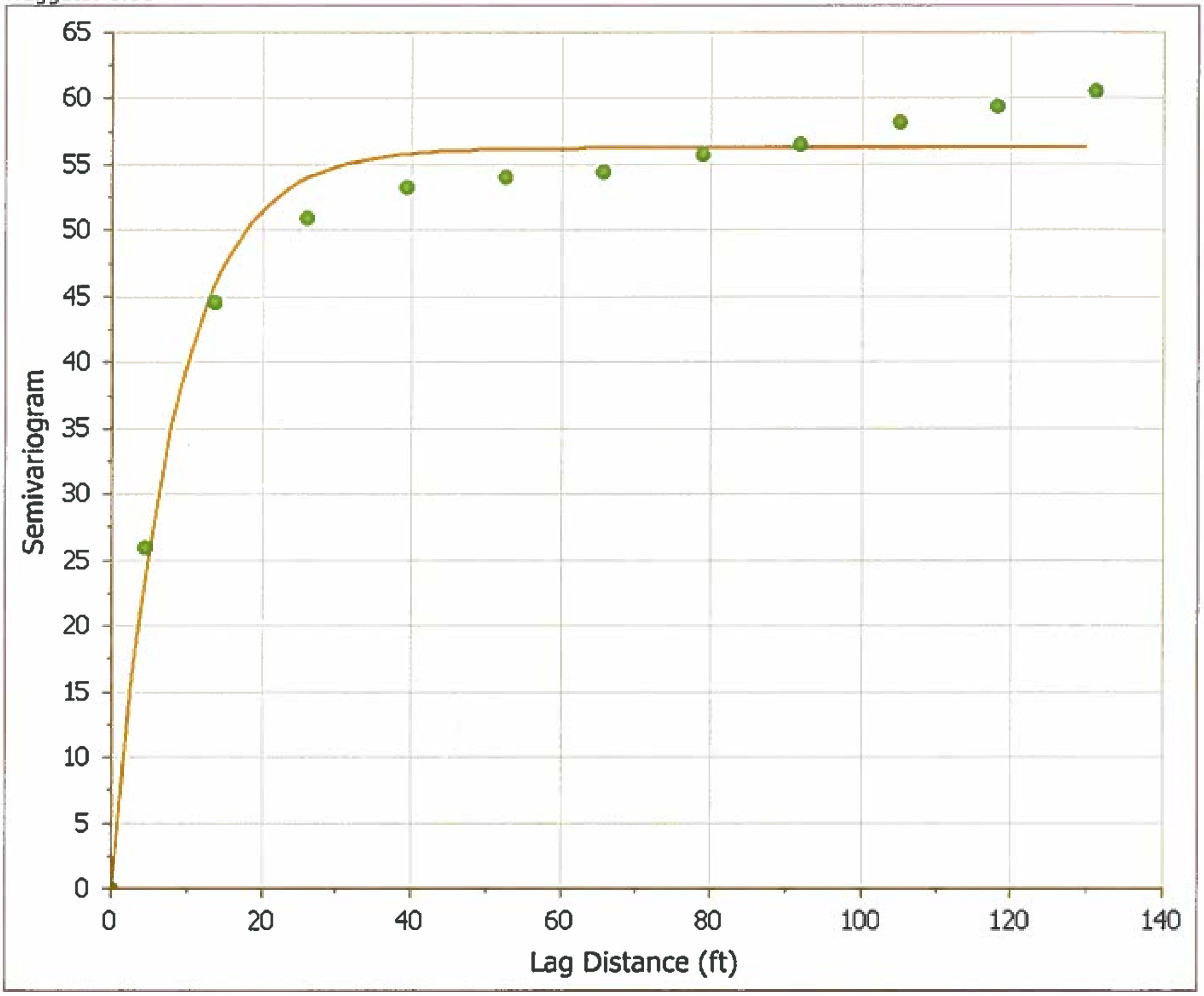
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	148.68
Standard Deviation	8.90
CoV (%)	6
Min	0.20
Max	150.00
Sample Size	88,105
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Semivariogram

Range (ft): 18.37
Sill: 50.41
Vertical Scale: 50.41
Nuggets: 0.00



Pass Count 2013-04-02 Last

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-04-02 Last
State Plane Zone: 1702 - Louisiana South

File Information

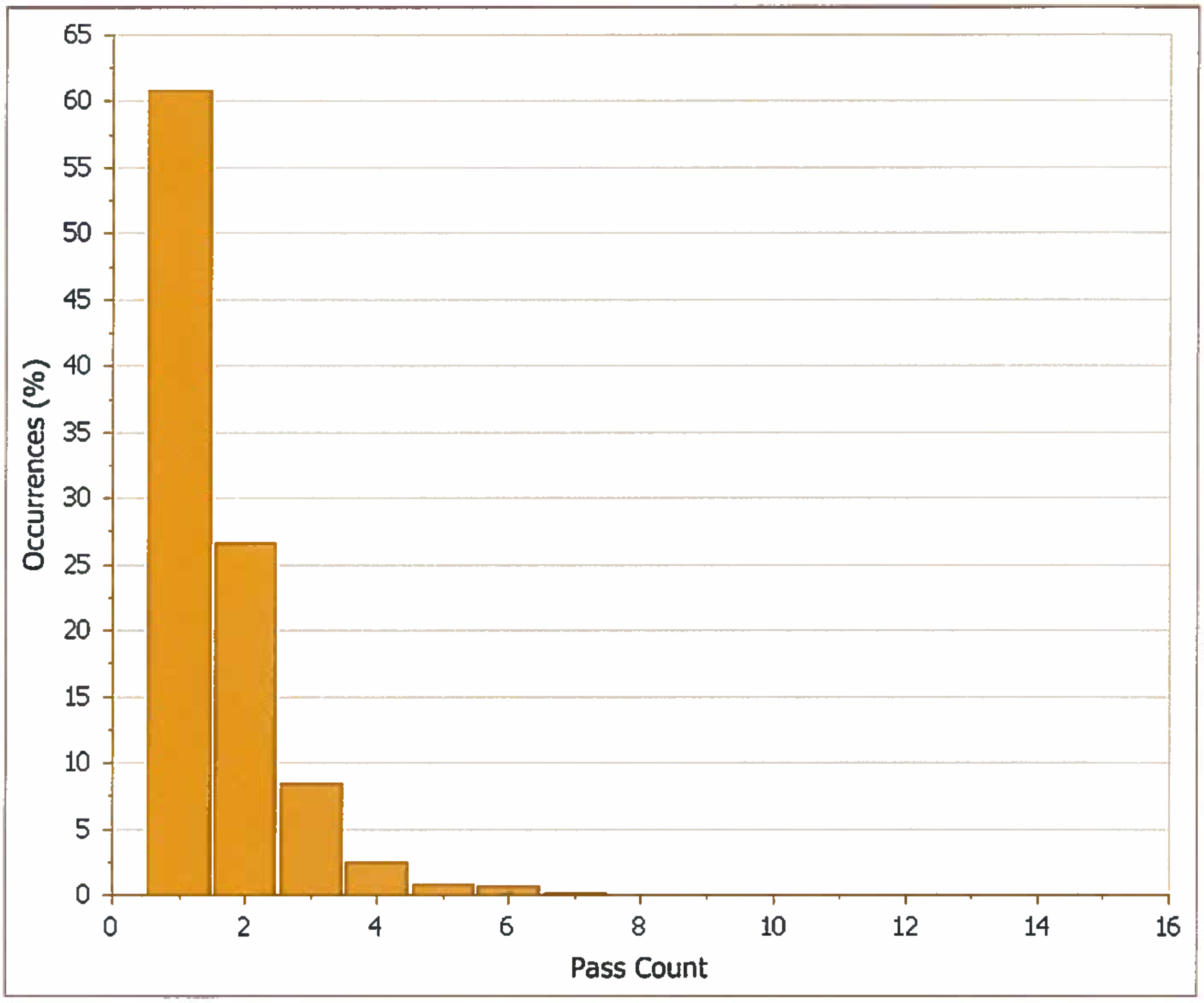
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

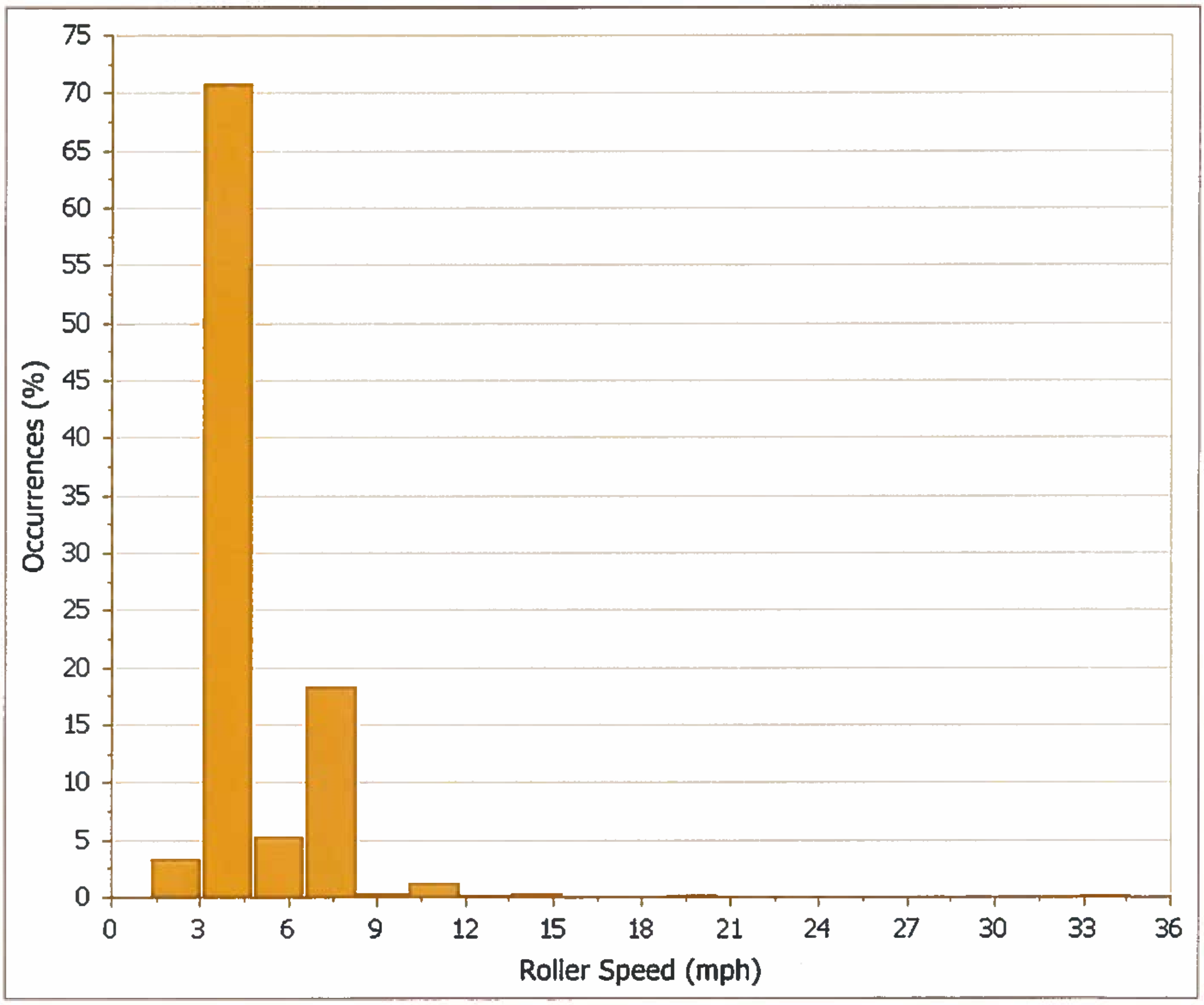
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	59
Min	1
Max	14
Sample Size	83,518
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	3.7
Standard Deviation (mph)	2.2
CoV (%)	61
Min (mph)	0.4
Max (mph)	35.5
Sample Size	83,518
Target Status	Passed
% of Target Achieved	100.00

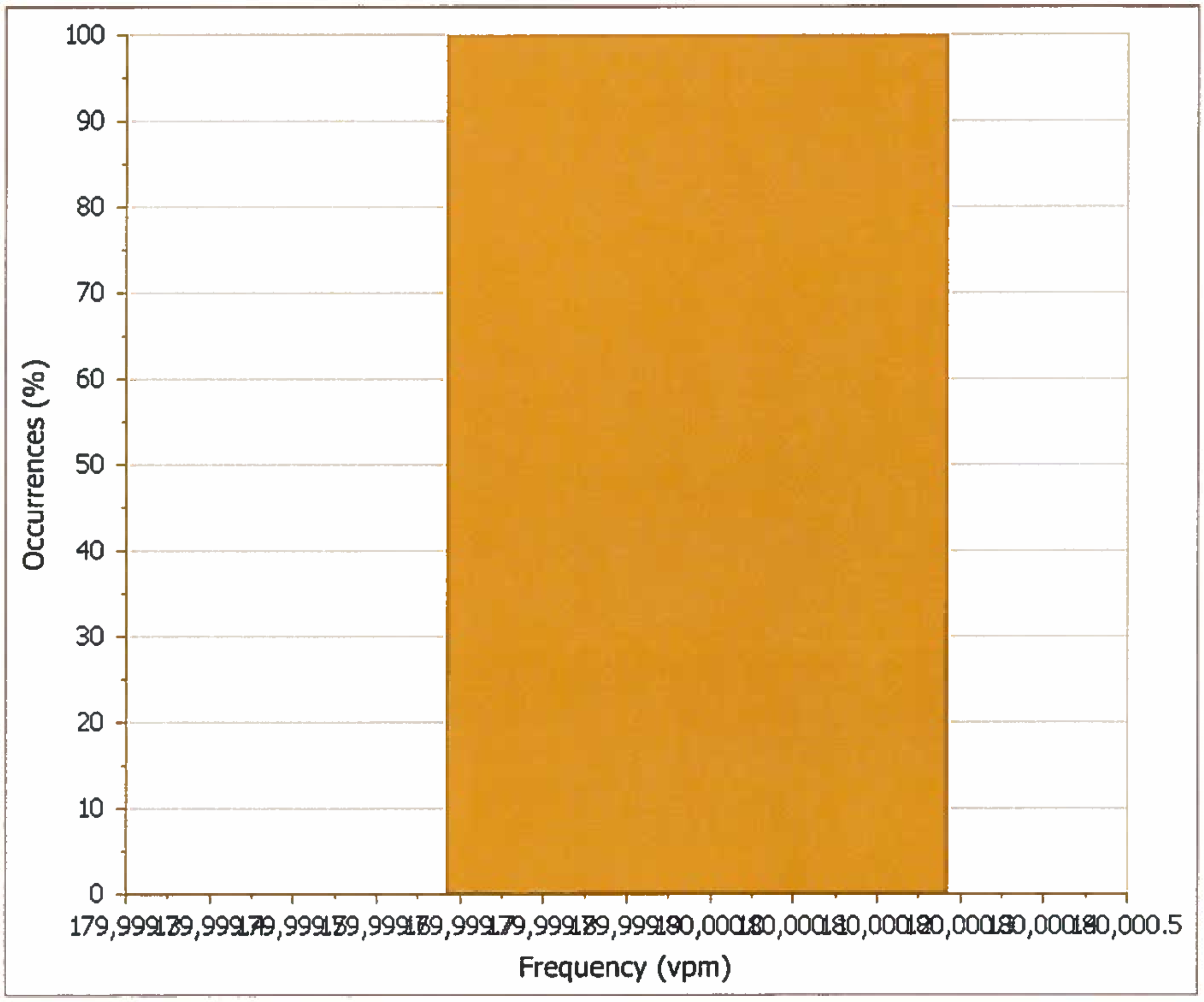


Pass Count 2013-04-02 Last

Final Coverage: Frequency

Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	77,195
Target Status	Passed
% of Target Achieved	99.99

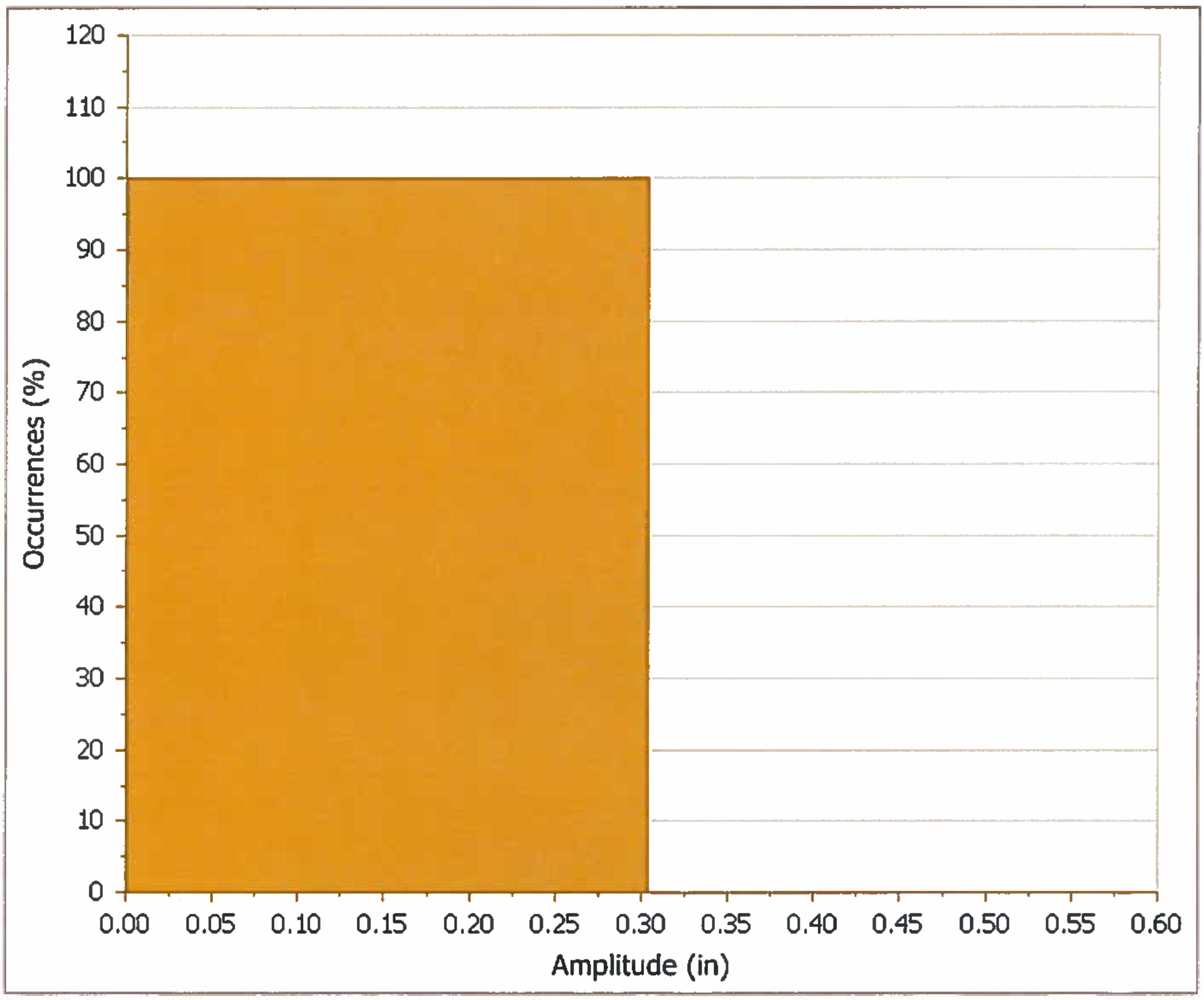


Pass Count 2013-04-02 Last

Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	77,195
Target Status	Failed
% of Target Achieved	0.00

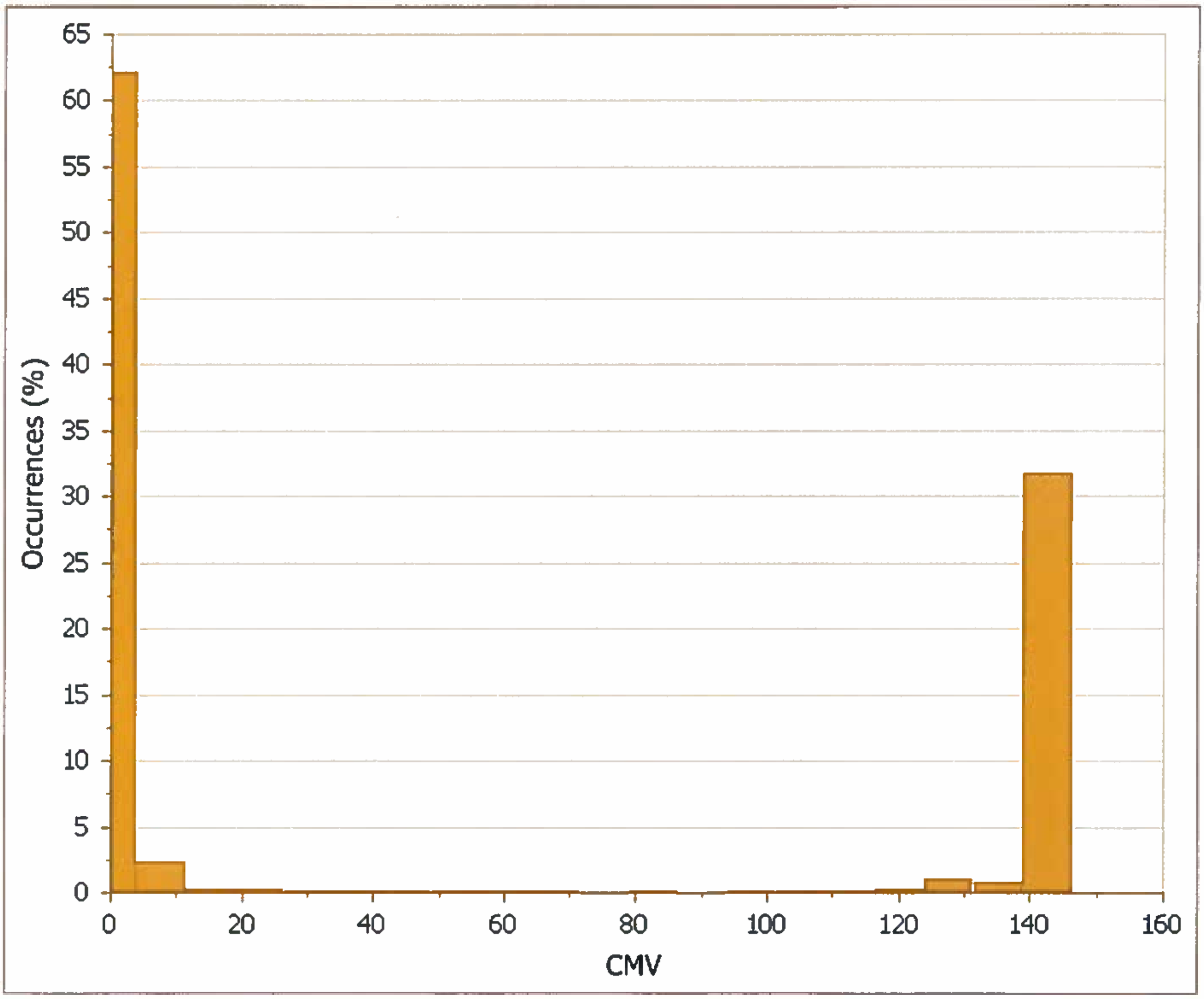


Pass Count 2013-04-02 Last

Final Coverage: CMV

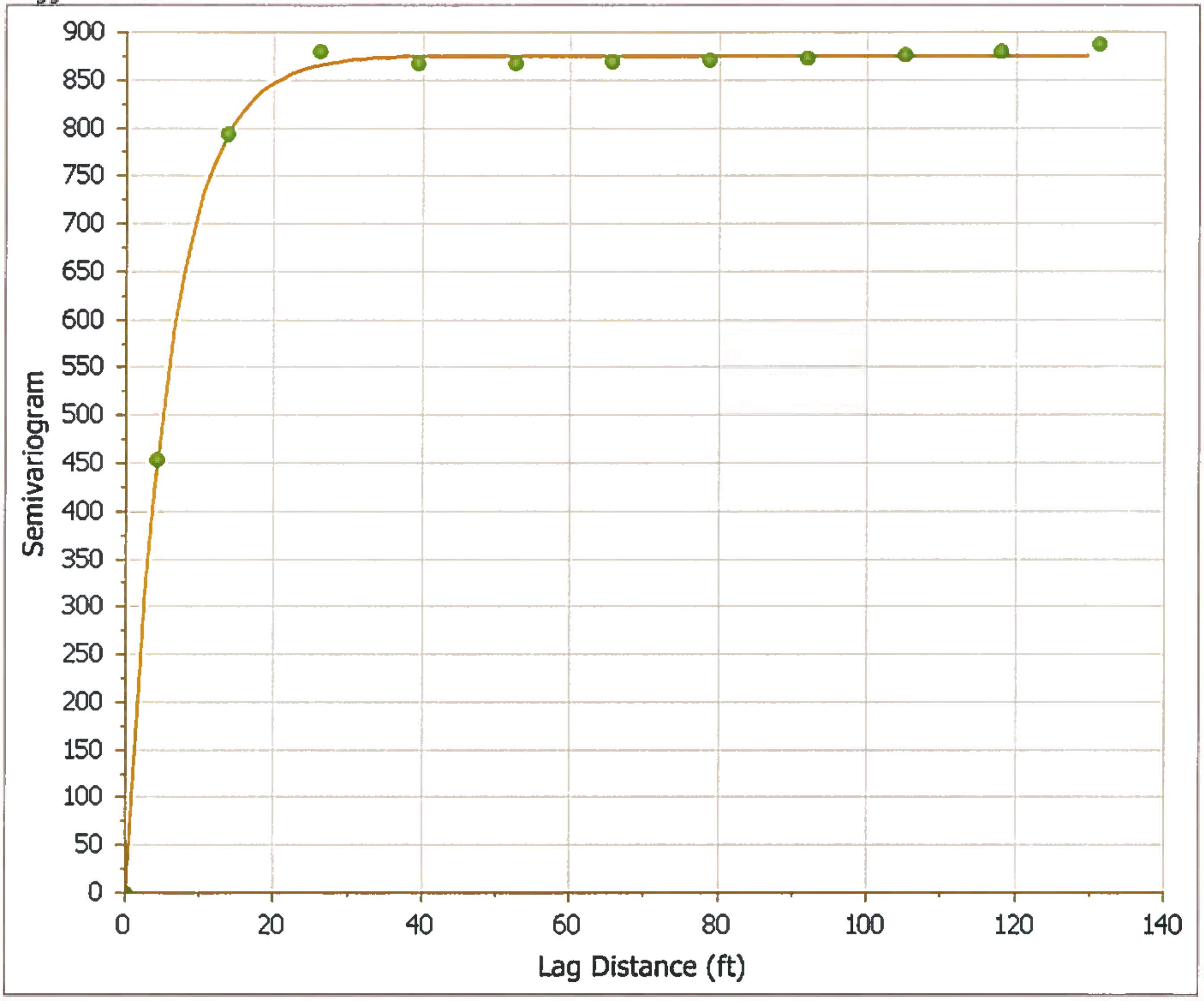
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	50.92
Standard Deviation	69.74
CoV (%)	137
Min	0.10
Max	150.00
Sample Size	77,195
Target Status	Passed
% of Target Achieved	37.90



Final Coverage: Semivariogram

Range (ft): 14.43
Sill: 802.81
Vertical Scale: 802.81
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Trimble
Machine Weight: 0.00
Material Type: Soil
UTM Zone: 15
Original File: Pass Count 2013-05-06 LAST
State Plane Zone: 1702 - Louisiana South

File Information

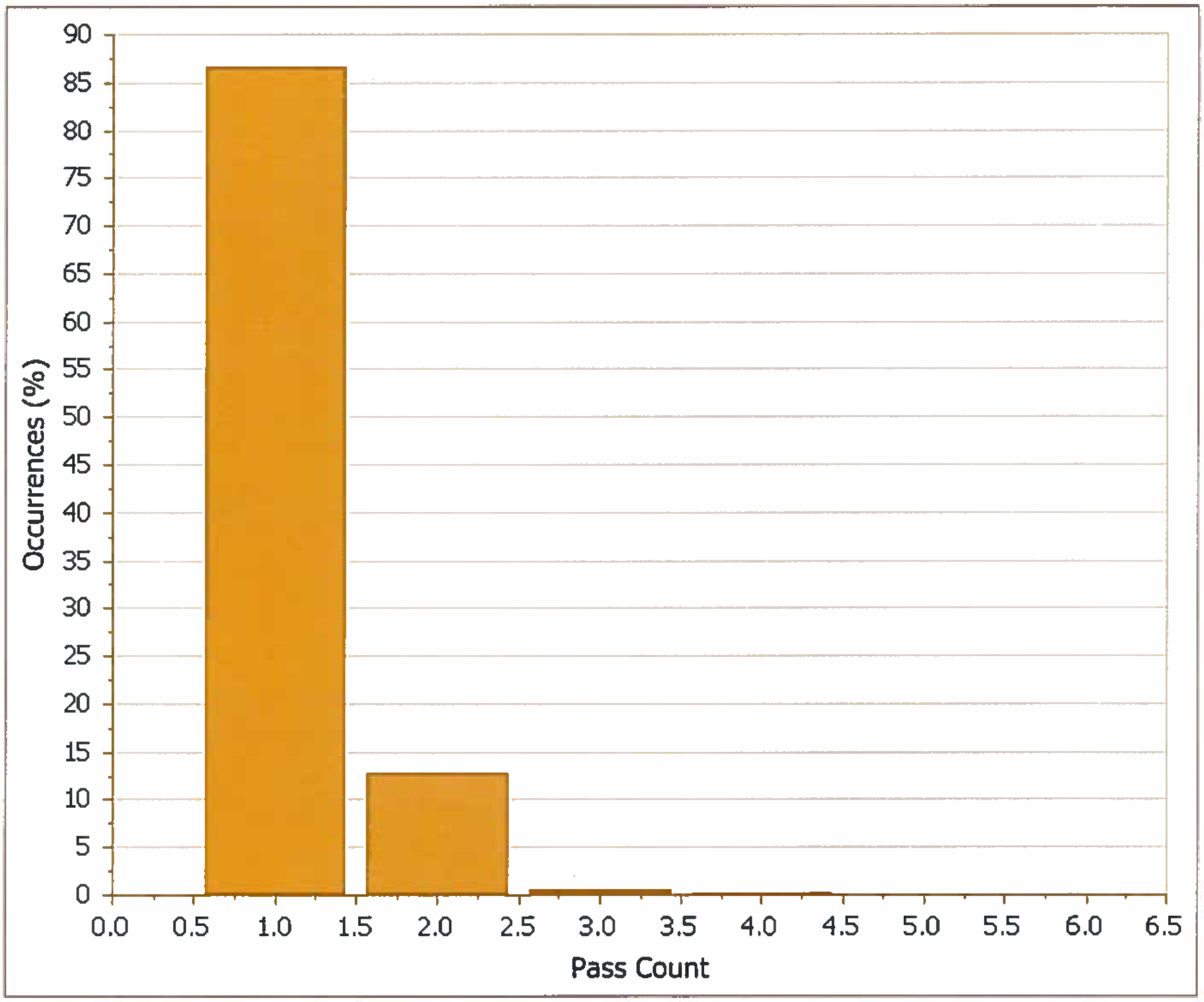
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	1
Standard Deviation	0
CoV (%)	33
Min	1
Max	6
Sample Size	36,830
Target Status	Passed
% of Target Achieved	100.00

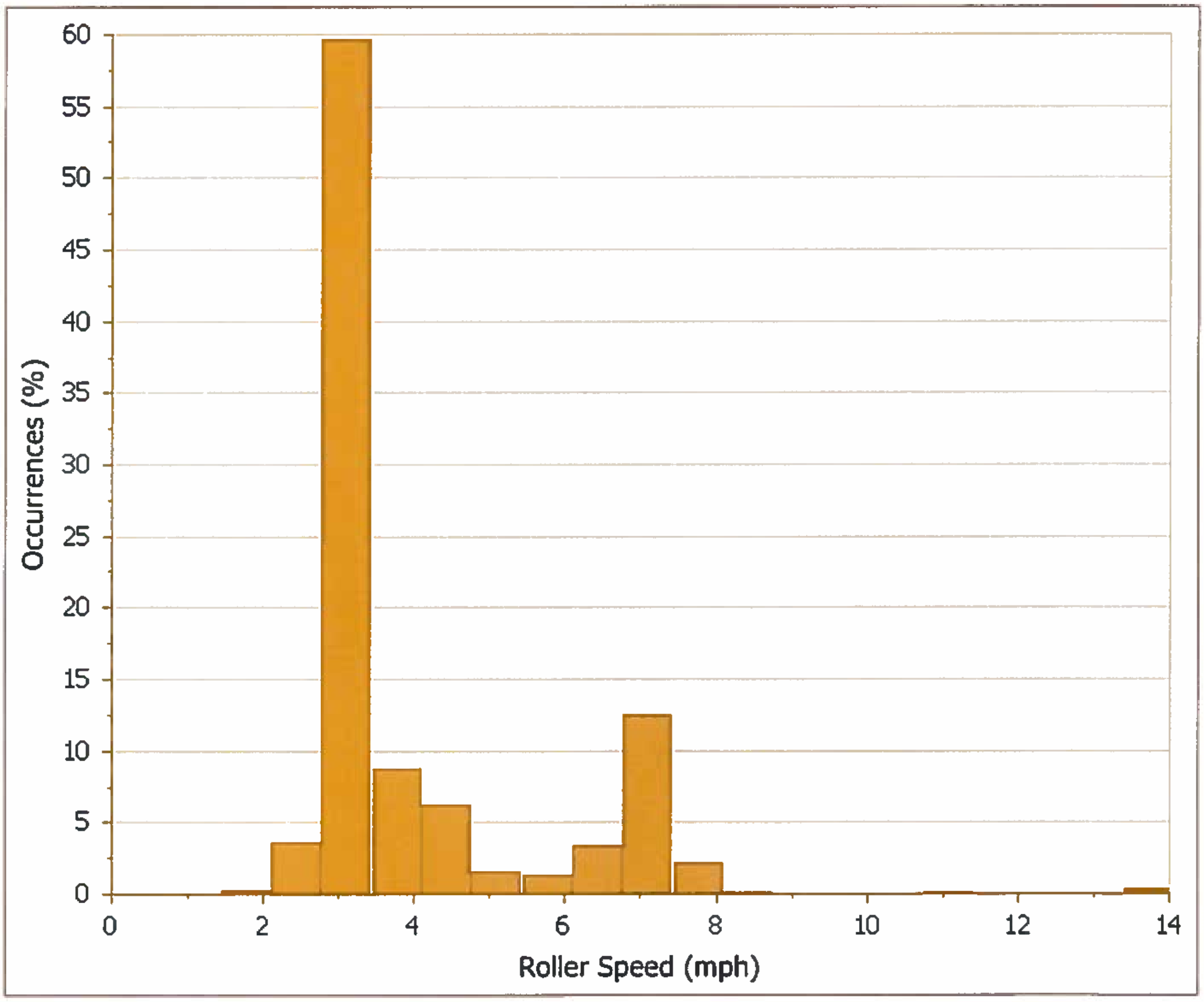


Pass Count 2013-05-06 LAST

Final Coverage: Roller Speed

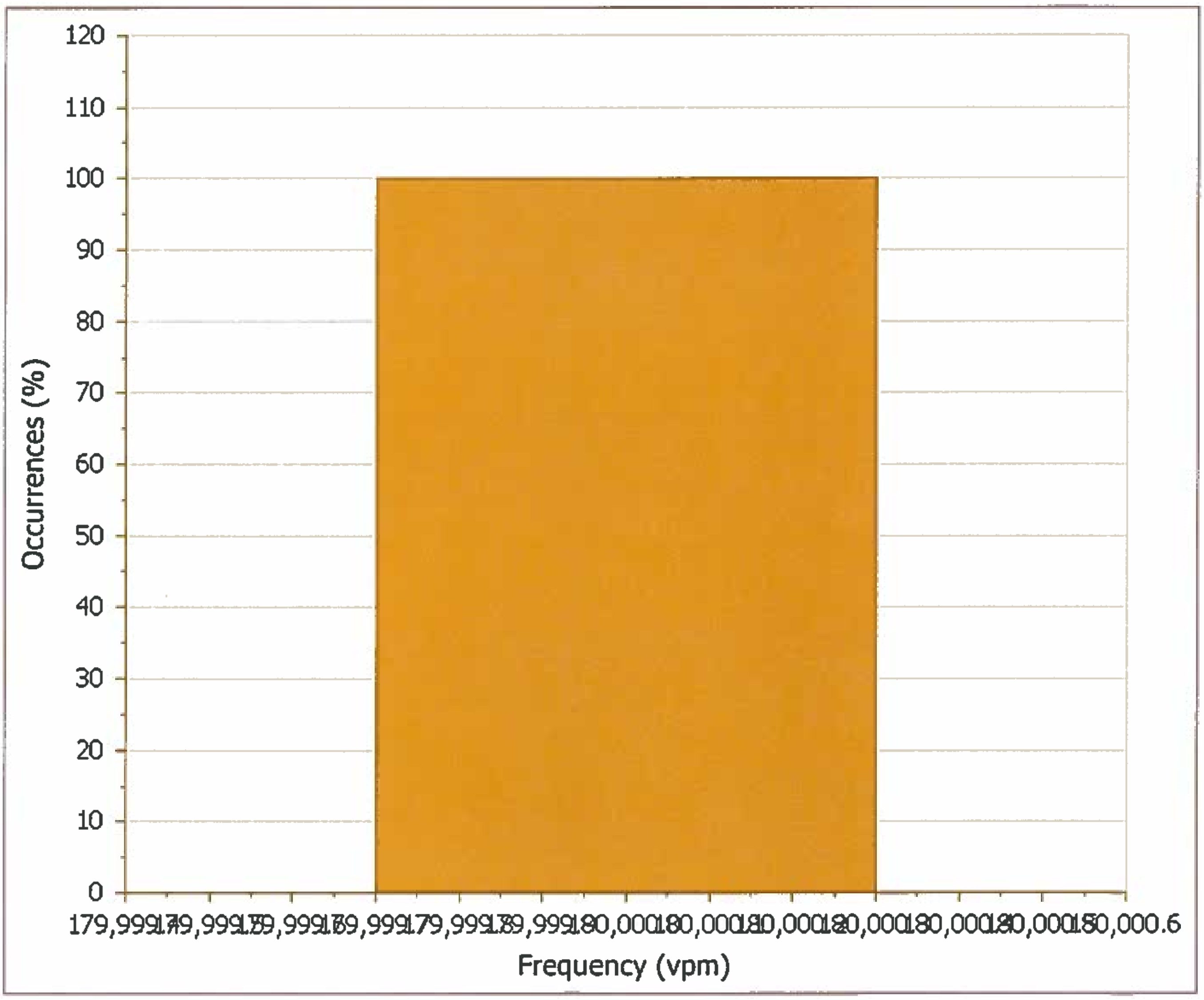
Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	3.7
Standard Deviation (mph)	1.7
CoV (%)	45
Min (mph)	1.1
Max (mph)	14.4
Sample Size	36,830
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Frequency
Target Percentage (%): 0.00
Target Value (vpm): 0

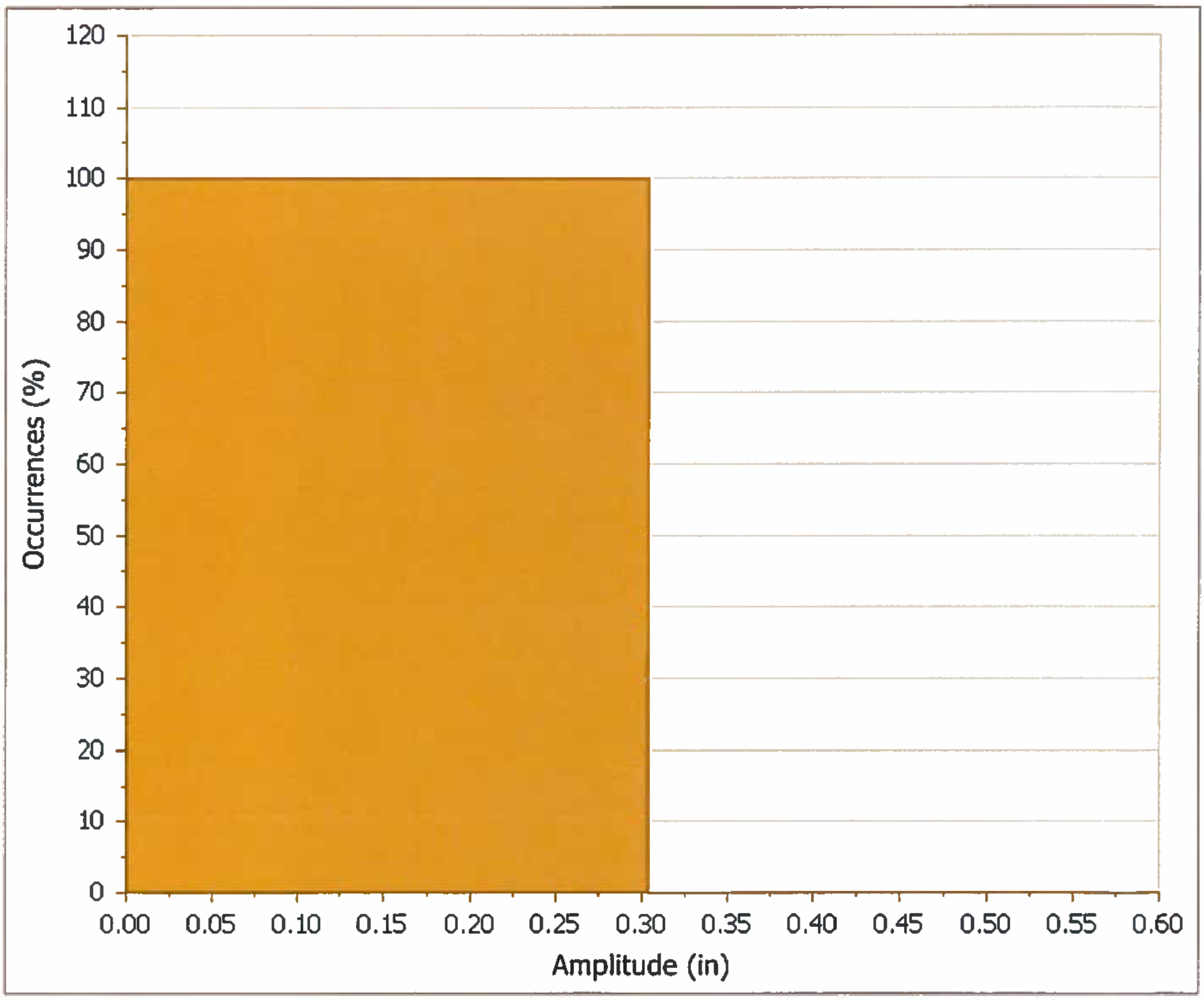
Statistic	Value
Mean (vpm)	180,000
Standard Deviation (vpm)	0
CoV (%)	0
Min (vpm)	180,000
Max (vpm)	180,000
Sample Size	29,279
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Amplitude

Target Percentage (%): 0.00
Target Value (in): 0.0

Statistic	Value
Mean (in)	0.00
Standard Deviation (in)	0.00
CoV (%)	0
Min (in)	0.00
Max (in)	0.00
Sample Size	29,279
Target Status	Failed
% of Target Achieved	0.00

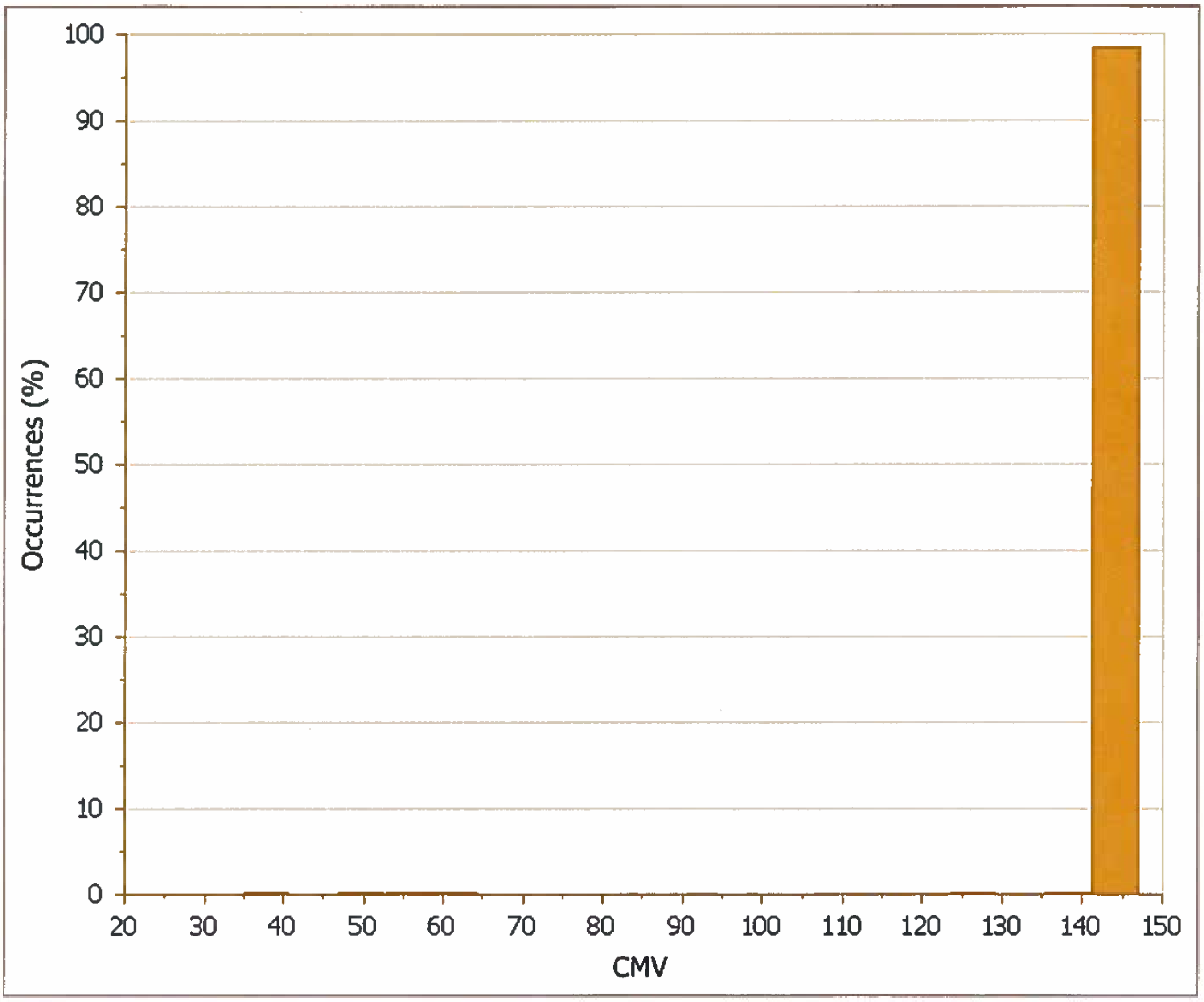


Pass Count 2013-05-06 LAST

Final Coverage: CMV

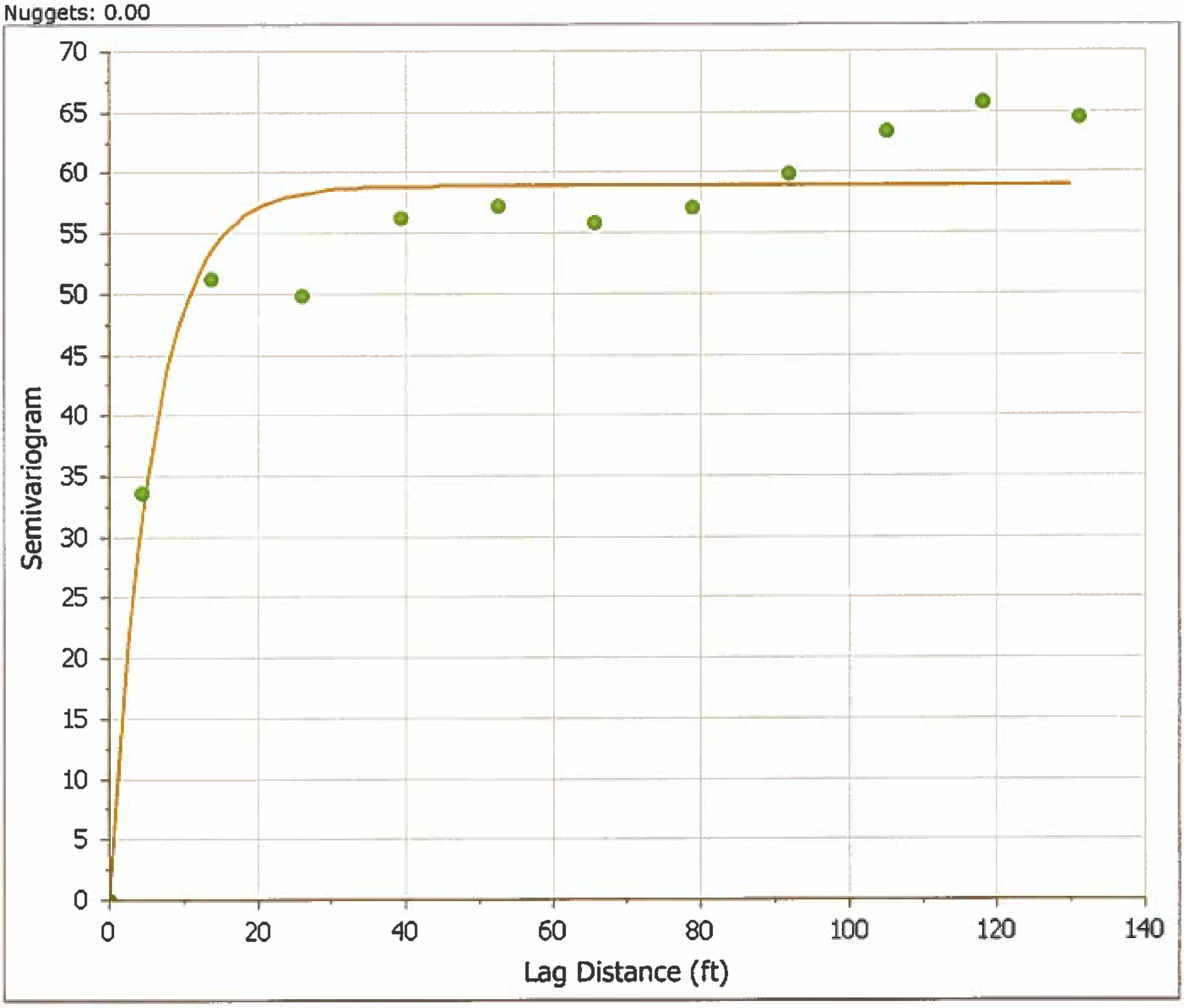
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	148.80
Standard Deviation	10.31
CoV (%)	7
Min	32.00
Max	150.00
Sample Size	29,279
Target Status	Passed
% of Target Achieved	99.98



Final Coverage: Semivariogram

Range (ft): 14.43
Sill: 54.13
Vertical Scale: 54.13
Nuggets: 0.00



APPENDIX H

APPENDIX H, VEDA analysis reports – asphalt layers

Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20131217-0250-09
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

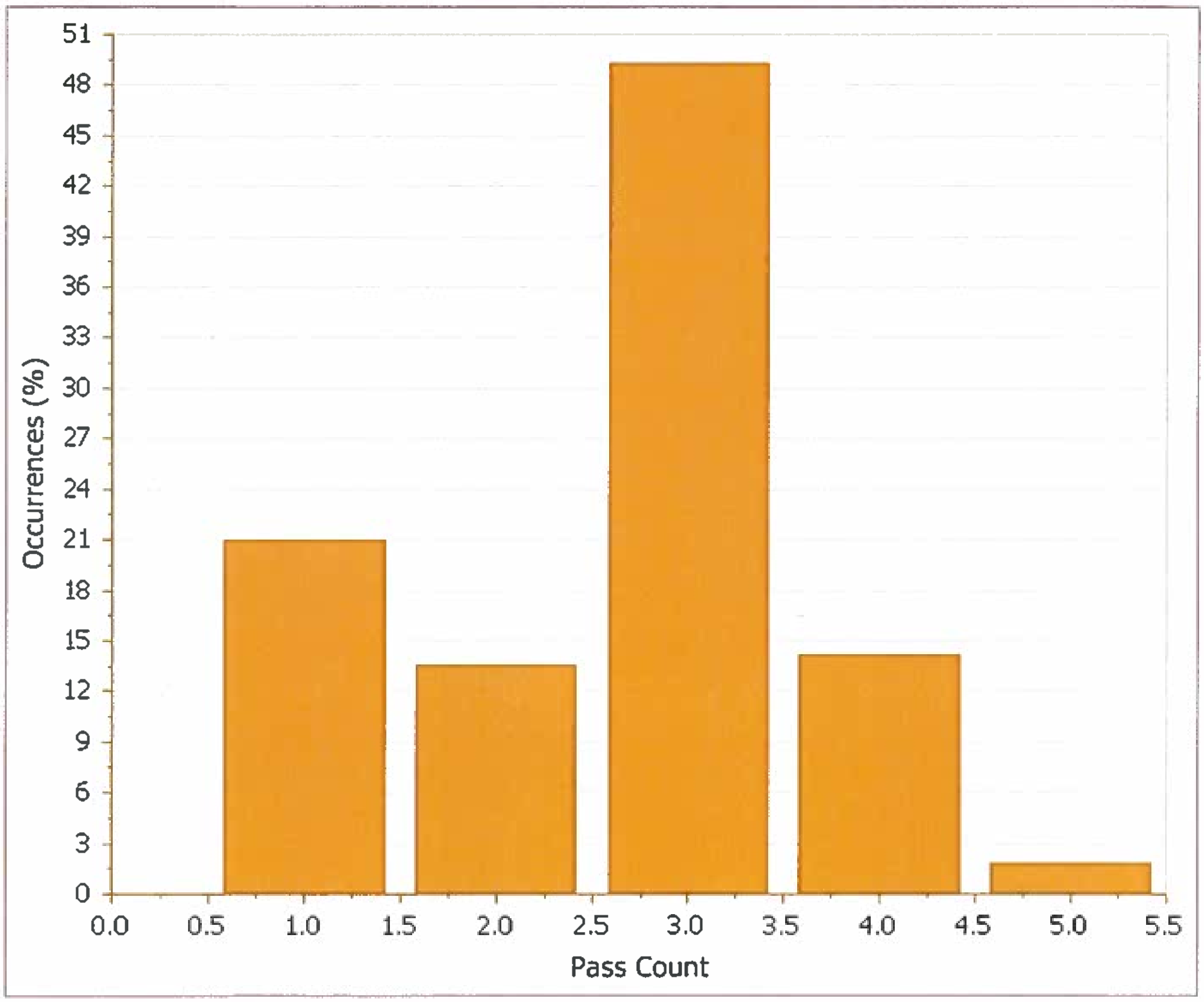
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

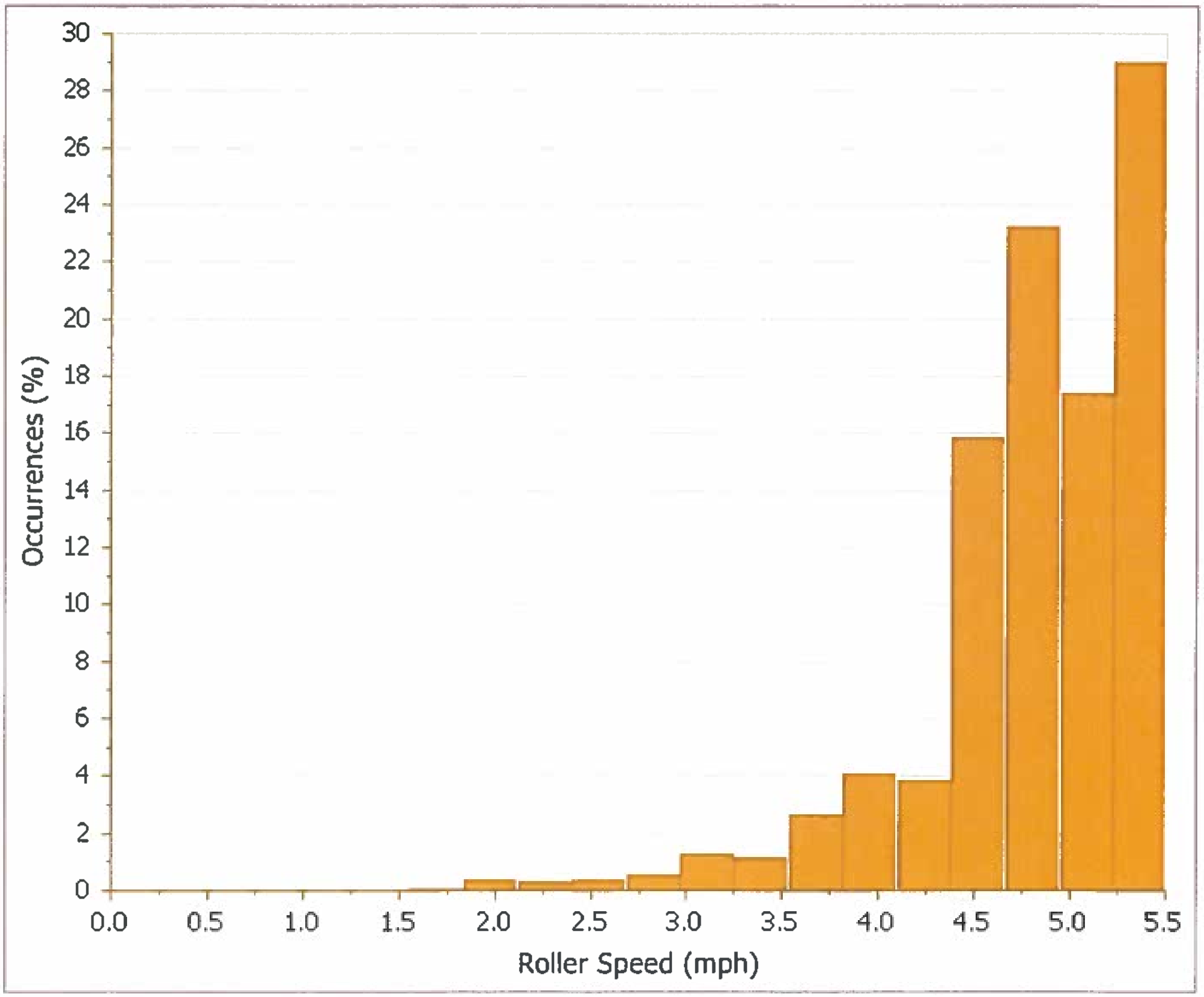
Statistic	Value
Mean	3
Standard Deviation	1
CoV (%)	39
Min	1
Max	5
Sample Size	27,913
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

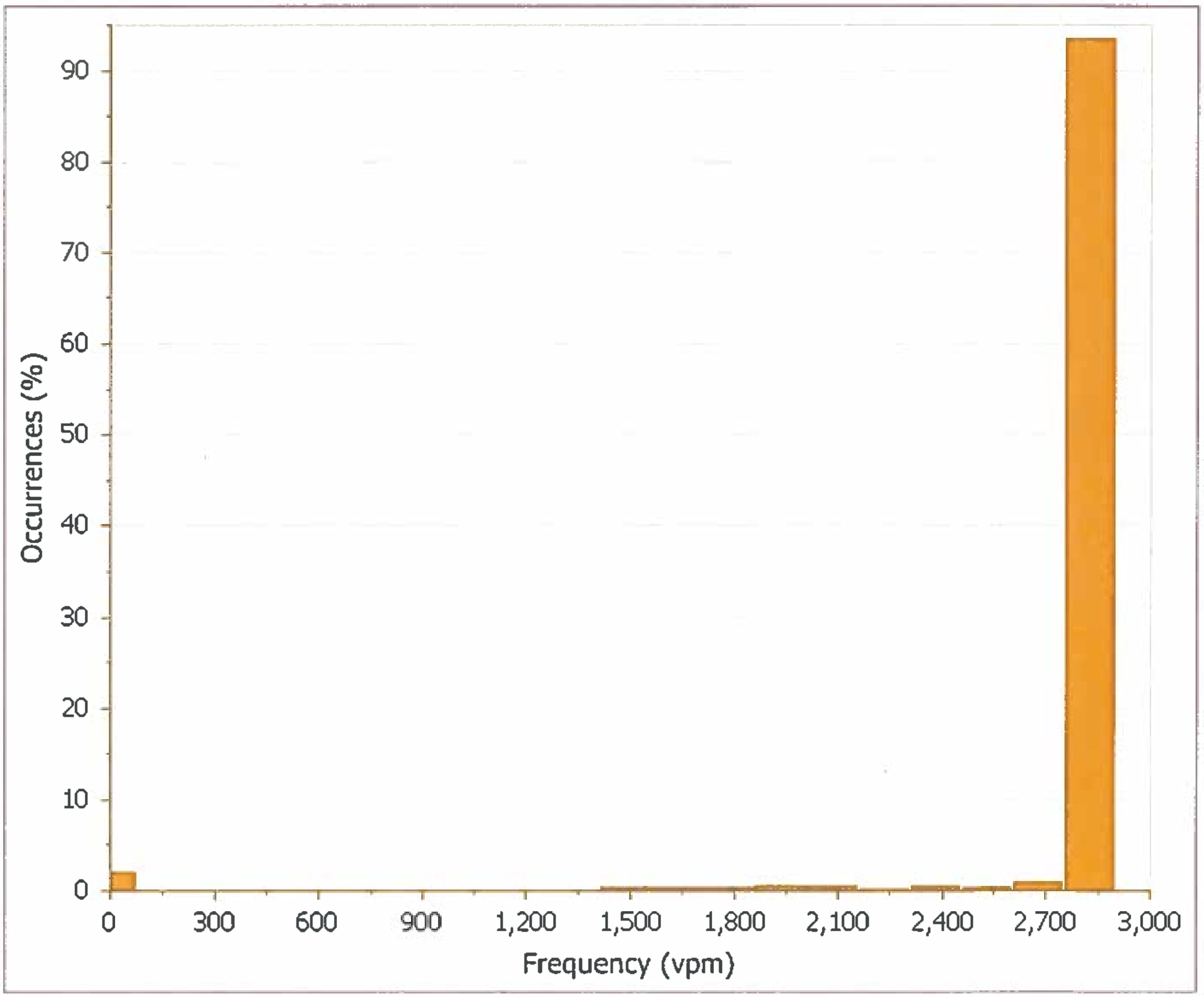
Statistic	Value
Mean (mph)	4.7
Standard Deviation (mph)	0.6
CoV (%)	13
Min (mph)	0.0
Max (mph)	5.7
Sample Size	27,913
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Frequency

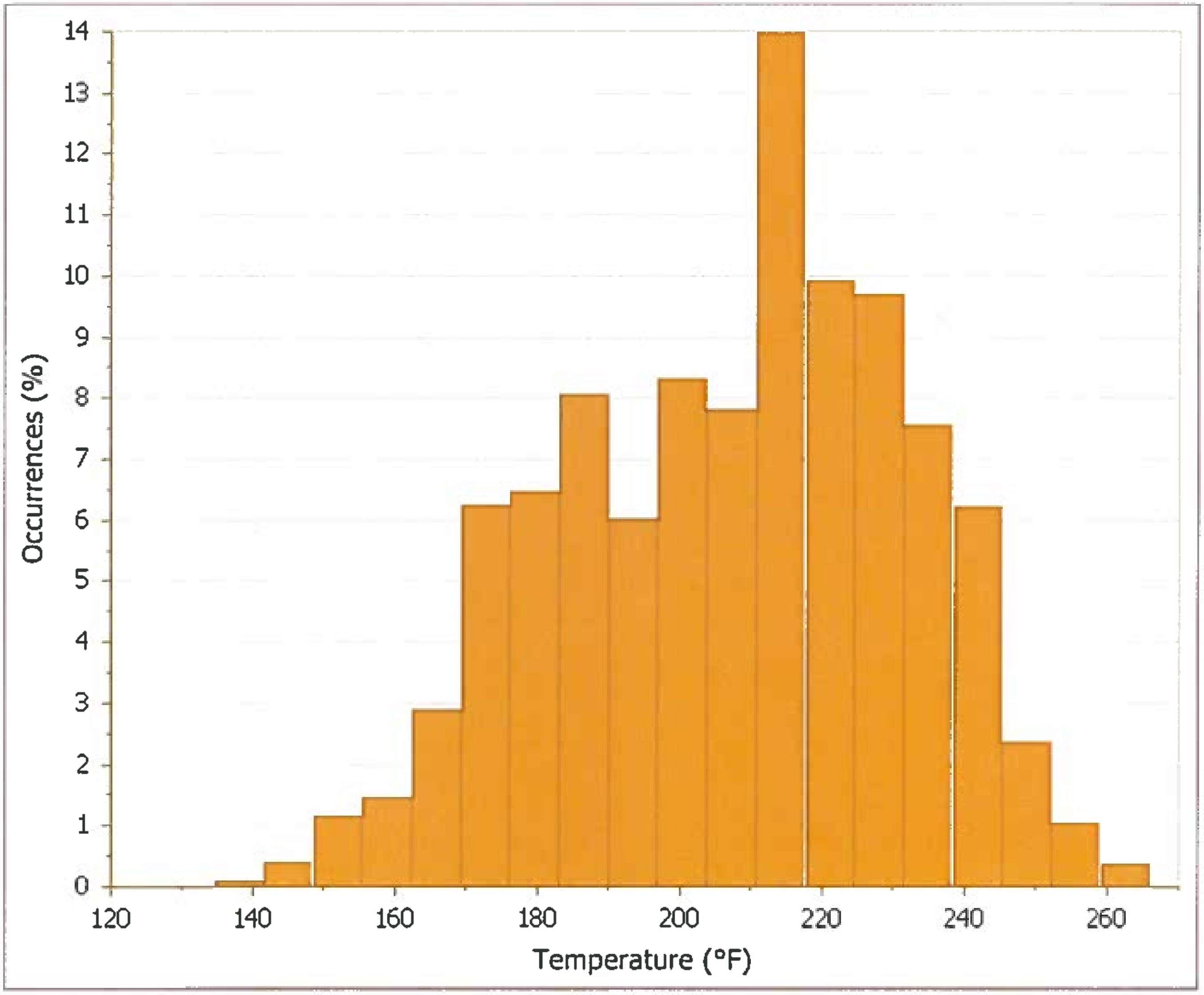
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,814
Standard Deviation (vpm)	444
CoV (%)	16
Min (vpm)	0
Max (vpm)	2,976
Sample Size	27,913
Target Status	Passed
% of Target Achieved	98.01



Final Coverage: Temperature

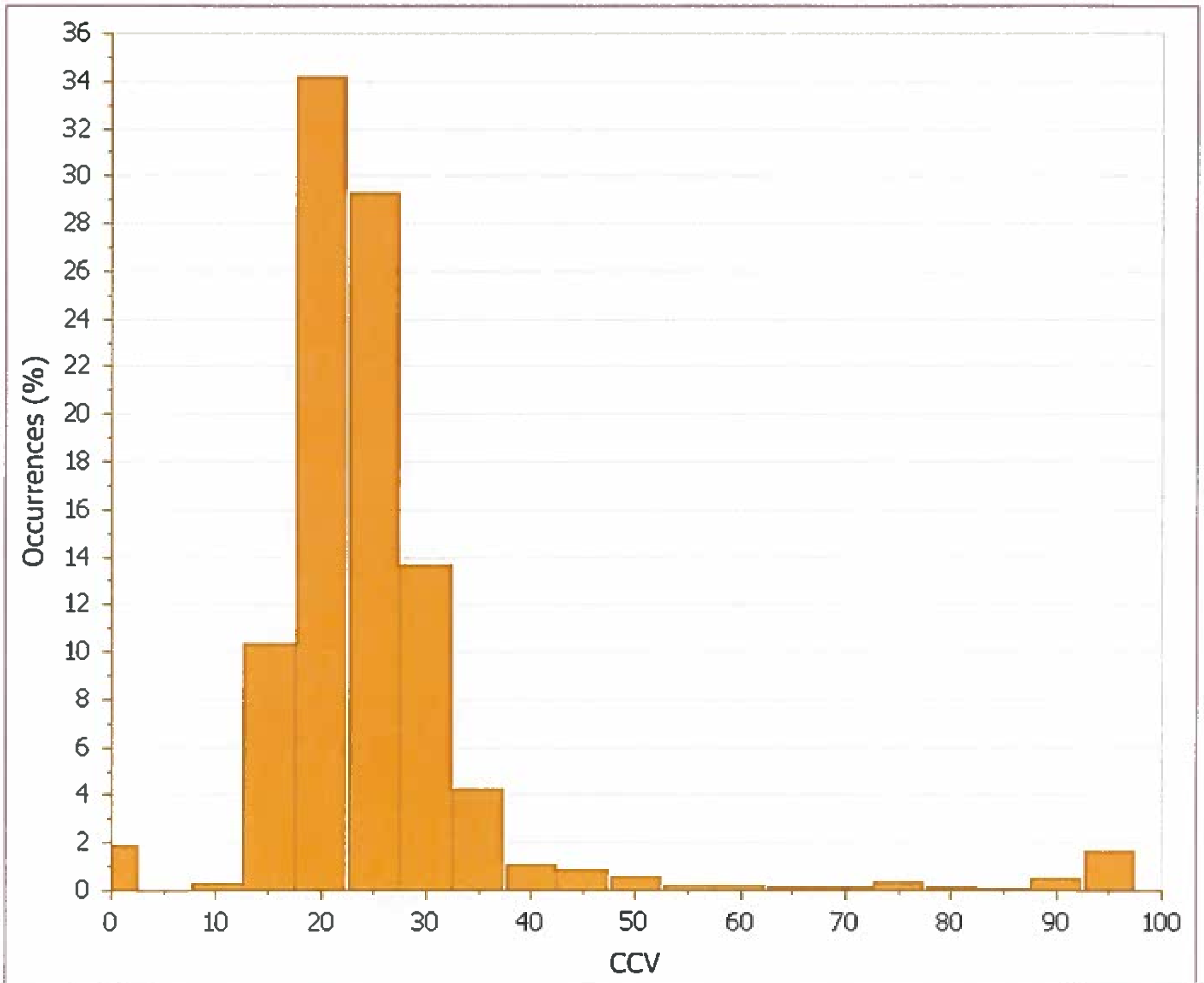
Statistic	Value
Mean (°F)	204.2
Standard Deviation (°F)	24.07
CoV (%)	12
Min (°F)	131.2
Max (°F)	269.5
Sample Size	27,913



Final Coverage: CCV

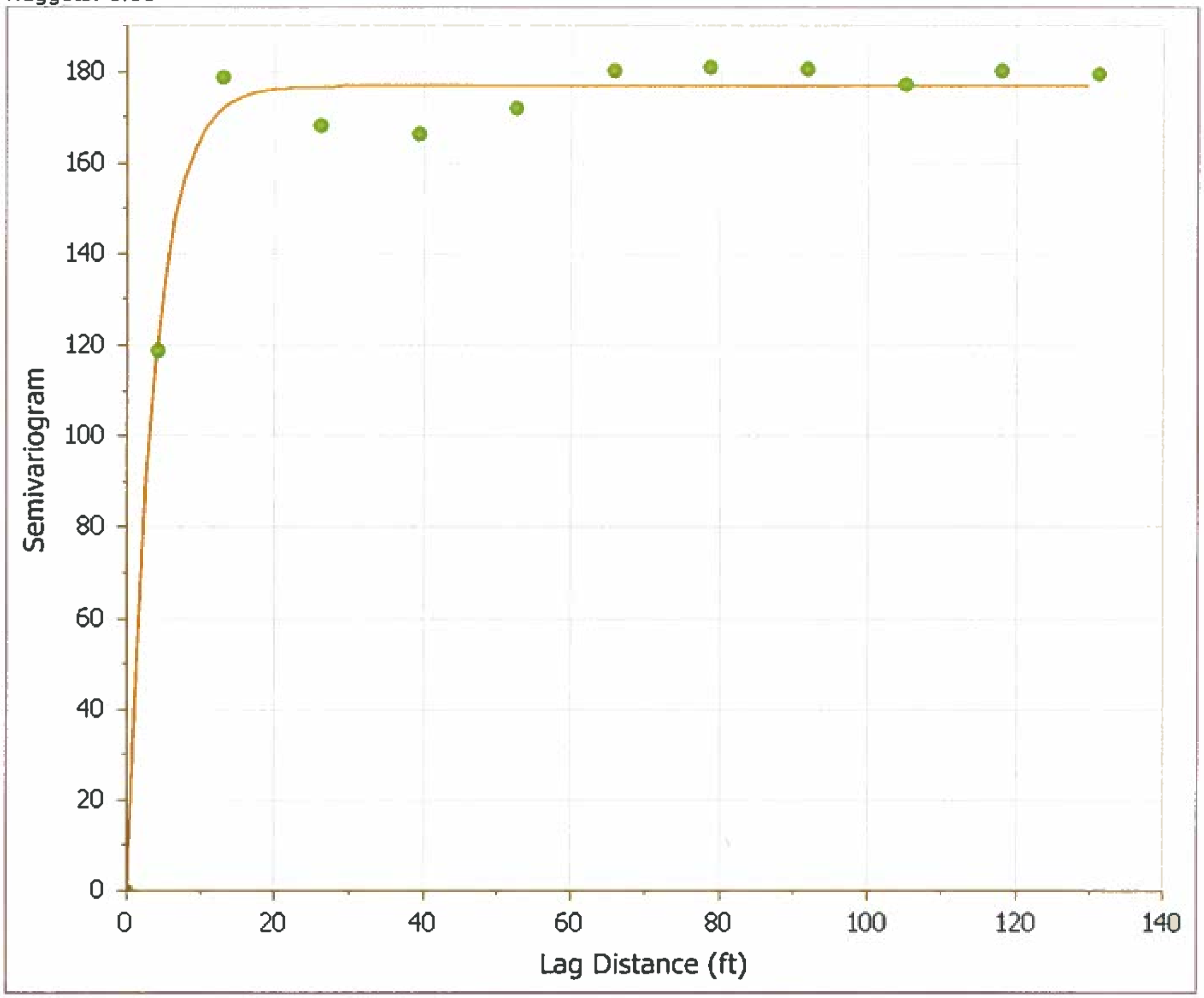
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	23.08
Standard Deviation	13.80
CoV (%)	60
Min	0.00
Max	100.00
Sample Size	27,913
Target Status	Passed
% of Target Achieved	98.14



Final Coverage: Semivariogram

Range (ft): 10.50
Sill: 167.20
Vertical Scale: 167.20
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20131217-0317-11
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

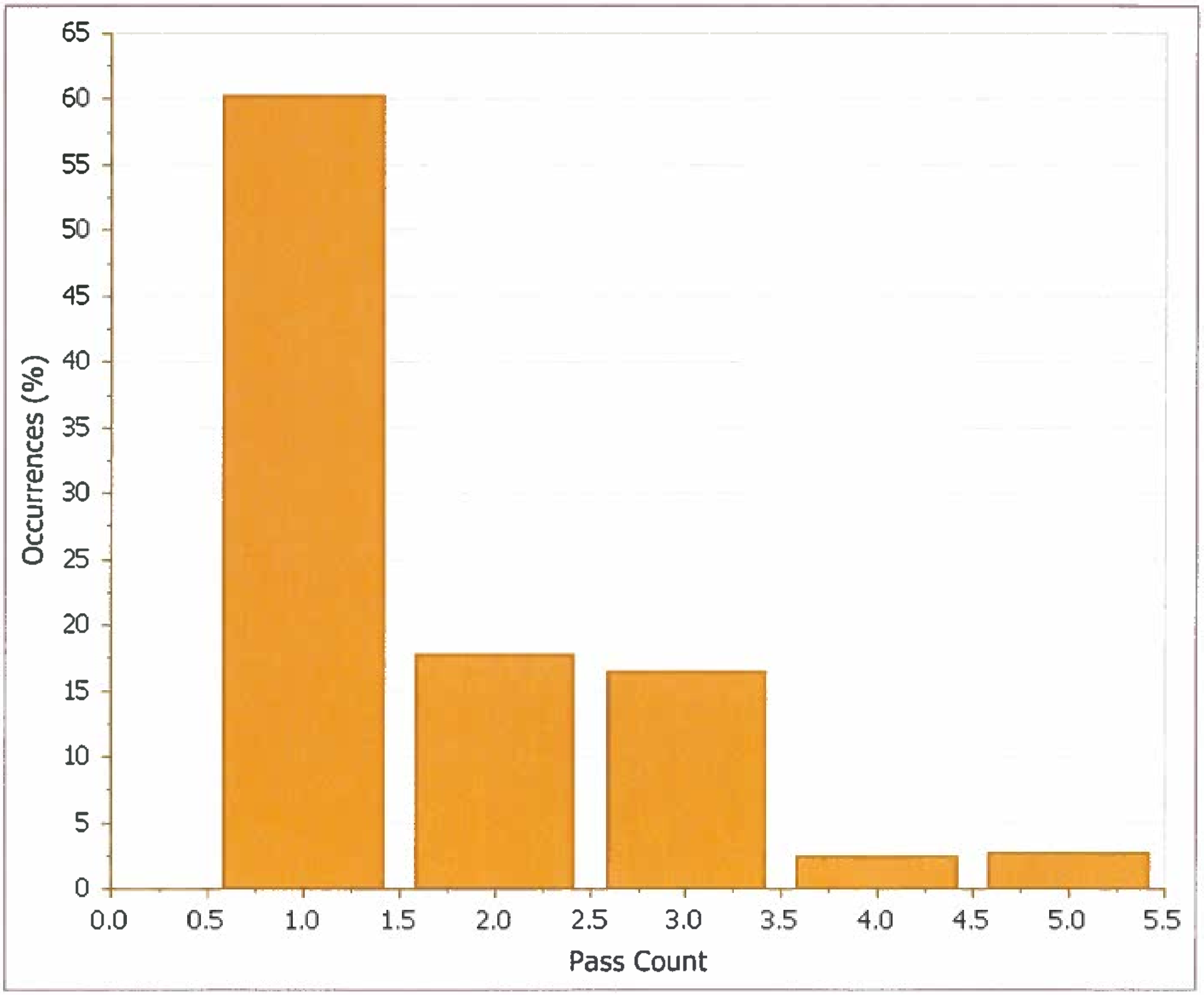
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

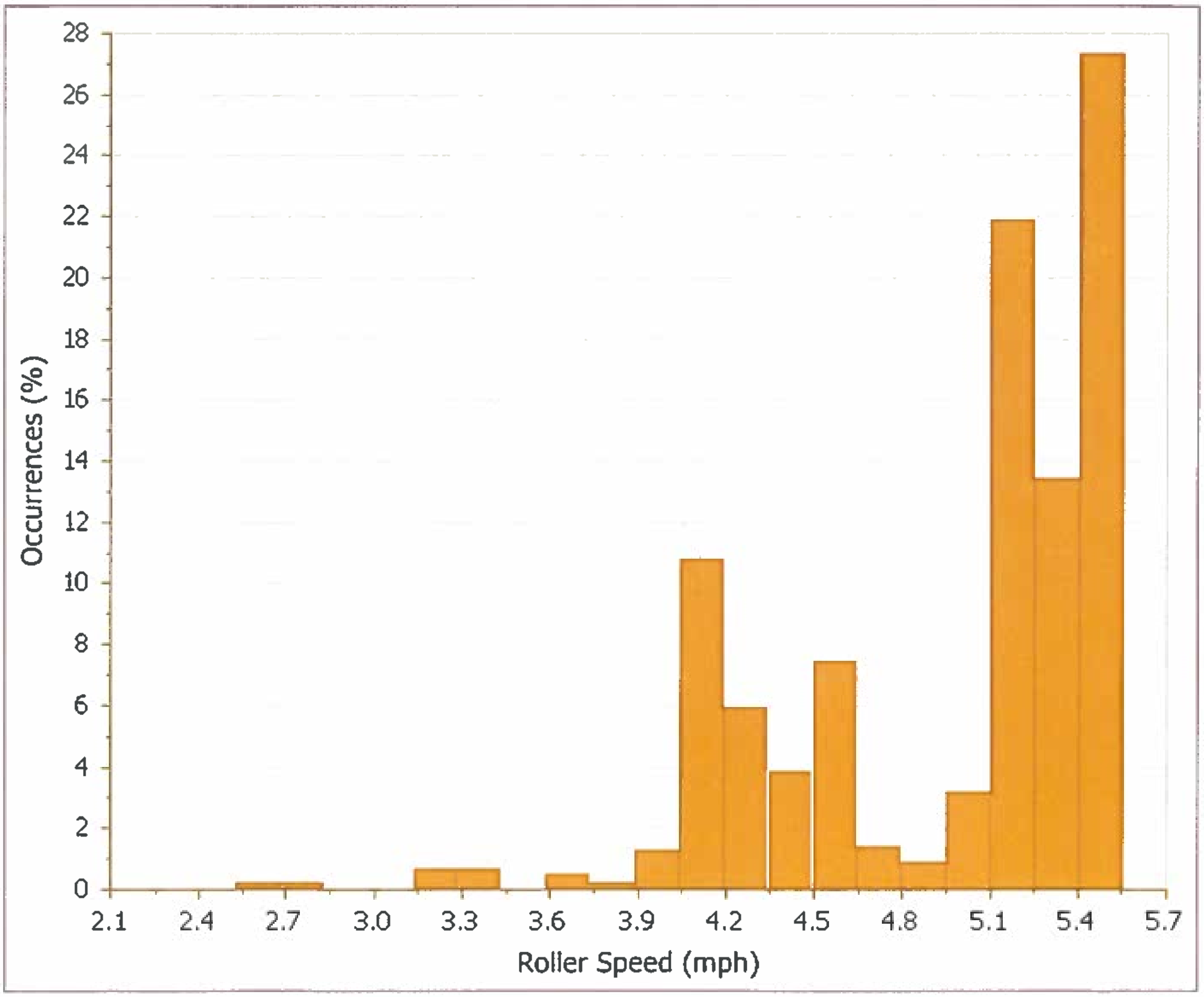
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	60
Min	1
Max	5
Sample Size	5,302
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

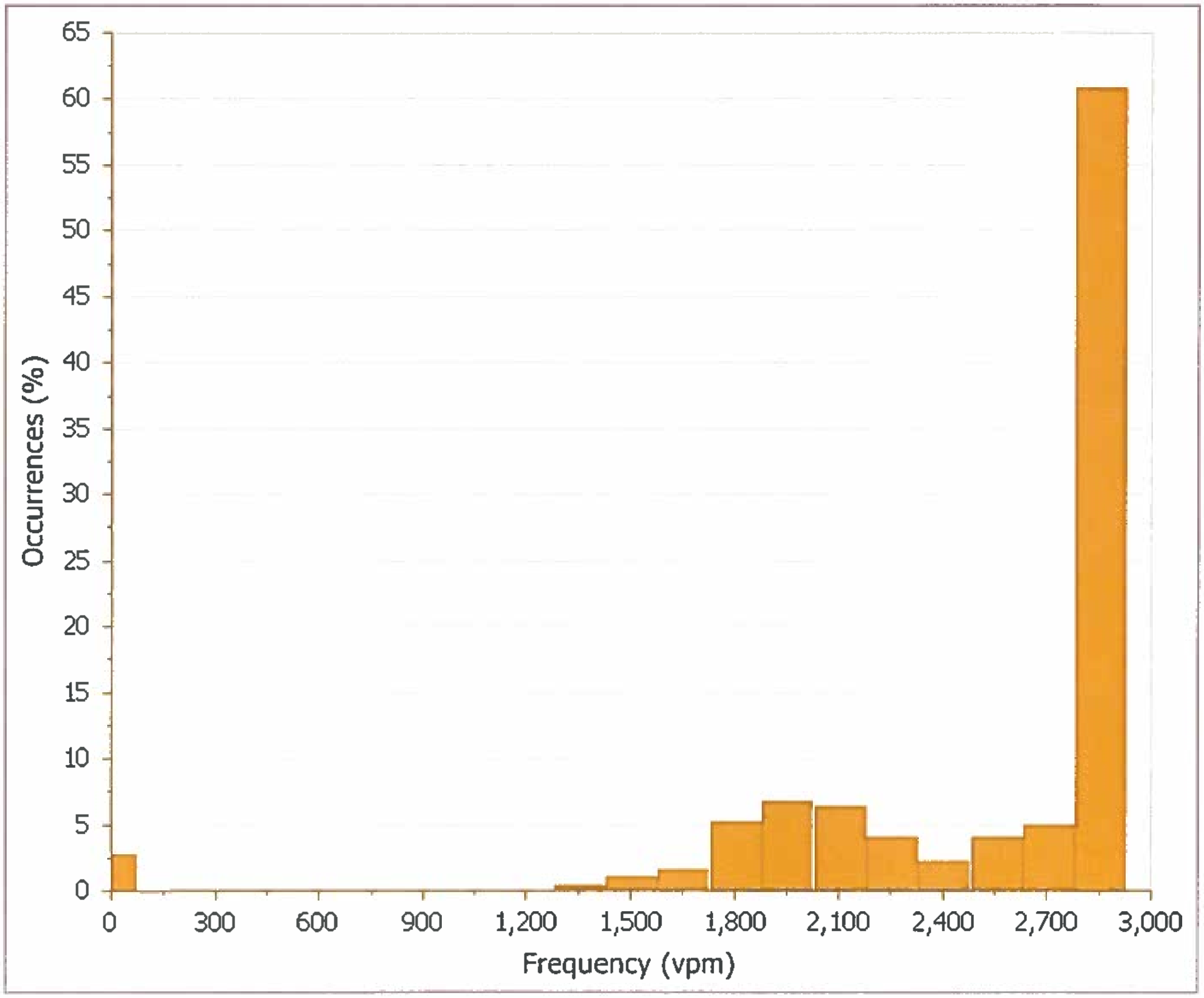
Statistic	Value
Mean (mph)	4.9
Standard Deviation (mph)	0.6
CoV (%)	12
Min (mph)	2.6
Max (mph)	5.6
Sample Size	5,302
Target Status	Passed
% of Target Achieved	99.77



Final Coverage: Frequency

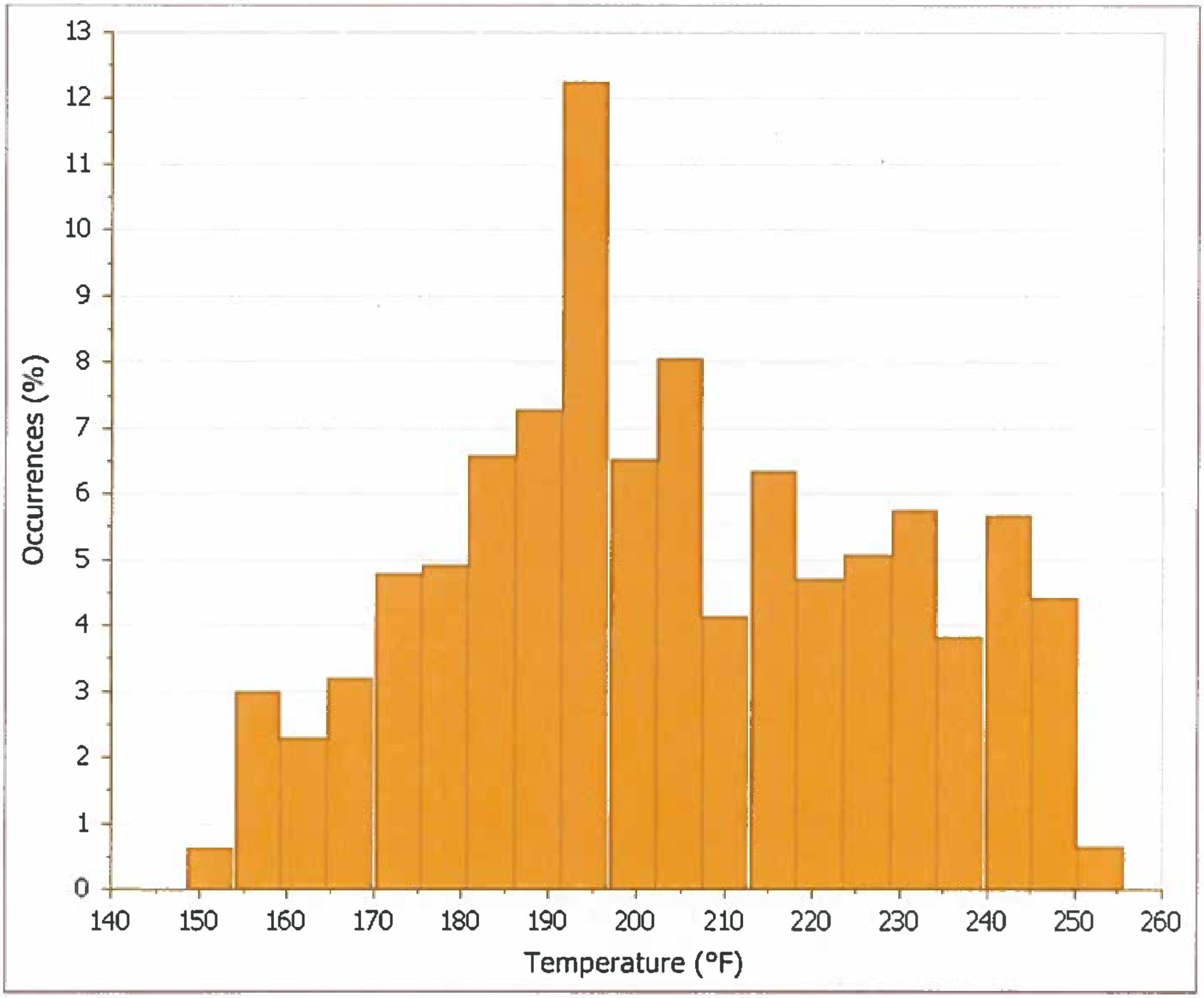
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,493
Standard Deviation (vpm)	595
CoV (%)	24
Min (vpm)	0
Max (vpm)	3,006
Sample Size	5,302
Target Status	Passed
% of Target Achieved	97.30



Final Coverage: Temperature

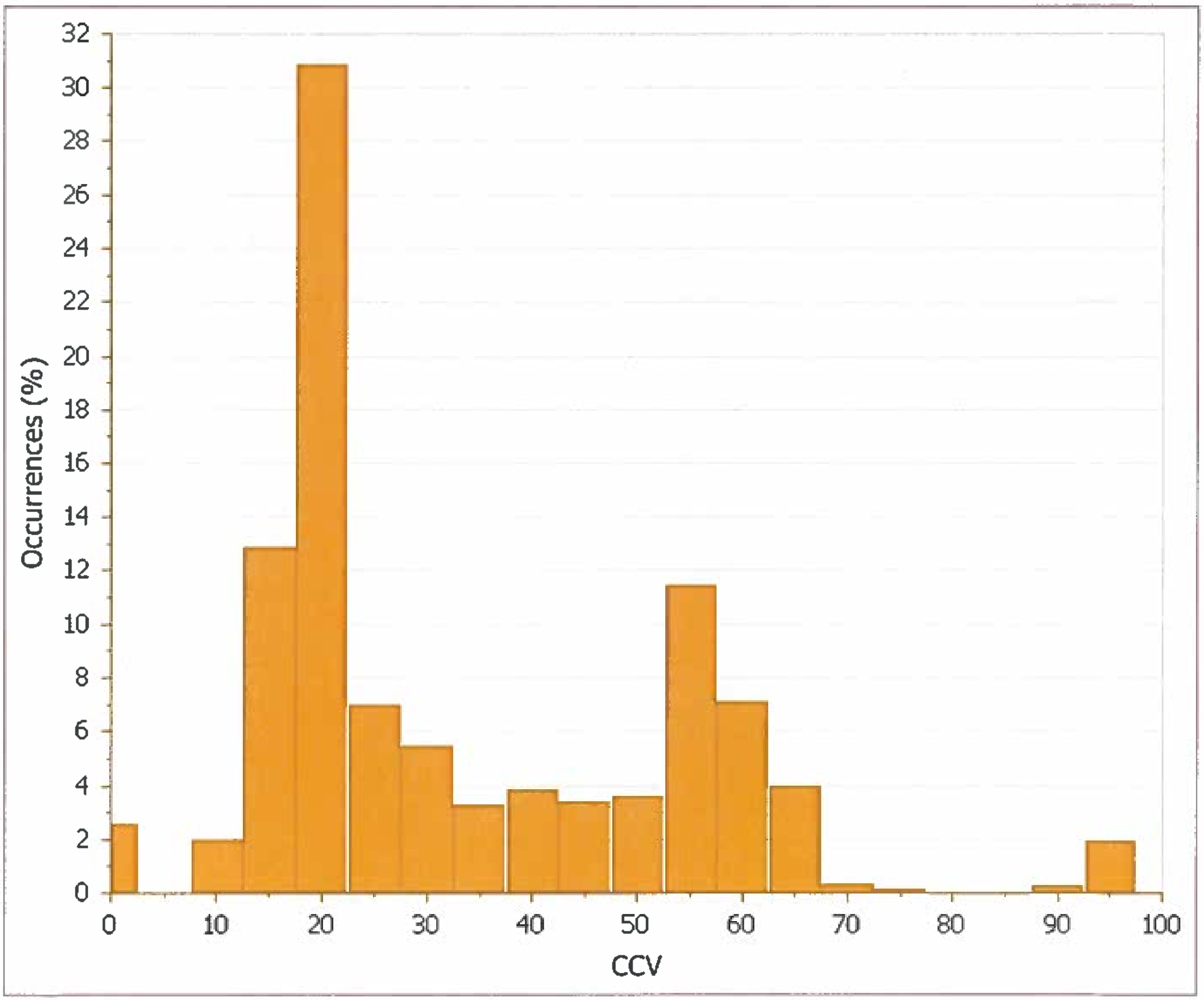
Statistic	Value
Mean (°F)	201.0
Standard Deviation (°F)	24.91
CoV (%)	12
Min (°F)	151.2
Max (°F)	258.4
Sample Size	5,302



Final Coverage: CCV

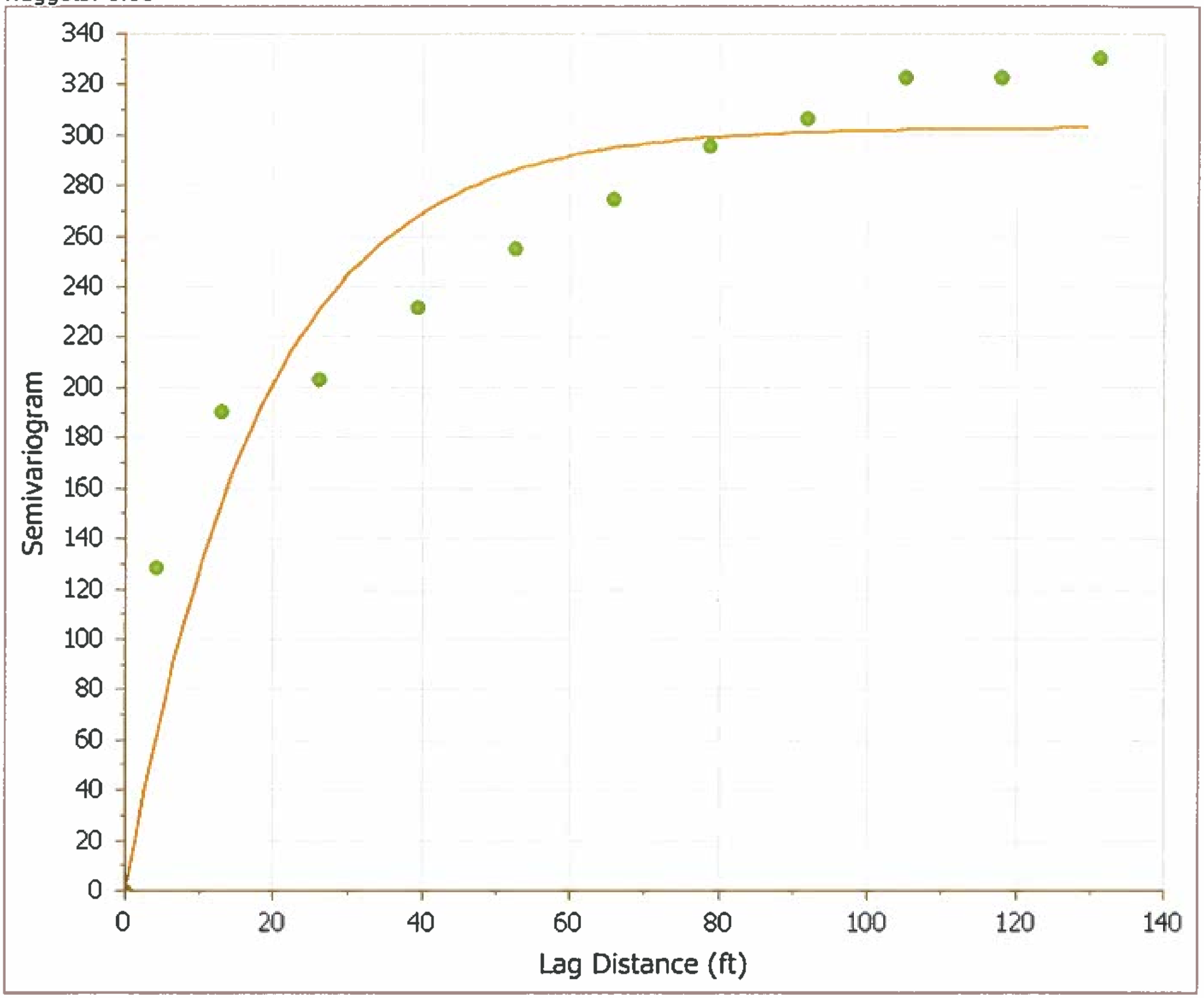
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	31.02
Standard Deviation	19.93
CoV (%)	64
Min	0.00
Max	100.00
Sample Size	5,302
Target Status	Passed
% of Target Achieved	97.43



Final Coverage: Semivariogram

Range (ft): 26.24
Sill: 231.20
Vertical Scale: 231.20
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20131217-2215-11
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

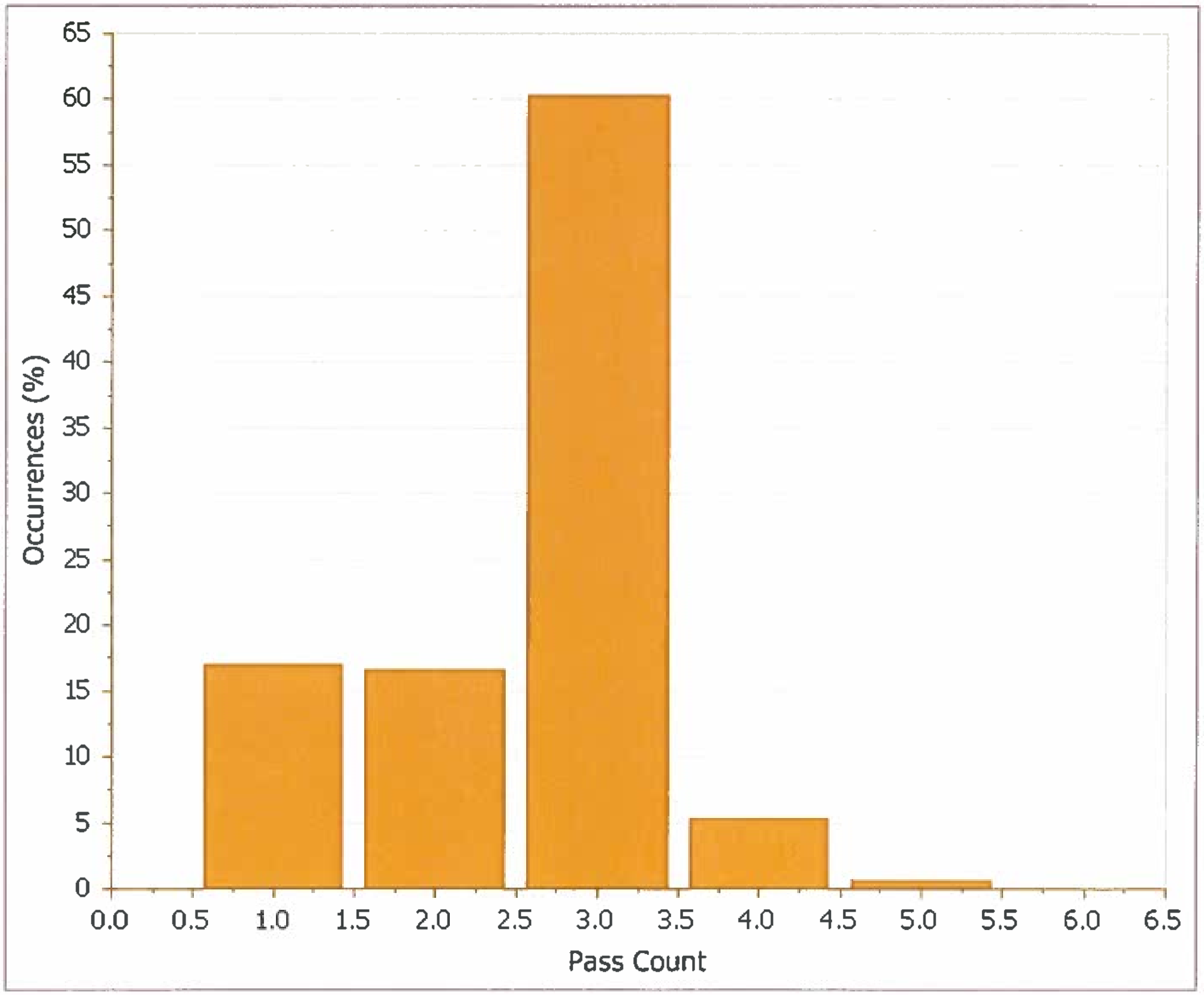
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

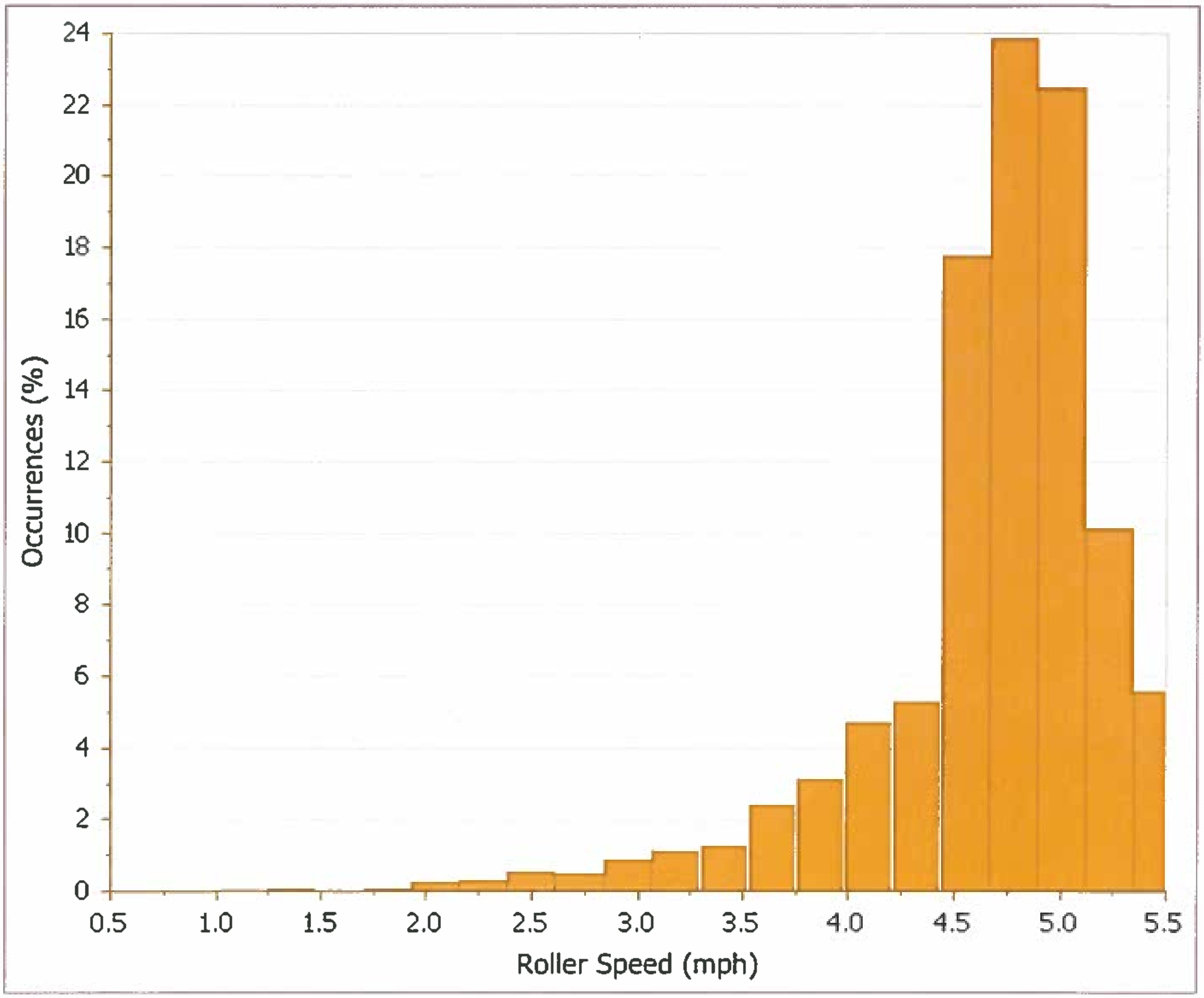
Statistic	Value
Mean	3
Standard Deviation	1
CoV (%)	34
Min	1
Max	6
Sample Size	46,019
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

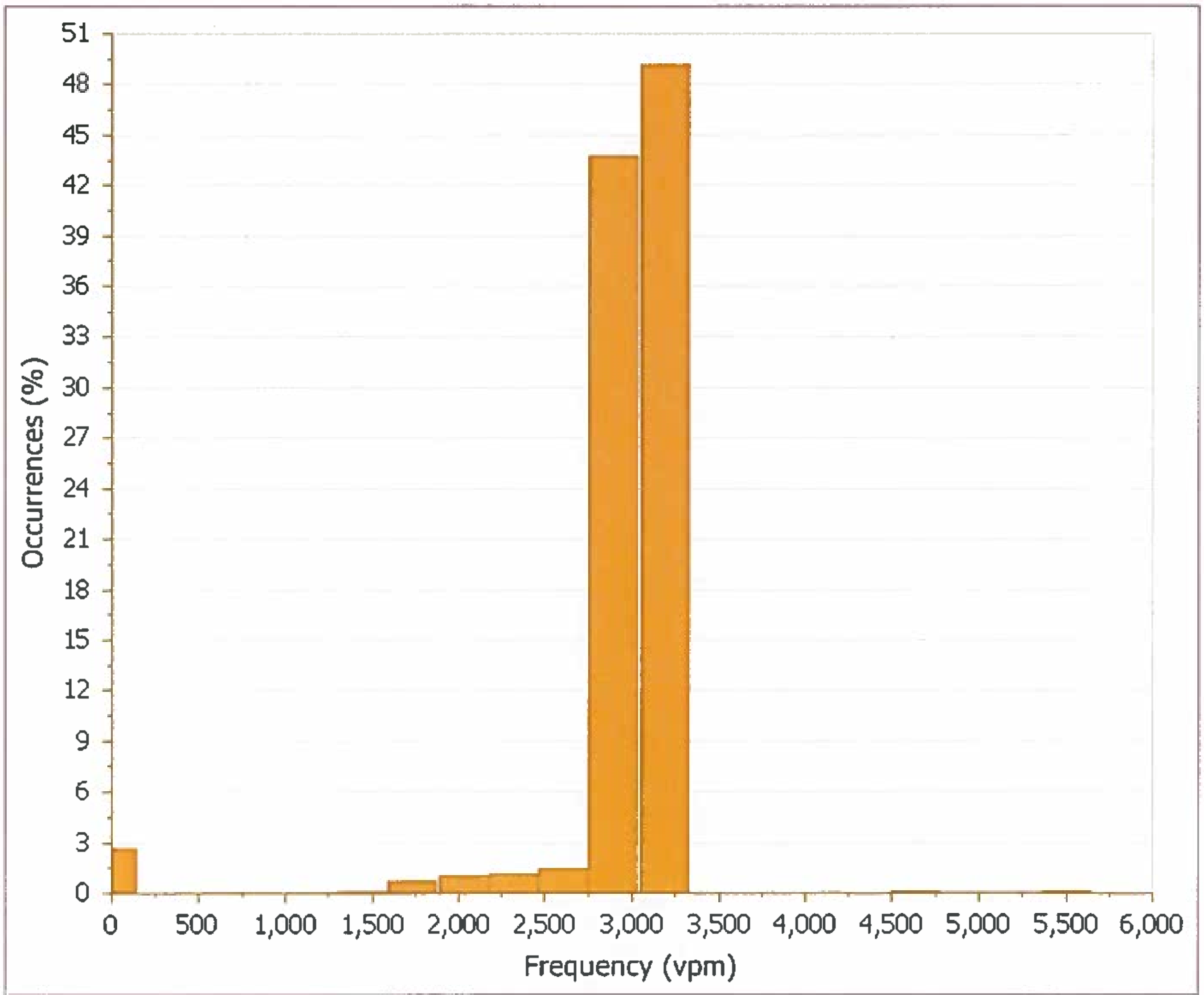
Statistic	Value
Mean (mph)	4.6
Standard Deviation (mph)	0.6
CoV (%)	12
Min (mph)	1.1
Max (mph)	5.7
Sample Size	46,019
Target Status	Passed
% of Target Achieved	99.98



Final Coverage: Frequency

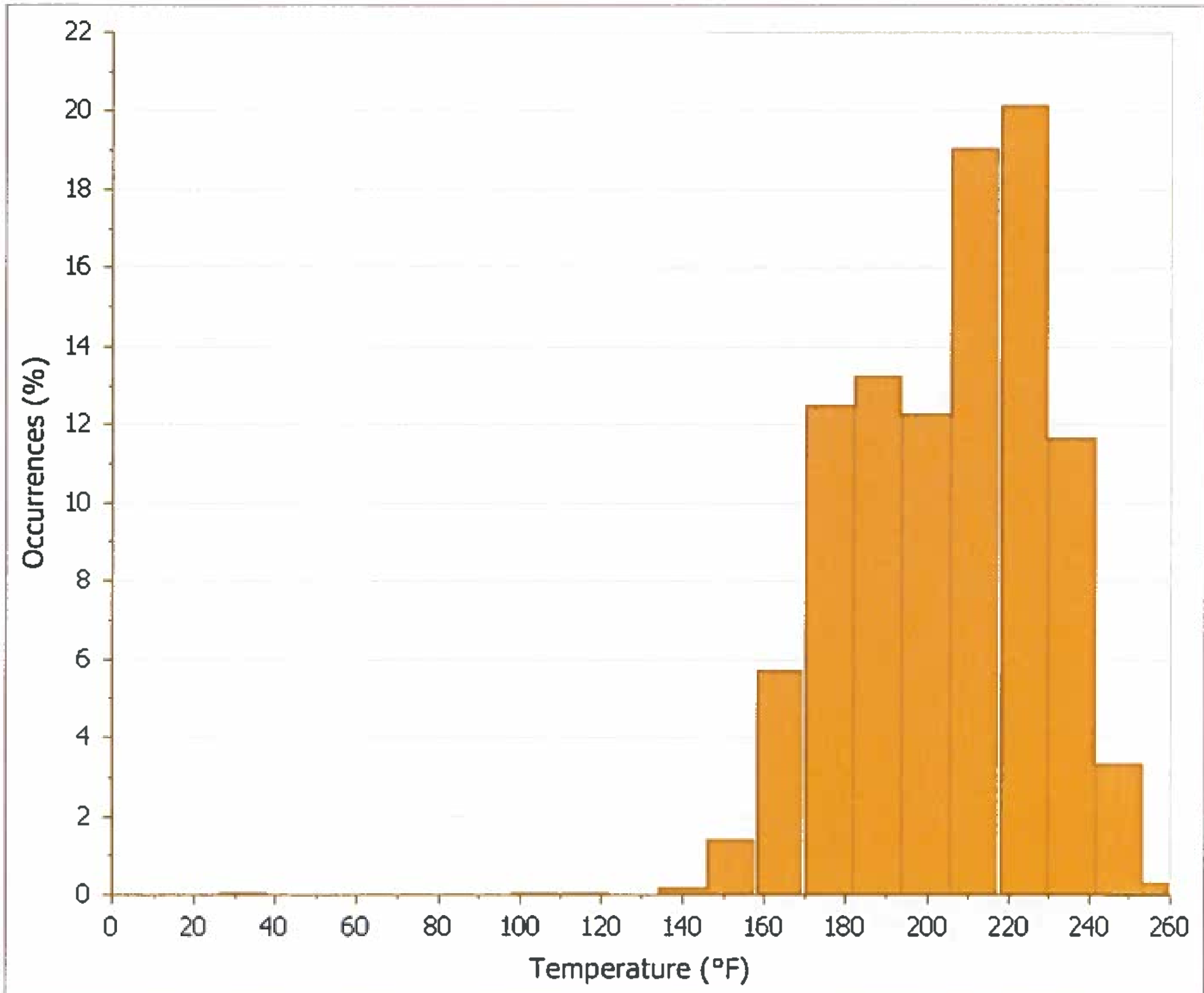
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,787
Standard Deviation (vpm)	500
CoV (%)	18
Min (vpm)	0
Max (vpm)	5,790
Sample Size	46,019
Target Status	Passed
% of Target Achieved	97.36



Final Coverage: Temperature

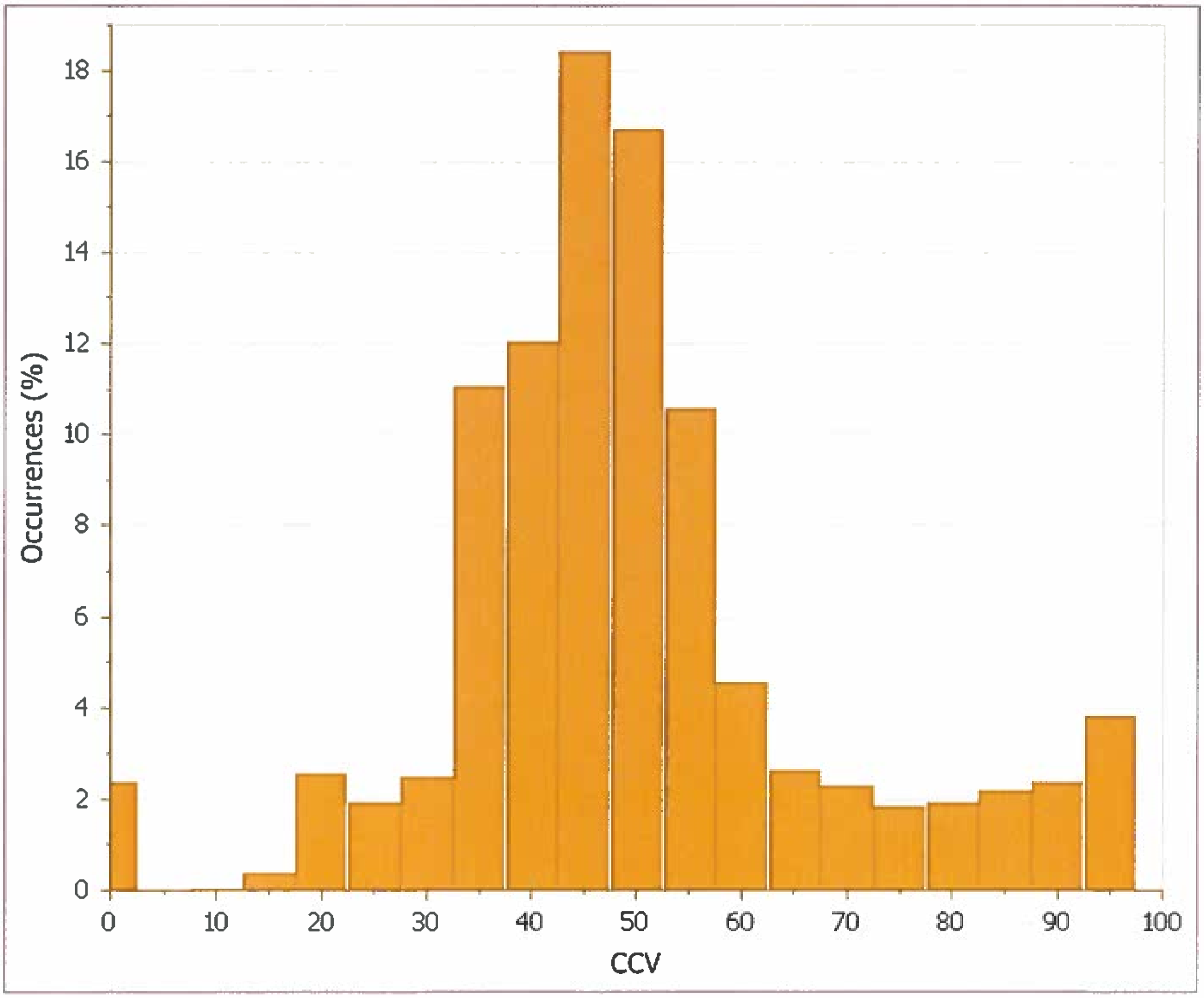
Statistic	Value
Mean (°F)	199.5
Standard Deviation (°F)	24.00
CoV (%)	12
Min (°F)	32.0
Max (°F)	271.5
Sample Size	46,019



Final Coverage: CCV

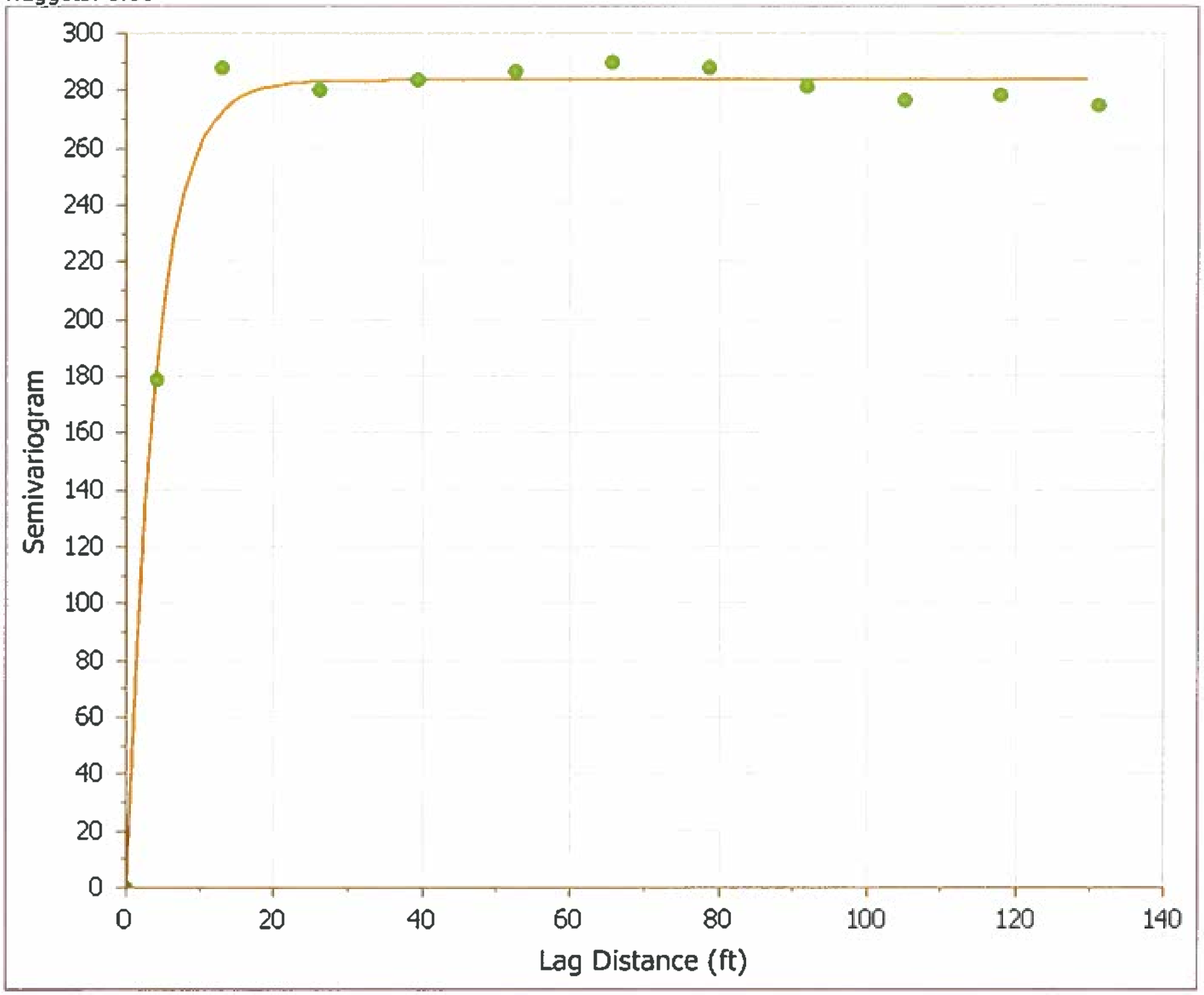
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	47.19
Standard Deviation	18.70
CoV (%)	40
Min	0.00
Max	100.00
Sample Size	46,019
Target Status	Passed
% of Target Achieved	97.63



Final Coverage: Semivariogram

Range (ft): 11.81
Sill: 269.09
Vertical Scale: 269.09
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20131218-0355-20
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

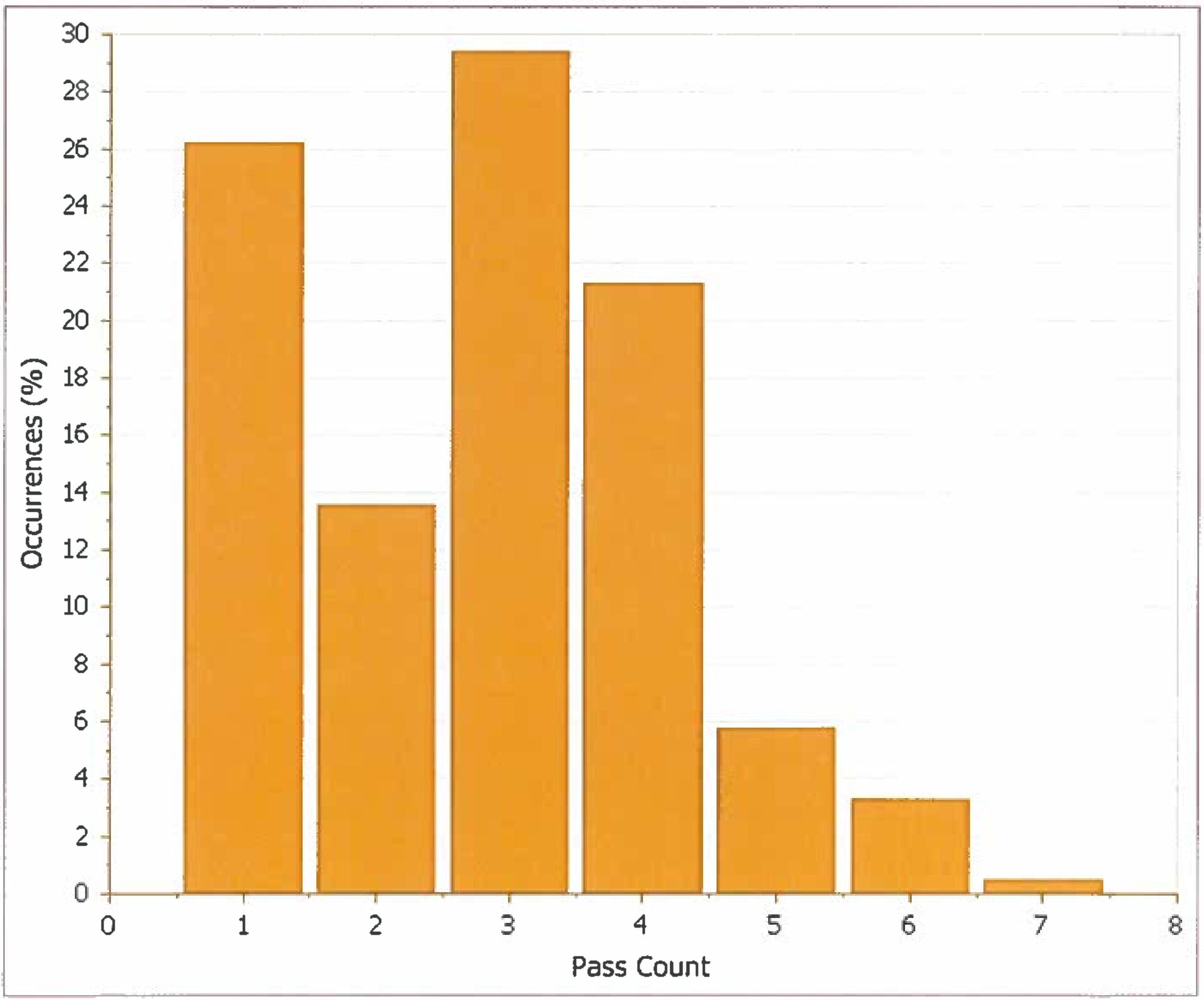
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

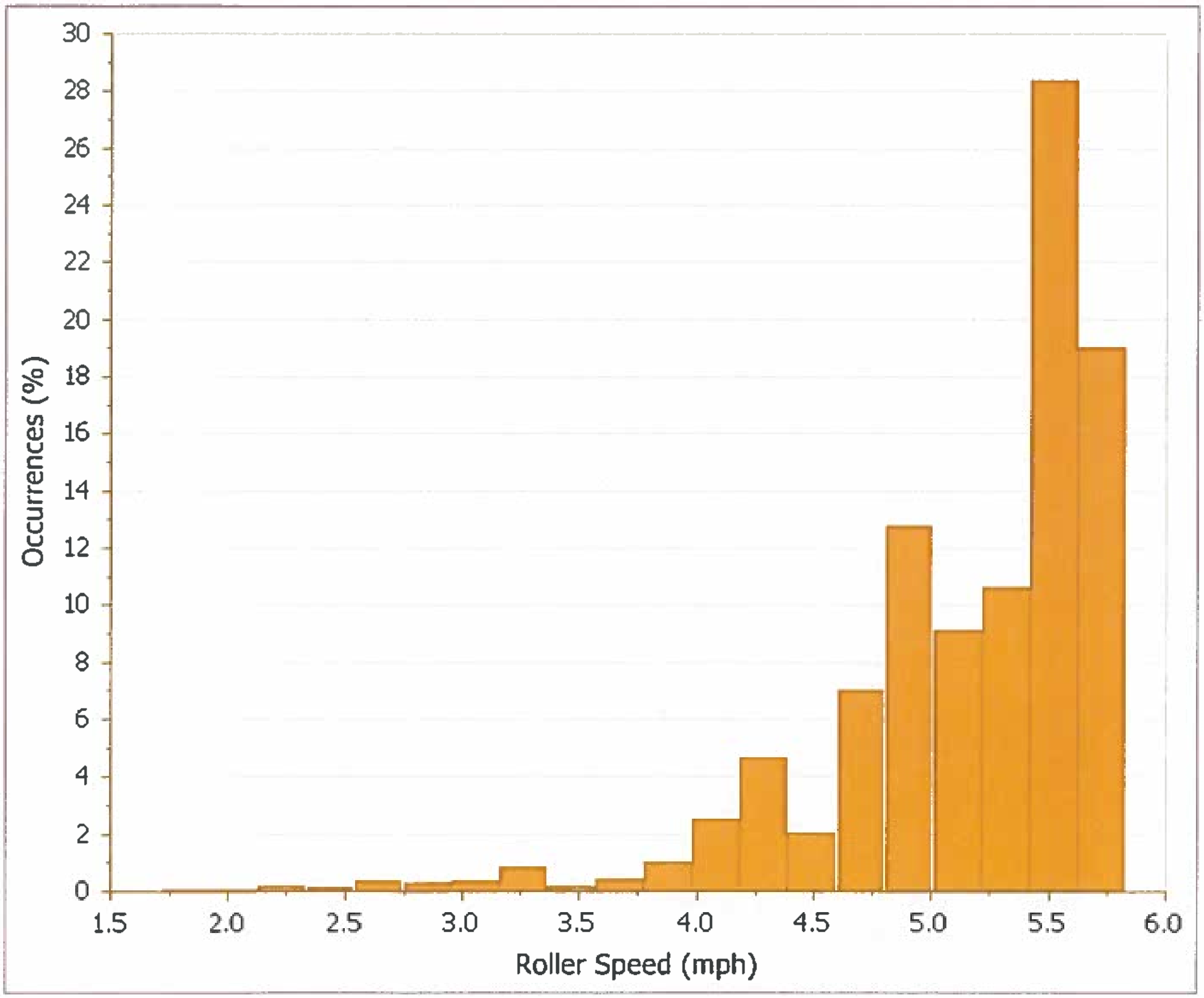
Statistic	Value
Mean	3
Standard Deviation	1
CoV (%)	50
Min	1
Max	7
Sample Size	16,377
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

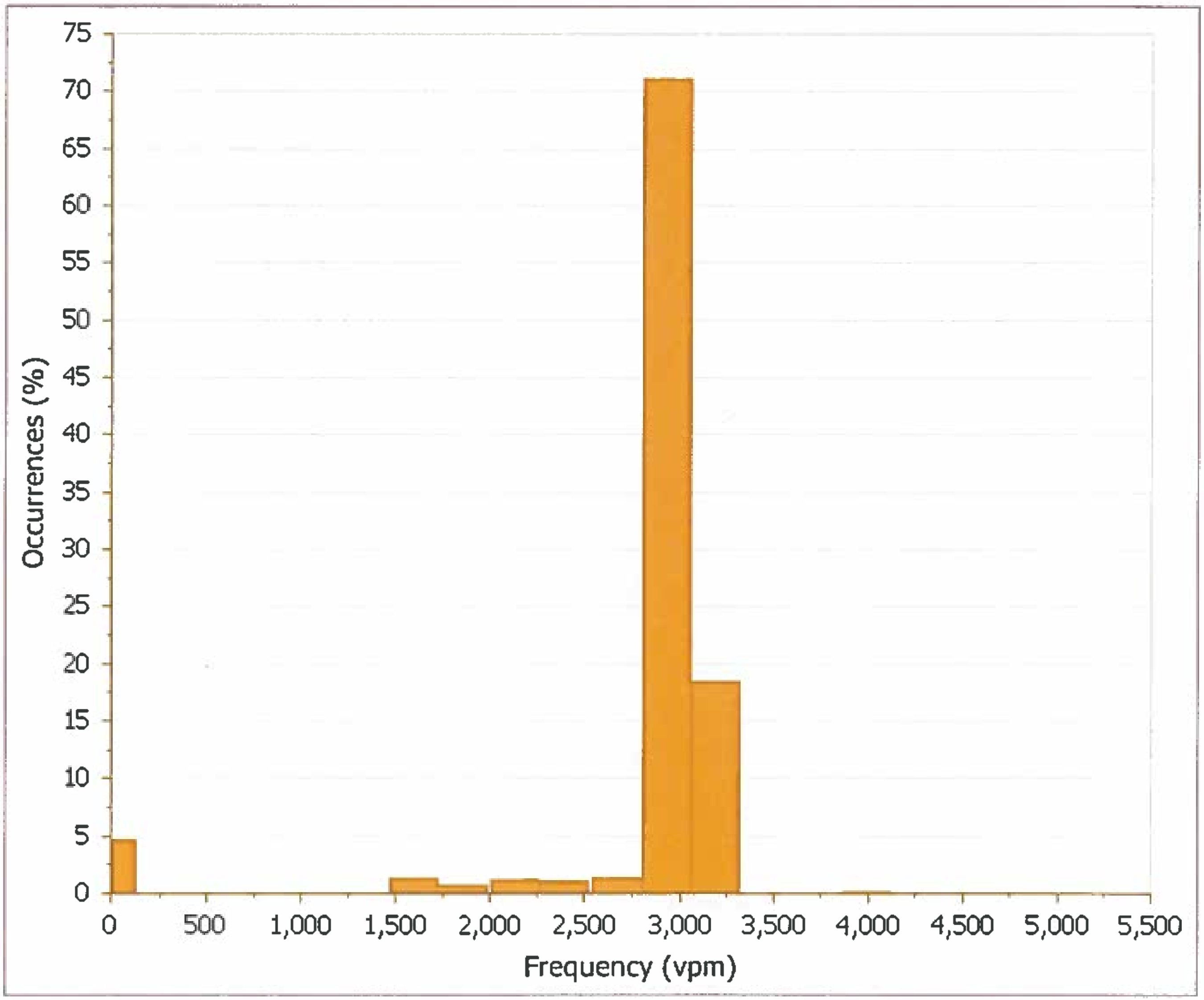
Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	5.1
Standard Deviation (mph)	0.6
CoV (%)	12
Min (mph)	1.8
Max (mph)	5.9
Sample Size	16,377
Target Status	Passed
% of Target Achieved	99.95



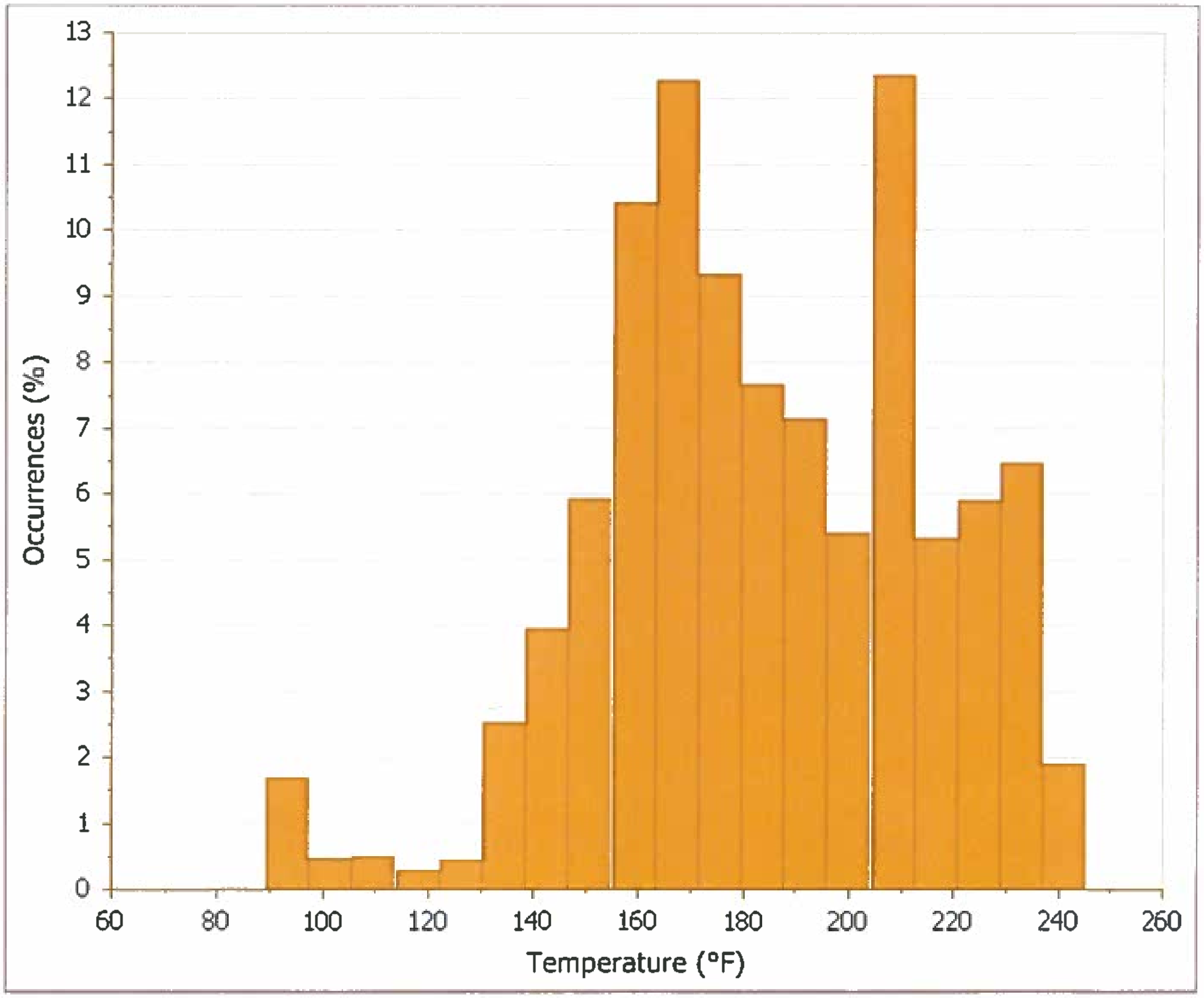
Final Coverage: Frequency
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,732
Standard Deviation (vpm)	649
CoV (%)	24
Min (vpm)	0
Max (vpm)	5,328
Sample Size	16,377
Target Status	Passed
% of Target Achieved	95.33



Final Coverage: Temperature

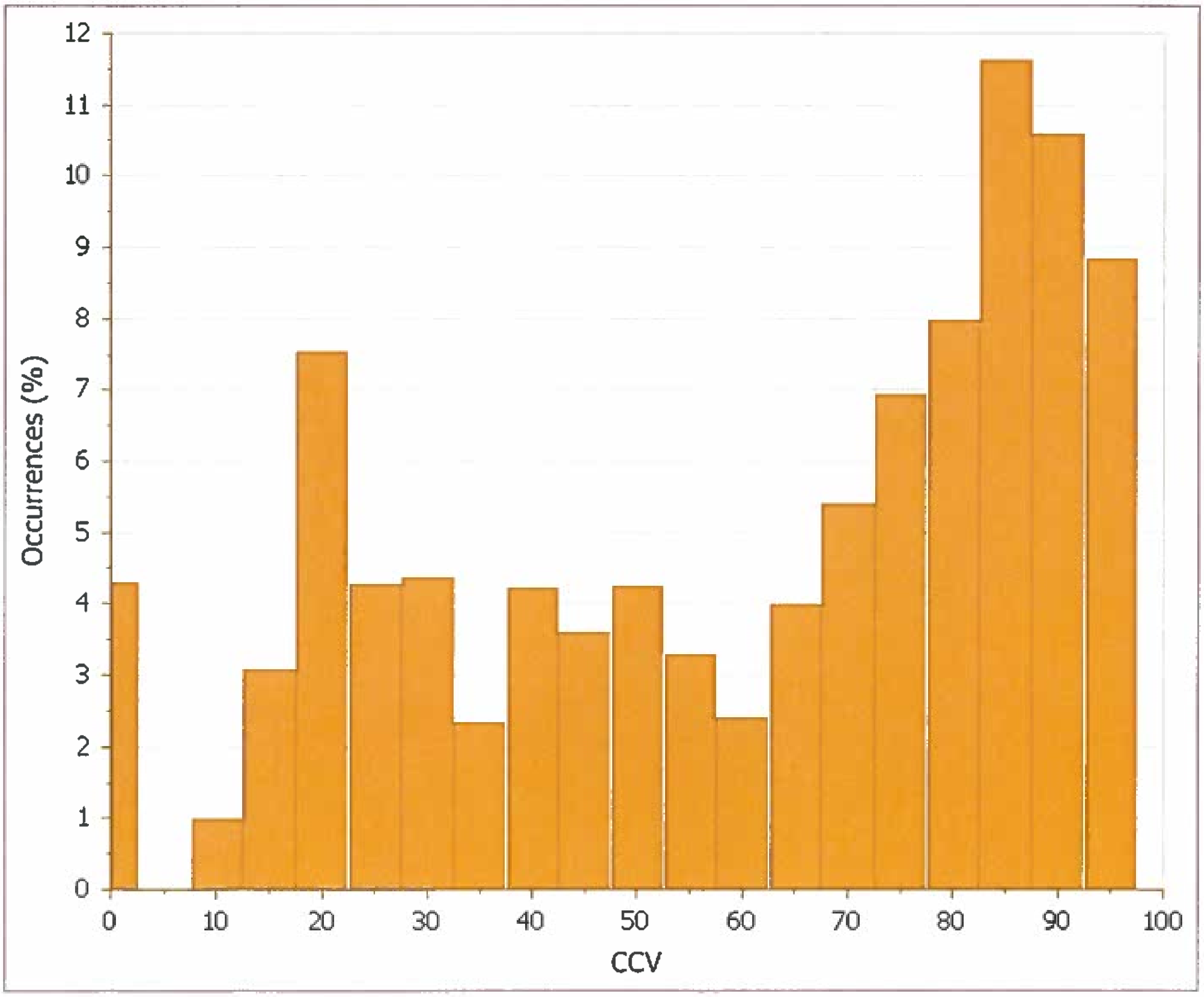
Statistic	Value
Mean (°F)	179.7
Standard Deviation (°F)	31.40
CoV (%)	17
Min (°F)	85.1
Max (°F)	249.4
Sample Size	16,377



Final Coverage: CCV

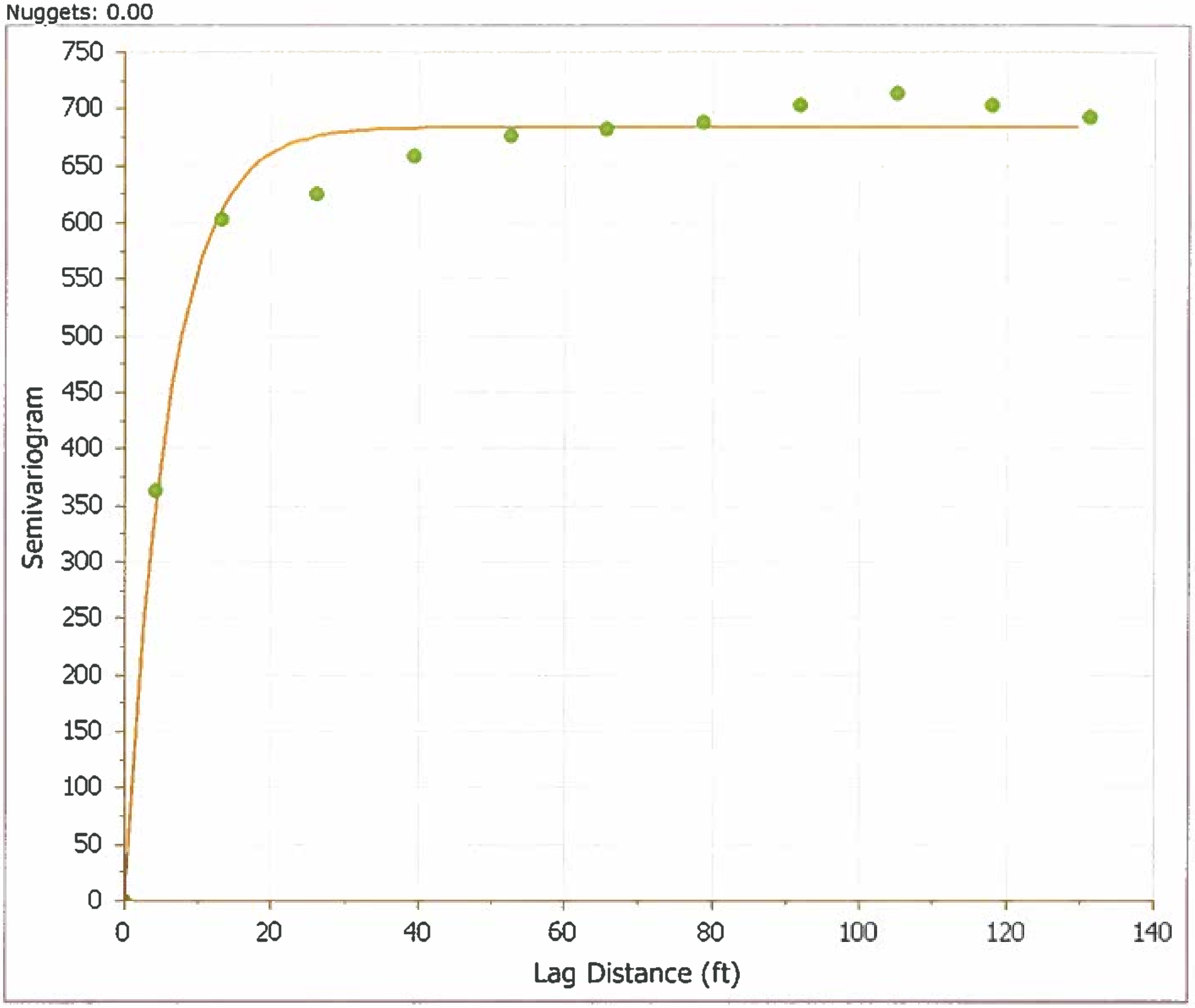
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	57.66
Standard Deviation	28.89
CoV (%)	50
Min	0.00
Max	100.00
Sample Size	16,377
Target Status	Passed
% of Target Achieved	95.71



Final Coverage: Semivariogram

Range (ft): 14.43
Sill: 624.58
Vertical Scale: 624.58
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20131218-1918-45
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

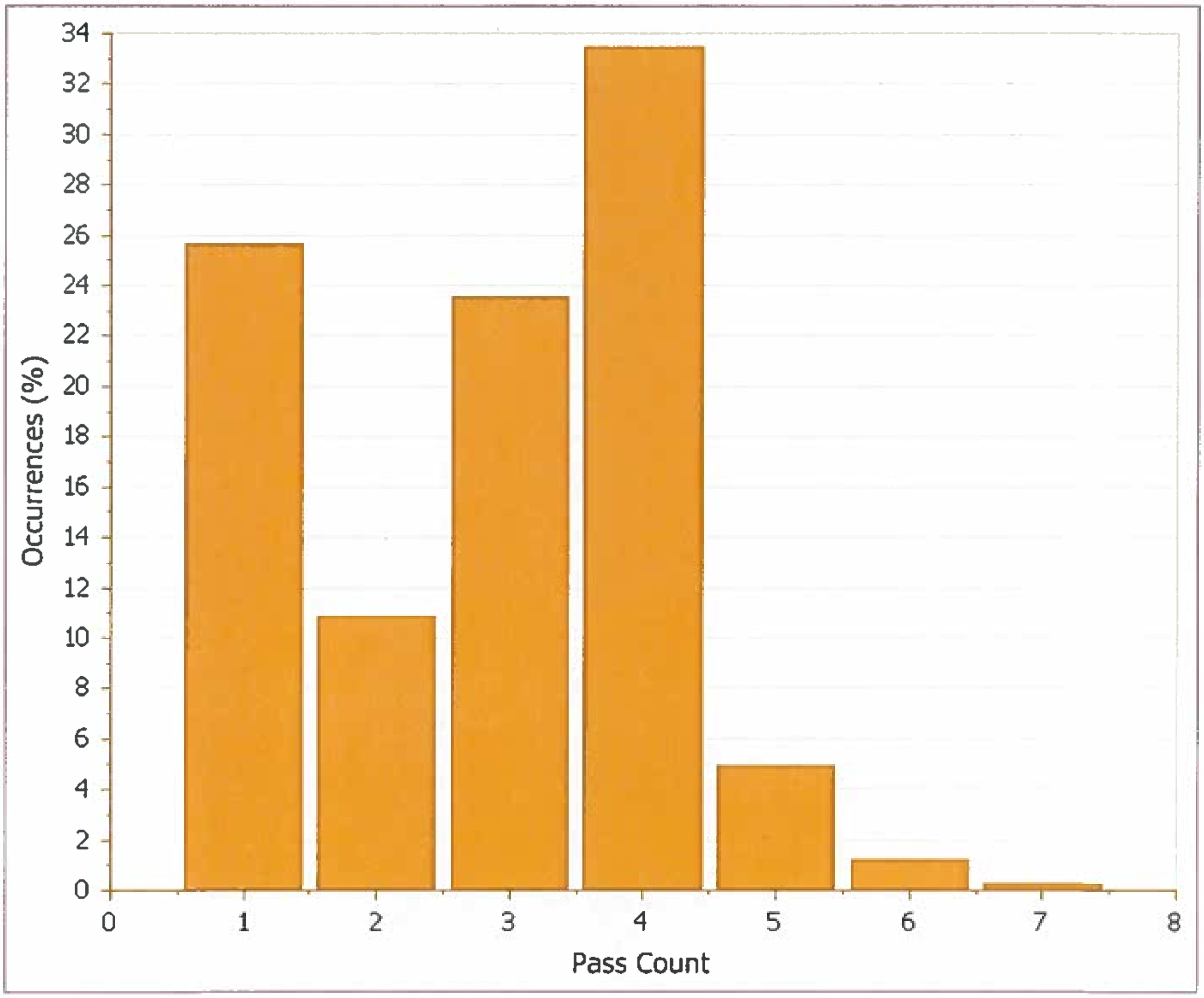
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

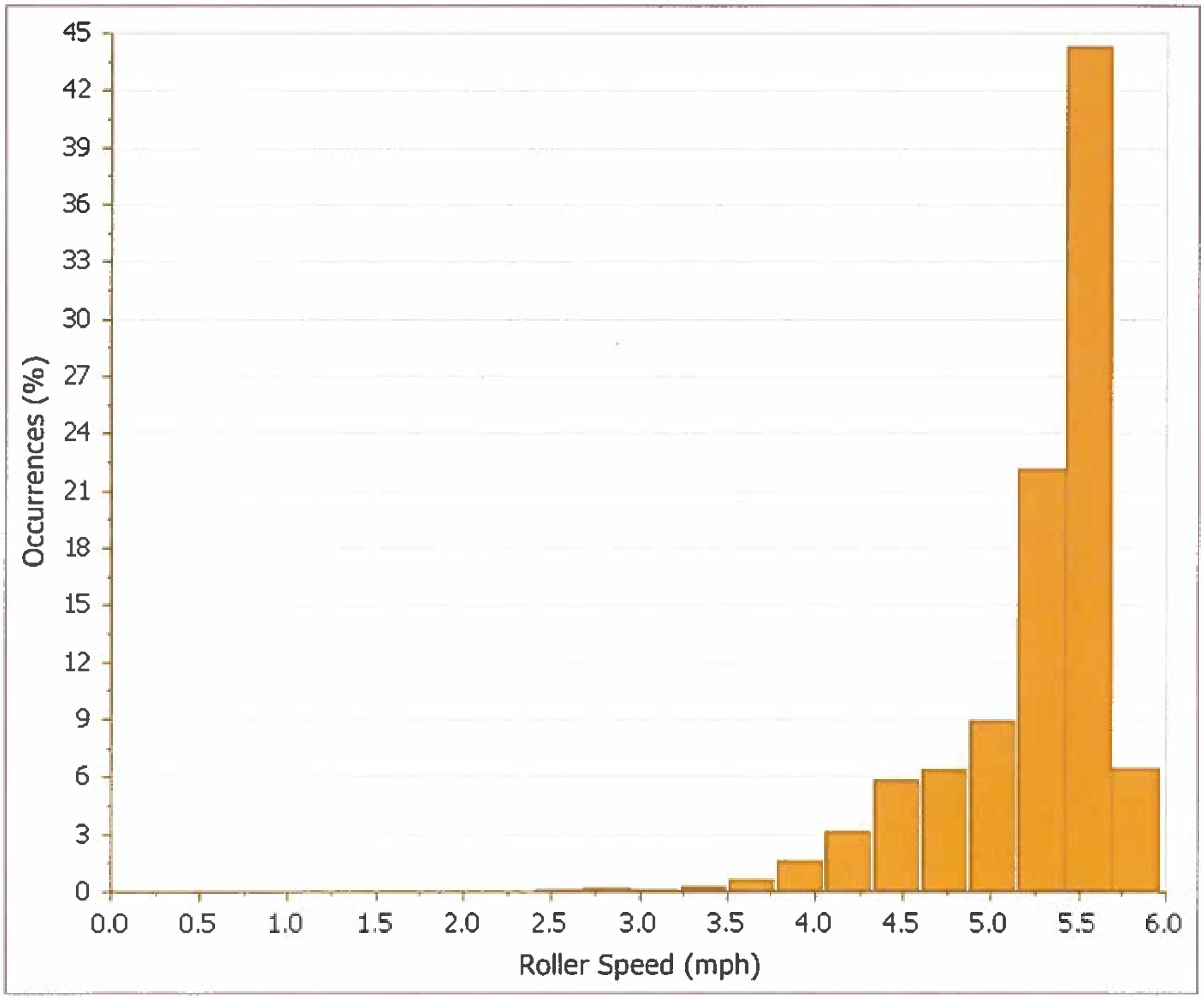
Statistic	Value
Mean	3
Standard Deviation	1
CoV (%)	47
Min	1
Max	7
Sample Size	89,955
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

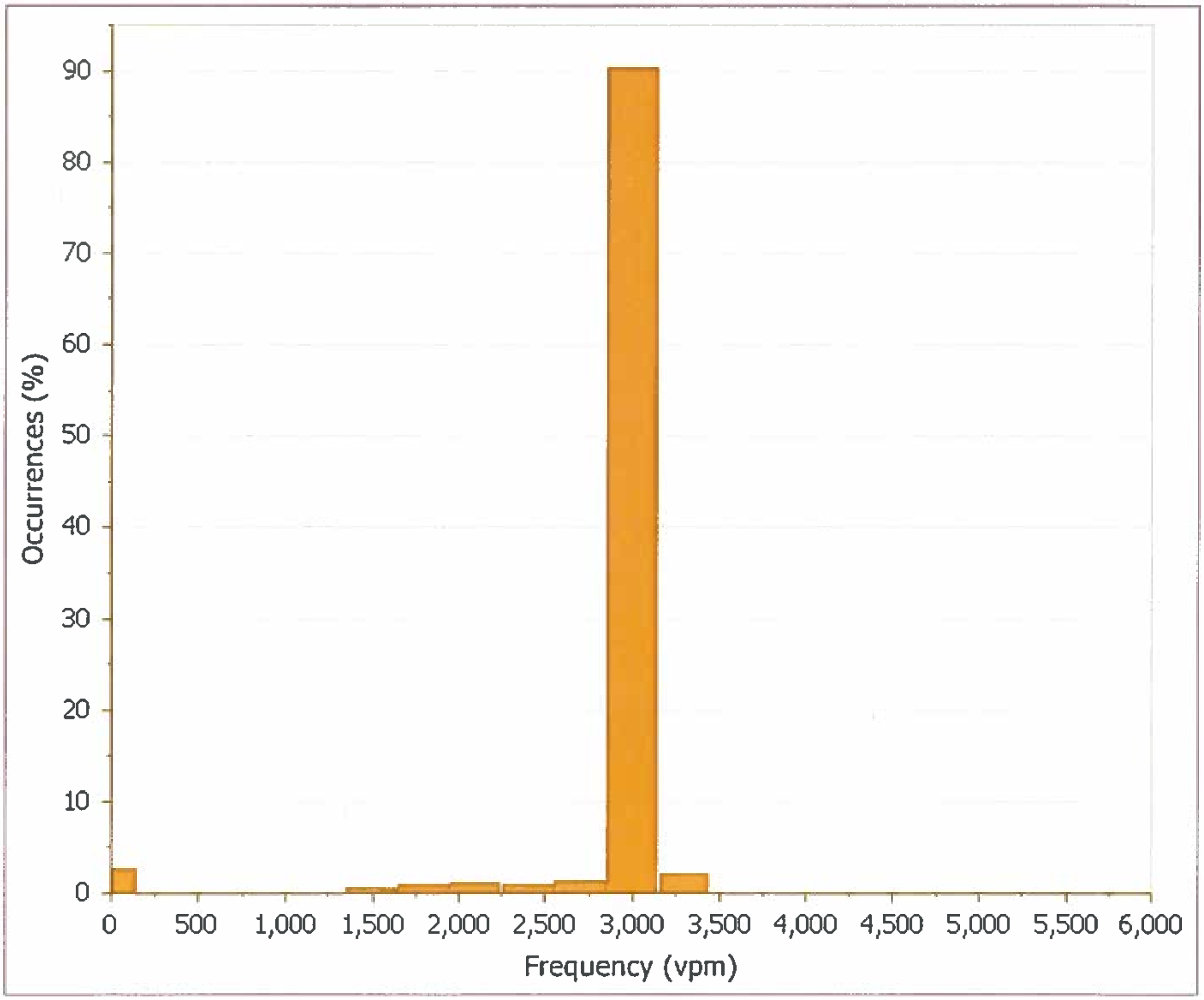
Target Percentage (%): 0.00
Target Value (mph): 0.0

Statistic	Value
Mean (mph)	5.1
Standard Deviation (mph)	0.5
CoV (%)	9
Min (mph)	0.6
Max (mph)	6.1
Sample Size	89,955
Target Status	Passed
% of Target Achieved	100.00



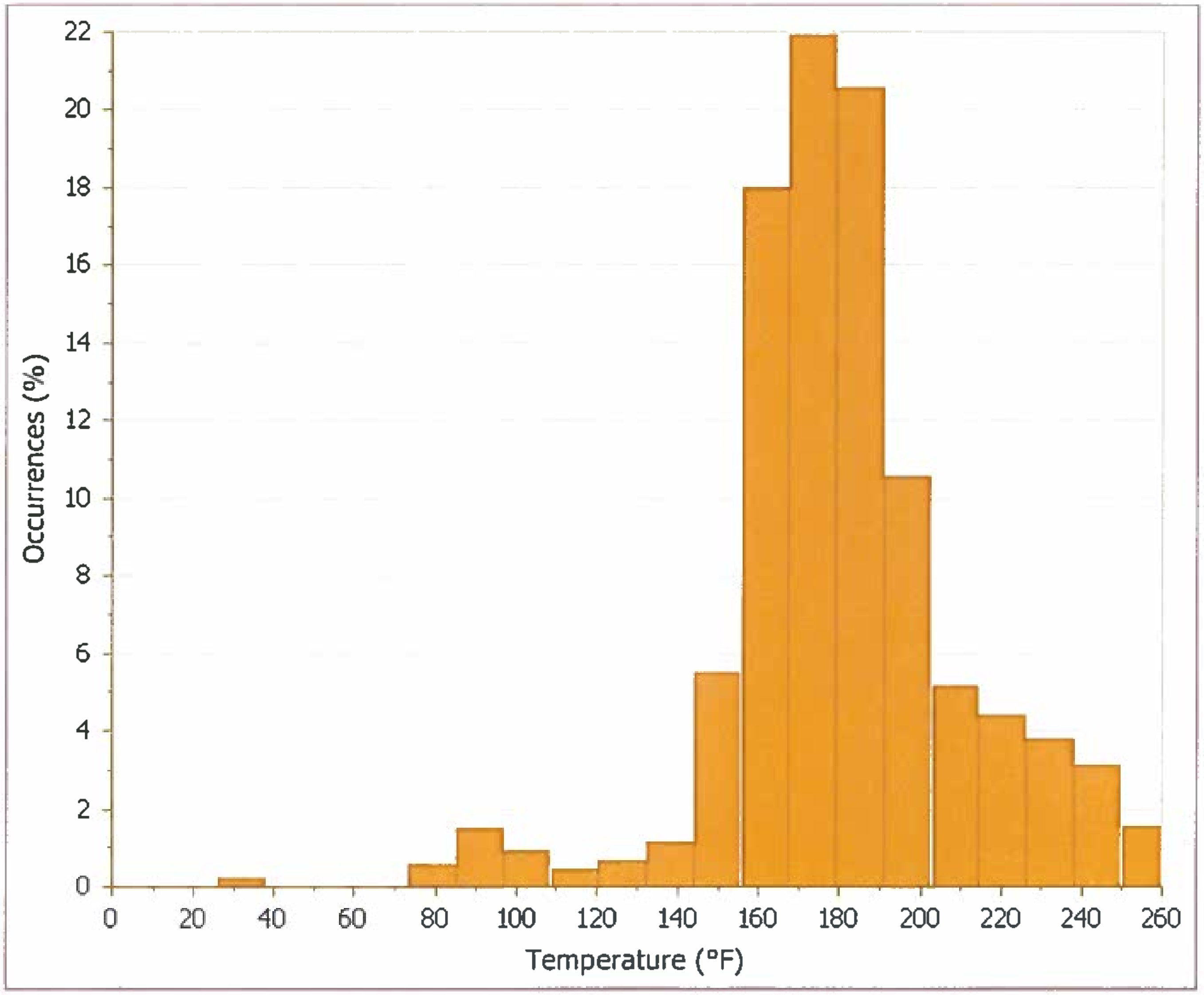
Final Coverage: Frequency
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,802
Standard Deviation (vpm)	514
CoV (%)	18
Min (vpm)	0
Max (vpm)	5,994
Sample Size	89,955
Target Status	Passed
% of Target Achieved	97.40



Final Coverage: Temperature

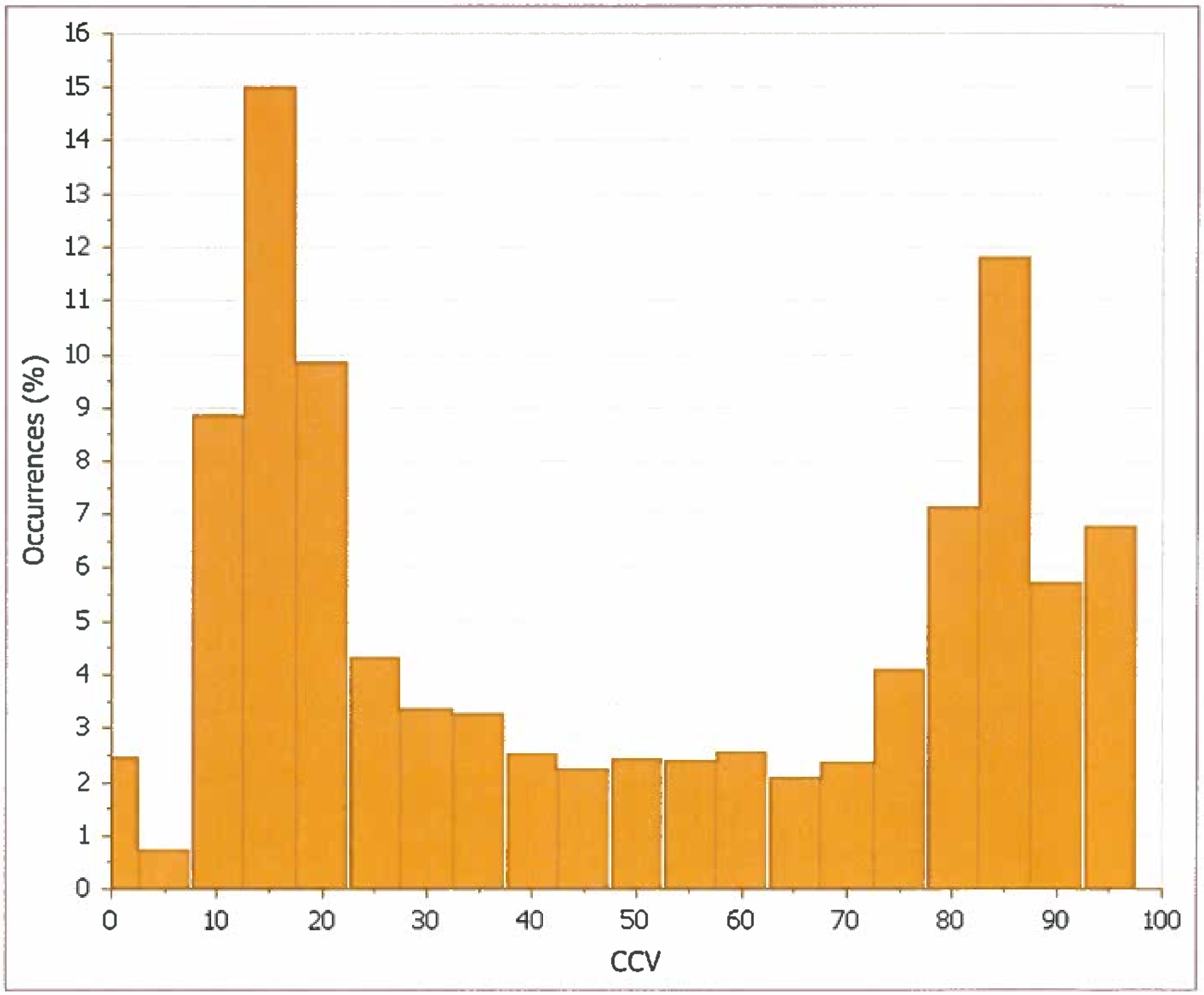
Statistic	Value
Mean (°F)	174.7
Standard Deviation (°F)	30.26
CoV (%)	17
Min (°F)	32.0
Max (°F)	267.5
Sample Size	89,955



Final Coverage: CCV

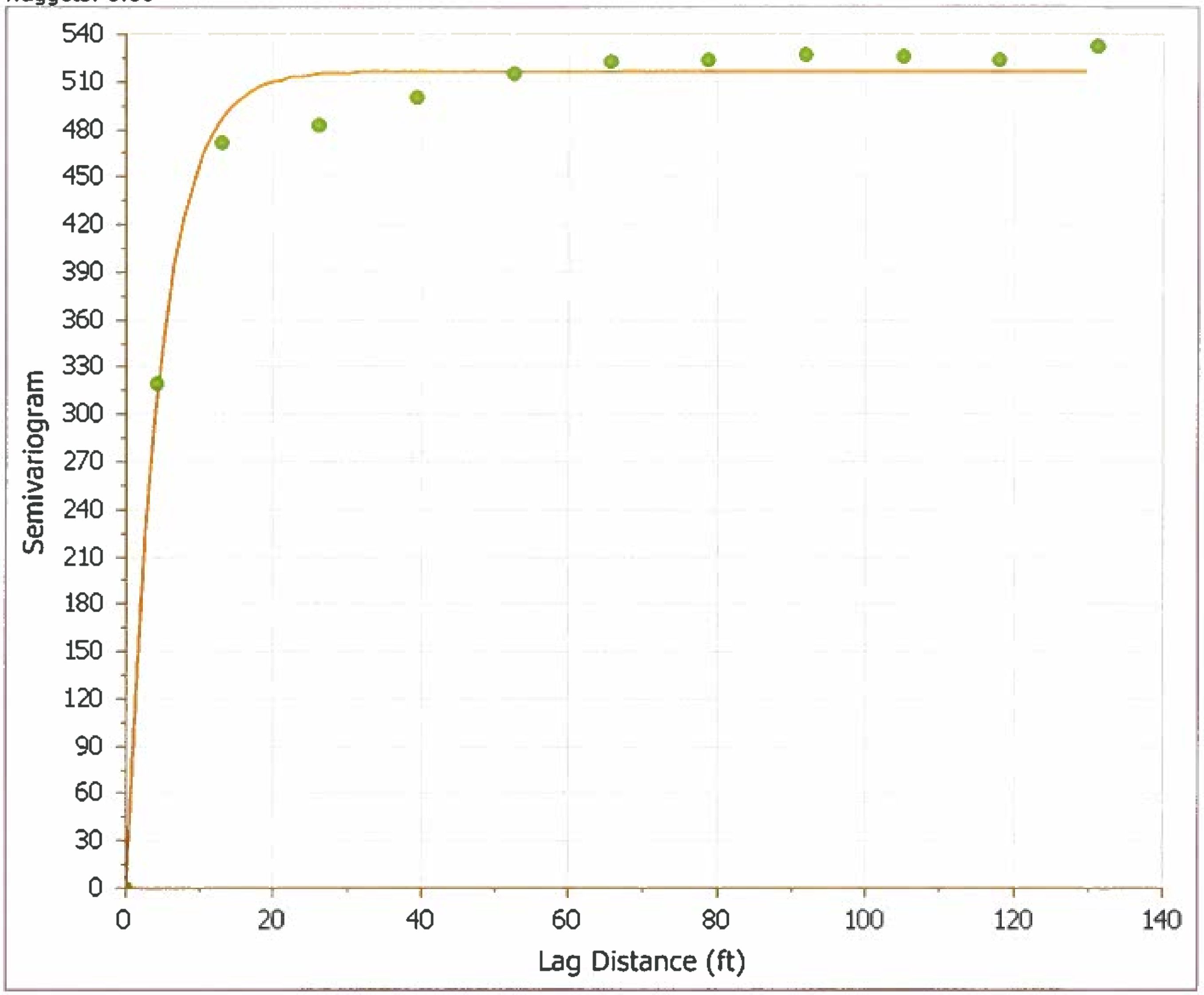
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	45.75
Standard Deviation	32.22
CoV (%)	70
Min	0.00
Max	100.00
Sample Size	89,955
Target Status	Passed
% of Target Achieved	97.55



Final Coverage: Semivariogram

Range (ft): 13.12
Sill: 487.79
Vertical Scale: 487.79
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20131219-1811-43
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

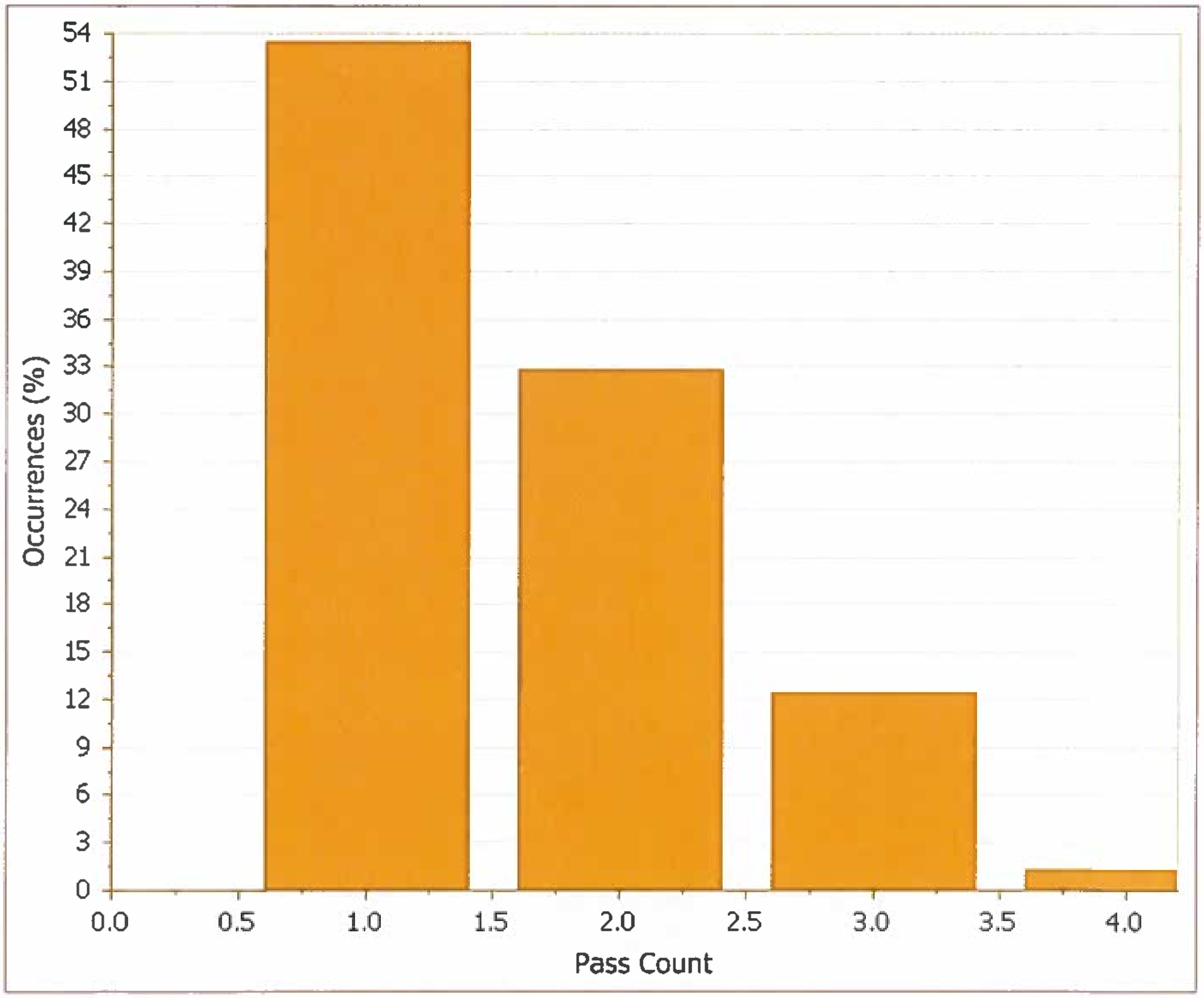
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

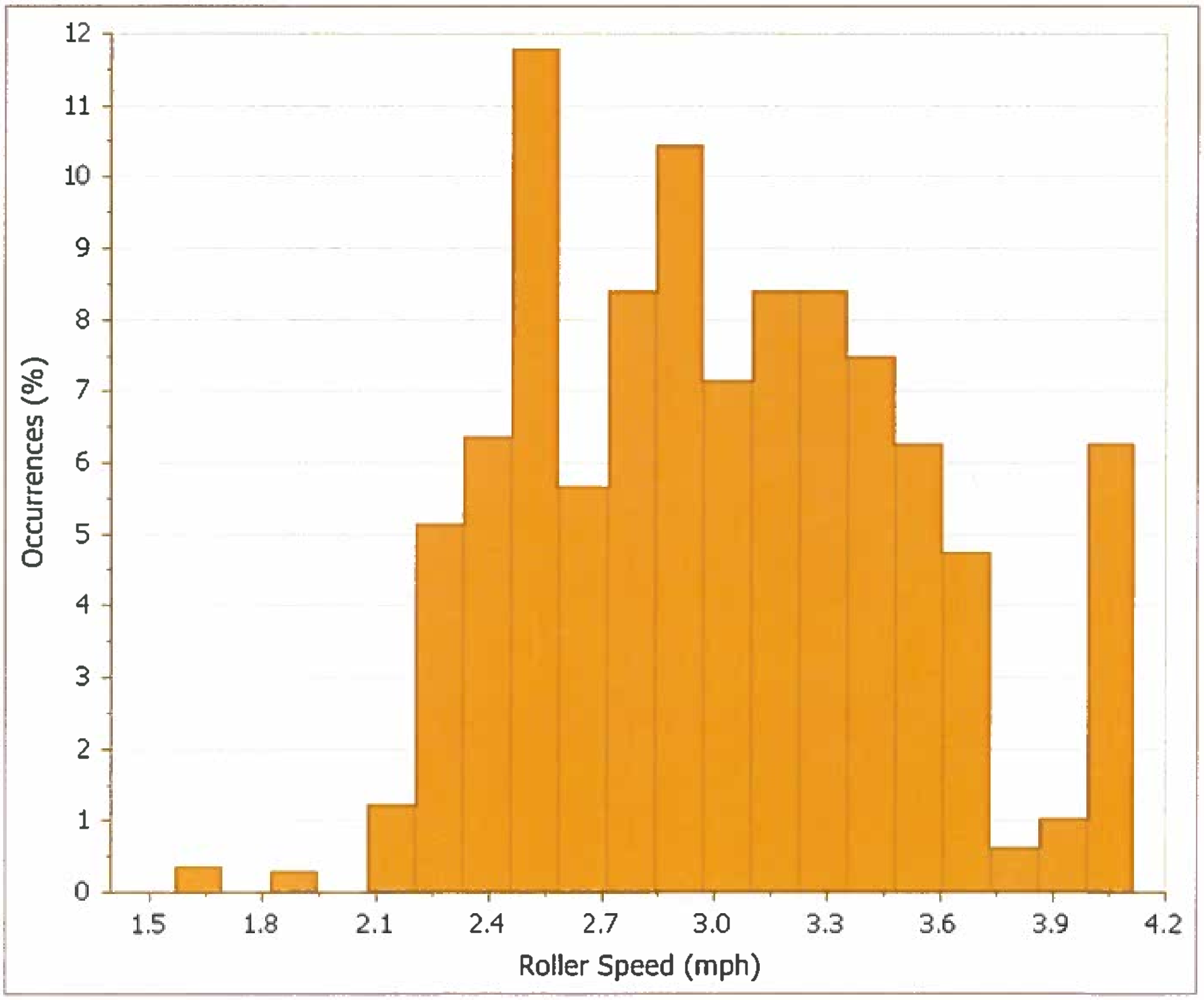
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	46
Min	1
Max	4
Sample Size	2,527
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

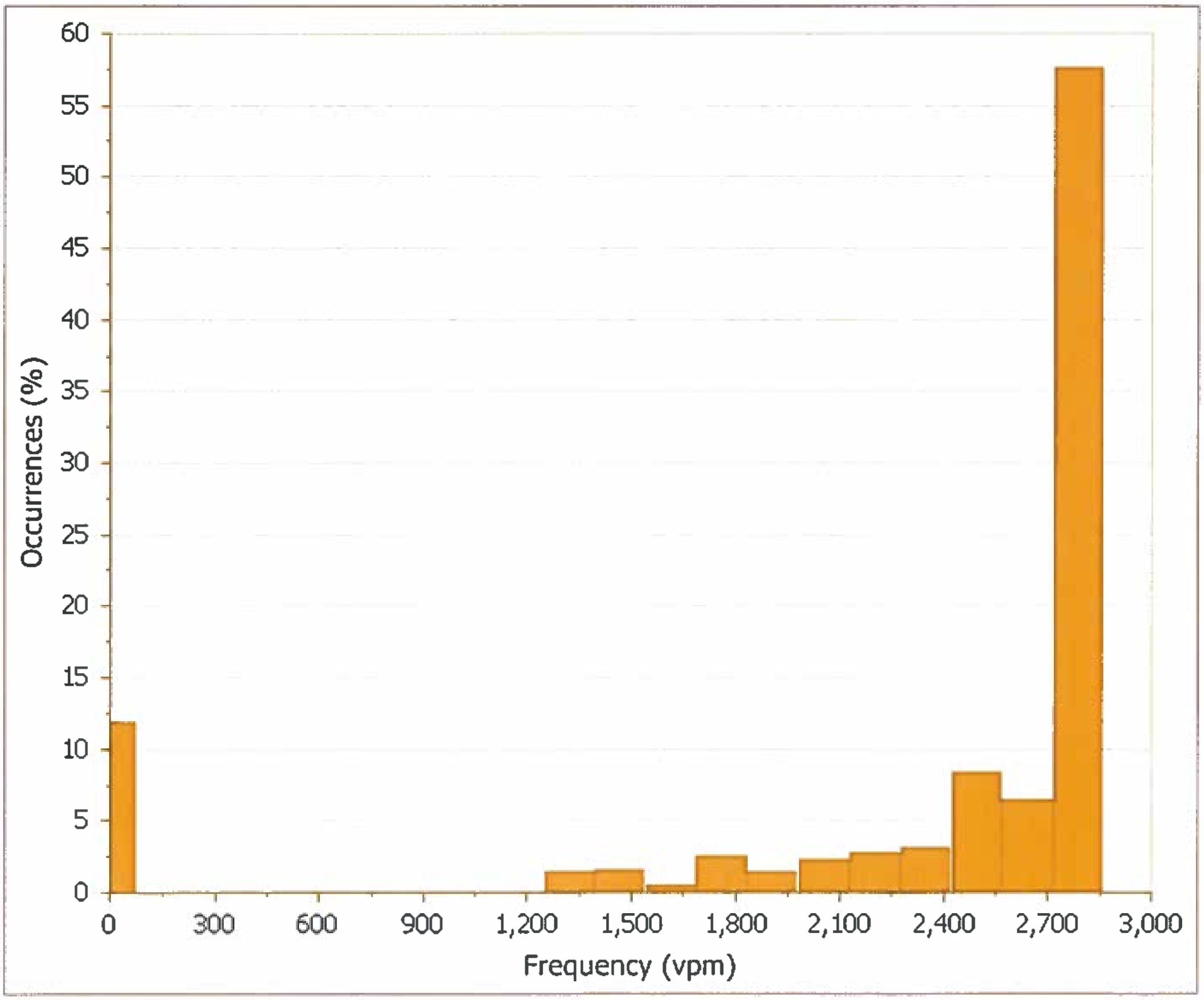
Statistic	Value
Mean (mph)	3.0
Standard Deviation (mph)	0.5
CoV (%)	18
Min (mph)	1.6
Max (mph)	4.2
Sample Size	2,527
Target Status	Passed
% of Target Achieved	99.64



Final Coverage: Frequency

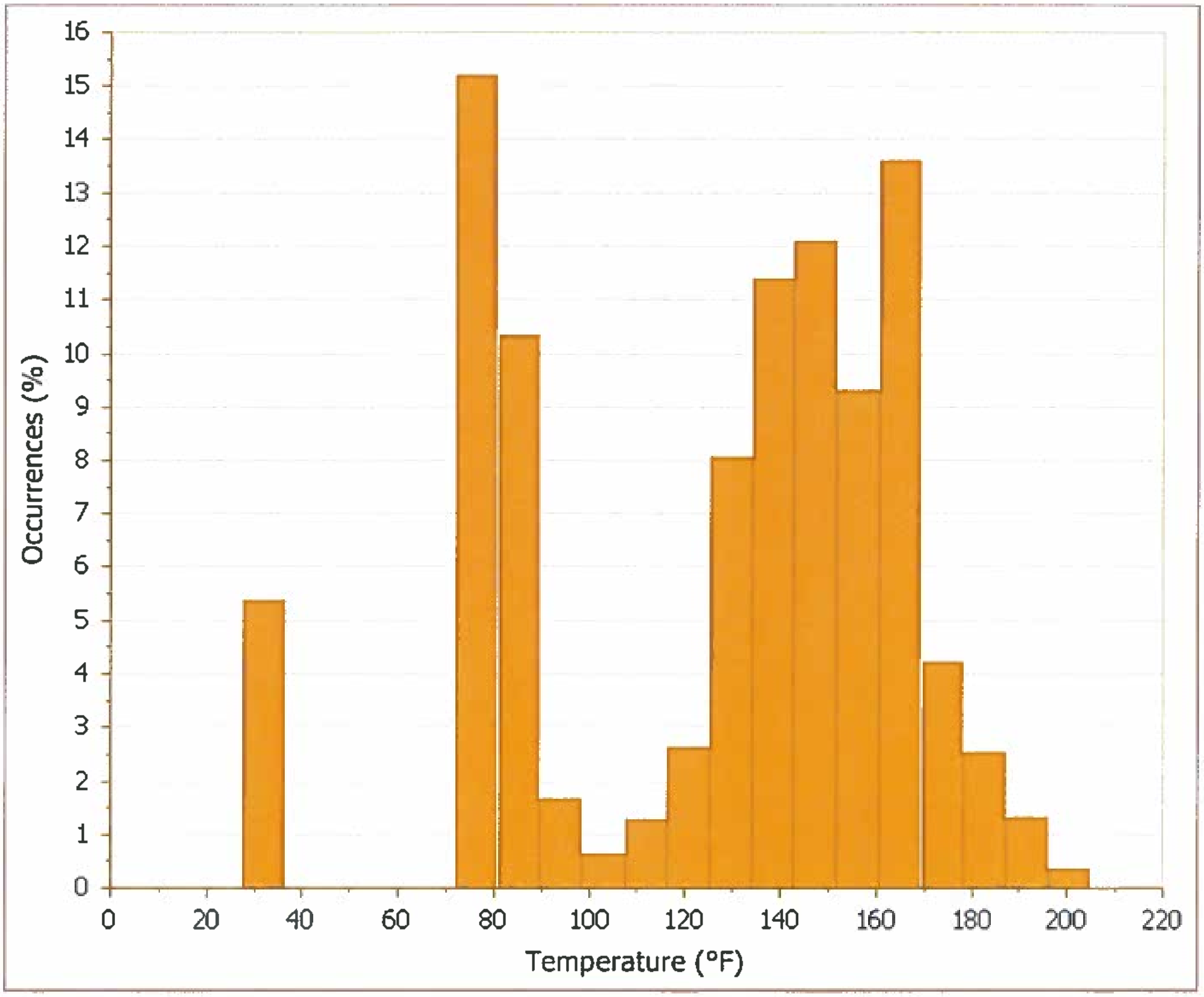
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,295
Standard Deviation (vpm)	920
CoV (%)	40
Min (vpm)	0
Max (vpm)	2,934
Sample Size	2,527
Target Status	Passed
% of Target Achieved	88.17



Final Coverage: Temperature

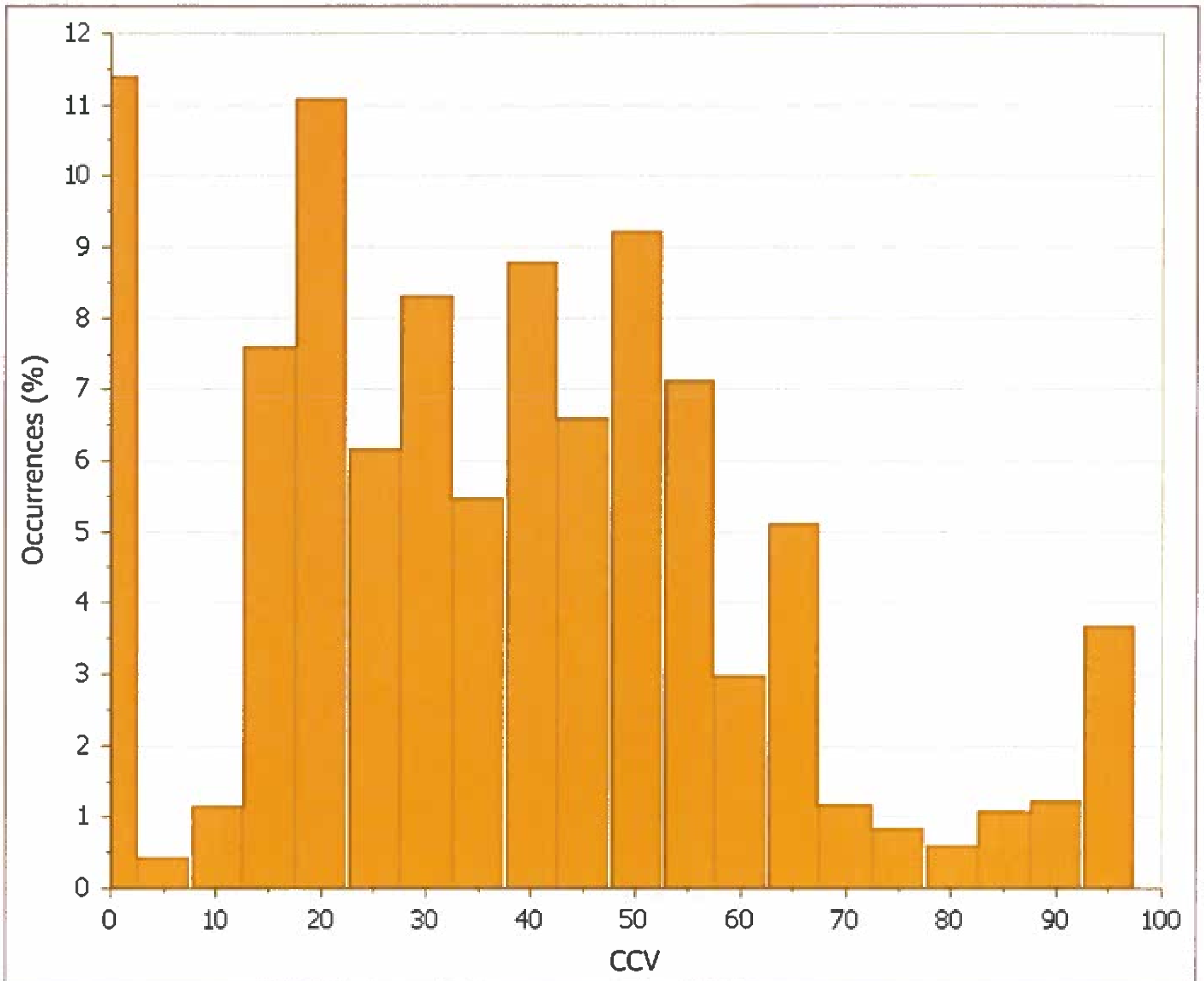
Statistic	Value
Mean (°F)	121.2
Standard Deviation (°F)	40.00
CoV (%)	33
Min (°F)	32.0
Max (°F)	209.3
Sample Size	2,527



Final Coverage: CCV

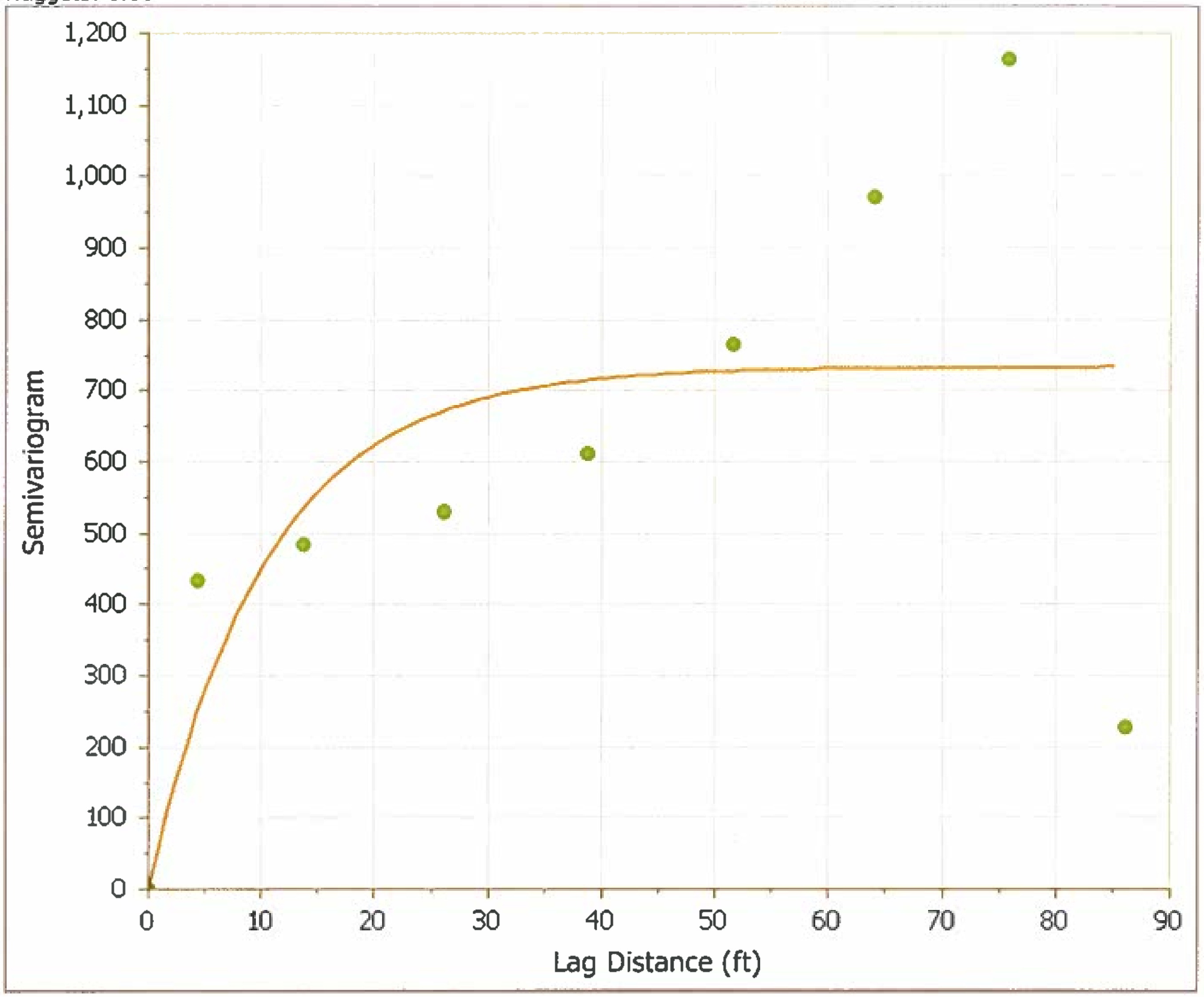
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	35.16
Standard Deviation	24.14
CoV (%)	69
Min	0.00
Max	100.00
Sample Size	2,527
Target Status	Passed
% of Target Achieved	88.60



Final Coverage: Semivariogram

Range (ft): 16.34
Sill: 579.02
Vertical Scale: 579.02
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20140113-1854-23
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

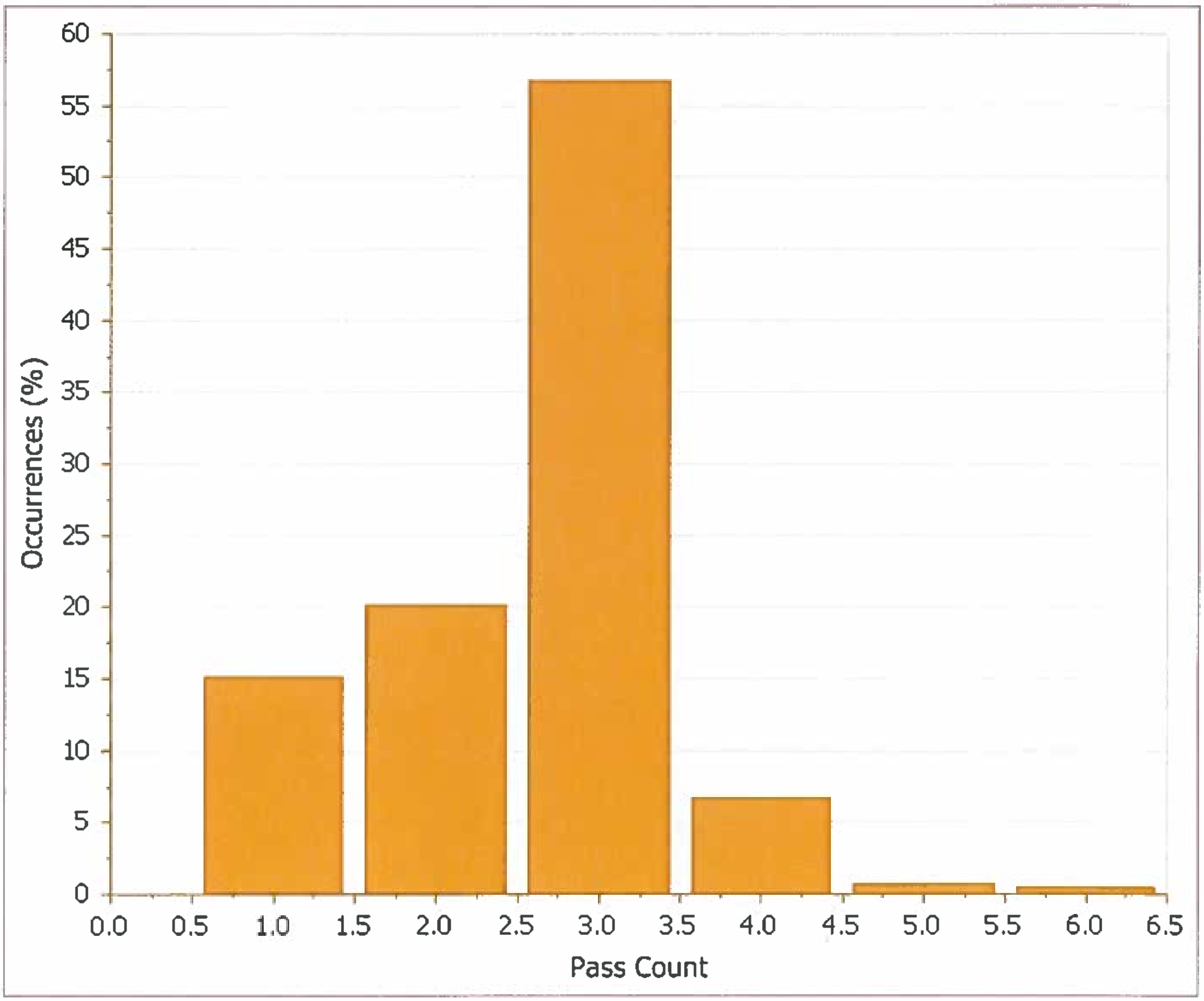
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

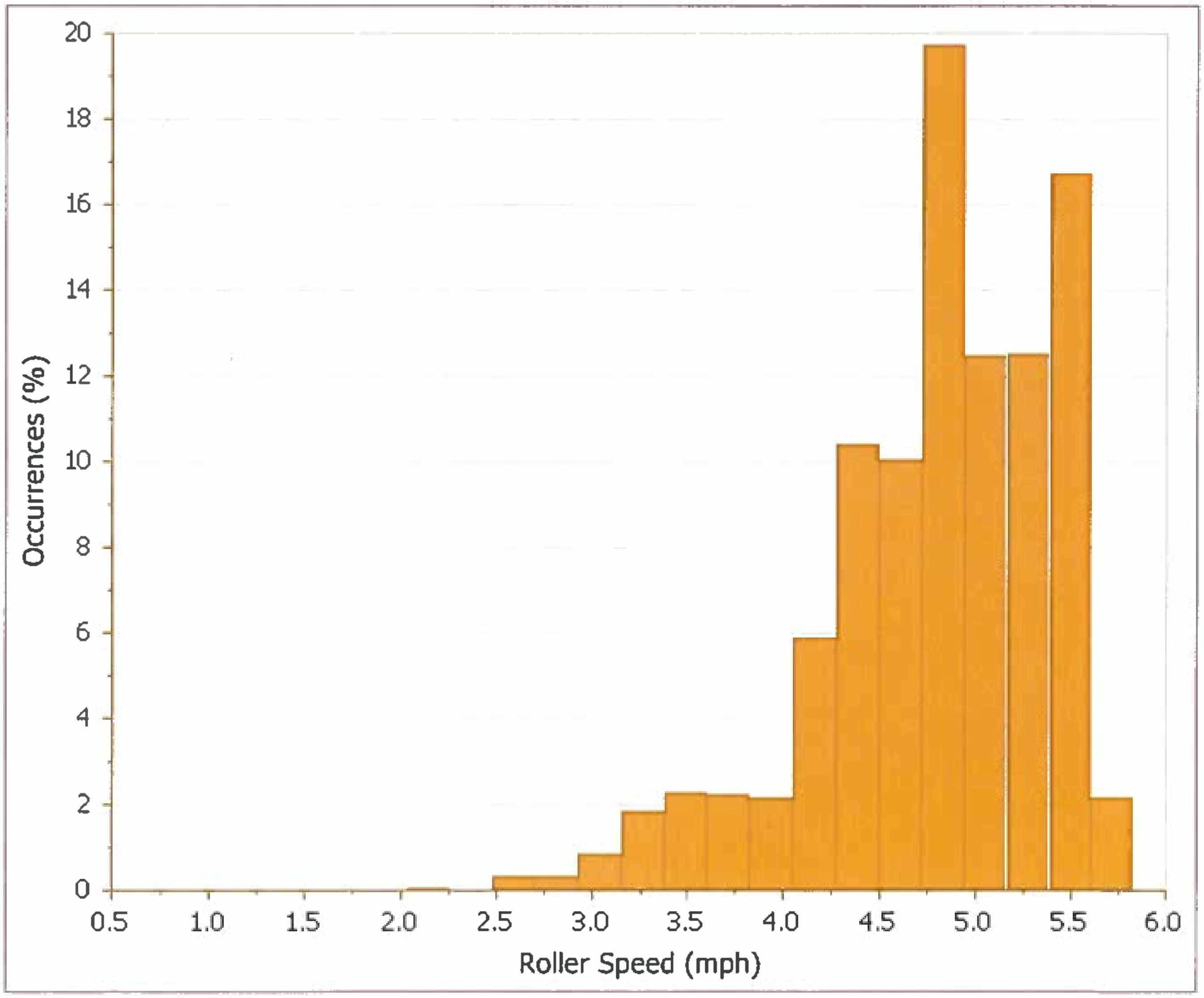
Statistic	Value
Mean	3
Standard Deviation	1
CoV (%)	34
Min	1
Max	6
Sample Size	50,137
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

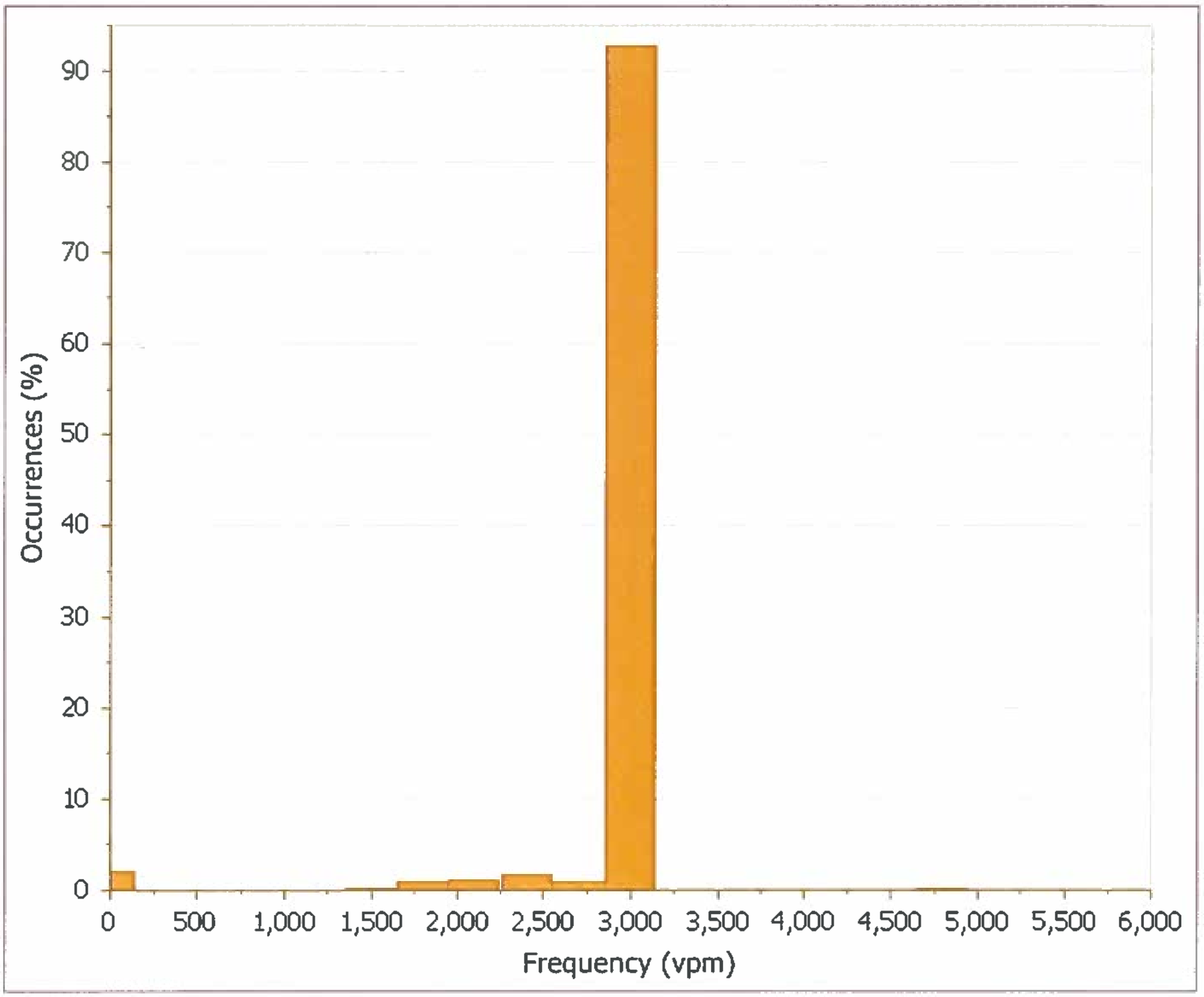
Statistic	Value
Mean (mph)	4.7
Standard Deviation (mph)	0.6
CoV (%)	13
Min (mph)	1.5
Max (mph)	5.9
Sample Size	50,137
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Frequency

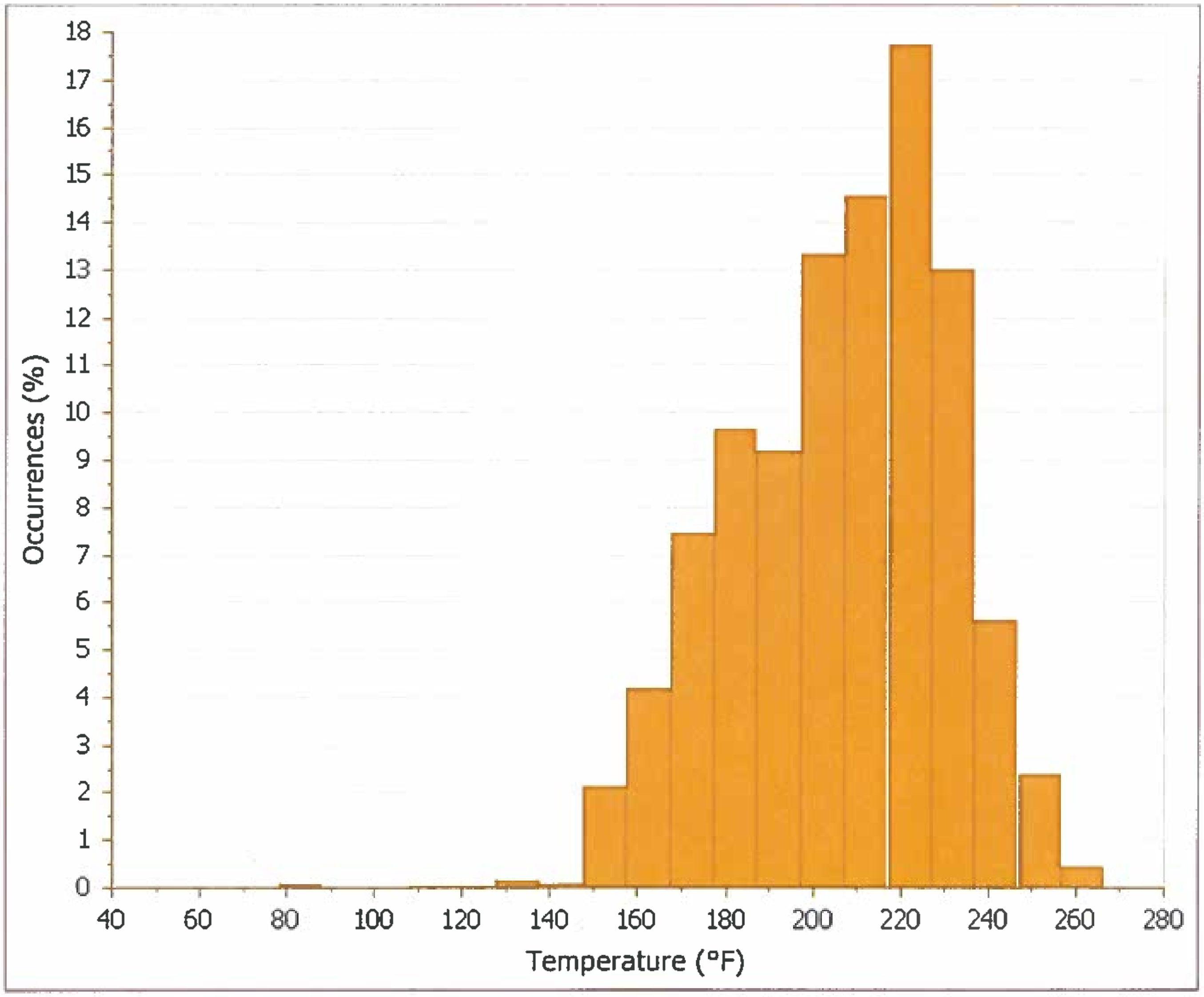
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,811
Standard Deviation (vpm)	465
CoV (%)	17
Min (vpm)	0
Max (vpm)	5,994
Sample Size	50,137
Target Status	Passed
% of Target Achieved	97.97



Final Coverage: Temperature

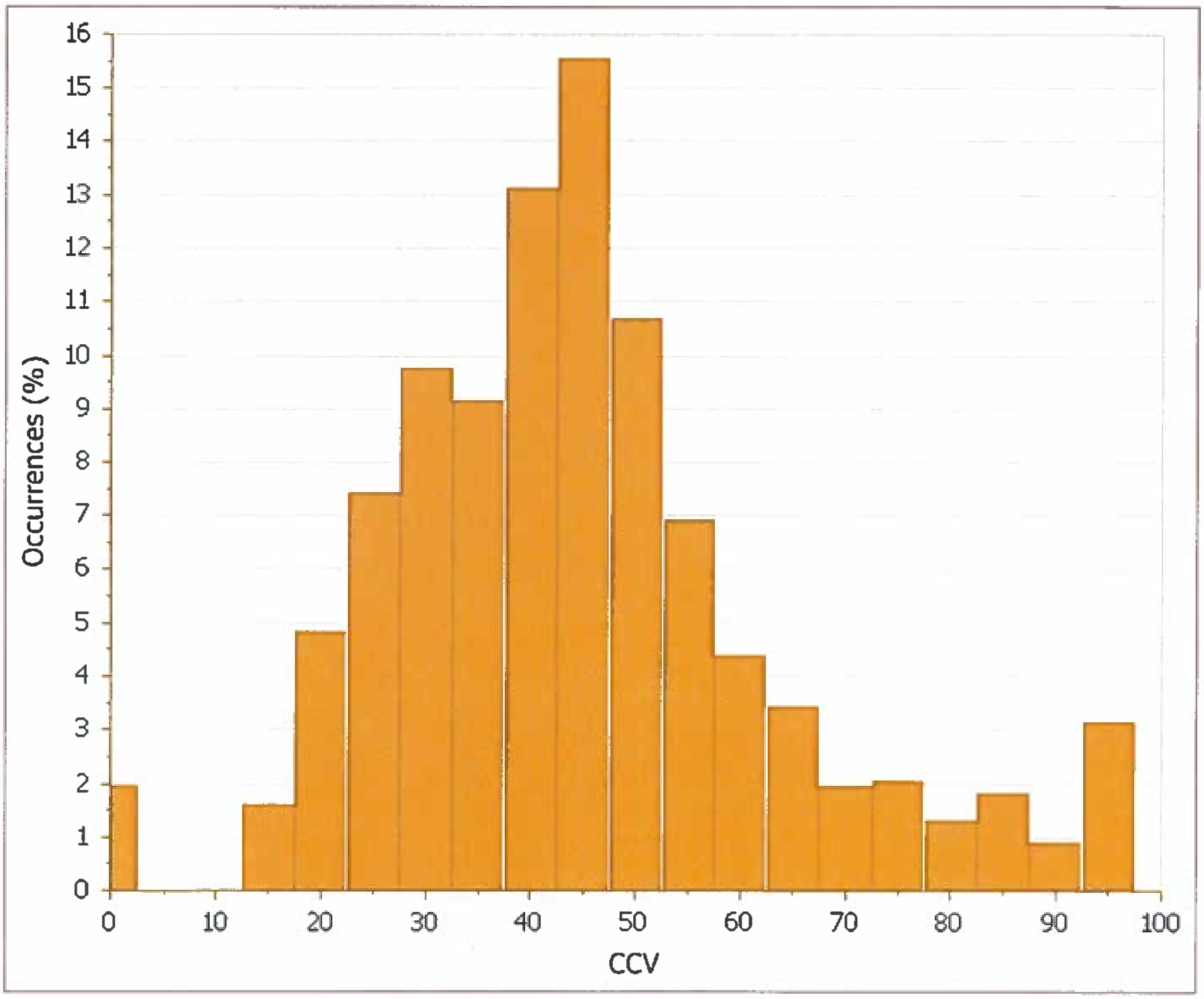
Statistic	Value
Mean (°F)	201.3
Standard Deviation (°F)	24.47
CoV (%)	12
Min (°F)	73.1
Max (°F)	271.5
Sample Size	50,137



Final Coverage: CCV

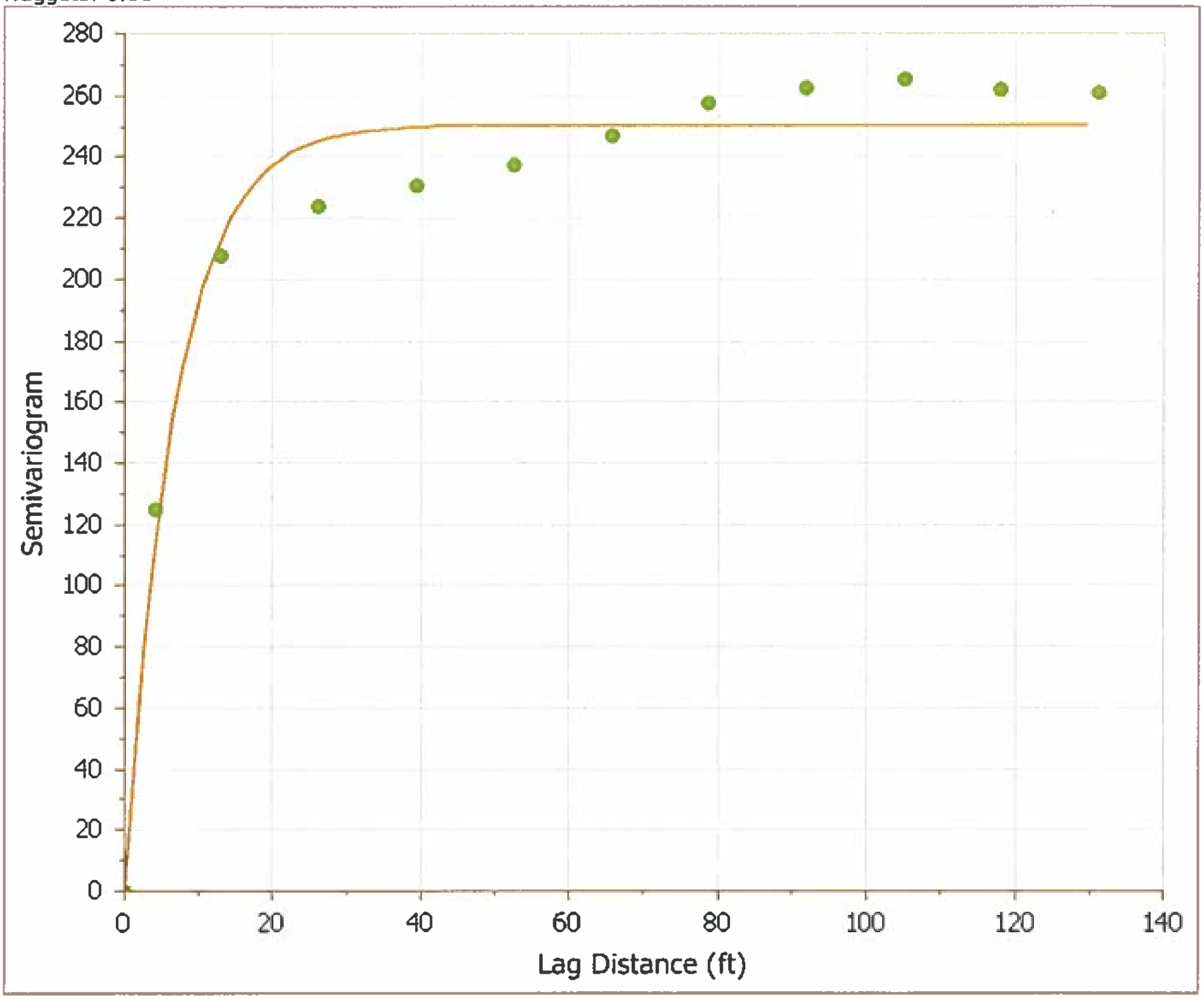
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	42.49
Standard Deviation	19.06
CoV (%)	45
Min	0.00
Max	100.00
Sample Size	50,137
Target Status	Passed
% of Target Achieved	98.06



Final Coverage: Semivariogram

Range (ft): 15.75
Sill: 225.77
Vertical Scale: 225.77
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20140113-2334-43
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

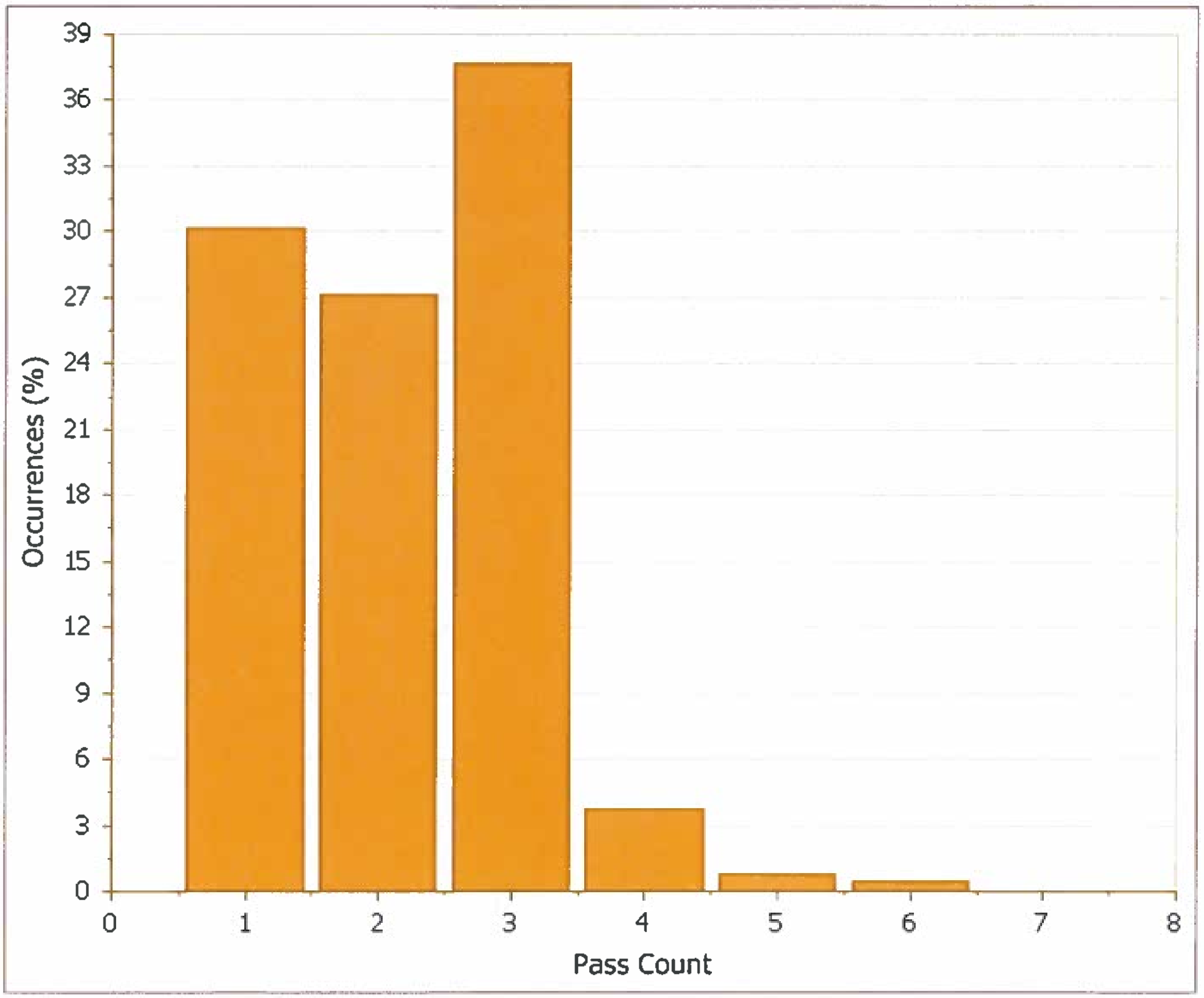
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

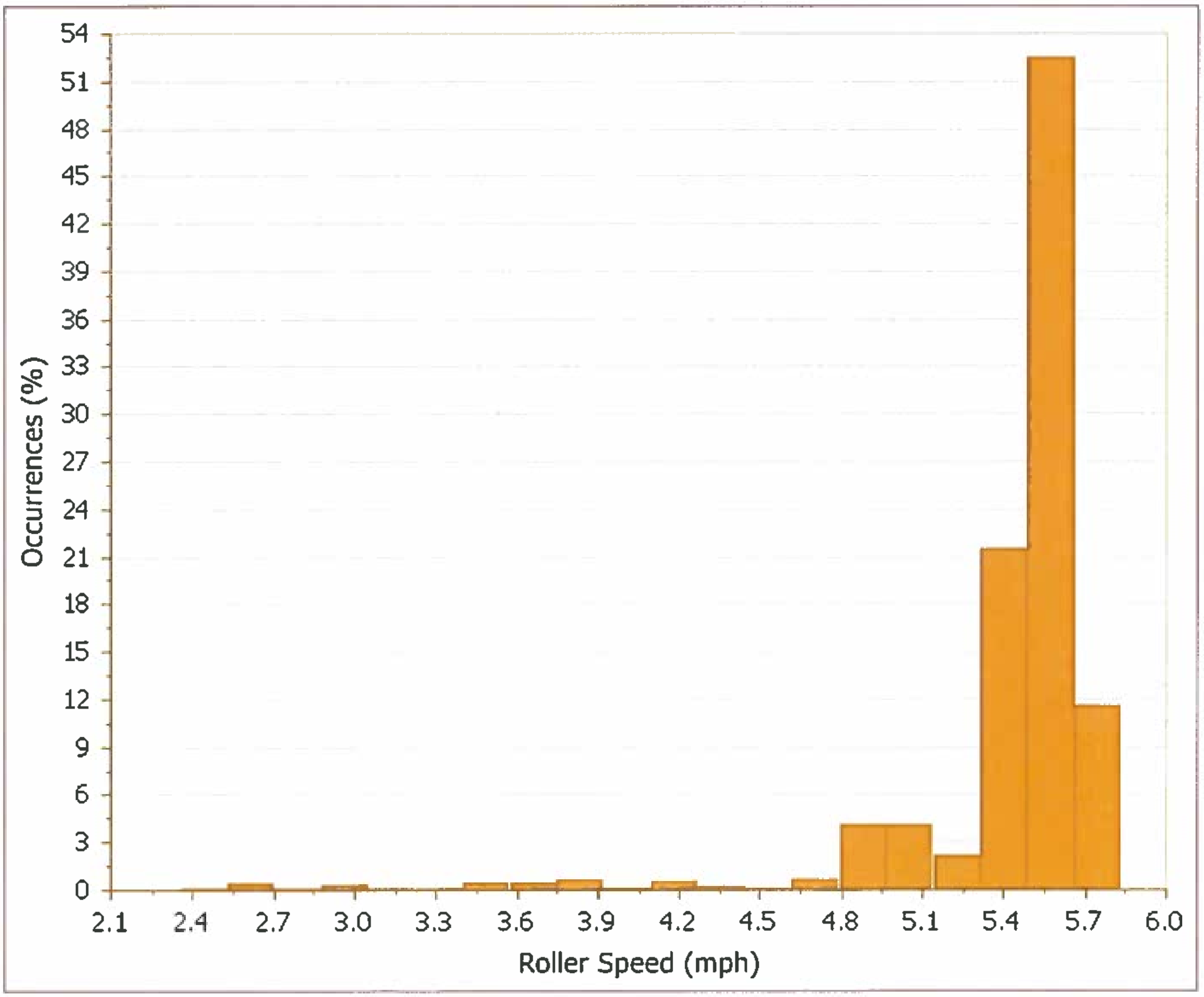
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	44
Min	1
Max	7
Sample Size	17,907
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

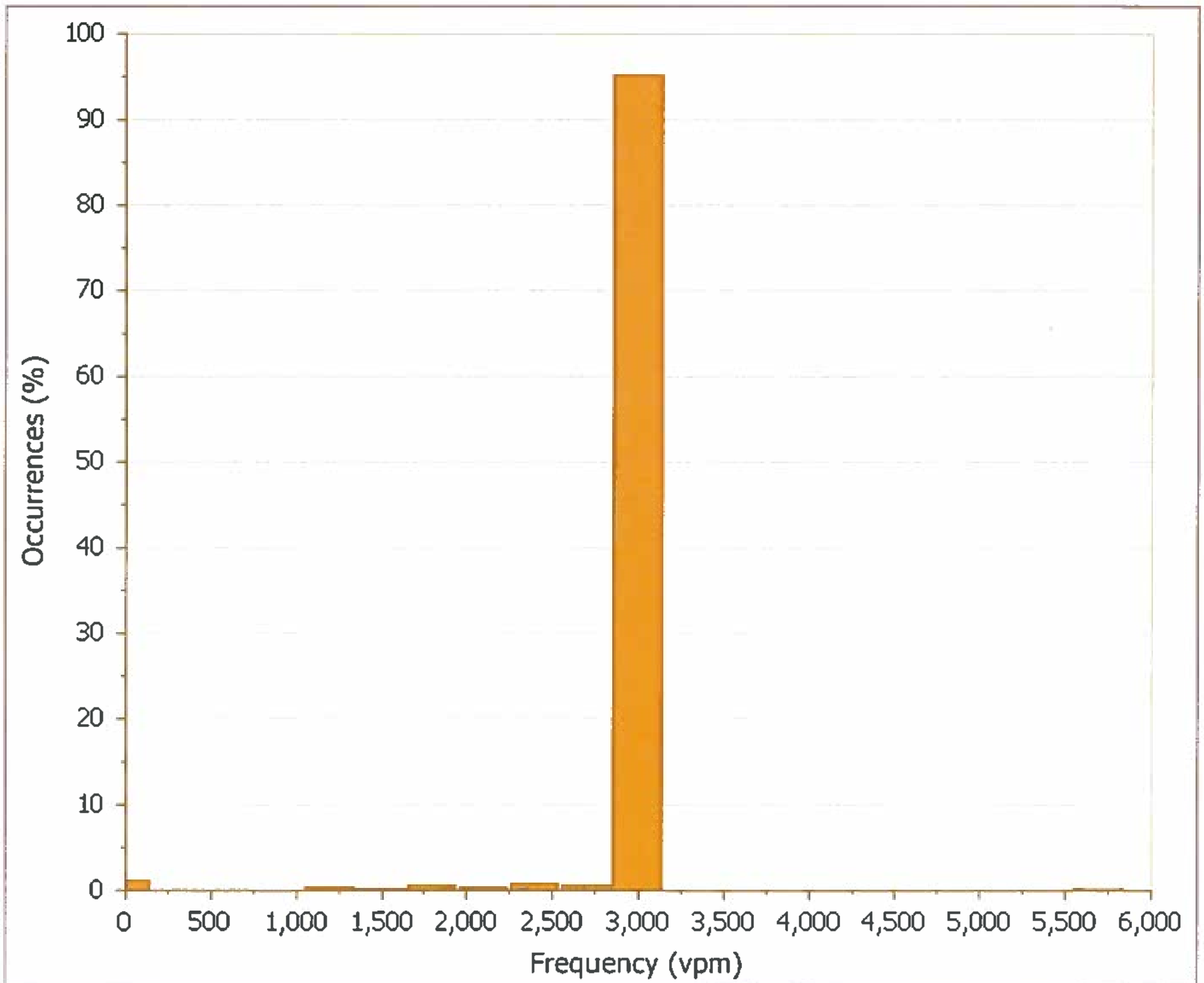
Statistic	Value
Mean (mph)	5.3
Standard Deviation (mph)	0.4
CoV (%)	8
Min (mph)	2.4
Max (mph)	5.9
Sample Size	17,907
Target Status	Passed
% of Target Achieved	99.93



Final Coverage: Frequency

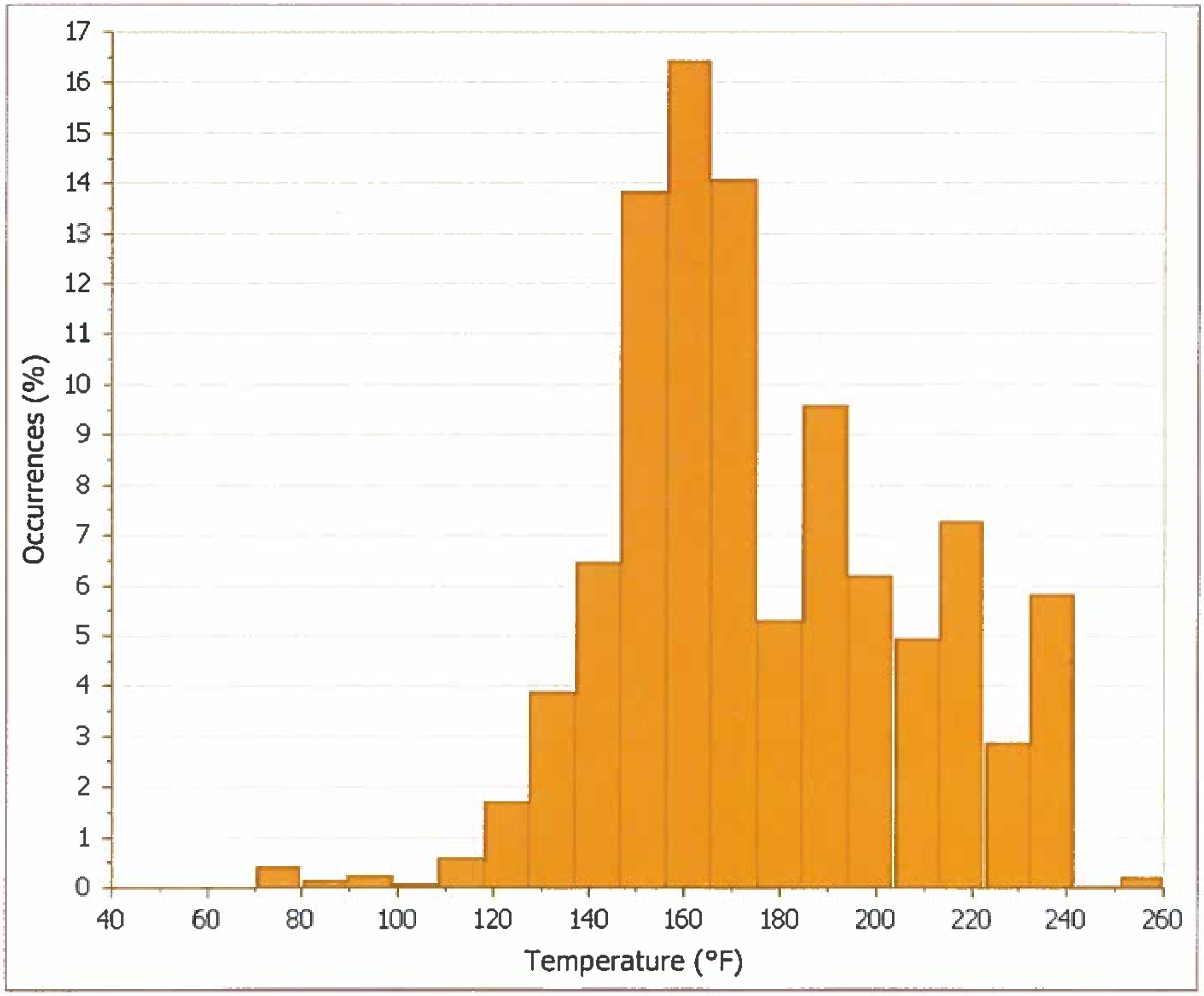
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,866
Standard Deviation (vpm)	393
CoV (%)	14
Min (vpm)	0
Max (vpm)	5,994
Sample Size	17,907
Target Status	Passed
% of Target Achieved	98.74



Final Coverage: Temperature

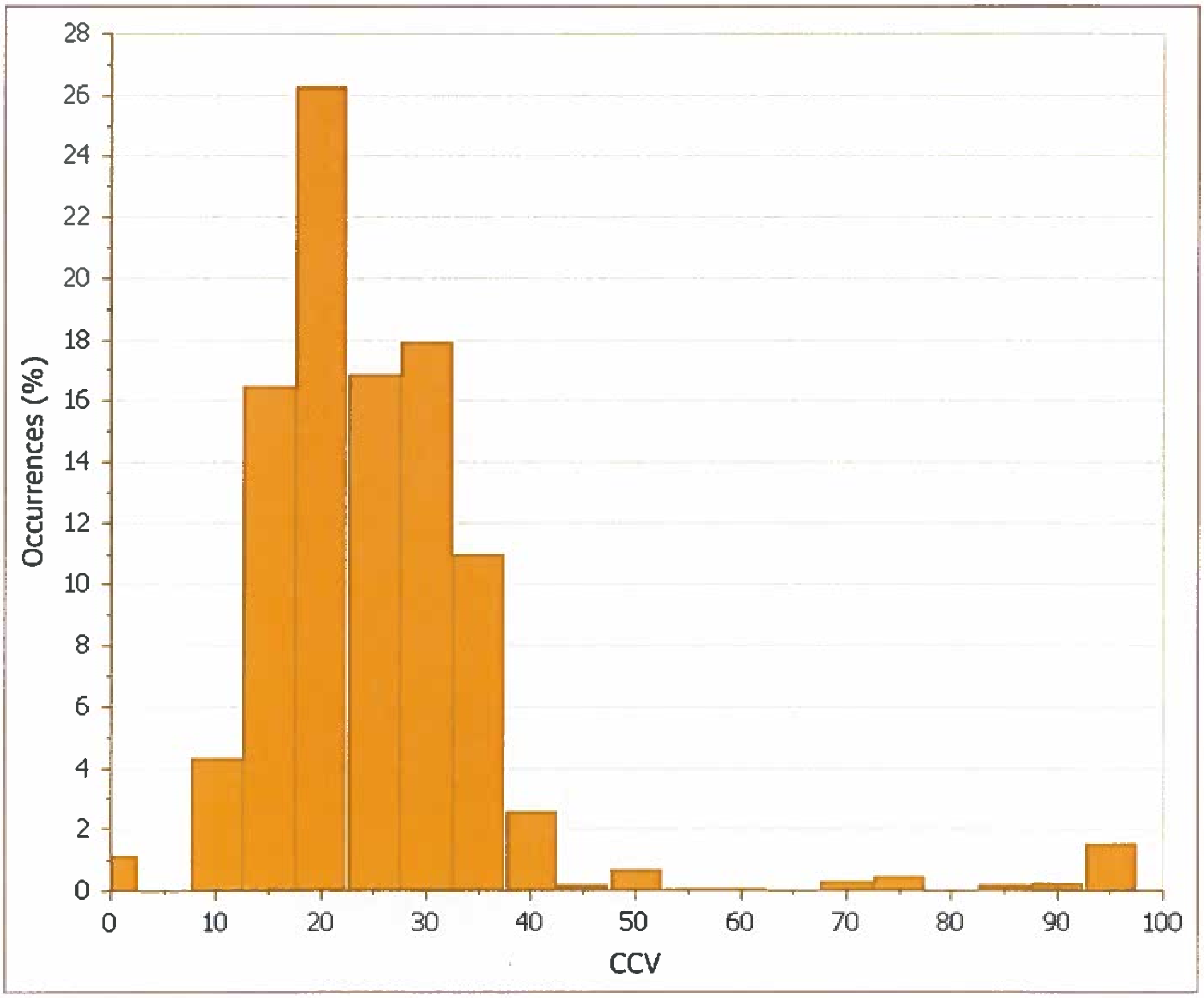
Statistic	Value
Mean (°F)	171.3
Standard Deviation (°F)	30.69
CoV (%)	18
Min (°F)	75.1
Max (°F)	265.5
Sample Size	17,907



Final Coverage: CCV

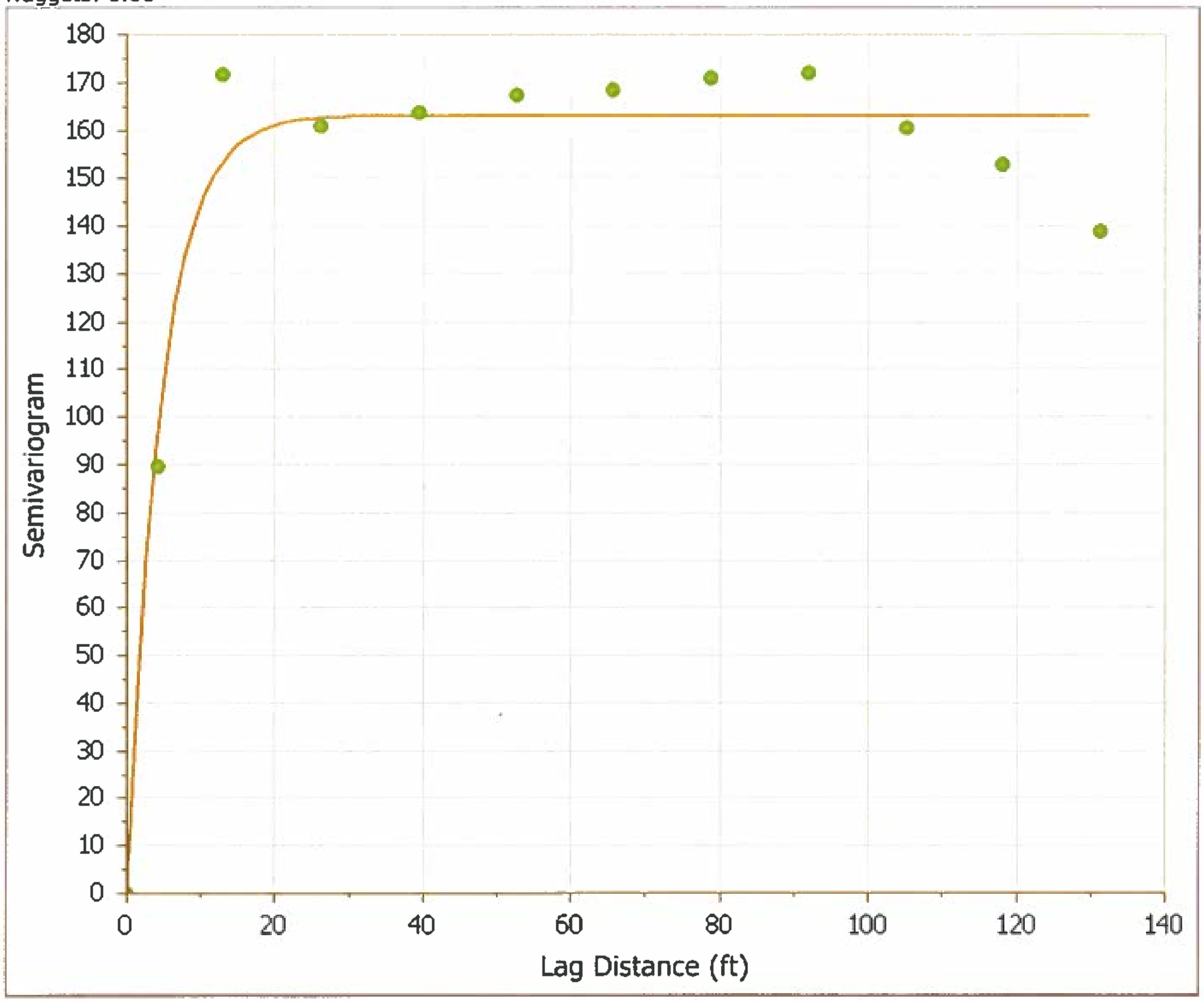
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	23.17
Standard Deviation	13.40
CoV (%)	58
Min	0.00
Max	100.00
Sample Size	17,907
Target Status	Passed
% of Target Achieved	98.88



Final Coverage: Semivariogram

Range (ft): 13.12
Sill: 153.81
Vertical Scale: 153.81
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20140114-1647-56
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

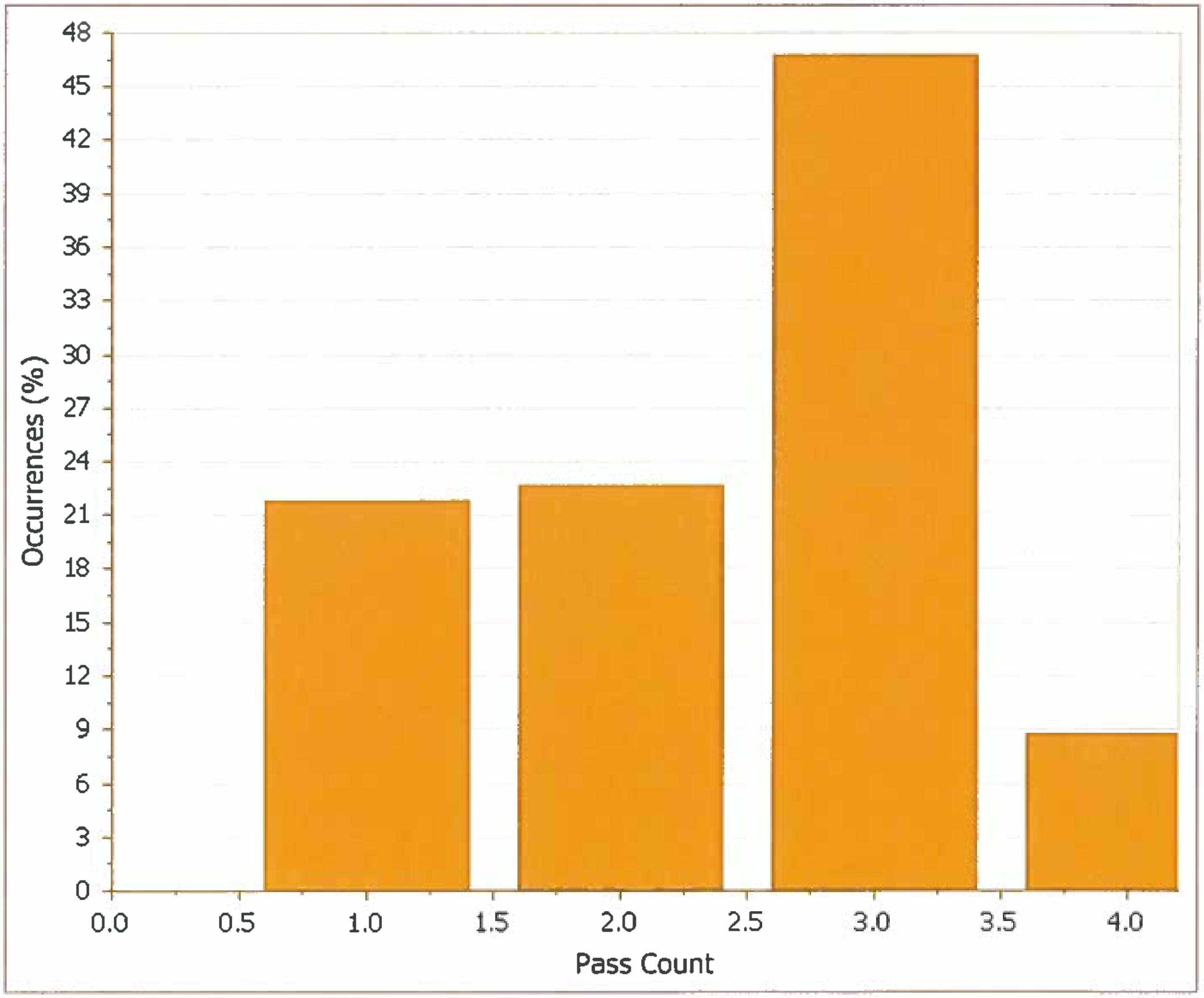
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

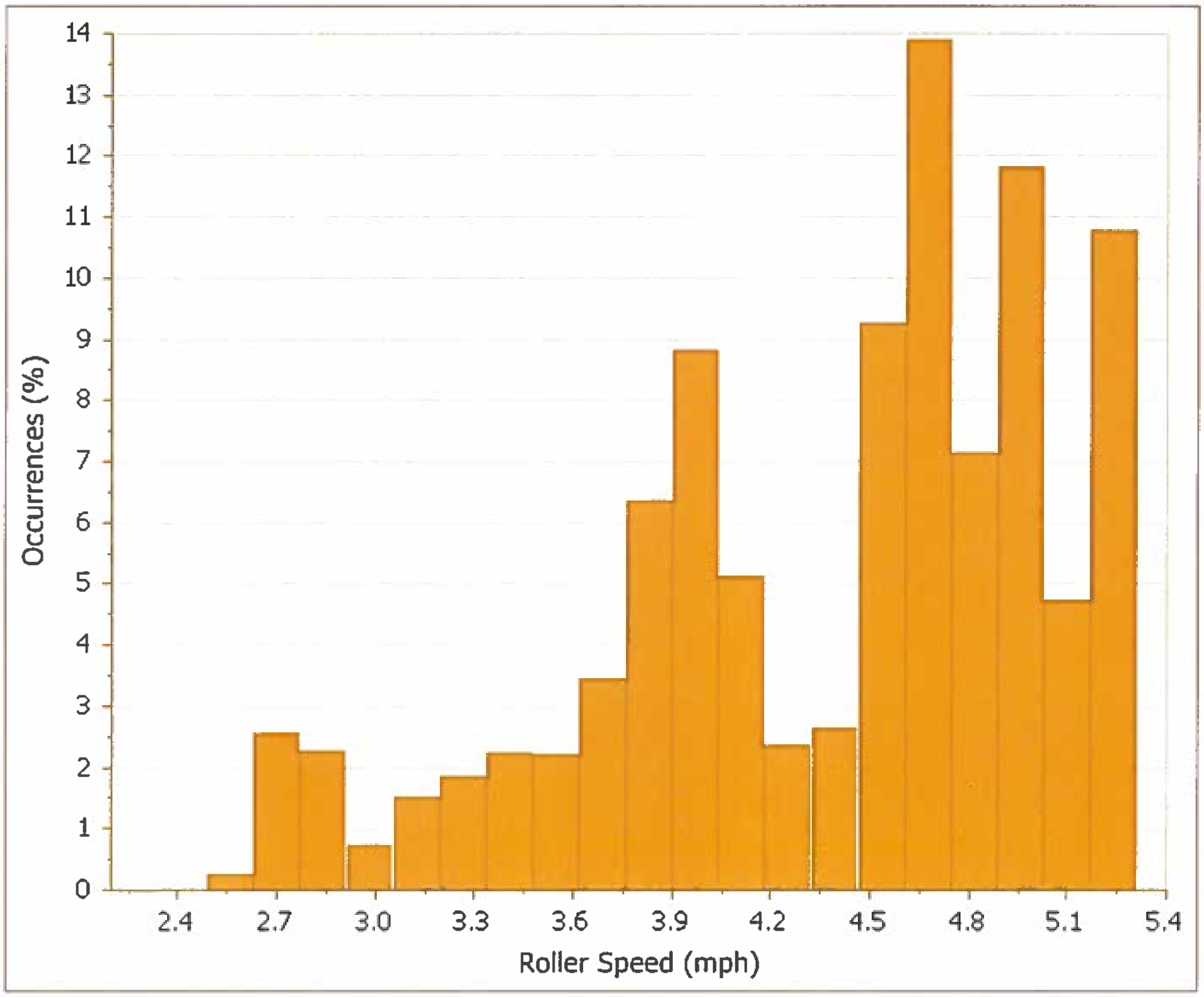
Statistic	Value
Mean	2
Standard Deviation	1
CoV (%)	38
Min	1
Max	4
Sample Size	7,913
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

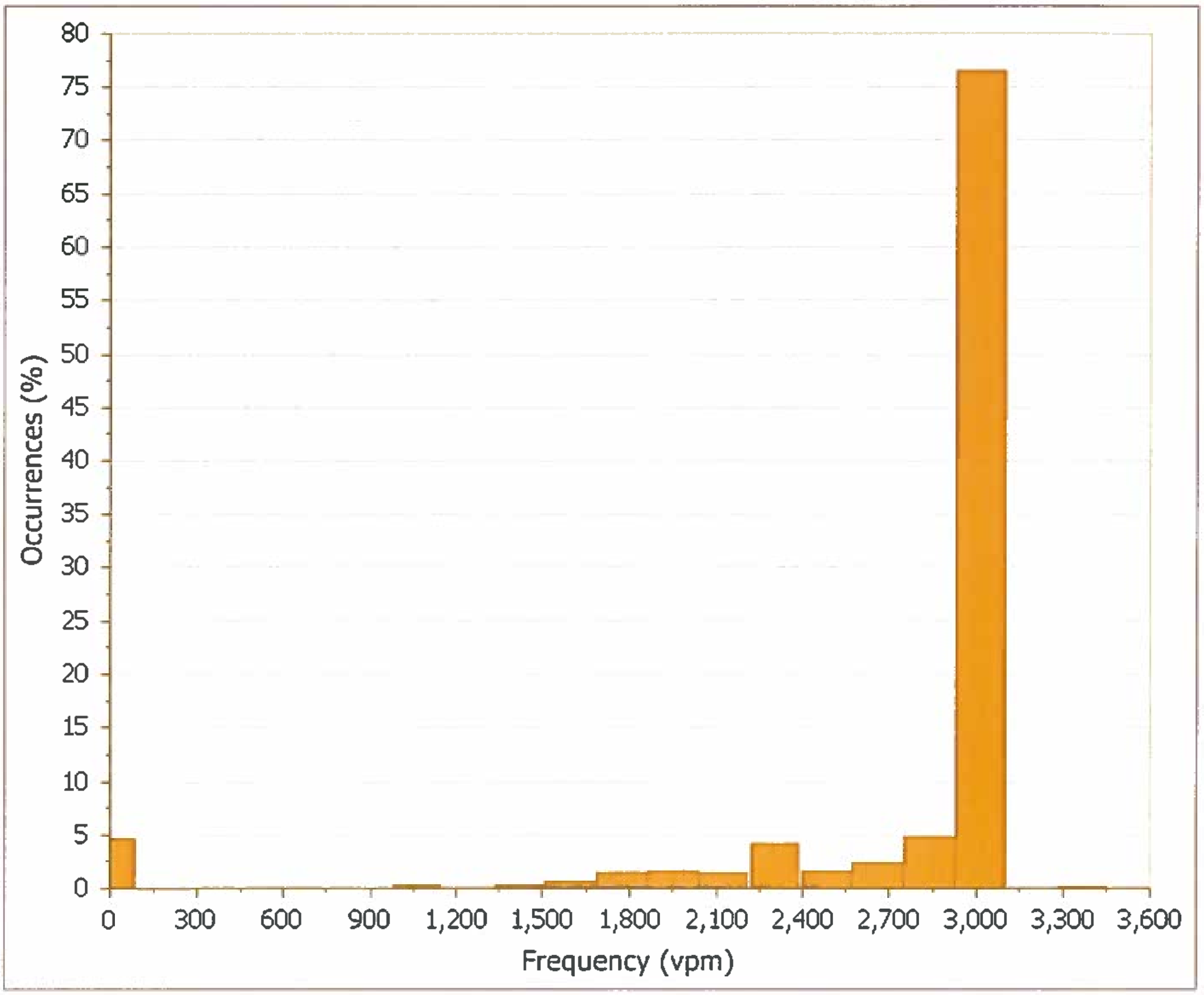
Statistic	Value
Mean (mph)	4.3
Standard Deviation (mph)	0.7
CoV (%)	16
Min (mph)	2.6
Max (mph)	5.4
Sample Size	7,913
Target Status	Passed
% of Target Achieved	99.76



Final Coverage: Frequency

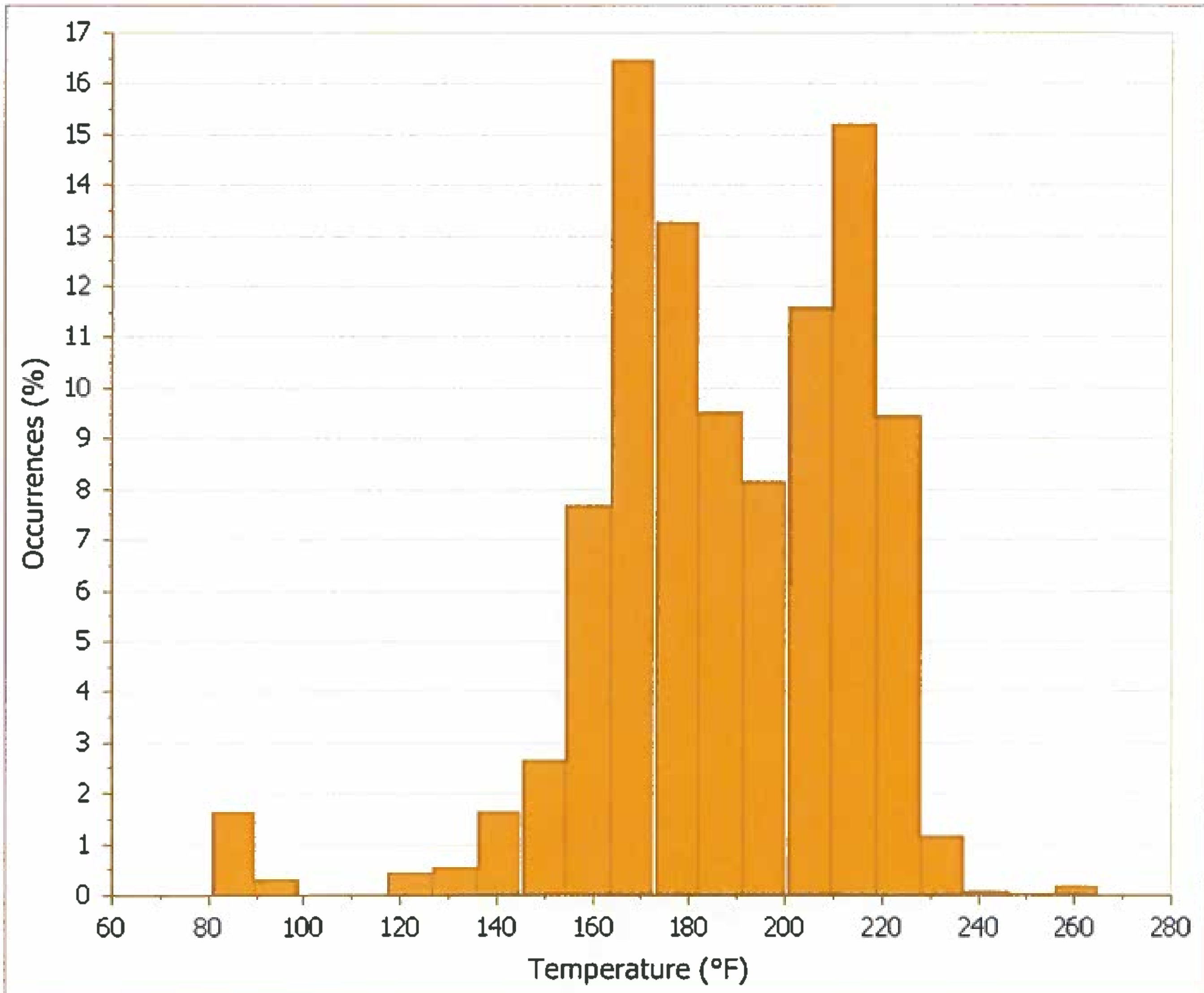
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,655
Standard Deviation (vpm)	668
CoV (%)	25
Min (vpm)	0
Max (vpm)	3,546
Sample Size	7,913
Target Status	Passed
% of Target Achieved	95.31



Final Coverage: Temperature

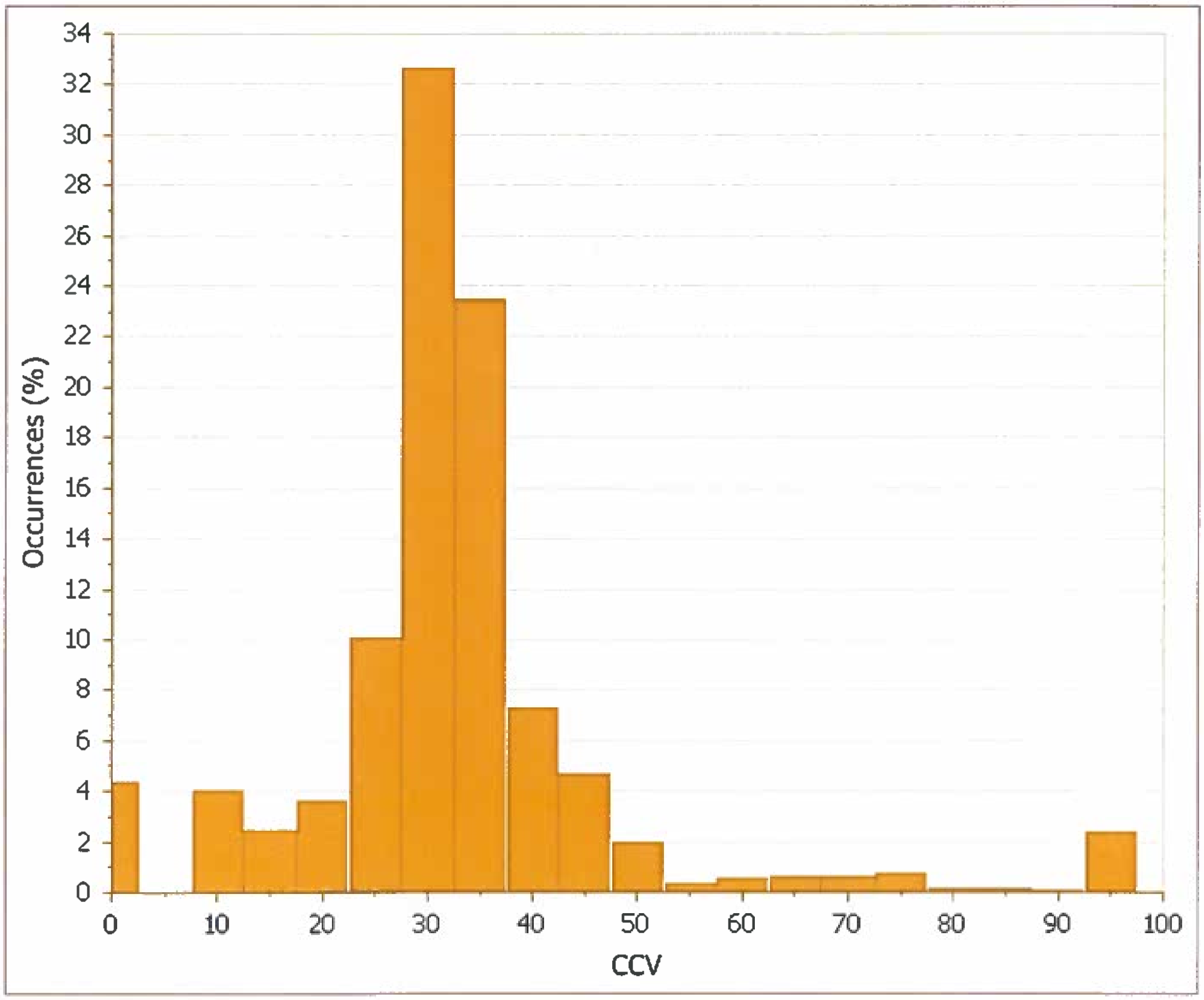
Statistic	Value
Mean (°F)	182.8
Standard Deviation (°F)	27.31
CoV (%)	15
Min (°F)	85.1
Max (°F)	269.5
Sample Size	7,913



Final Coverage: CCV

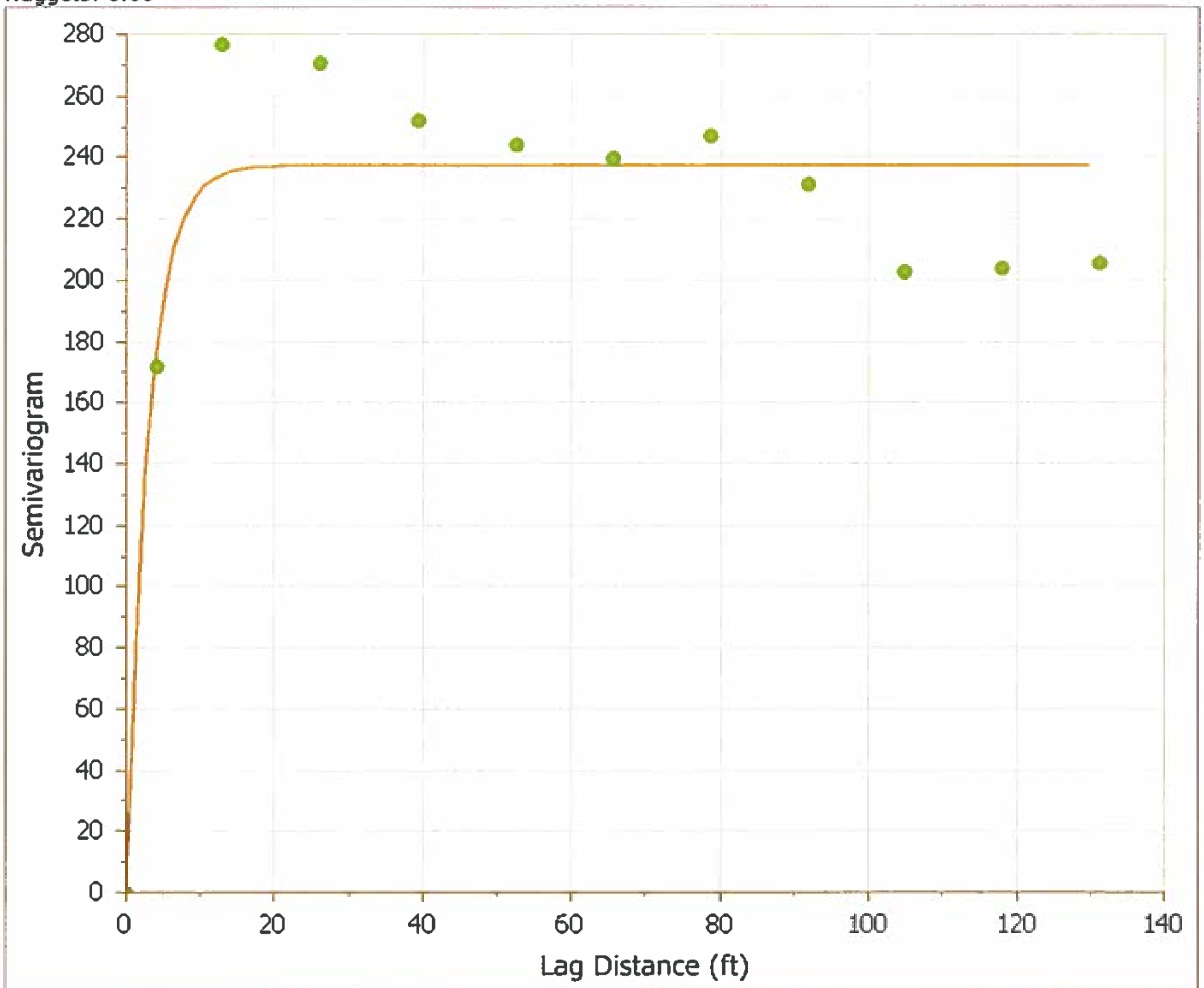
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	30.23
Standard Deviation	15.85
CoV (%)	52
Min	0.00
Max	100.00
Sample Size	7,913
Target Status	Passed
% of Target Achieved	95.63



Final Coverage: Semivariogram

Range (ft): 9.18
Sill: 226.60
Vertical Scale: 226.60
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20140115-1254-41
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

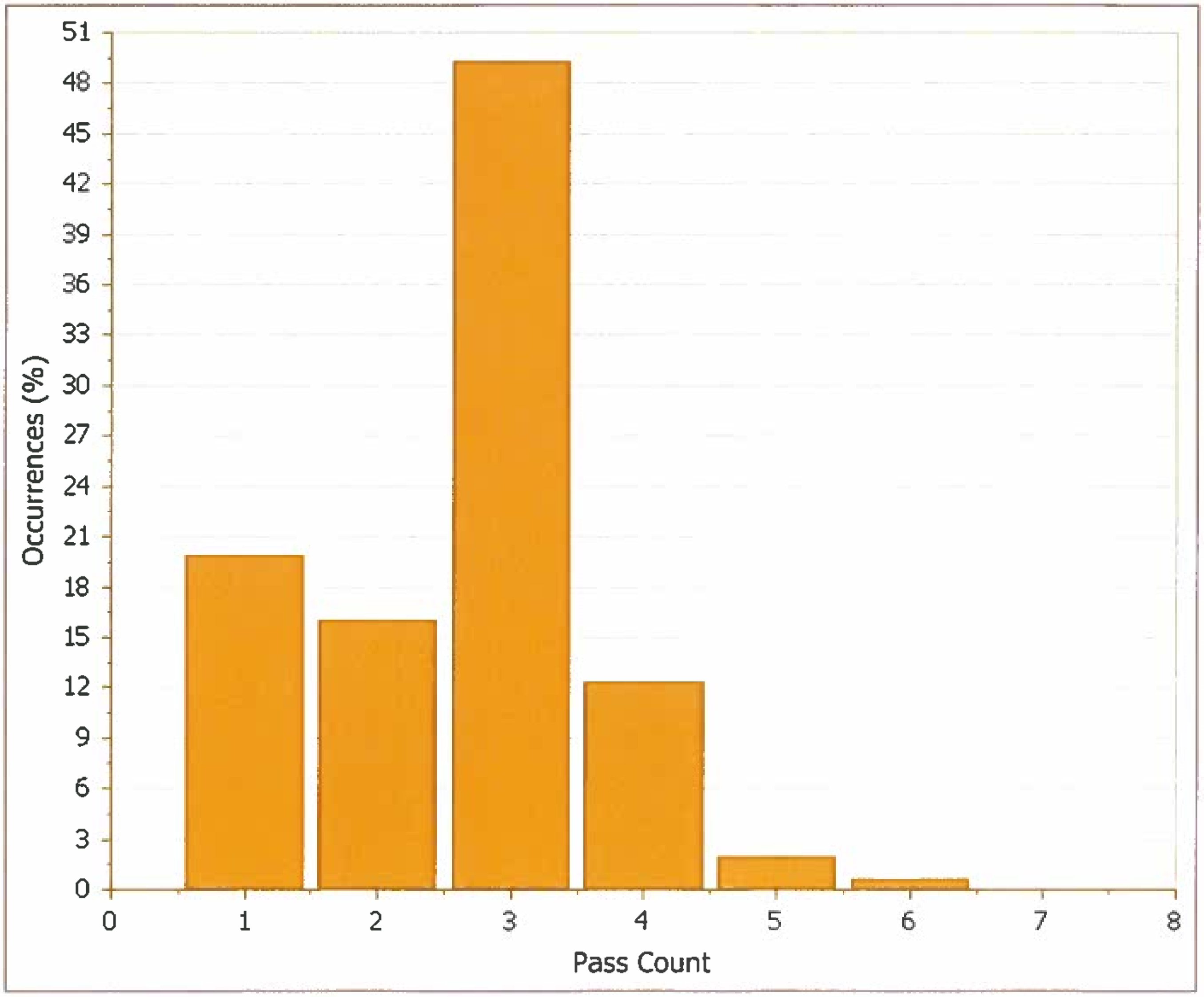
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

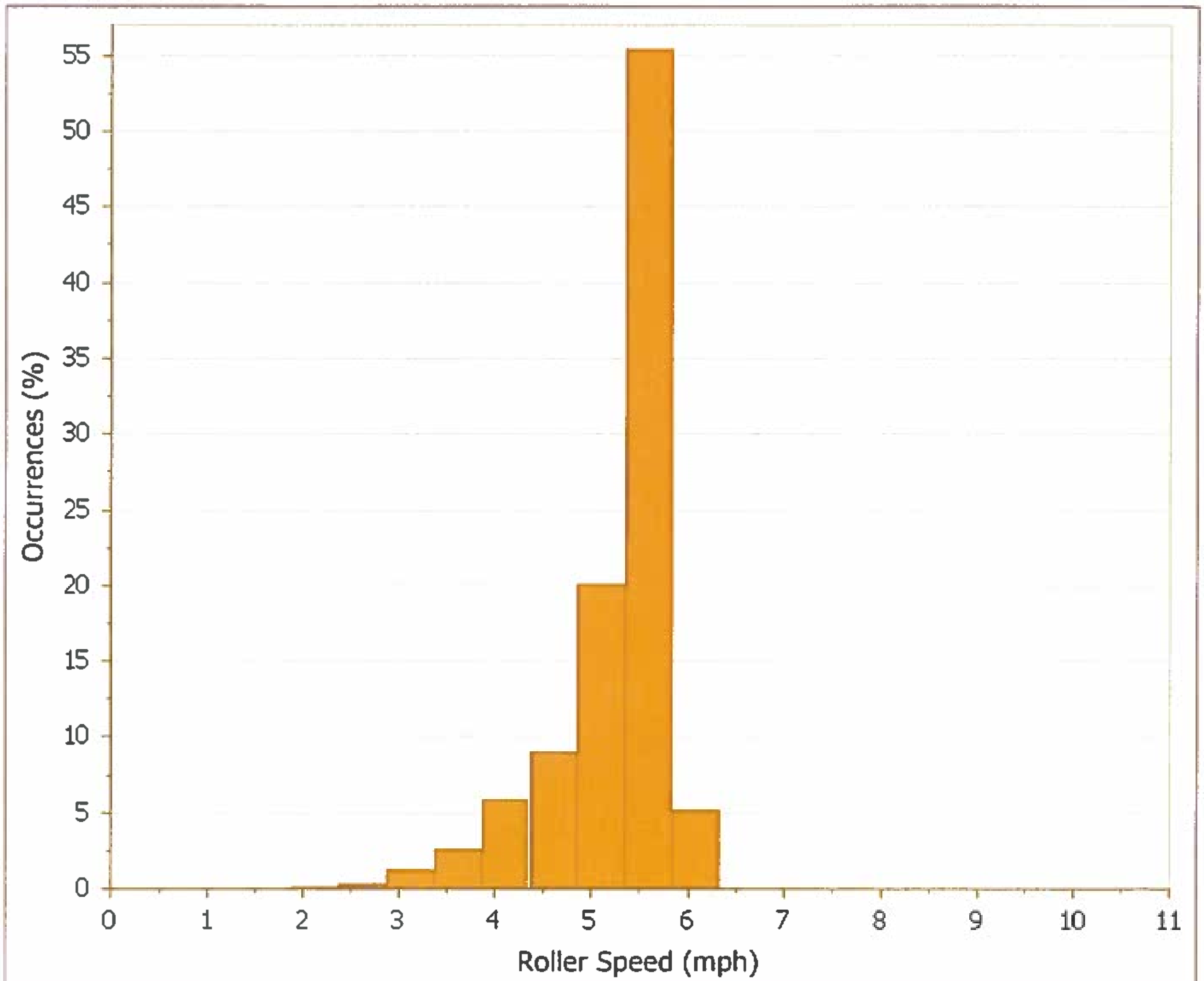
Statistic	Value
Mean	3
Standard Deviation	1
CoV (%)	39
Min	1
Max	7
Sample Size	75,706
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

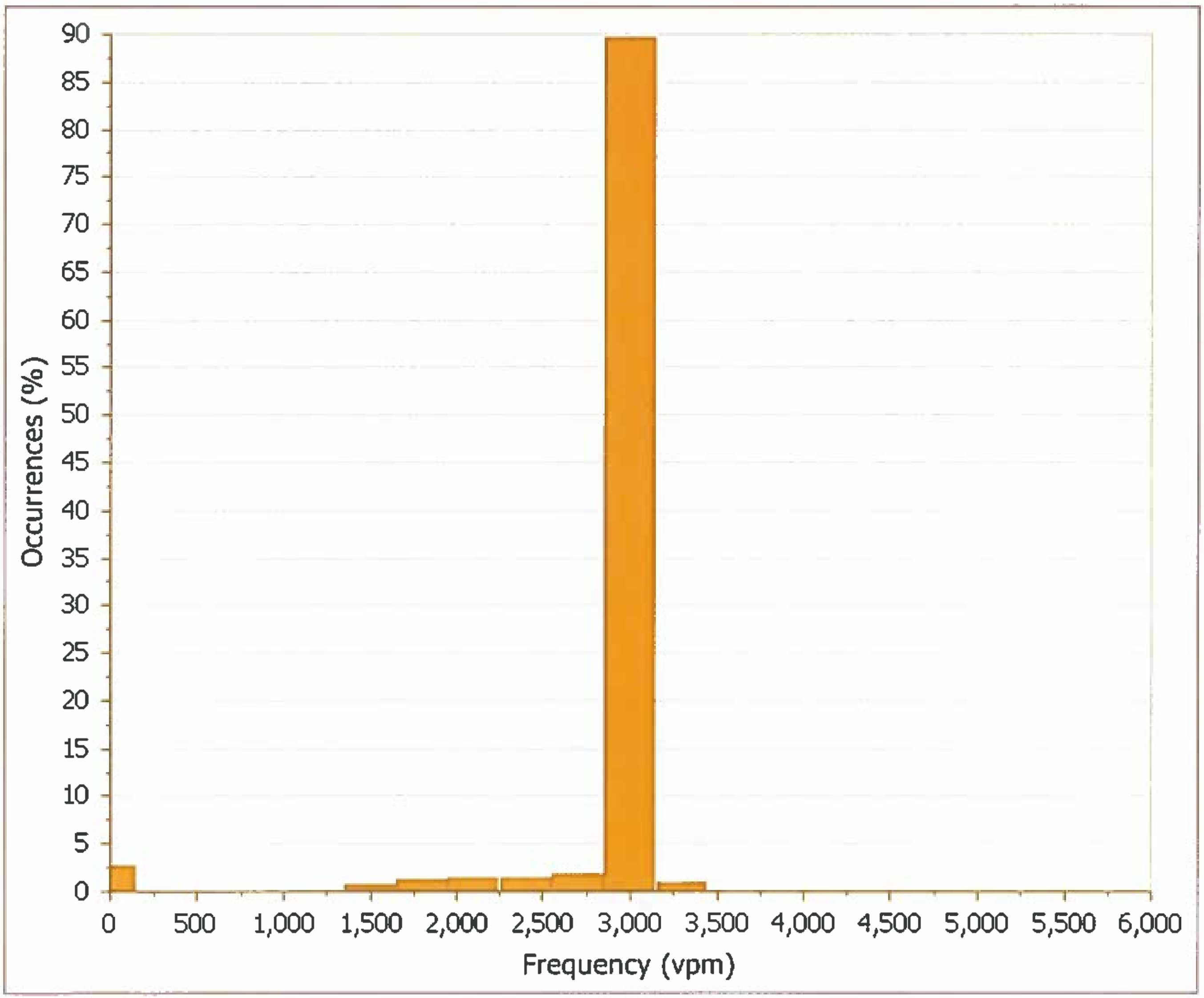
Statistic	Value
Mean (mph)	5.0
Standard Deviation (mph)	0.6
CoV (%)	13
Min (mph)	1.1
Max (mph)	11.0
Sample Size	75,706
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Frequency

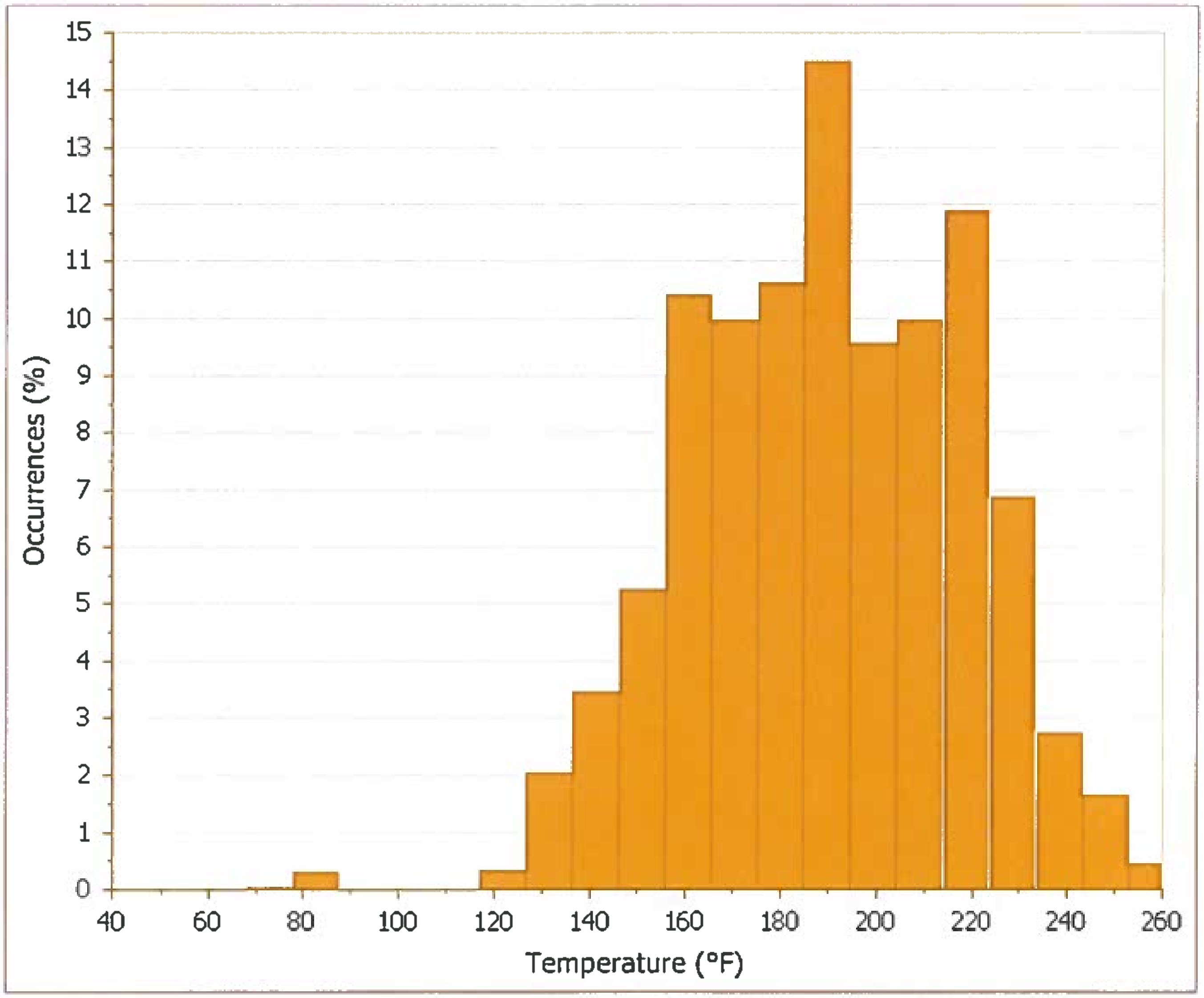
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,781
Standard Deviation (vpm)	522
CoV (%)	19
Min (vpm)	0
Max (vpm)	5,994
Sample Size	75,706
Target Status	Passed
% of Target Achieved	97.39



Final Coverage: Temperature

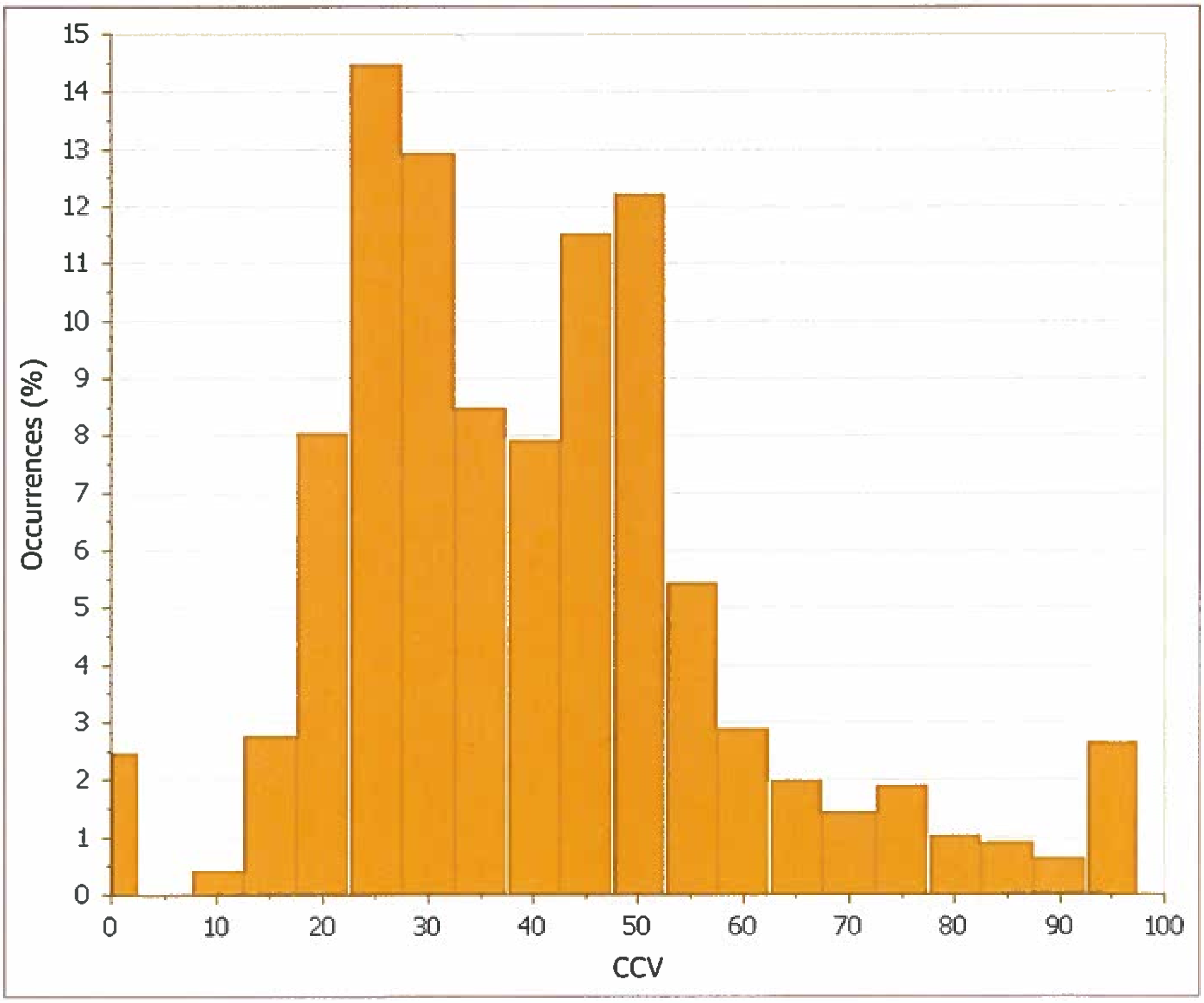
Statistic	Value
Mean (°F)	185.1
Standard Deviation (°F)	28.36
CoV (%)	15
Min (°F)	73.1
Max (°F)	267.5
Sample Size	75,706



Final Coverage: CCV

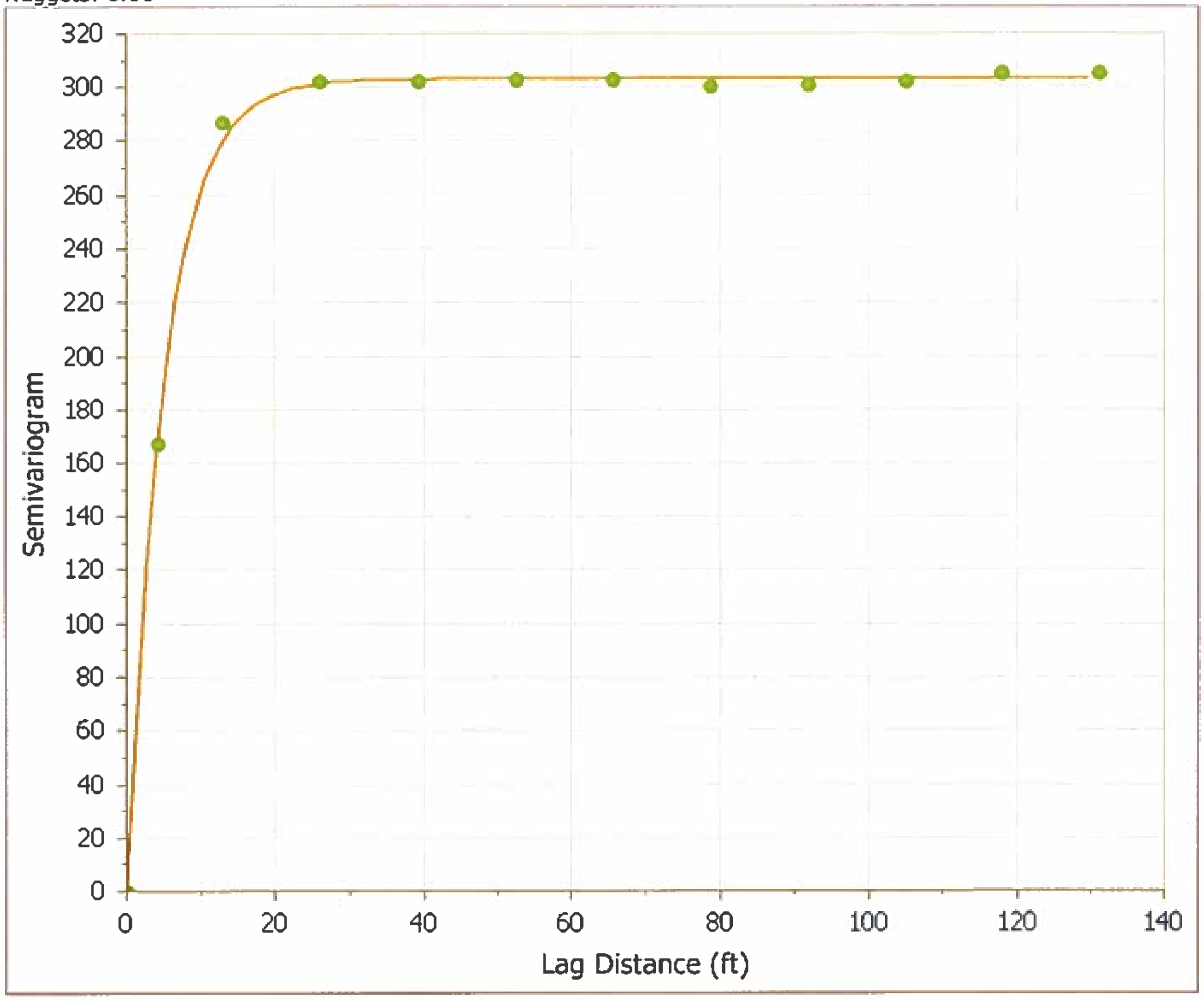
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	37.84
Standard Deviation	19.13
CoV (%)	51
Min	0.00
Max	100.00
Sample Size	75,706
Target Status	Passed
% of Target Achieved	97.55



Final Coverage: Semivariogram

Range (ft): 13.12
Sill: 280.80
Vertical Scale: 280.80
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130625-0710-02
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

Pass 17
Final Coverage: False

Pass 18
Final Coverage: False

Pass 19
Final Coverage: False

Pass 20
Final Coverage: False

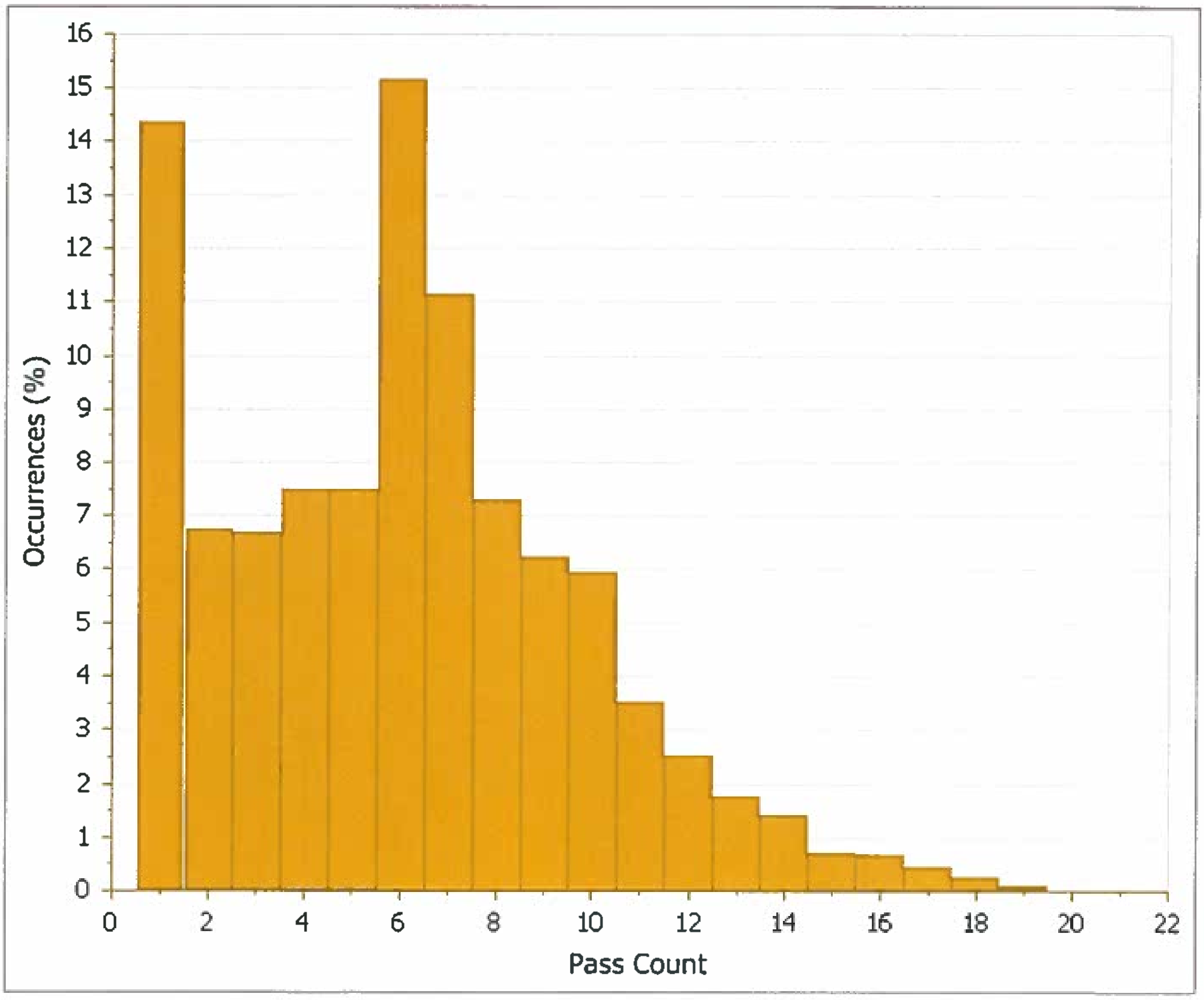
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

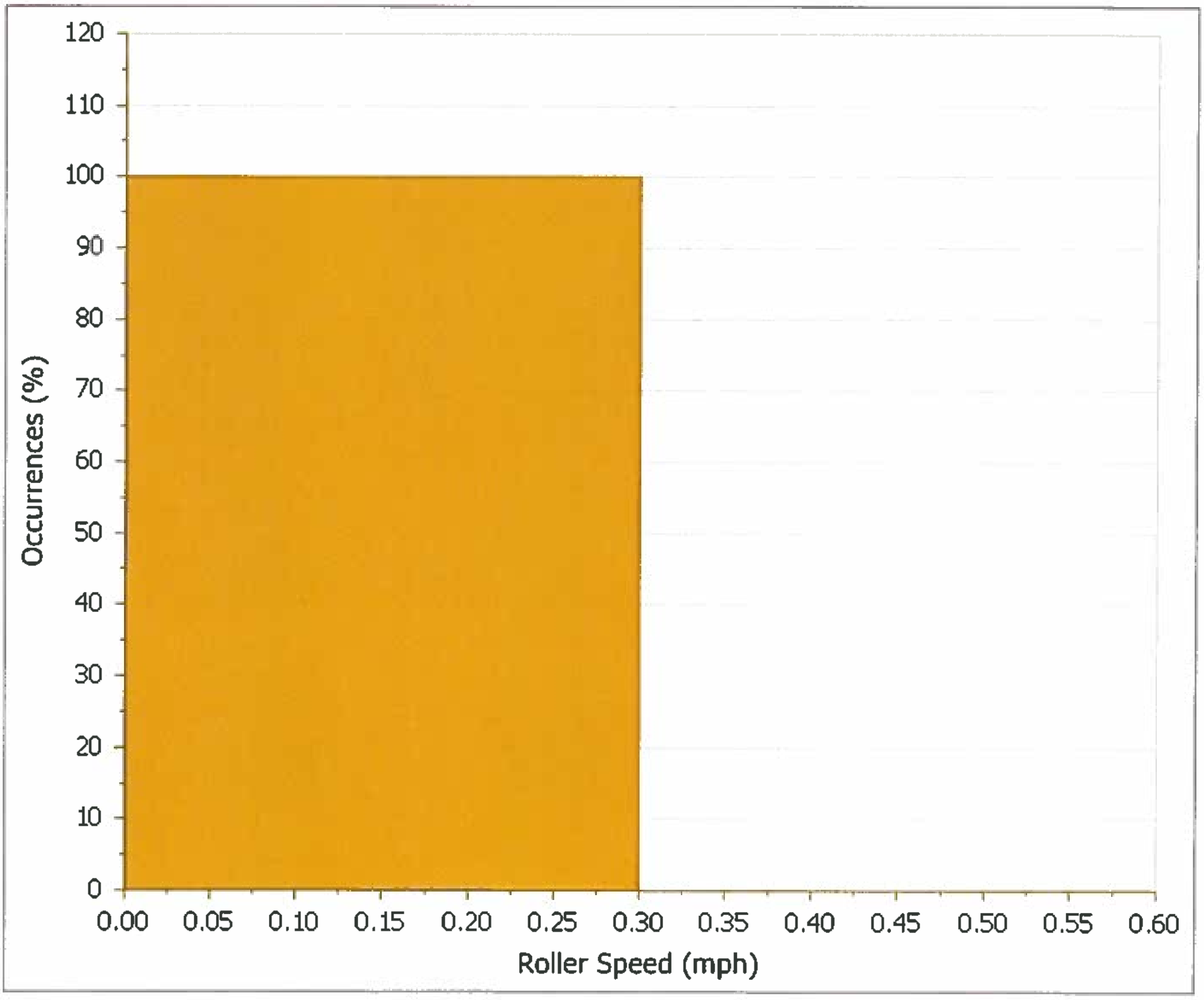
Statistic	Value
Mean	6
Standard Deviation	4
CoV (%)	61
Min	1
Max	20
Sample Size	43,132
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

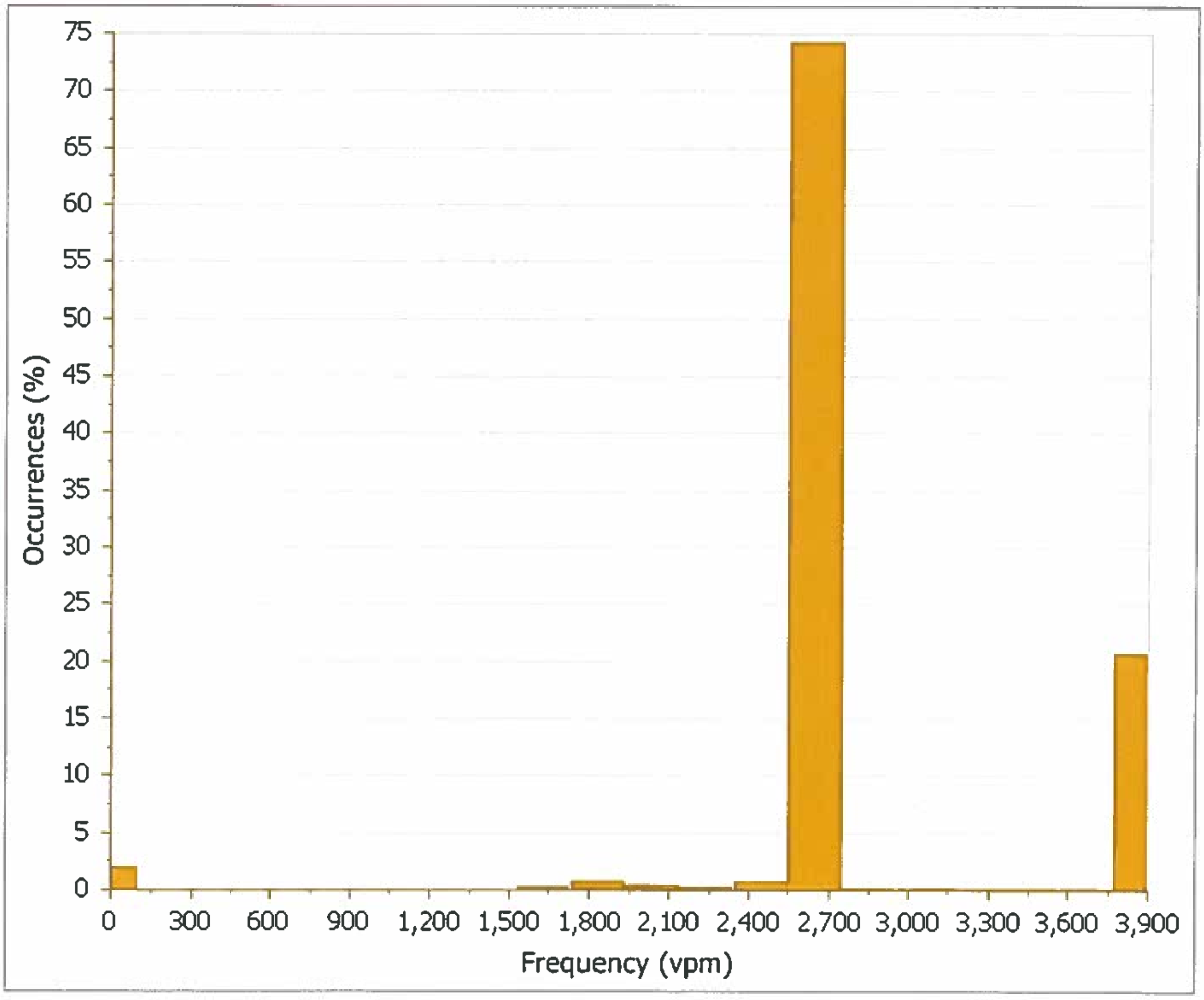
Statistic	Value
Mean (mph)	0.0
Standard Deviation (mph)	0.0
CoV (%)	NaN
Min (mph)	0.0
Max (mph)	0.0
Sample Size	43,132
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Frequency

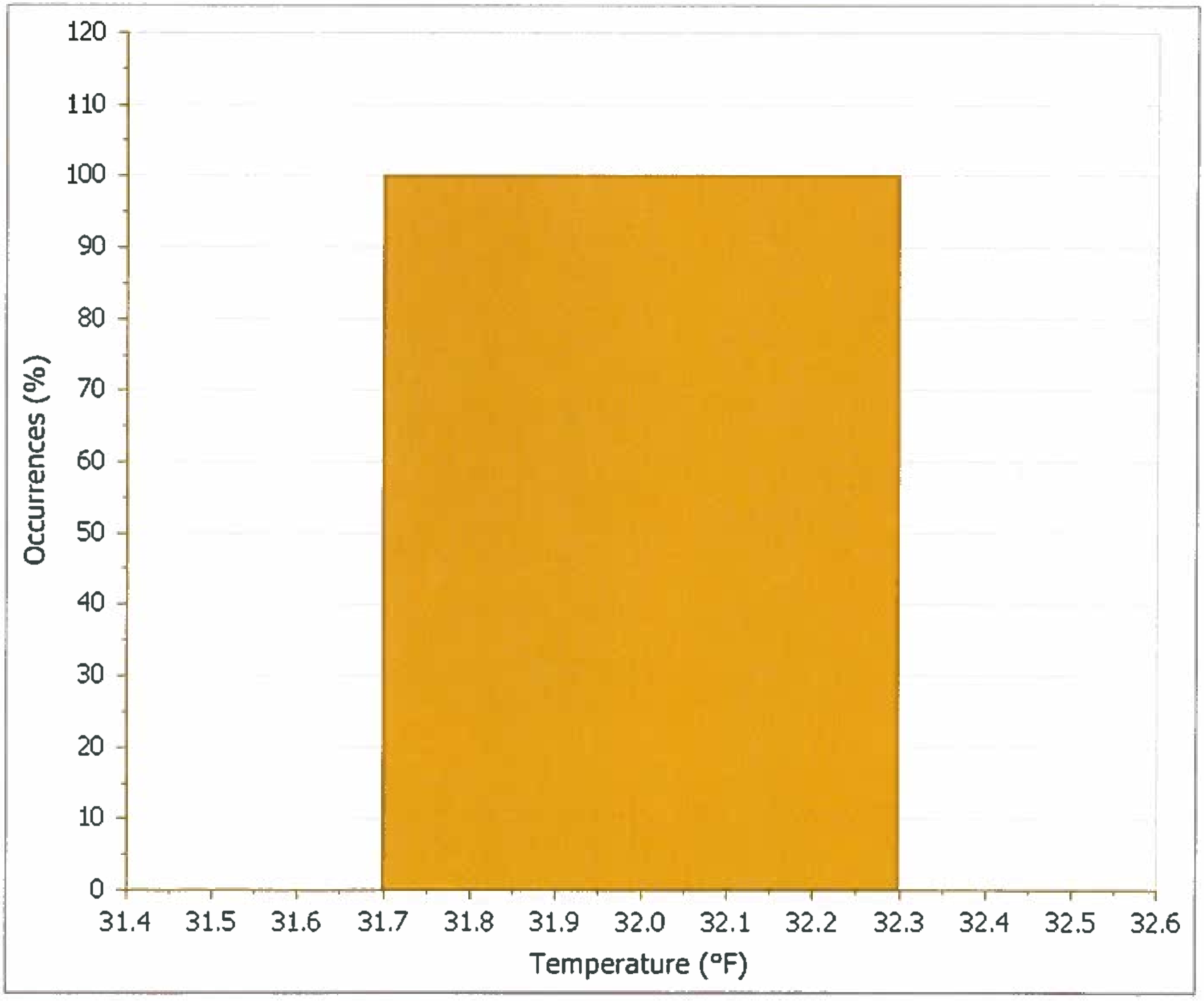
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,750
Standard Deviation (vpm)	740
CoV (%)	27
Min (vpm)	0
Max (vpm)	4,074
Sample Size	43,132
Target Status	Passed
% of Target Achieved	98.12



Final Coverage: Temperature

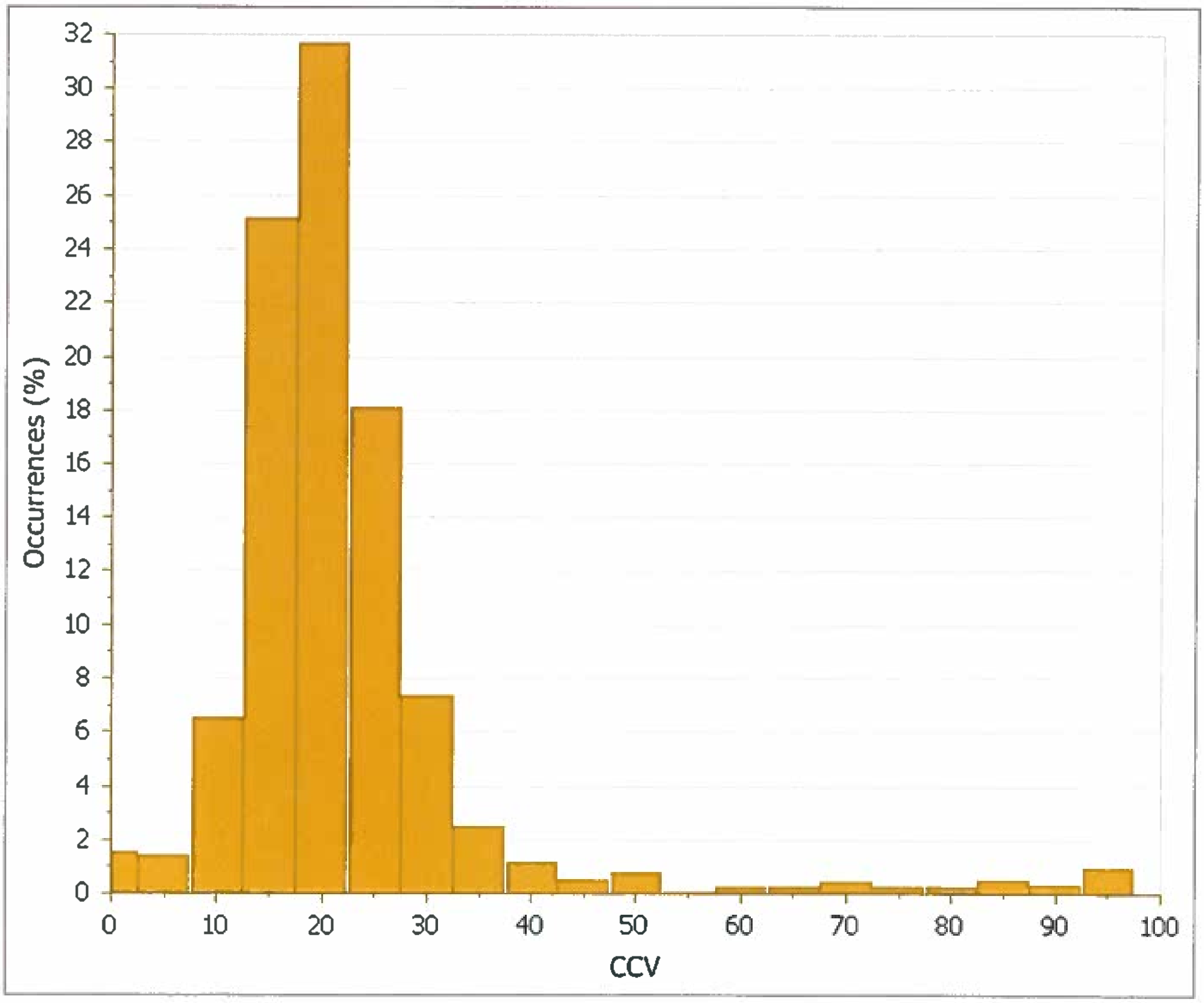
Statistic	Value
Mean (°F)	32.0
Standard Deviation (°F)	0.00
CoV (%)	0
Min (°F)	32.0
Max (°F)	32.0
Sample Size	43,132



Final Coverage: CCV

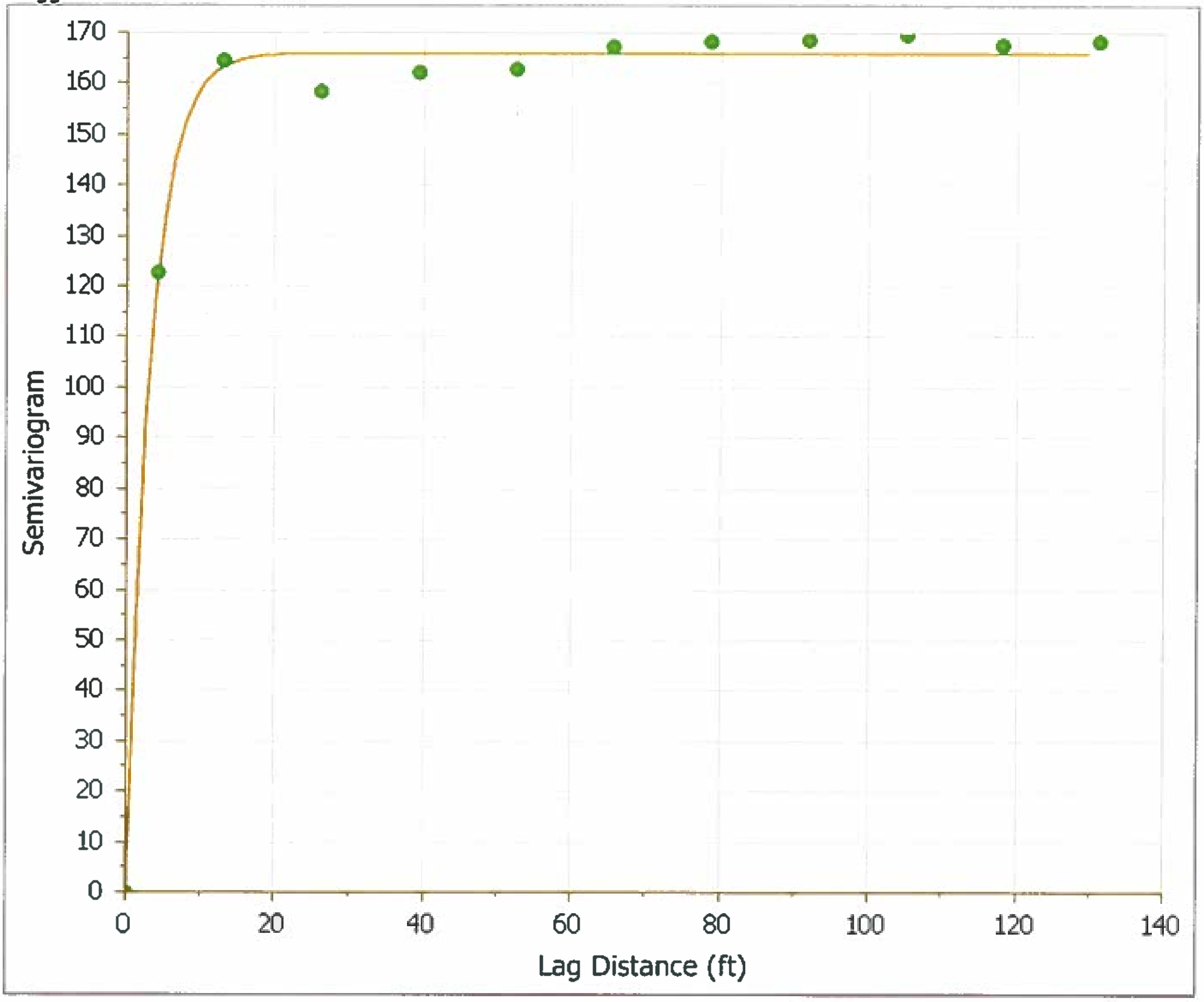
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	19.91
Standard Deviation	13.51
CoV (%)	68
Min	0.00
Max	100.00
Sample Size	43,132
Target Status	Passed
% of Target Achieved	98.48



Final Coverage: Semivariogram

Range (ft): 10.49
Sill: 160.09
Vertical Scale: 160.09
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130626-0706-55
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

Pass 17
Final Coverage: False

Pass 18
Final Coverage: False

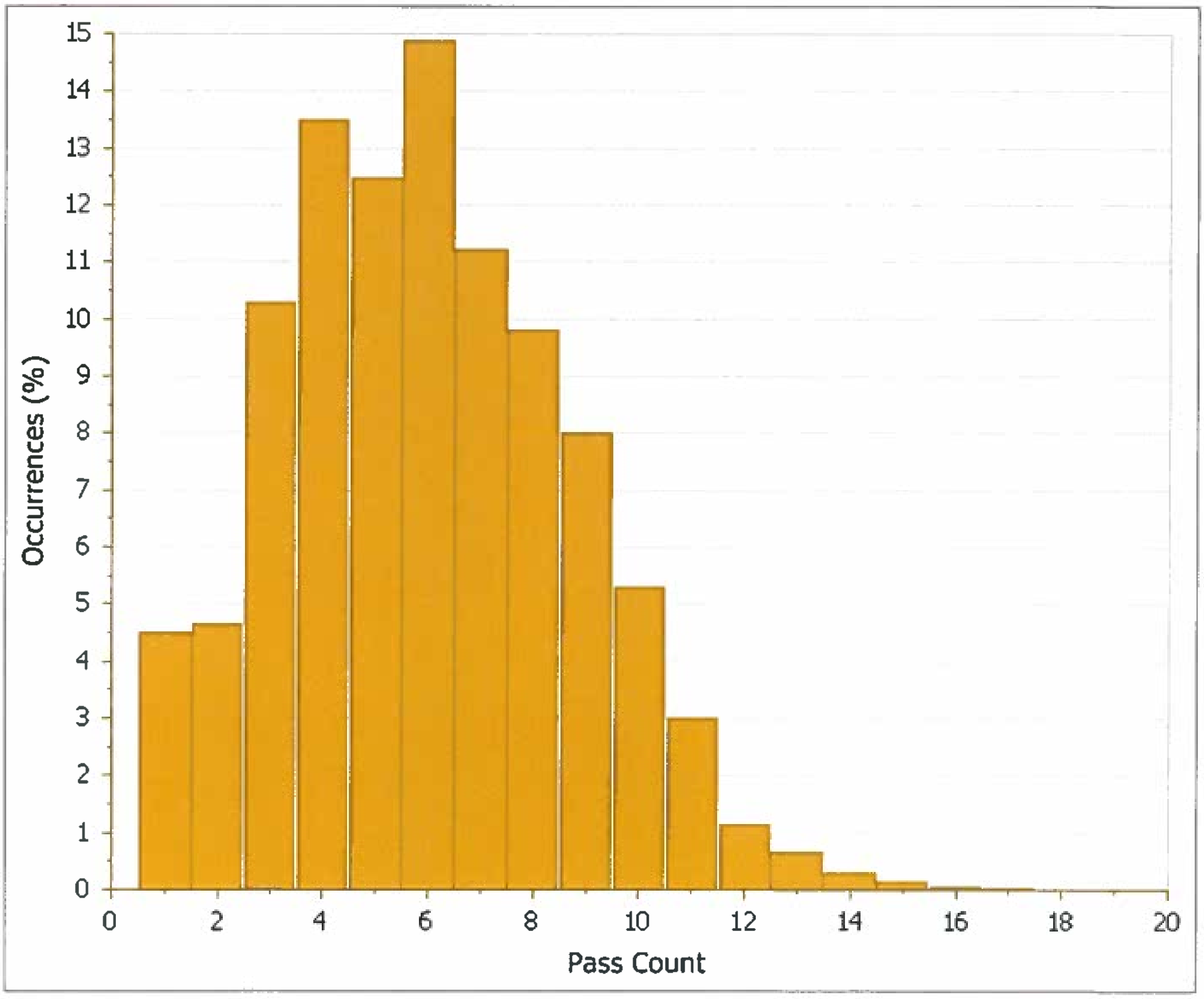
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

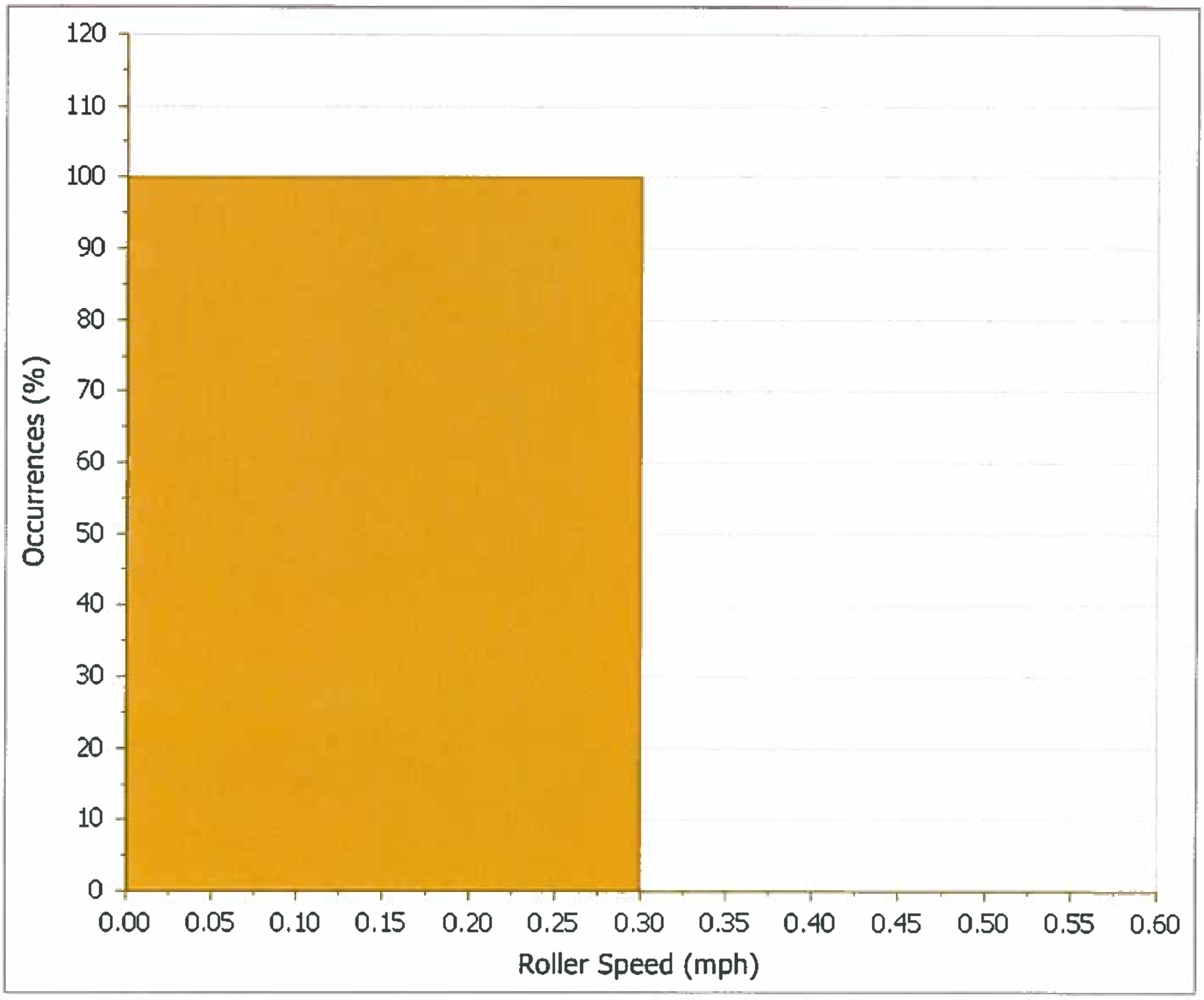
Statistic	Value
Mean	6
Standard Deviation	3
CoV (%)	46
Min	1
Max	18
Sample Size	123,657
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

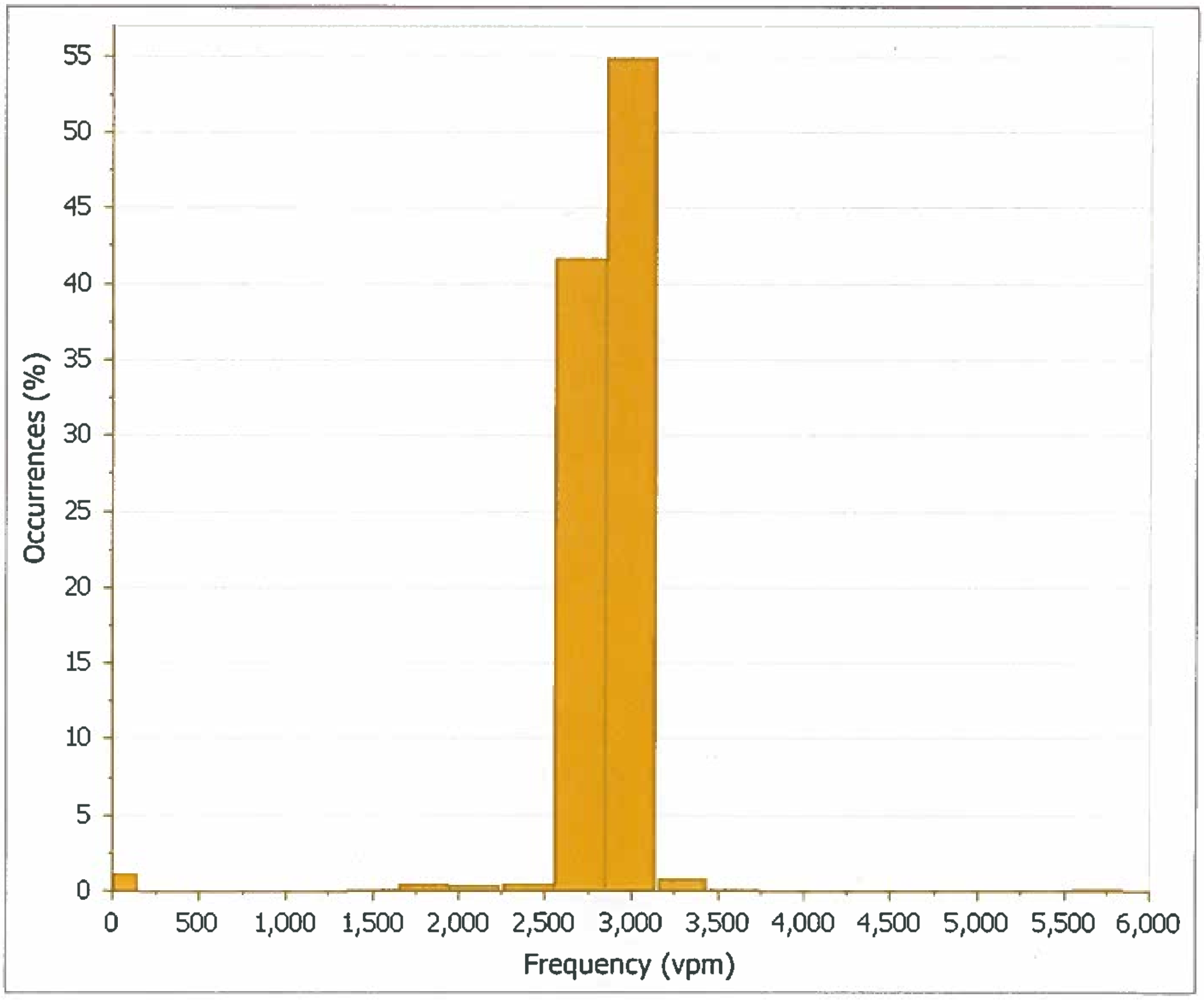
Statistic	Value
Mean (mph)	0.0
Standard Deviation (mph)	0.0
CoV (%)	NaN
Min (mph)	0.0
Max (mph)	0.0
Sample Size	123,657
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Frequency

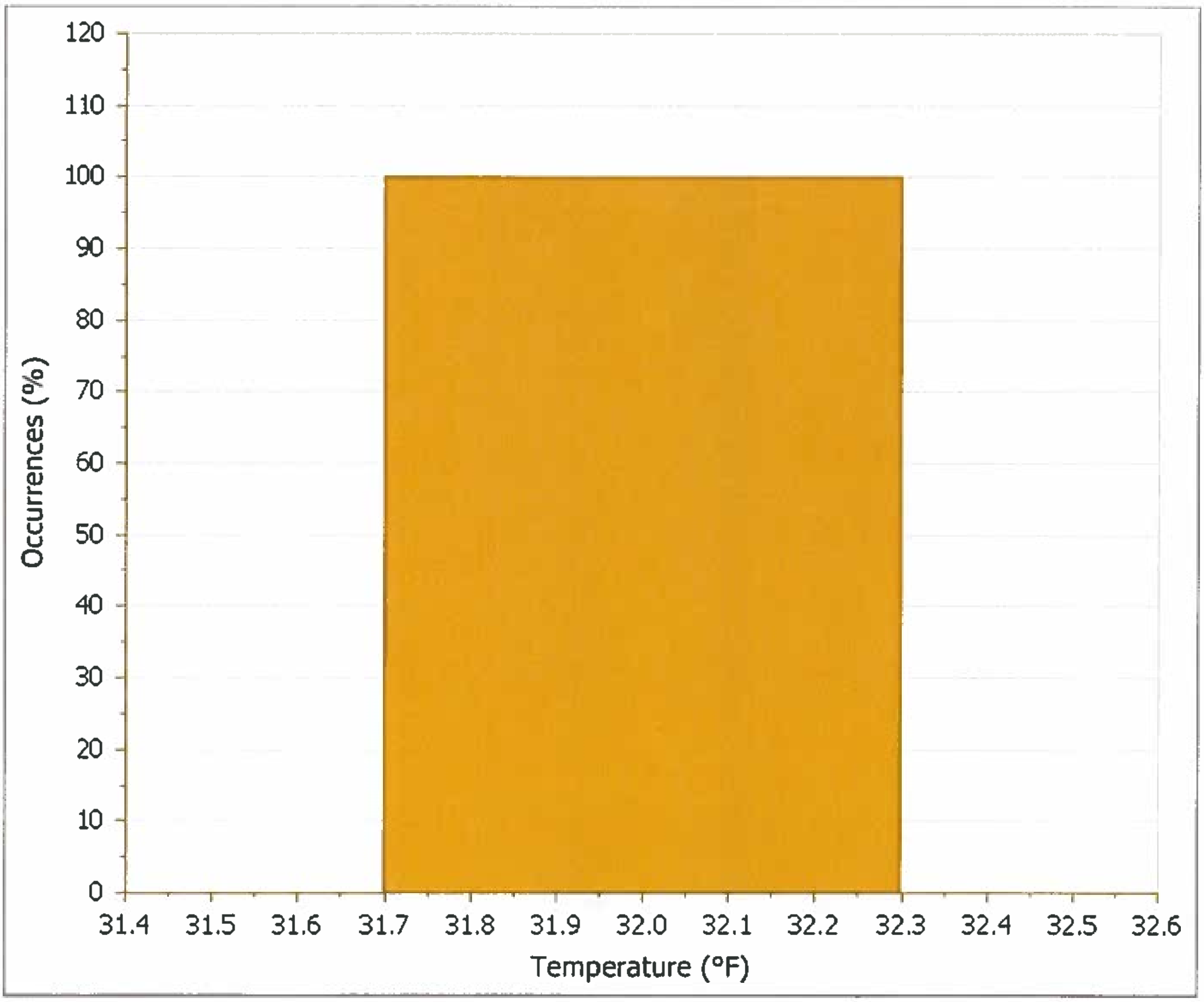
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,710
Standard Deviation (vpm)	393
CoV (%)	15
Min (vpm)	0
Max (vpm)	5,994
Sample Size	123,657
Target Status	Passed
% of Target Achieved	98.85



Final Coverage: Temperature

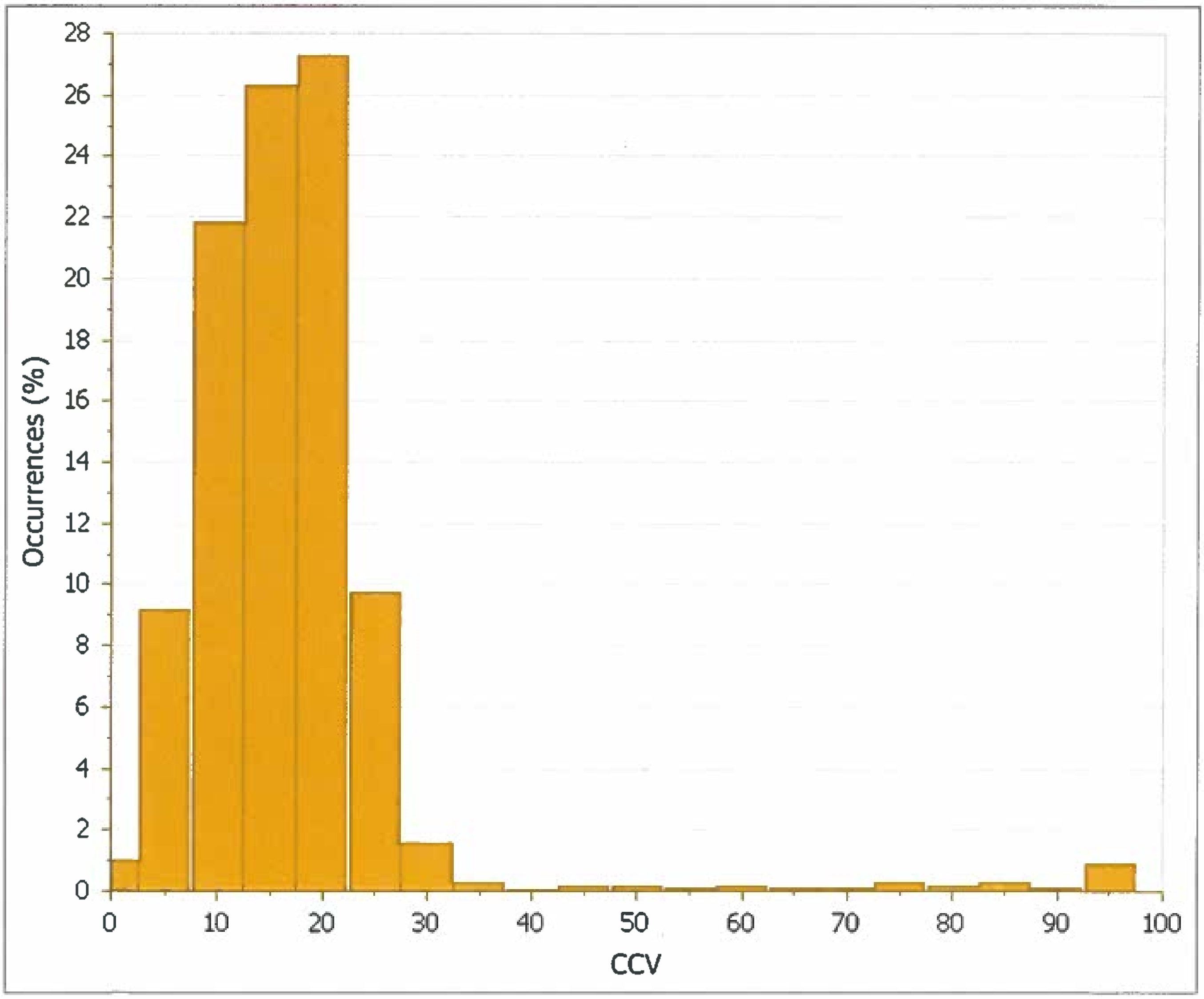
Statistic	Value
Mean (°F)	32.0
Standard Deviation (°F)	0.00
CoV (%)	0
Min (°F)	32.0
Max (°F)	32.0
Sample Size	123,657



Final Coverage: CCV

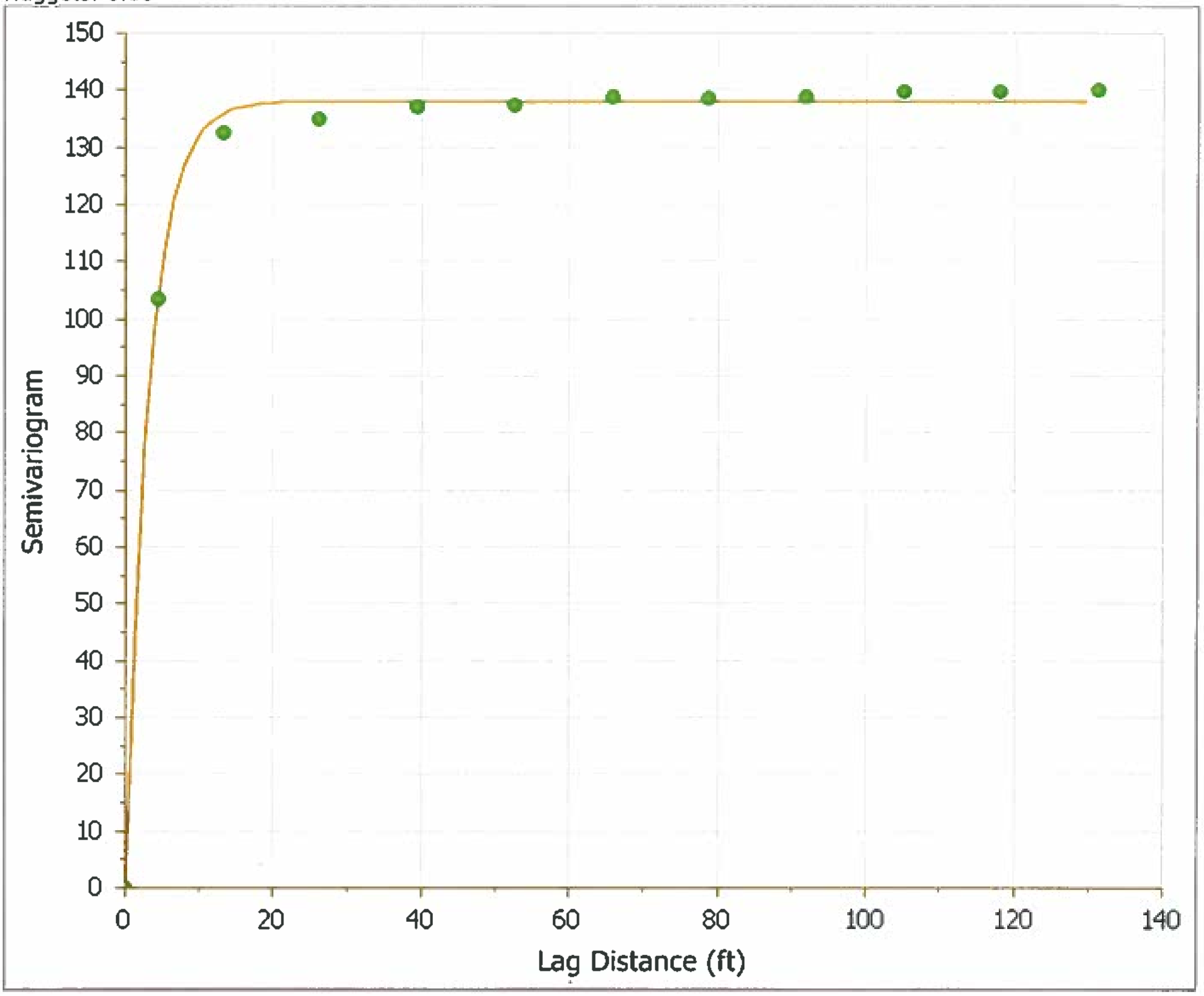
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	14.78
Standard Deviation	12.37
CoV (%)	84
Min	0.00
Max	100.00
Sample Size	123,657
Target Status	Passed
% of Target Achieved	98.98



Final Coverage: Semivariogram

Range (ft): 10.50
Sill: 133.17
Vertical Scale: 133.17
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130628-0709-47
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

Pass 17
Final Coverage: False

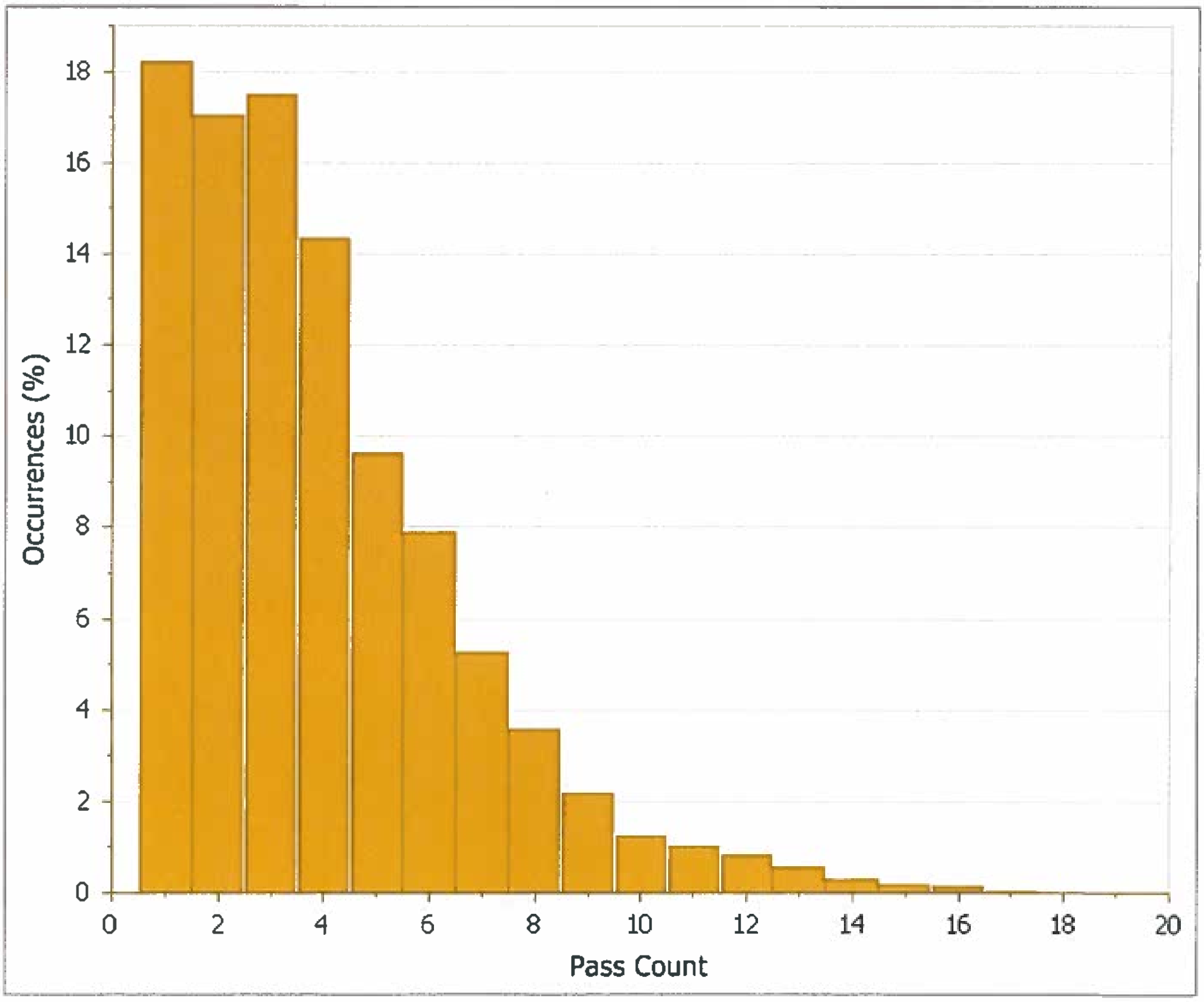
Pass 18
Final Coverage: False

Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count
Target Percentage (%): 0.00
Target Value: 0.00

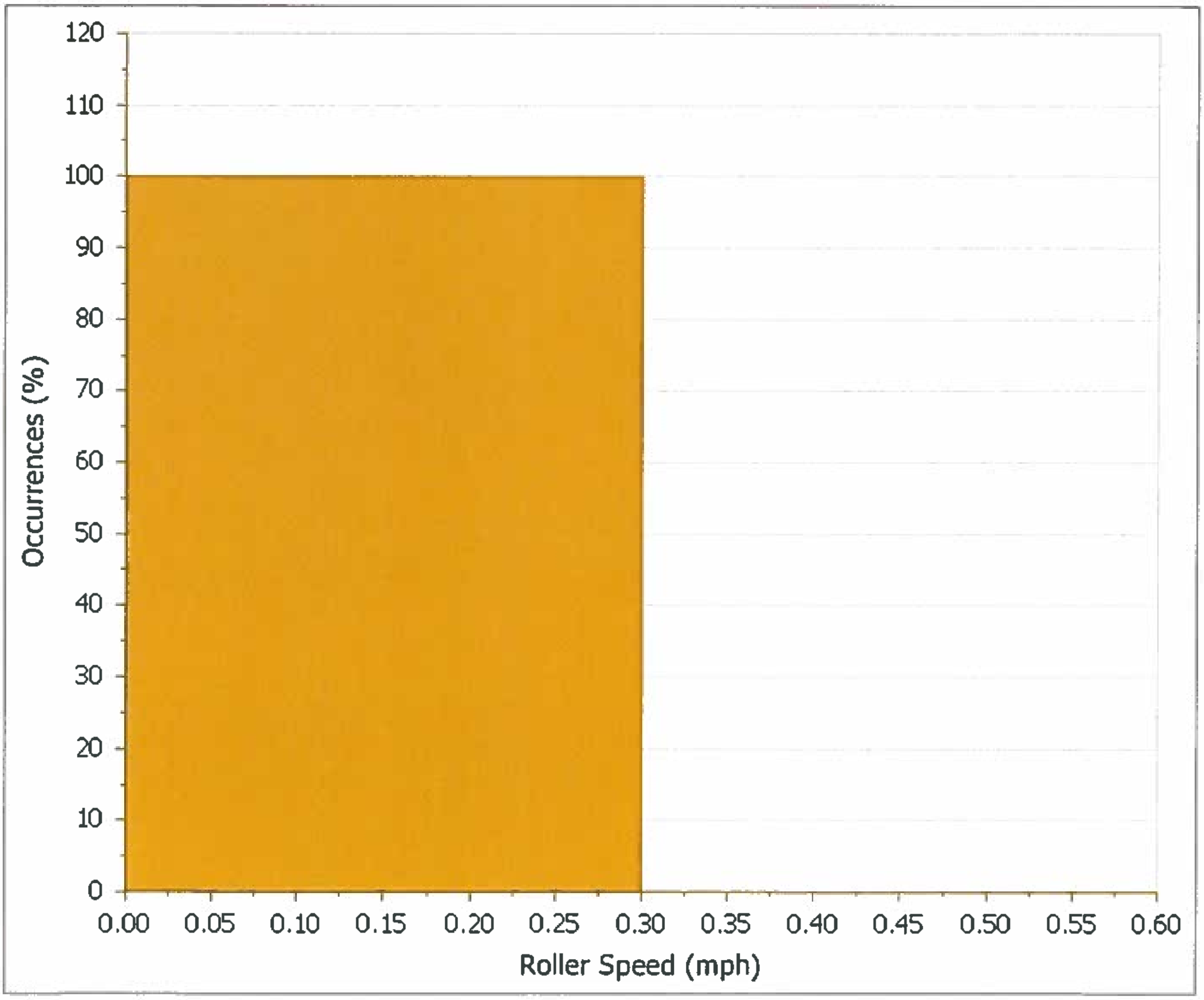
Statistic	Value
Mean	4
Standard Deviation	3
CoV (%)	68
Min	1
Max	18
Sample Size	124,795
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

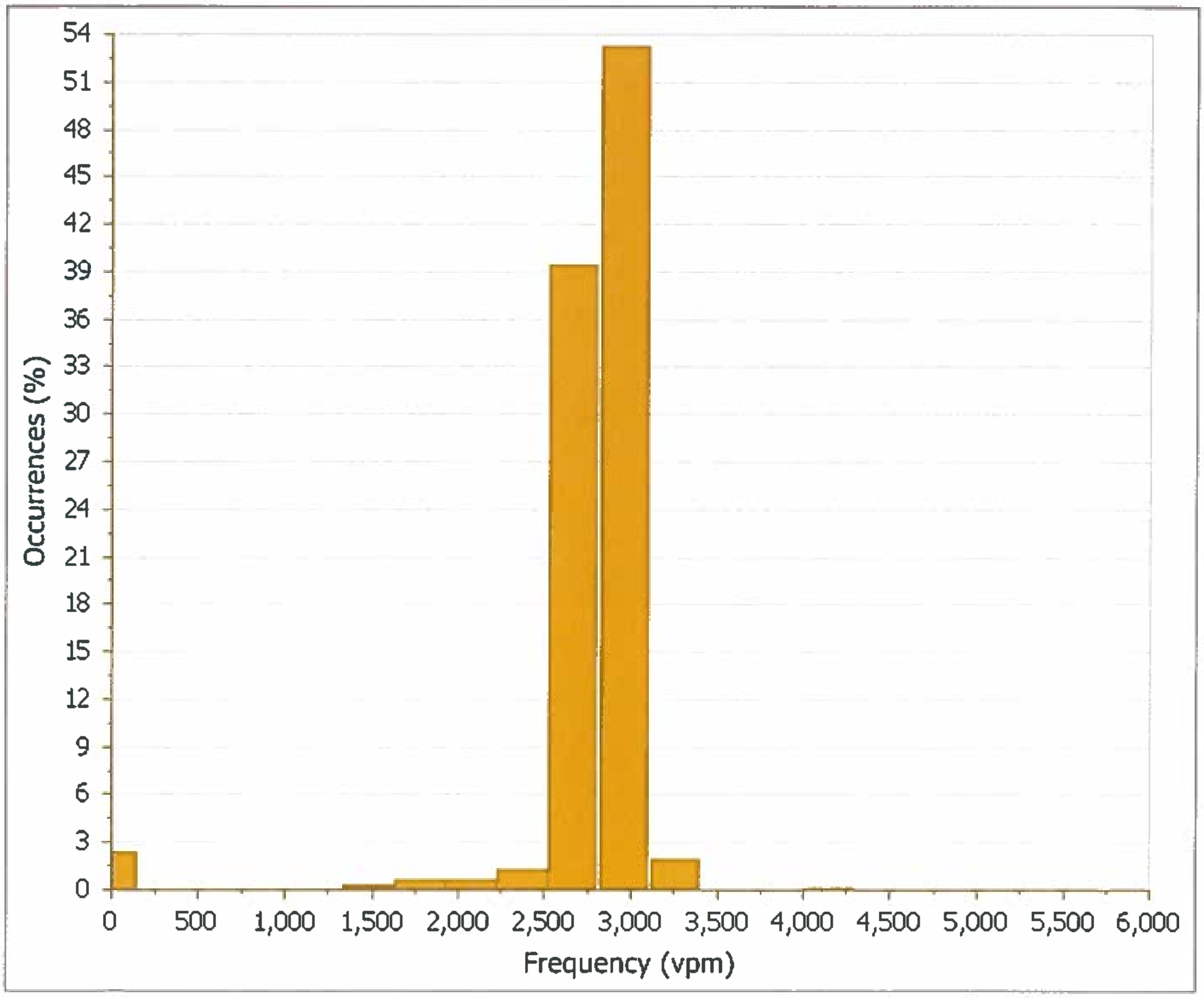
Statistic	Value
Mean (mph)	0.0
Standard Deviation (mph)	0.0
CoV (%)	NaN
Min (mph)	0.0
Max (mph)	0.0
Sample Size	124,795
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Frequency

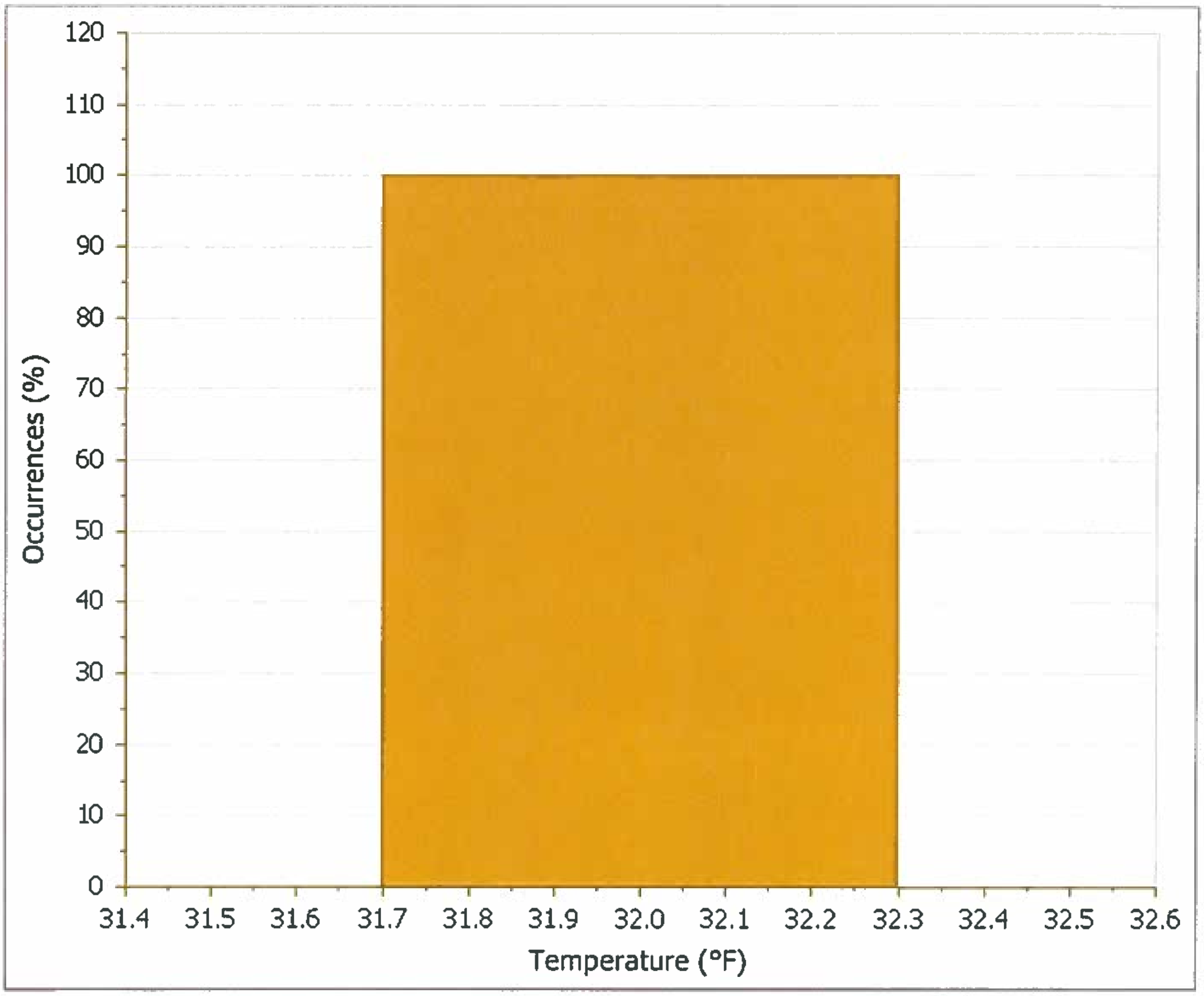
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,632
Standard Deviation (vpm)	497
CoV (%)	19
Min (vpm)	0
Max (vpm)	5,922
Sample Size	124,795
Target Status	Passed
% of Target Achieved	97.64



Final Coverage: Temperature

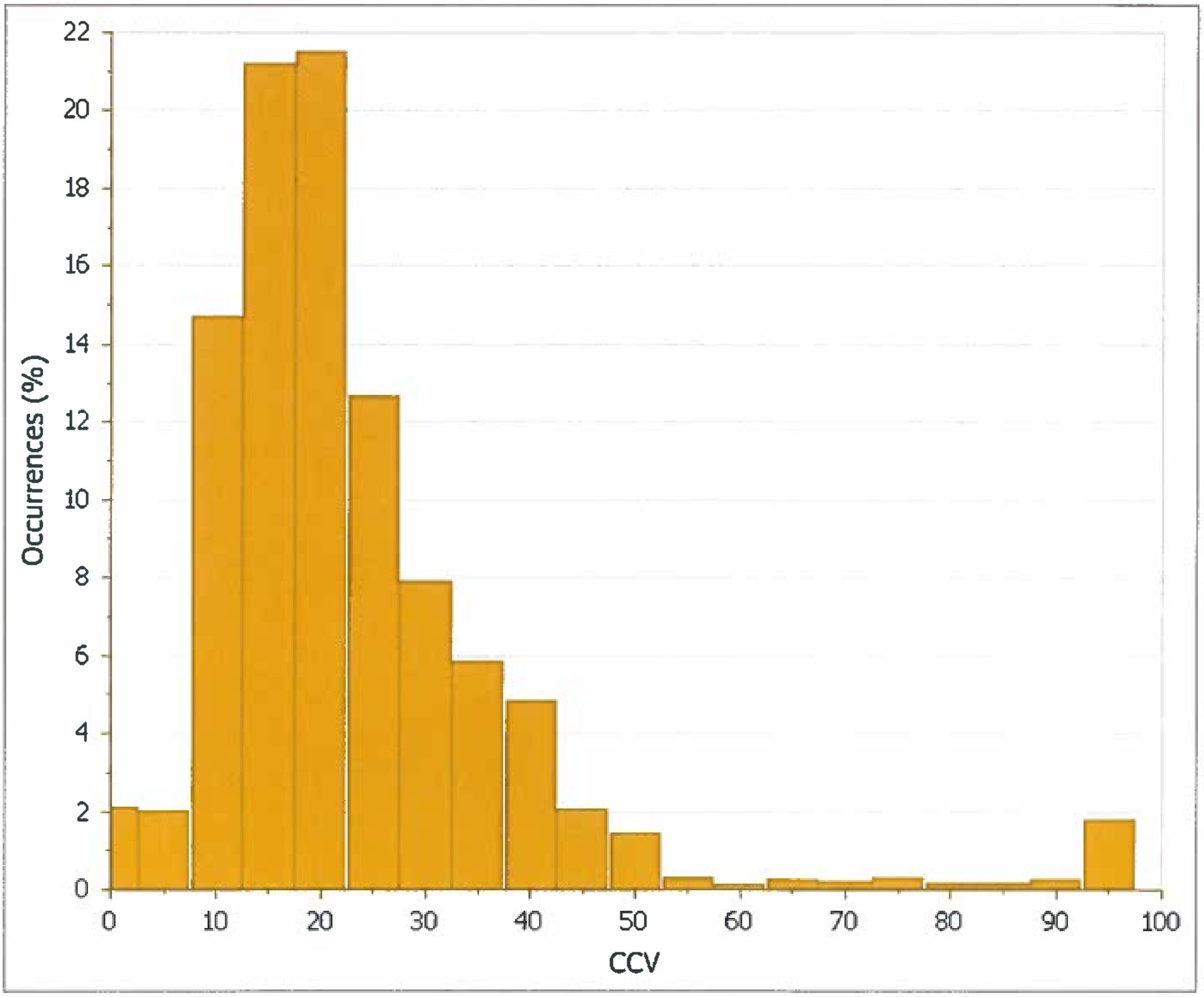
Statistic	Value
Mean (°F)	32.0
Standard Deviation (°F)	0.00
CoV (%)	0
Min (°F)	32.0
Max (°F)	32.0
Sample Size	124,795



Final Coverage: CCV

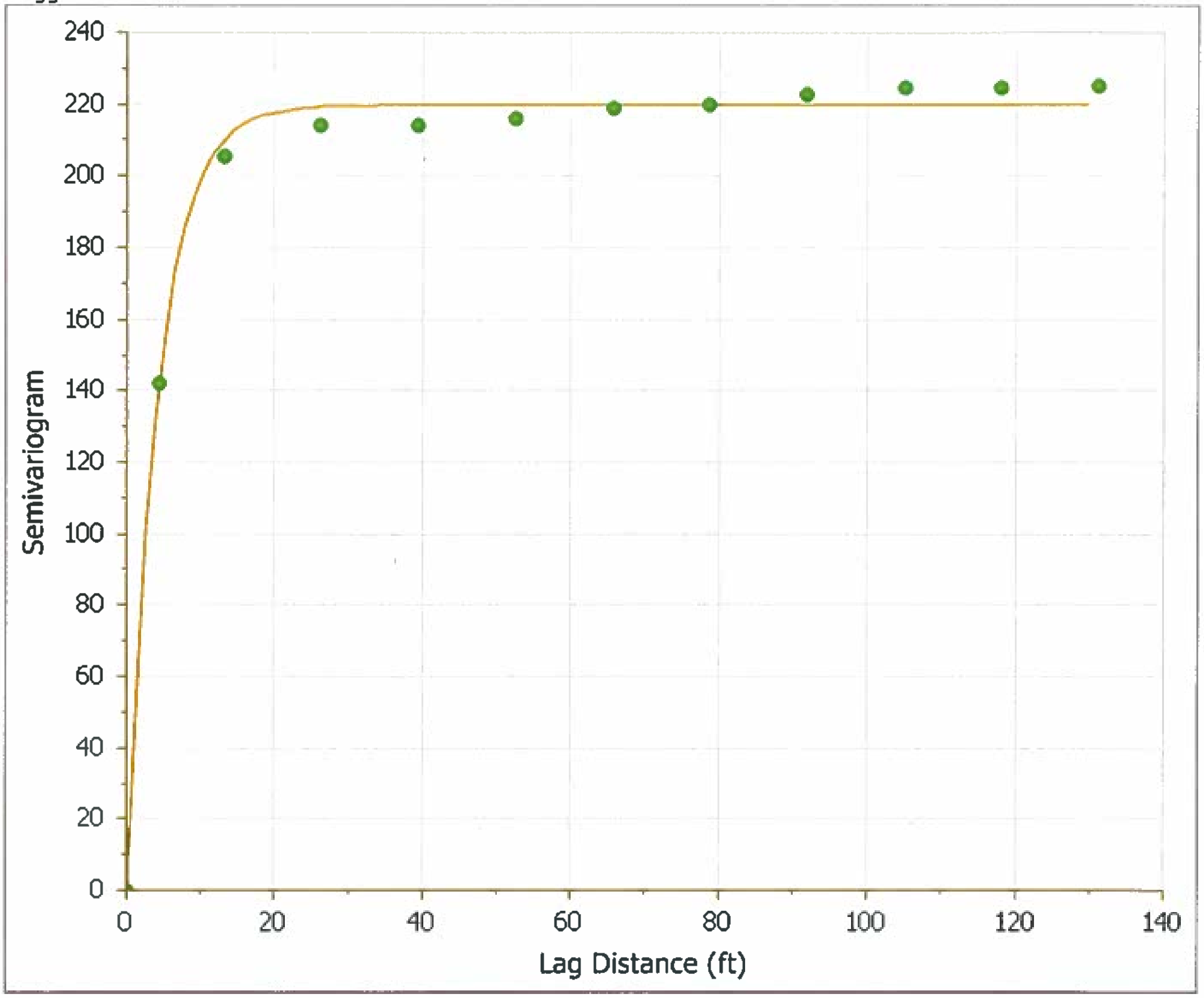
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	20.93
Standard Deviation	16.09
CoV (%)	77
Min	0.00
Max	100.00
Sample Size	124,795
Target Status	Passed
% of Target Achieved	97.89



Final Coverage: Semivariogram

Range (ft): 11.81
Sill: 206.22
Vertical Scale: 206.22
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130628-1600-23
State Plane Zone: 1702 - Louisiana South

File Information

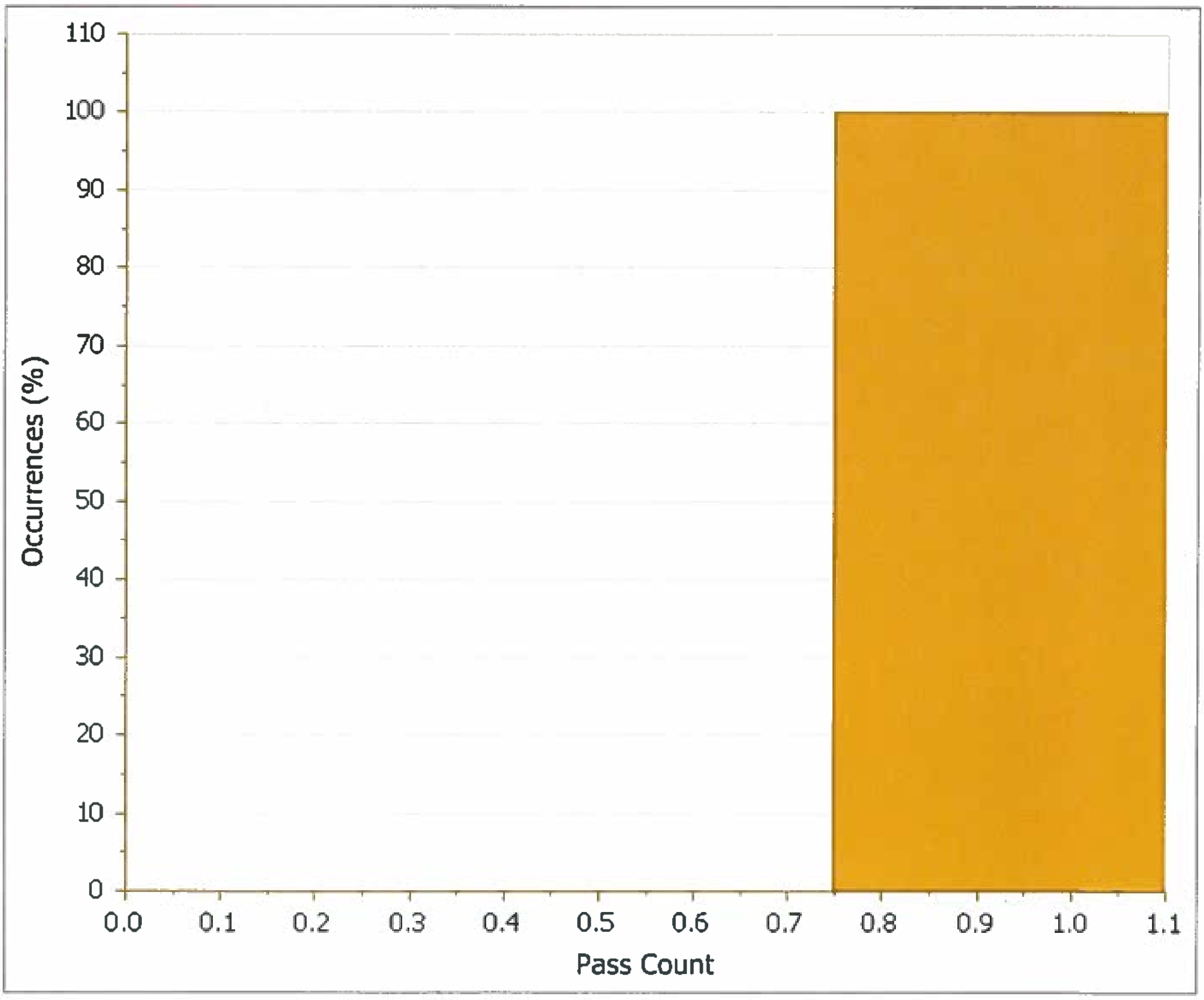
Pass 01
Final Coverage: False

Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count
Target Percentage (%): 0.00
Target Value: 0.00

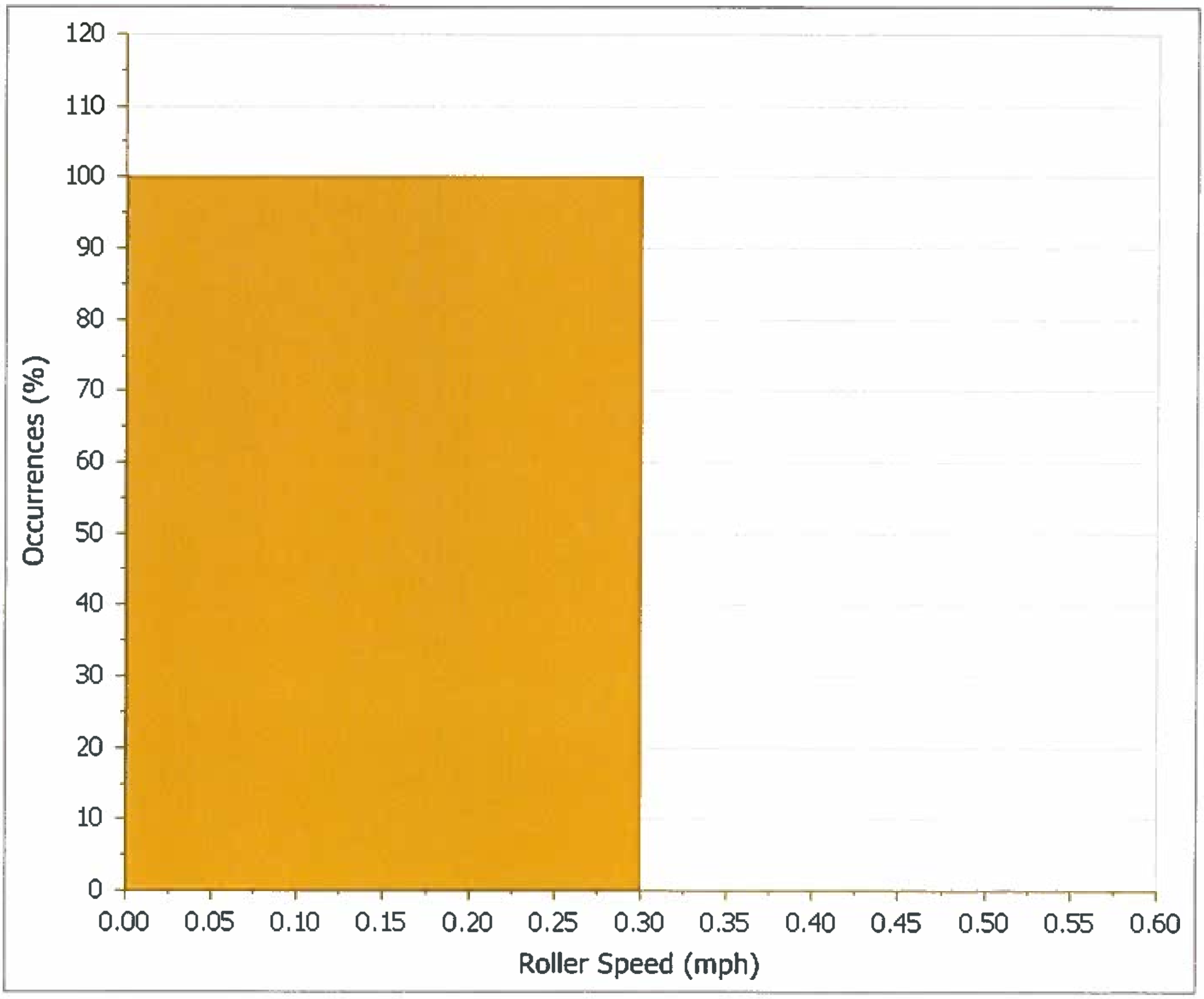
Statistic	Value
Mean	1
Standard Deviation	0
CoV (%)	0
Min	1
Max	1
Sample Size	299
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

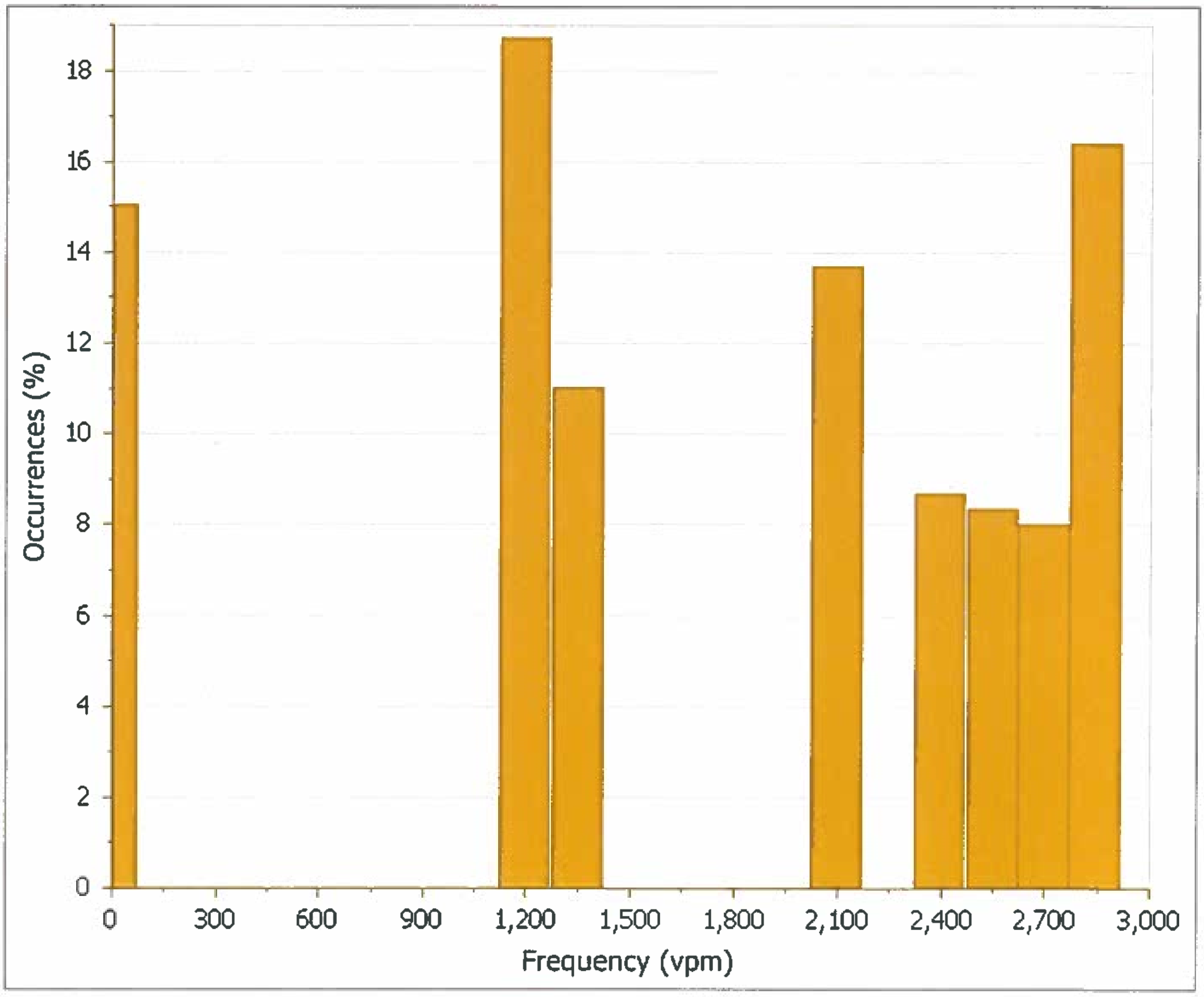
Statistic	Value
Mean (mph)	0.0
Standard Deviation (mph)	0.0
CoV (%)	NaN
Min (mph)	0.0
Max (mph)	0.0
Sample Size	299
Target Status	Failed
% of Target Achieved	0.00



Final Coverage: Frequency

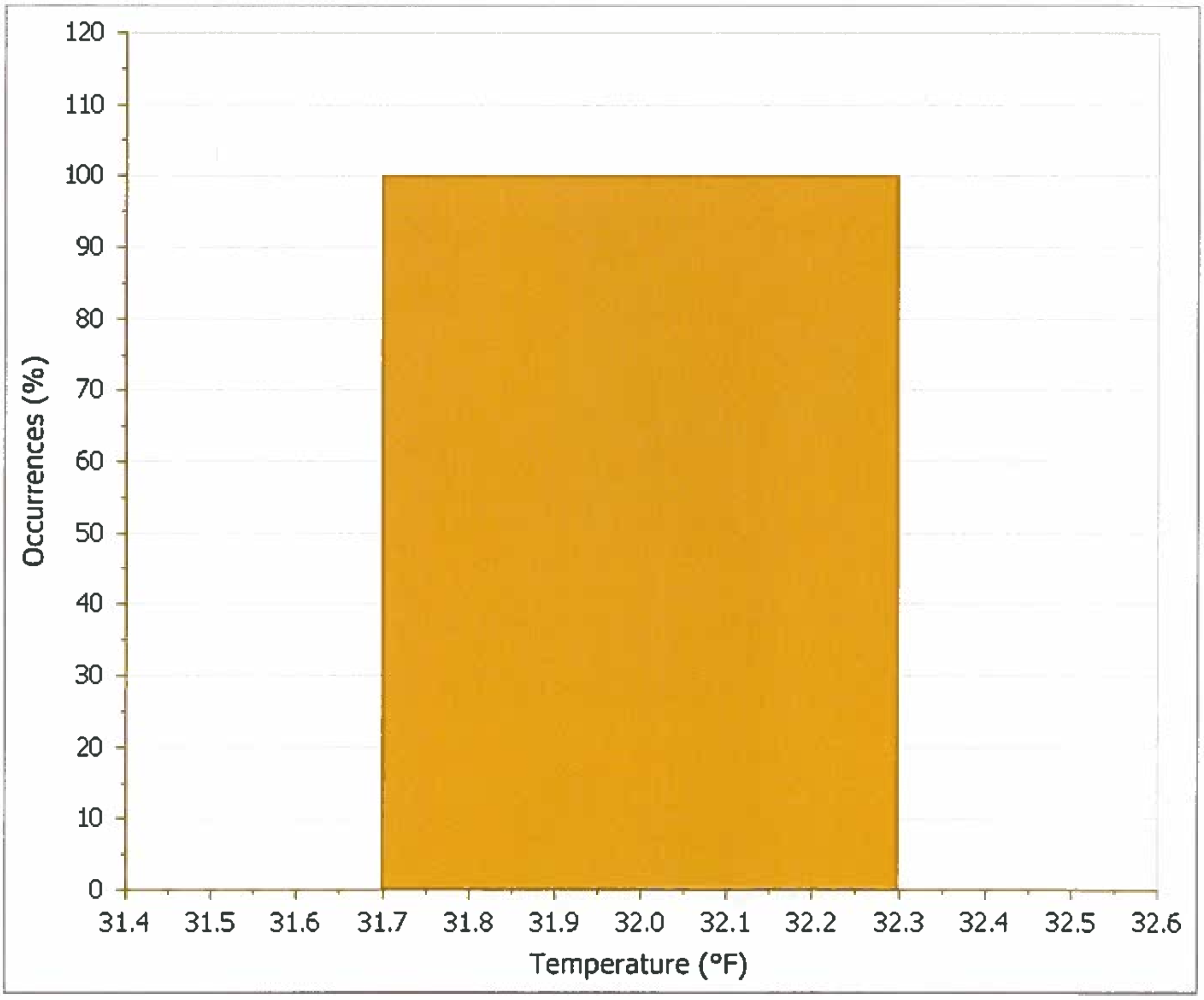
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	1,737
Standard Deviation (vpm)	968
CoV (%)	56
Min (vpm)	0
Max (vpm)	2,994
Sample Size	299
Target Status	Passed
% of Target Achieved	84.95



Final Coverage: Temperature

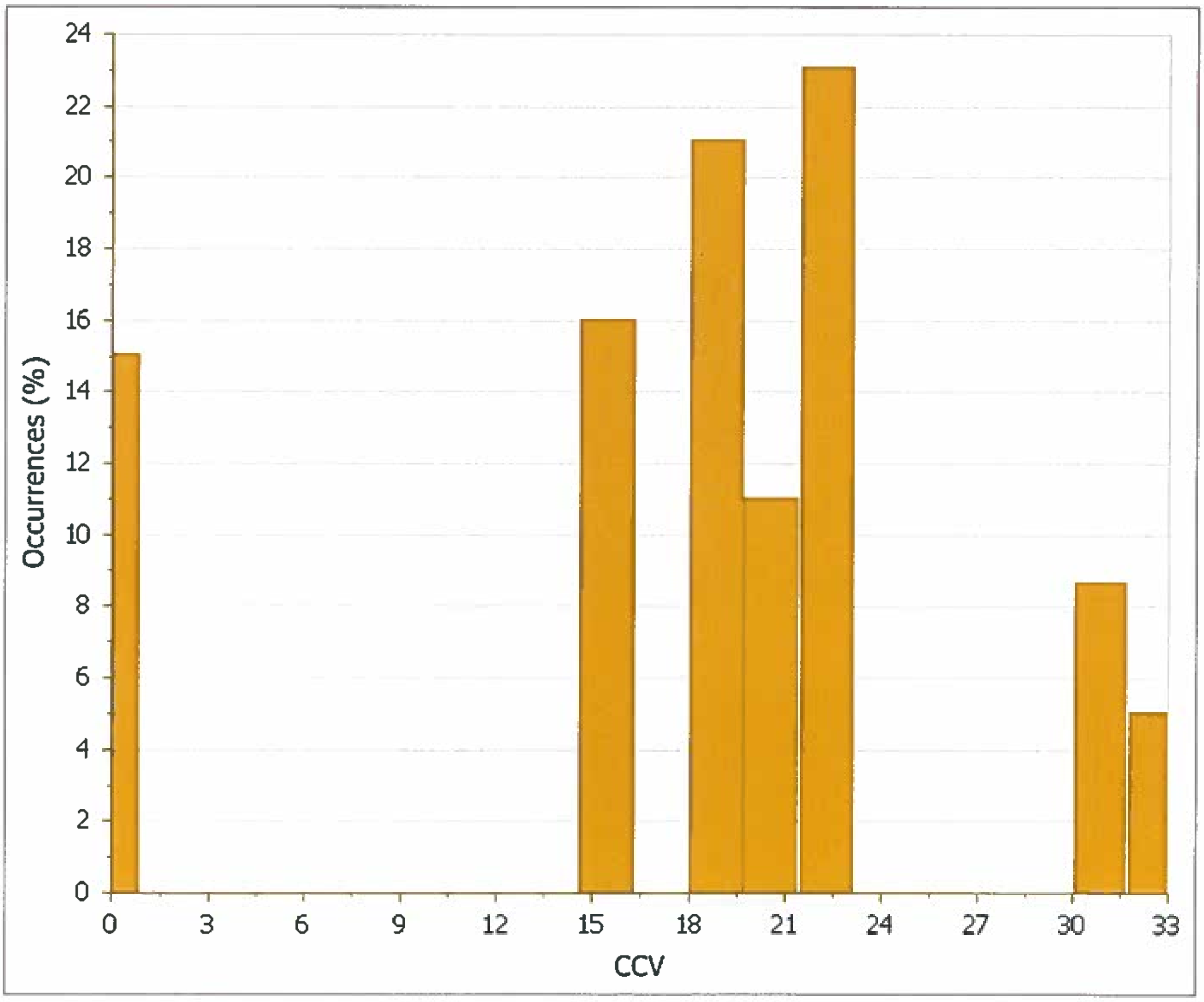
Statistic	Value
Mean (°F)	32.0
Standard Deviation (°F)	0.00
CoV (%)	0
Min (°F)	32.0
Max (°F)	32.0
Sample Size	299



Final Coverage: CCV

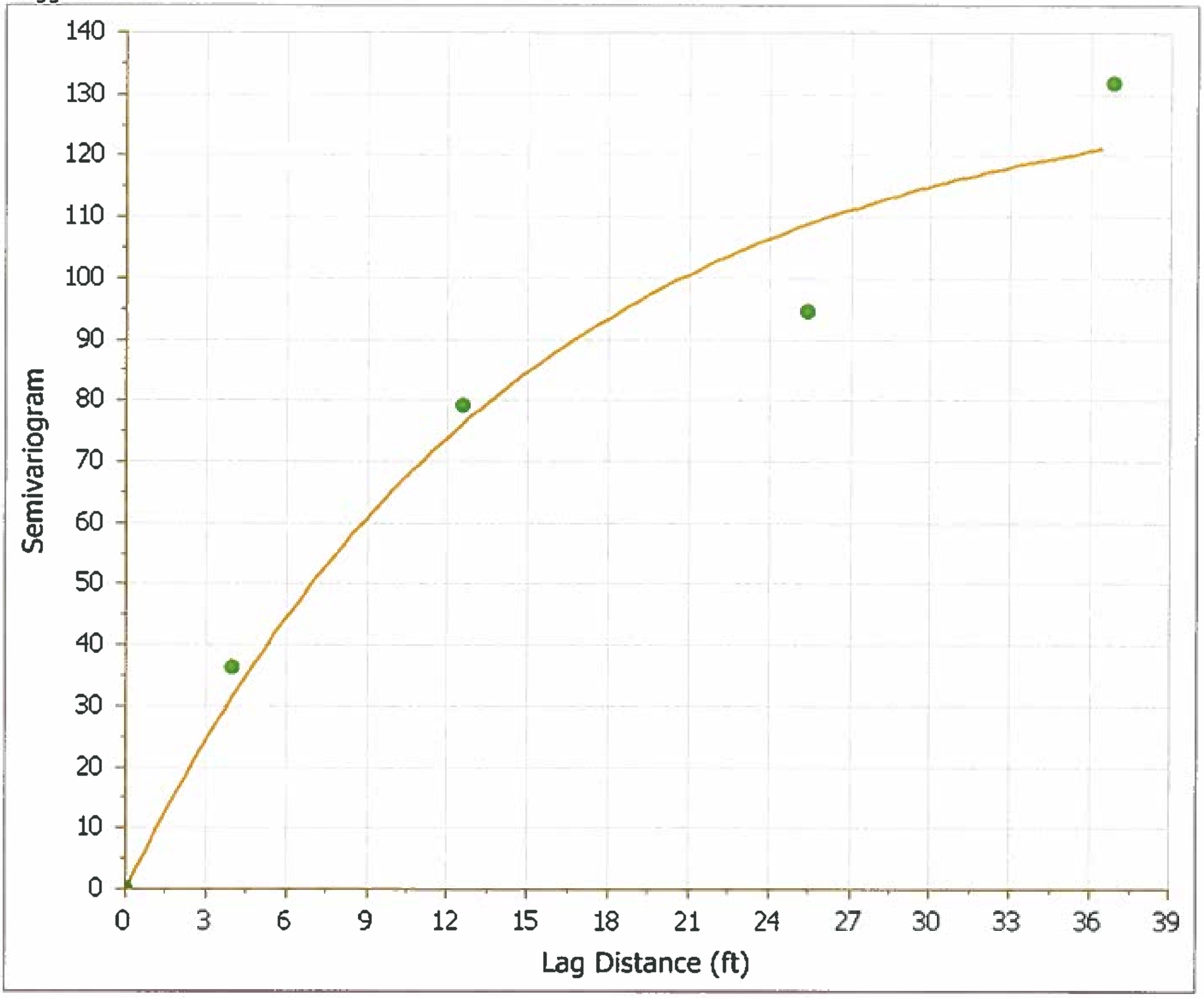
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	17.24
Standard Deviation	8.77
CoV (%)	51
Min	0.00
Max	34.30
Sample Size	299
Target Status	Passed
% of Target Achieved	84.95



Final Coverage: Semivariogram

Range (ft): 6.63
Sill: 48.19
Vertical Scale: 48.19
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130629-1031-41
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0

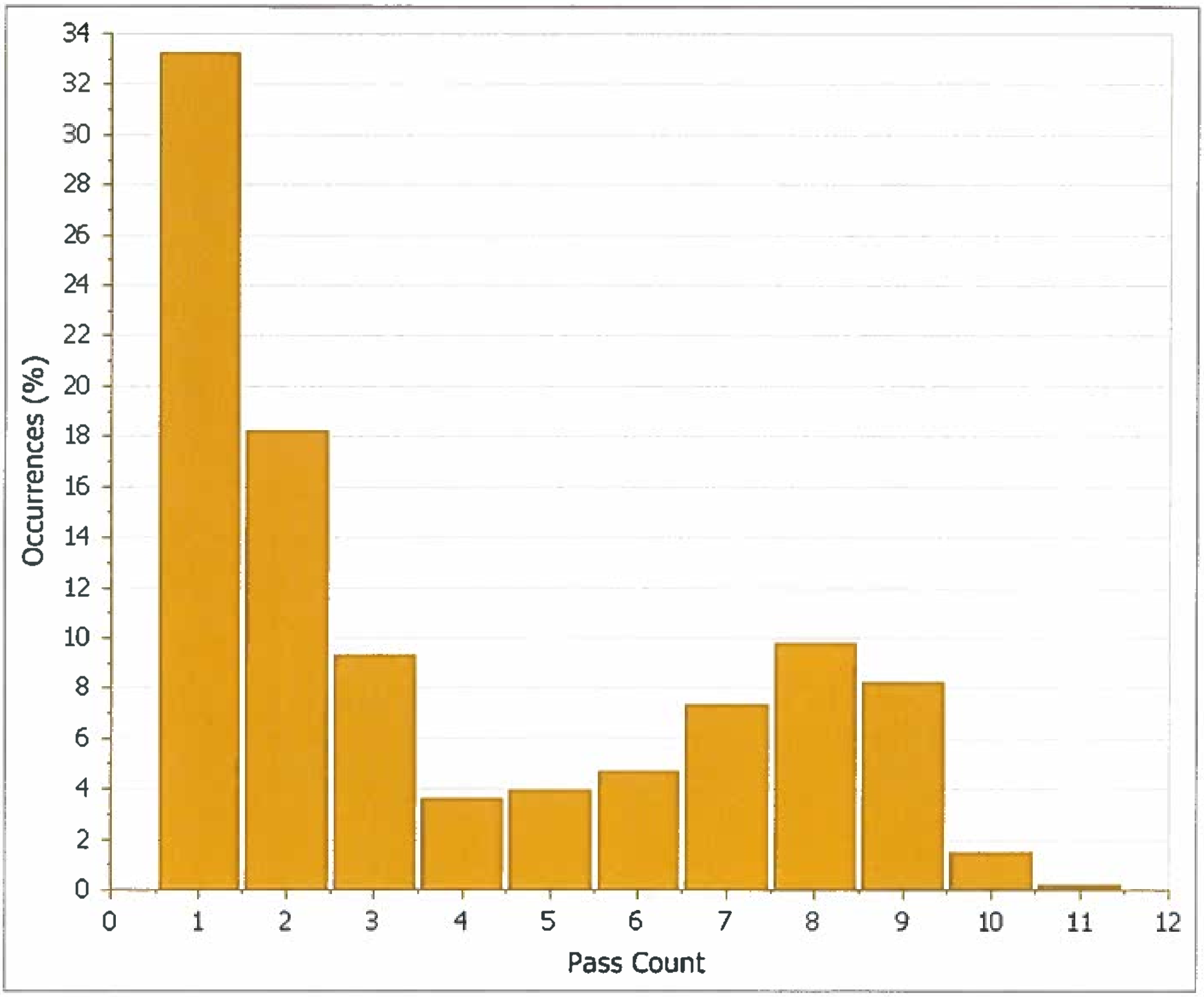
AREA_20130629-1031-41

Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

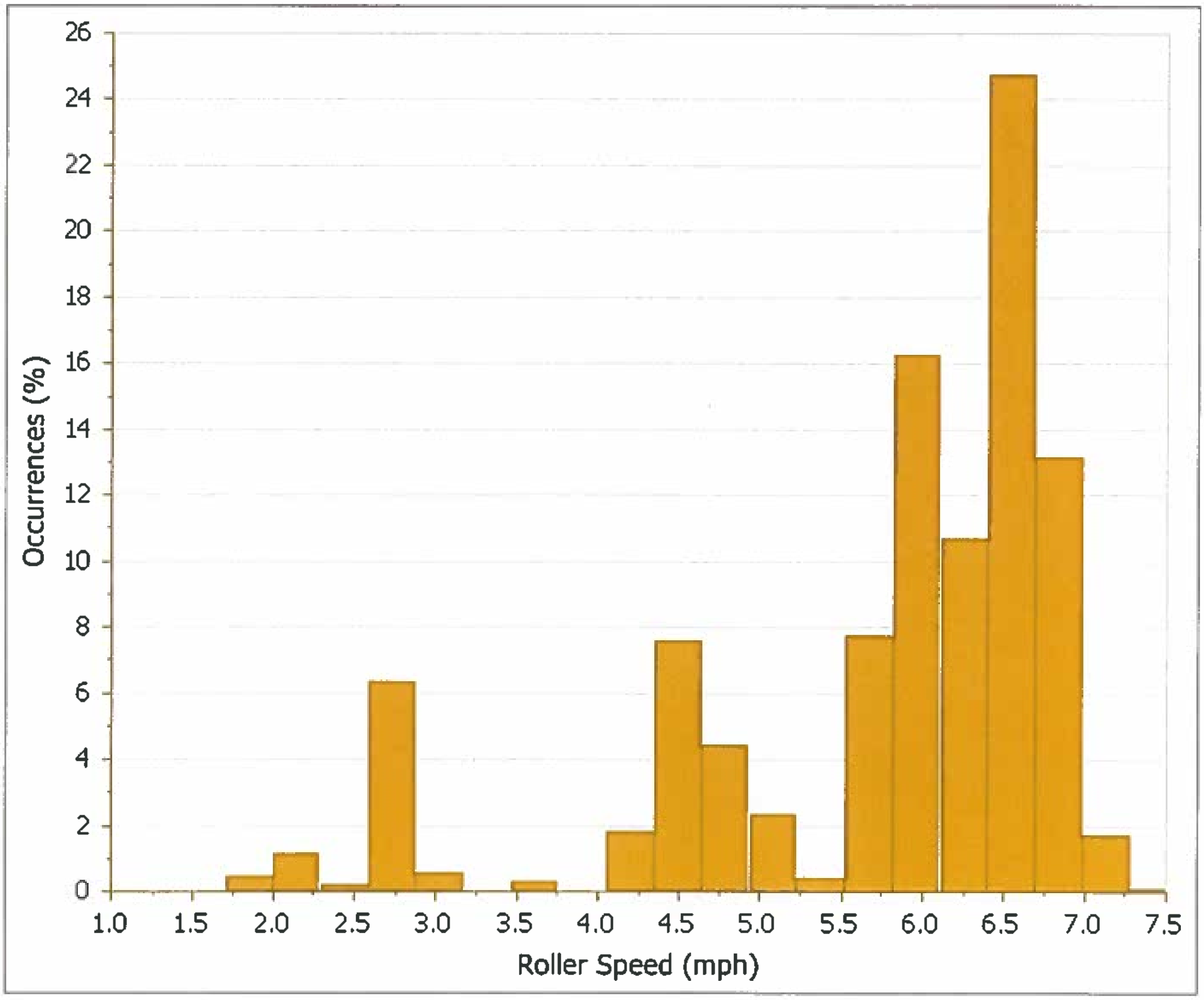
Statistic	Value
Mean	4
Standard Deviation	3
CoV (%)	78
Min	1
Max	11
Sample Size	4,906
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

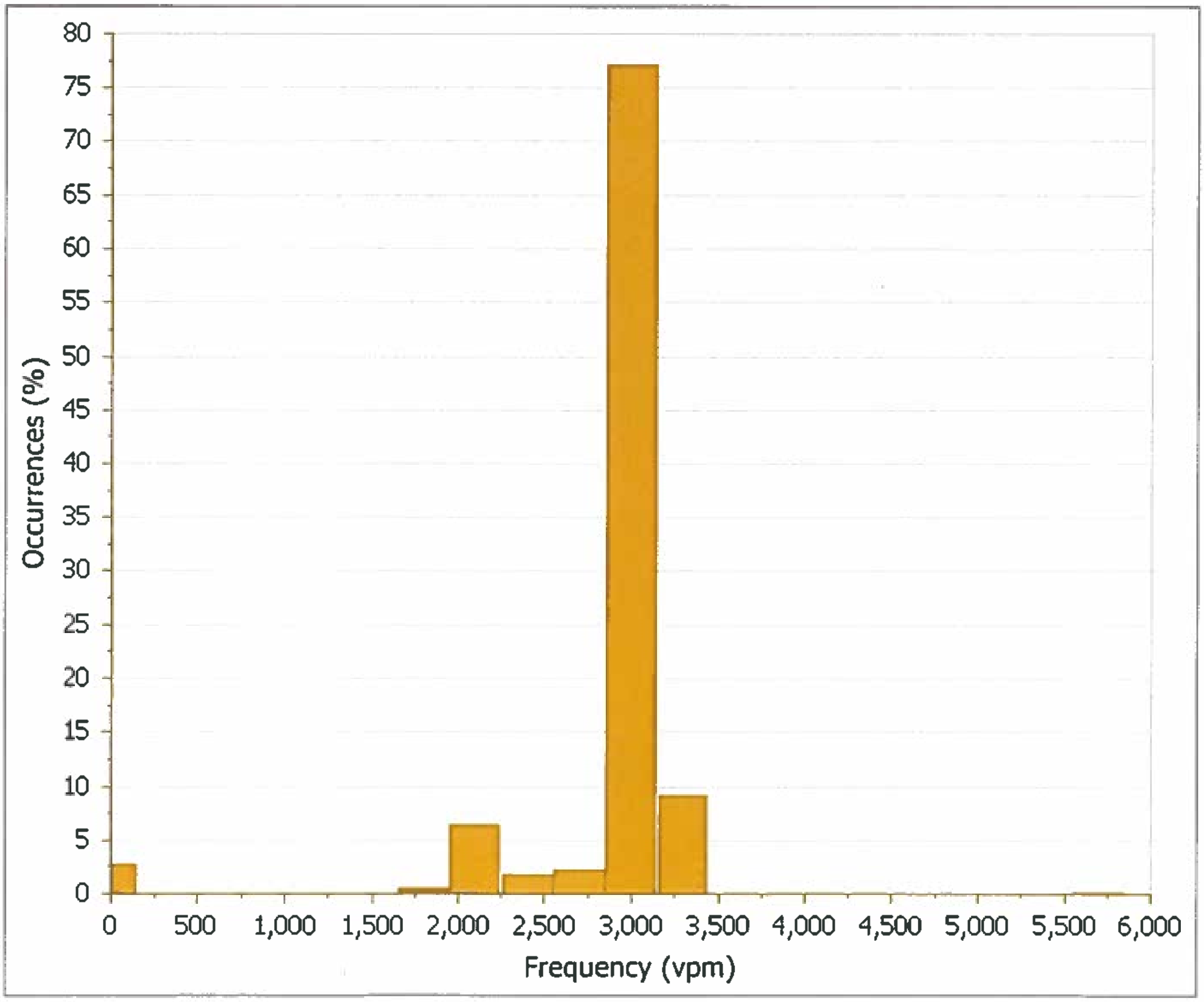
Statistic	Value
Mean (mph)	5.6
Standard Deviation (mph)	1.2
CoV (%)	22
Min (mph)	1.9
Max (mph)	7.7
Sample Size	4,906
Target Status	Passed
% of Target Achieved	99.53



Final Coverage: Frequency

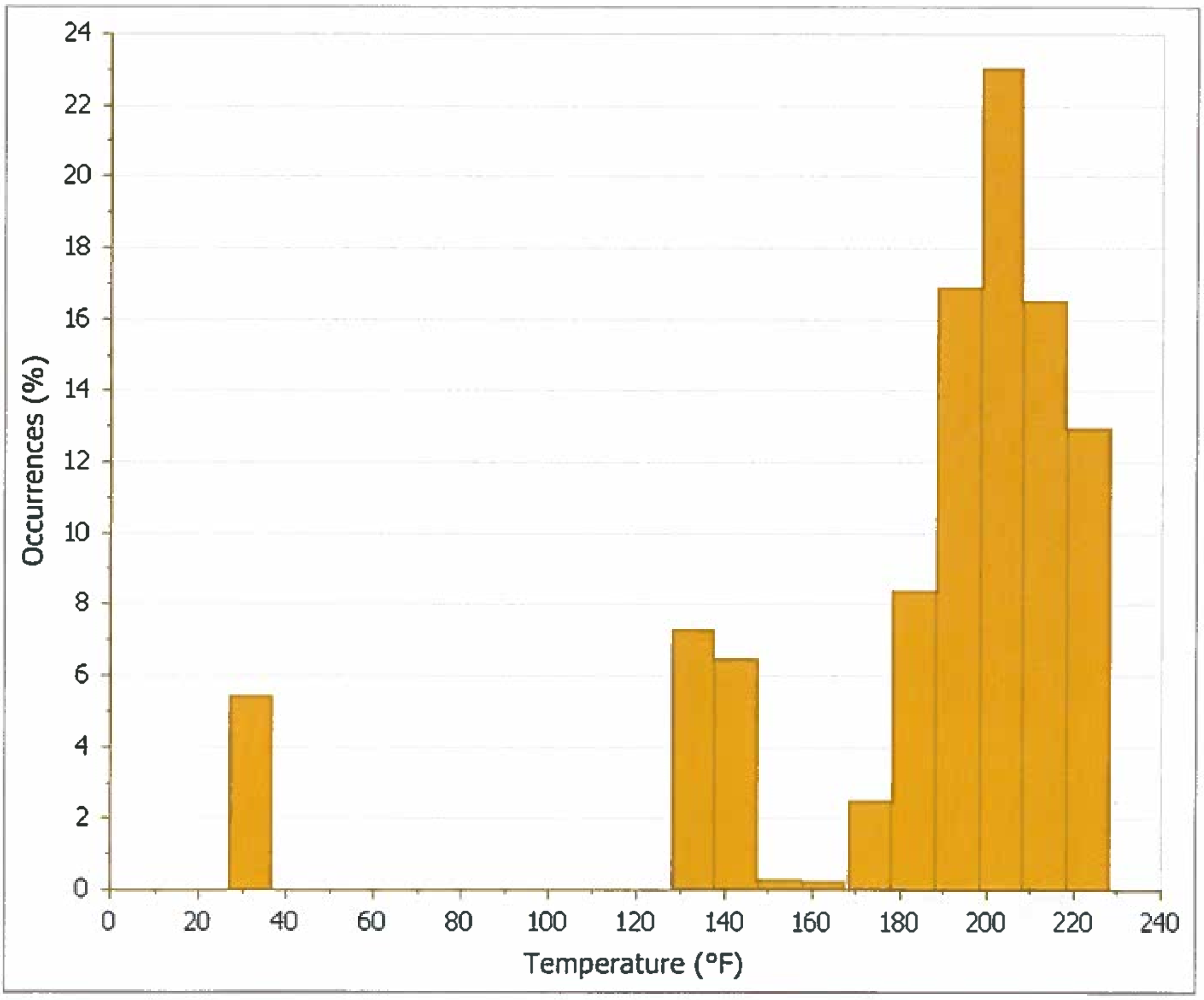
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,799
Standard Deviation (vpm)	557
CoV (%)	20
Min (vpm)	0
Max (vpm)	5,994
Sample Size	4,906
Target Status	Passed
% of Target Achieved	97.25



Final Coverage: Temperature

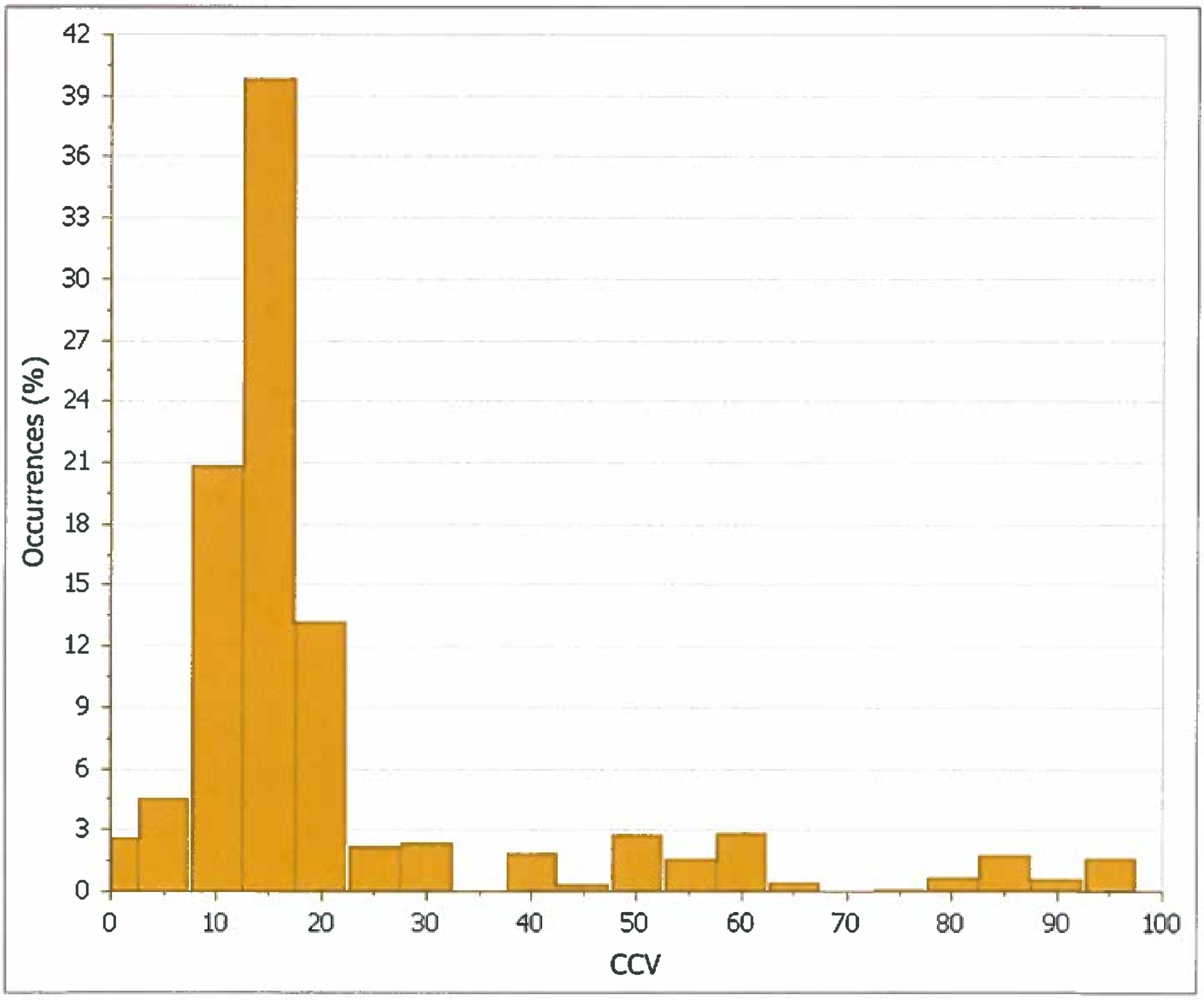
Statistic	Value
Mean (°F)	179.5
Standard Deviation (°F)	43.79
CoV (%)	24
Min (°F)	32.0
Max (°F)	233.4
Sample Size	4,906



Final Coverage: CCV

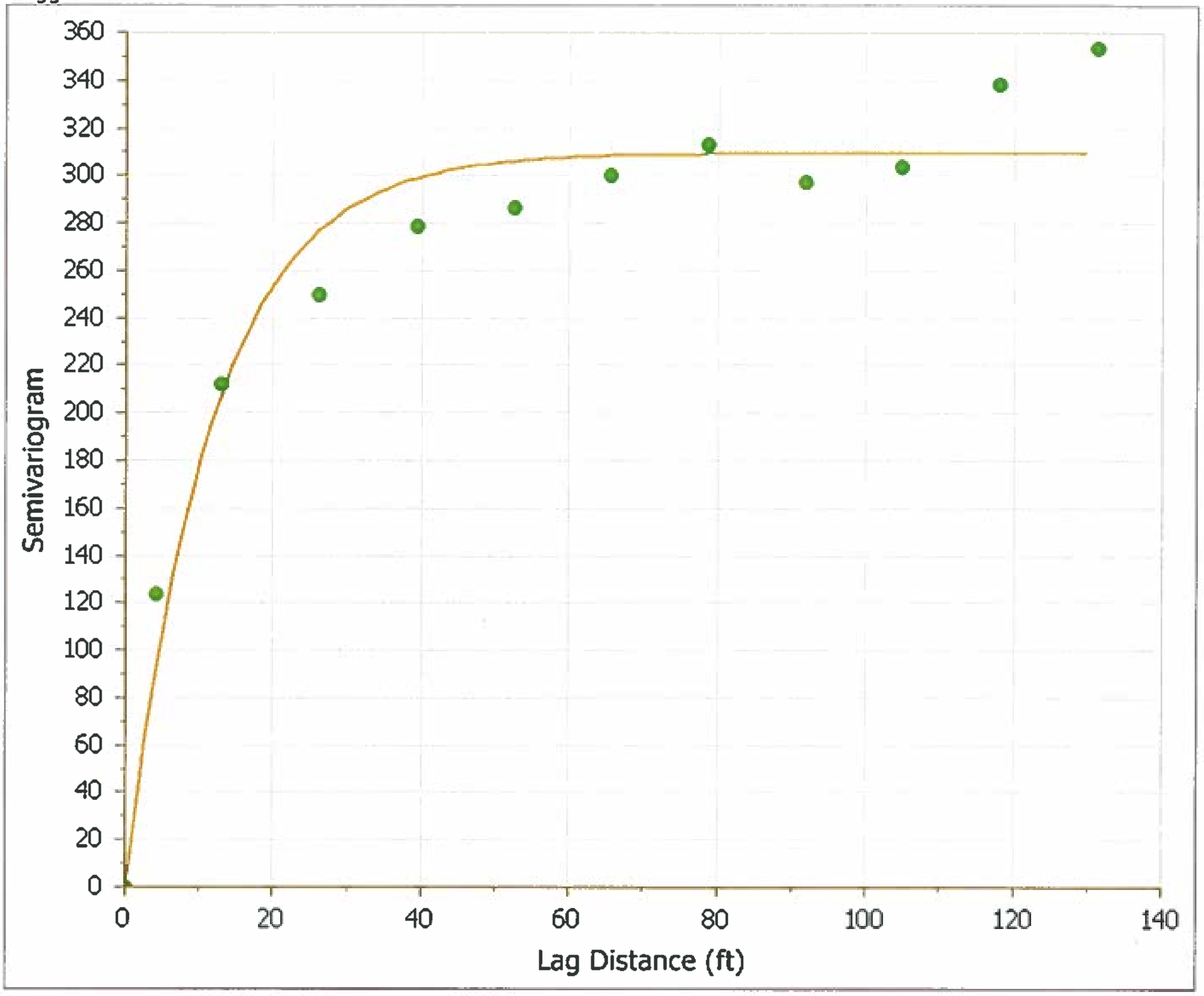
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	18.99
Standard Deviation	19.92
CoV (%)	105
Min	0.00
Max	100.00
Sample Size	4,906
Target Status	Passed
% of Target Achieved	97.43



Final Coverage: Semivariogram

Range (ft): 22.30
Sill: 263.78
Vertical Scale: 263.78
Nuggets: 0.00



Project Information

Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130710-0717-16
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

Pass 17
Final Coverage: False

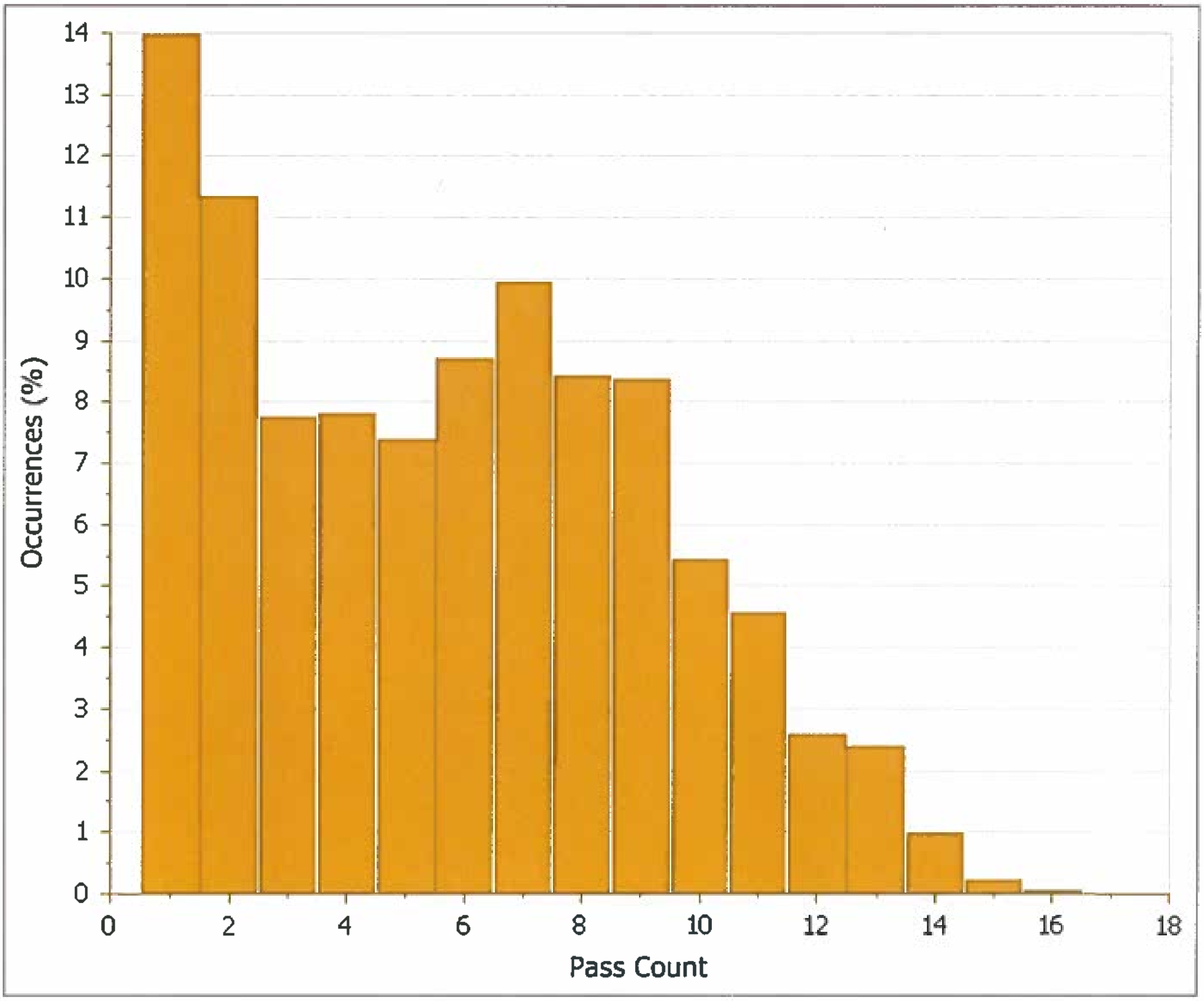
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

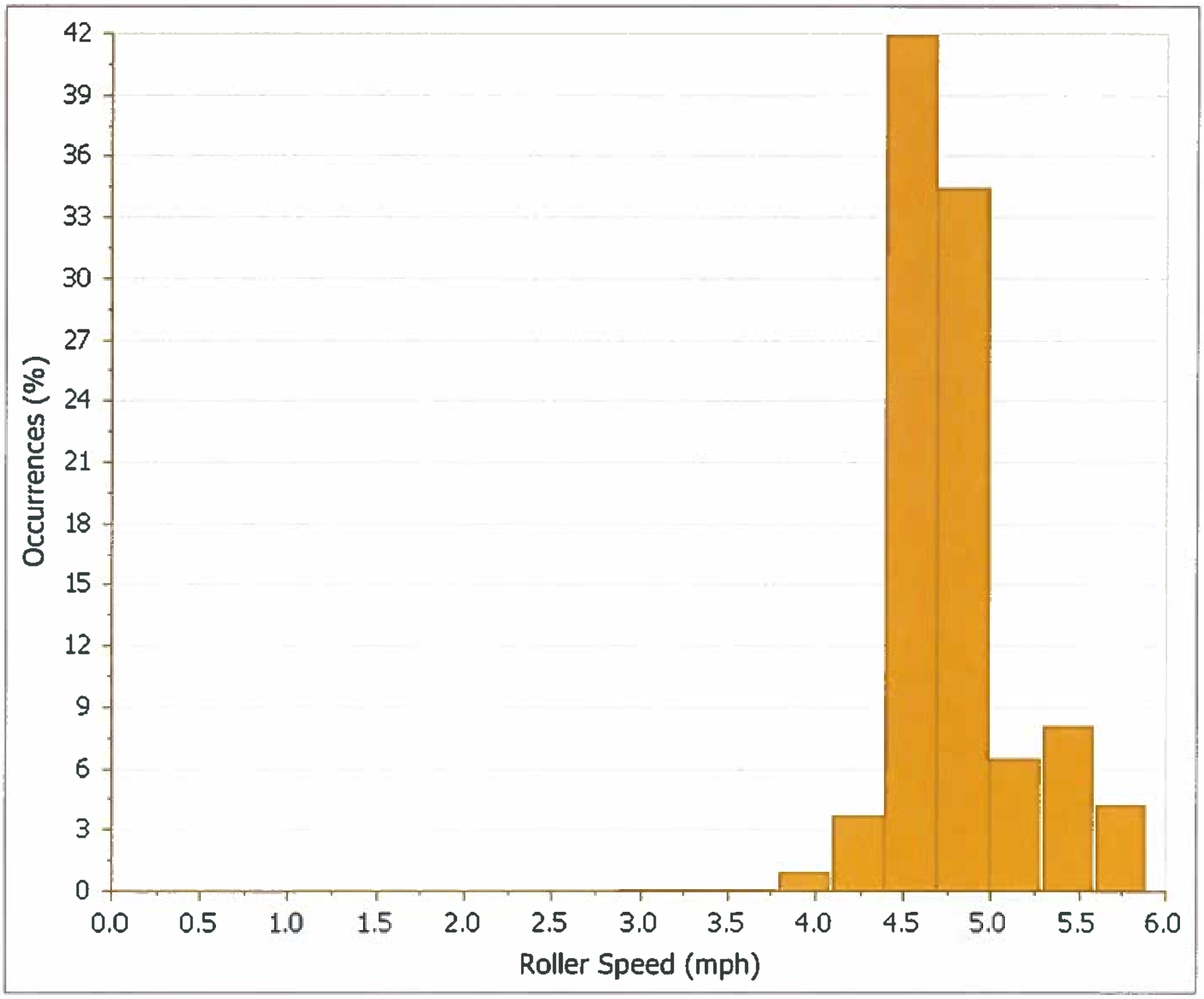
Statistic	Value
Mean	6
Standard Deviation	4
CoV (%)	61
Min	1
Max	17
Sample Size	46,515
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

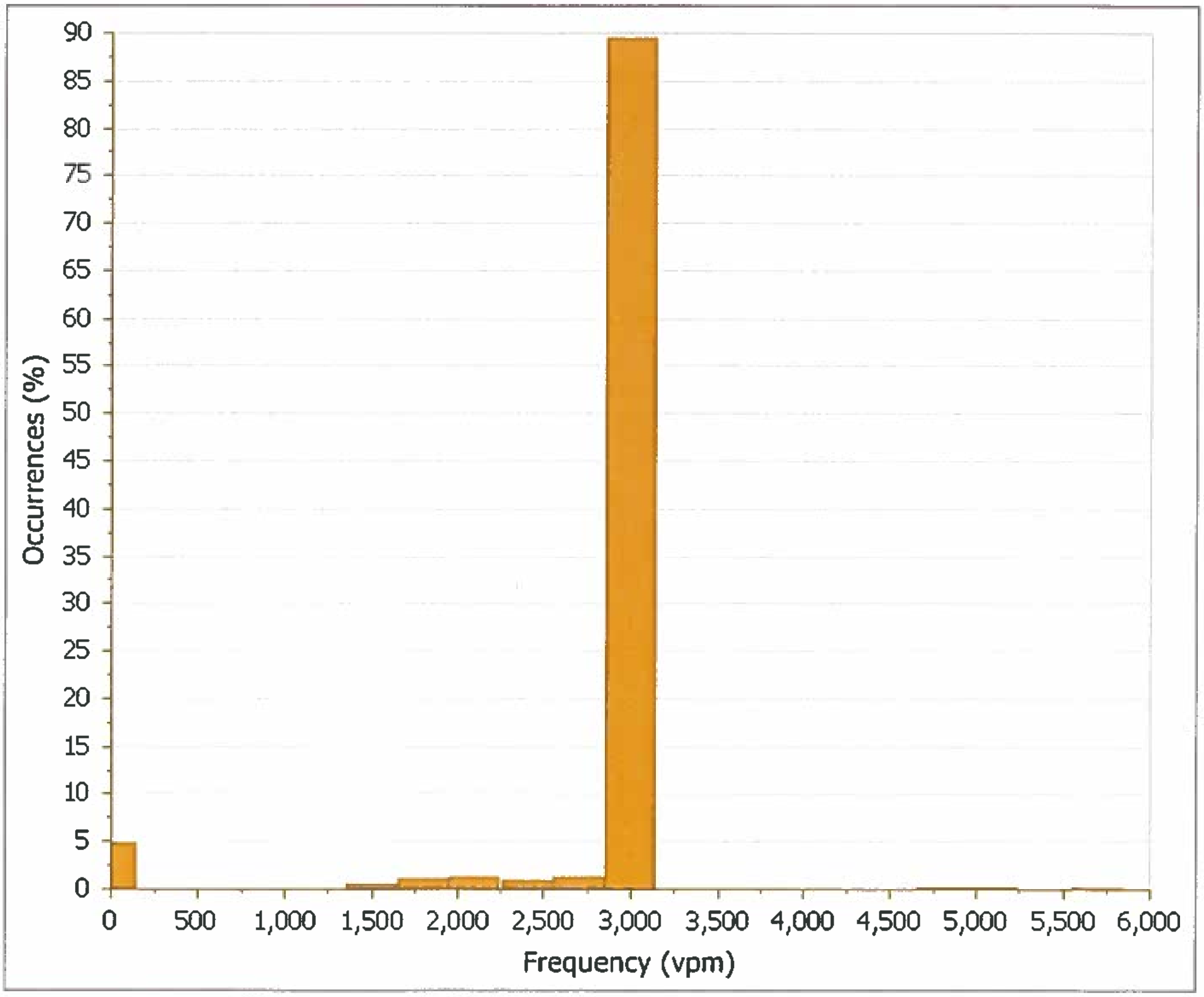
Statistic	Value
Mean (mph)	4.6
Standard Deviation (mph)	0.4
CoV (%)	8
Min (mph)	0.0
Max (mph)	6.0
Sample Size	46,515
Target Status	Passed
% of Target Achieved	99.97



Final Coverage: Frequency

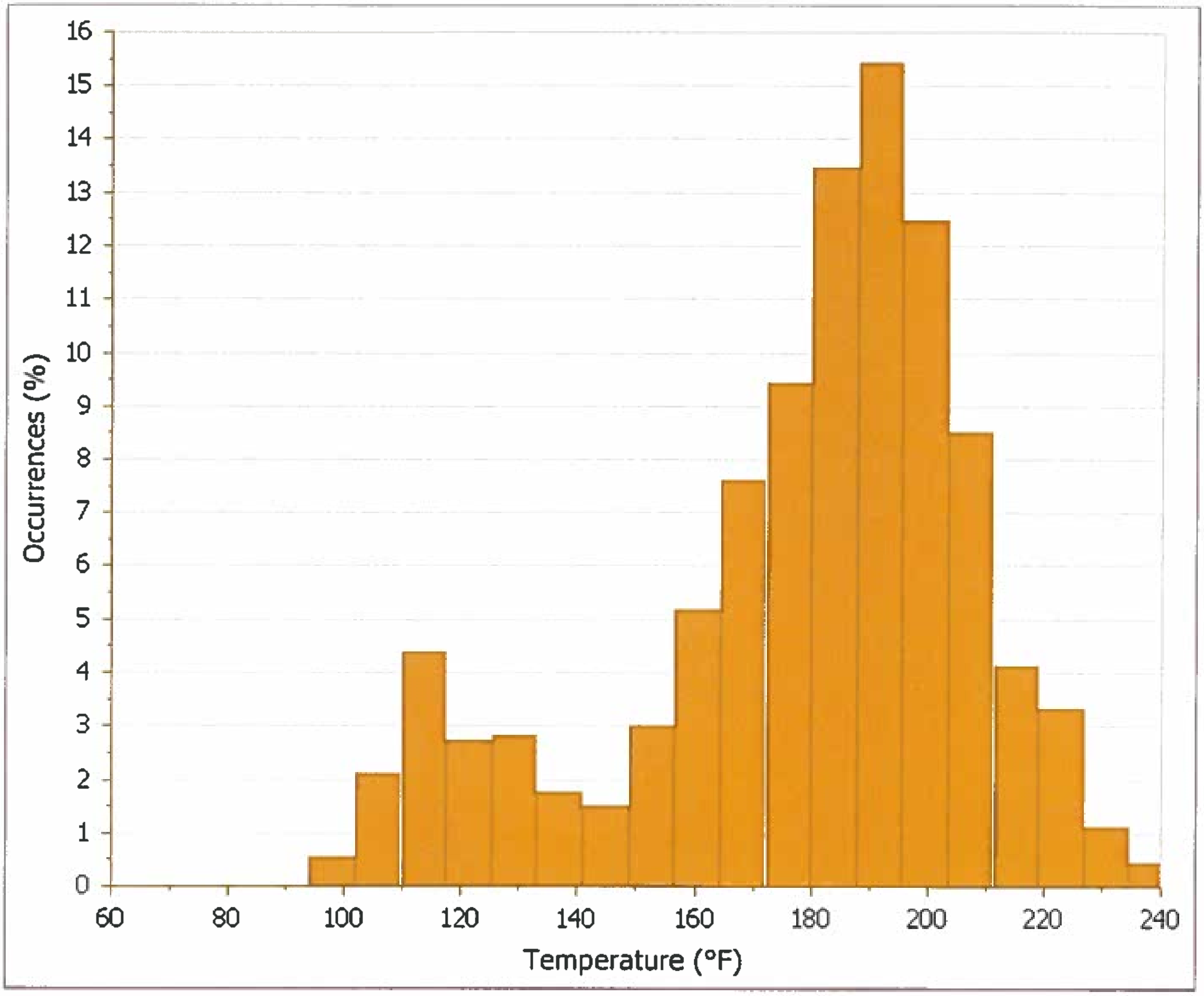
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,746
Standard Deviation (vpm)	678
CoV (%)	25
Min (vpm)	0
Max (vpm)	5,994
Sample Size	46,515
Target Status	Passed
% of Target Achieved	95.19



Final Coverage: Temperature

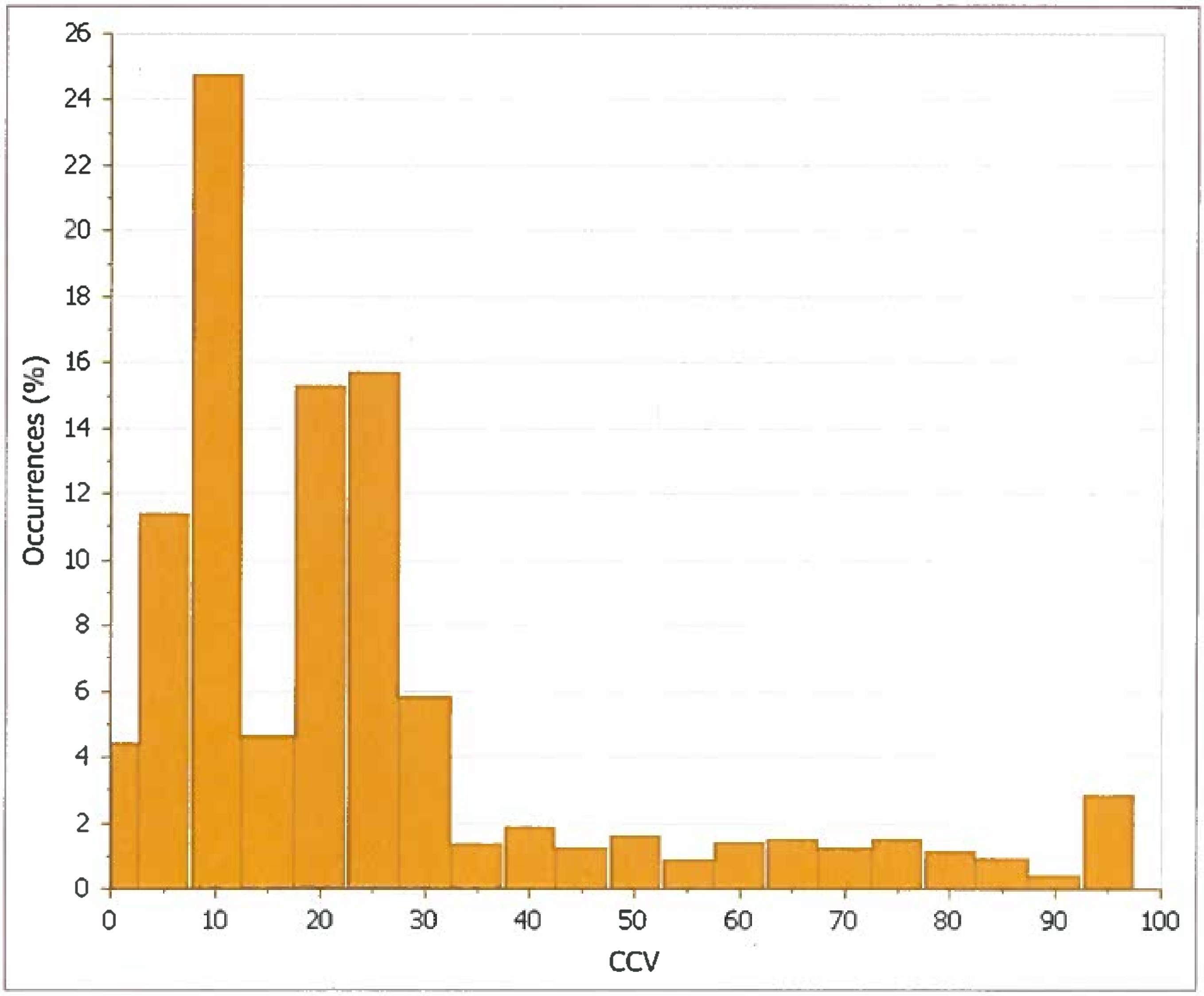
Statistic	Value
Mean (°F)	174.7
Standard Deviation (°F)	30.13
CoV (%)	17
Min (°F)	90.1
Max (°F)	246.4
Sample Size	46,515



Final Coverage: CCV

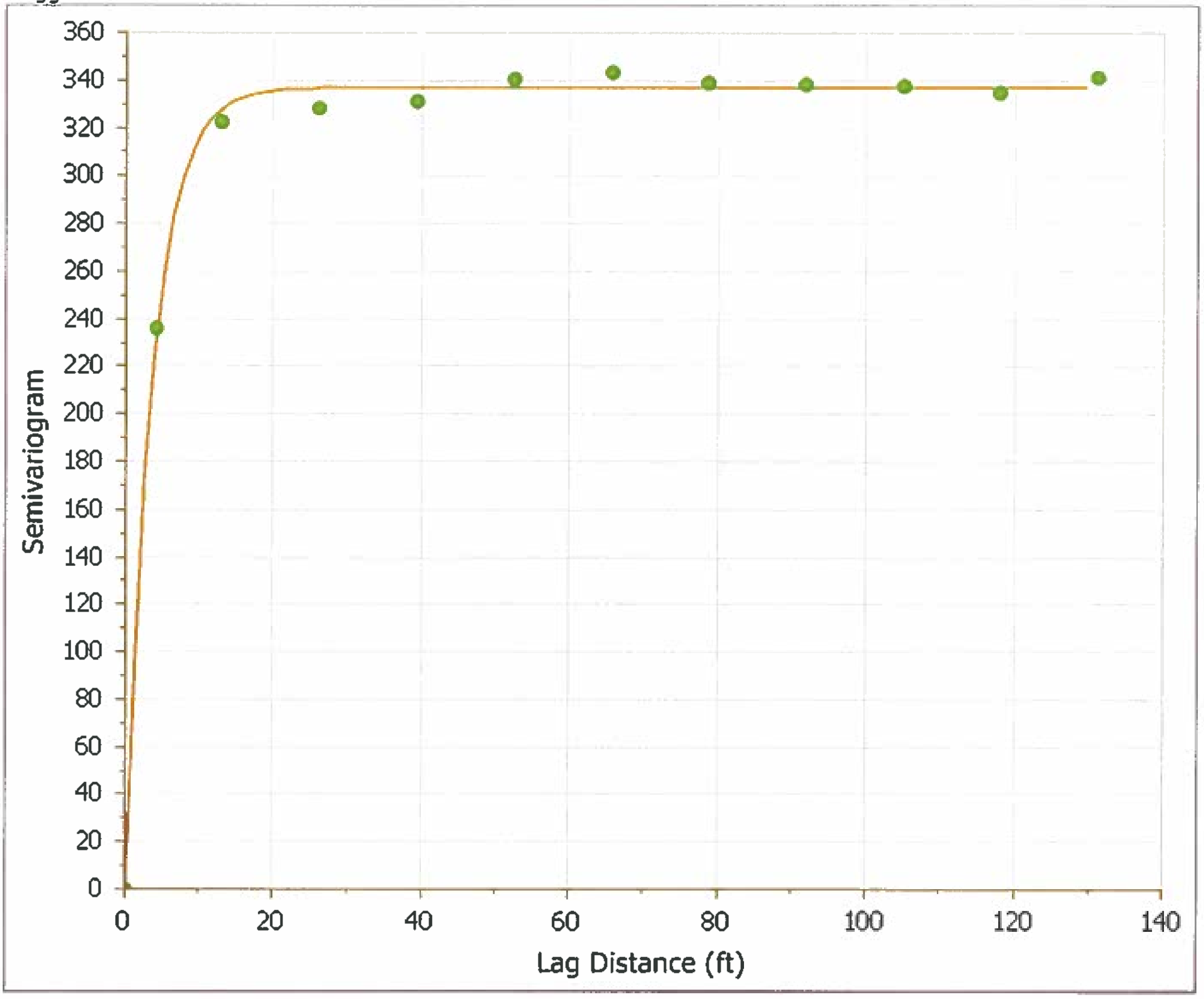
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	22.06
Standard Deviation	22.78
CoV (%)	103
Min	0.00
Max	100.00
Sample Size	46,515
Target Status	Passed
% of Target Achieved	95.60



Final Coverage: Semivariogram

Range (ft): 10.50
Sill: 319.10
Vertical Scale: 319.10
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130710-1320-01
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

Pass 17
Final Coverage: False

Pass 18
Final Coverage: False

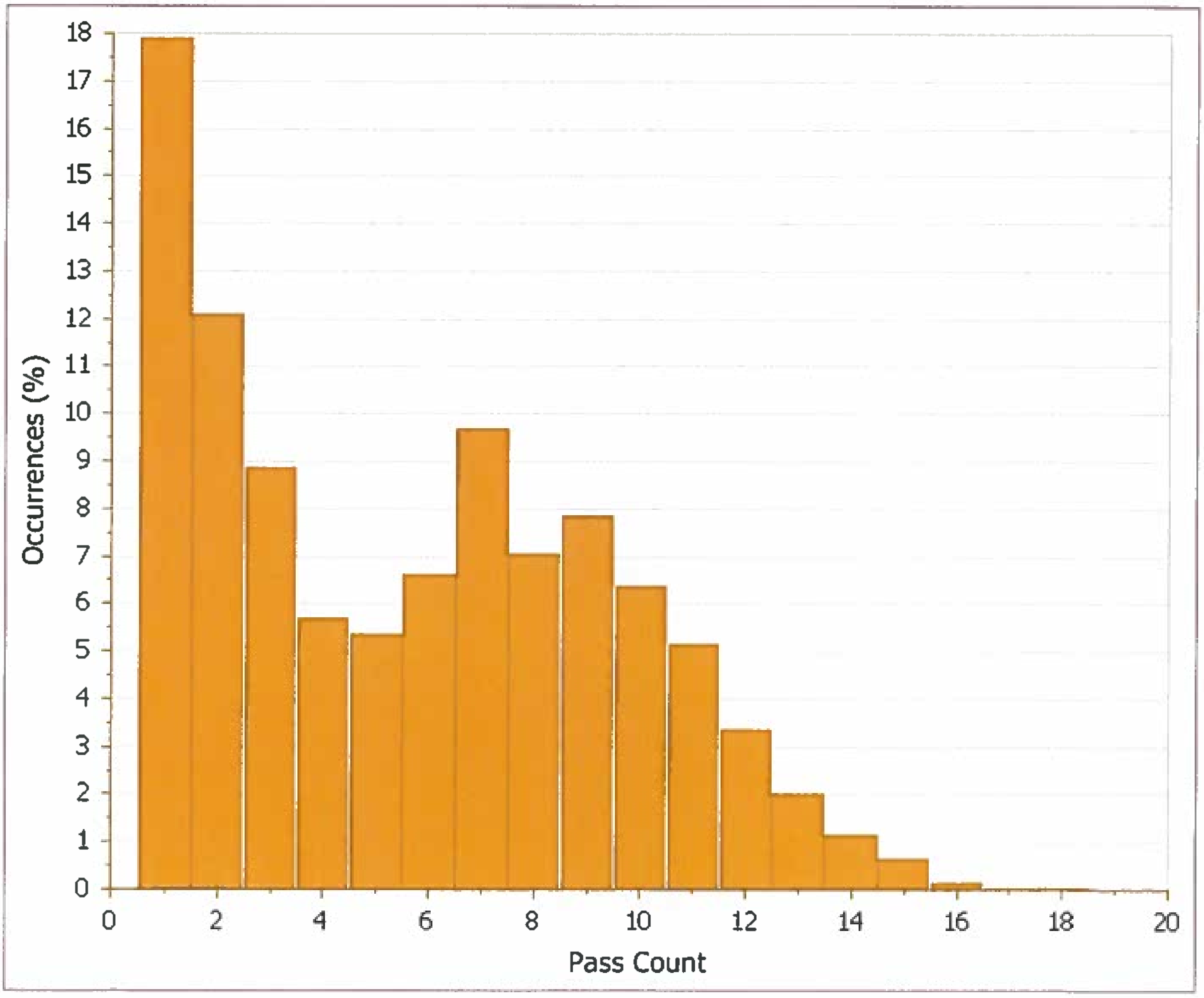
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

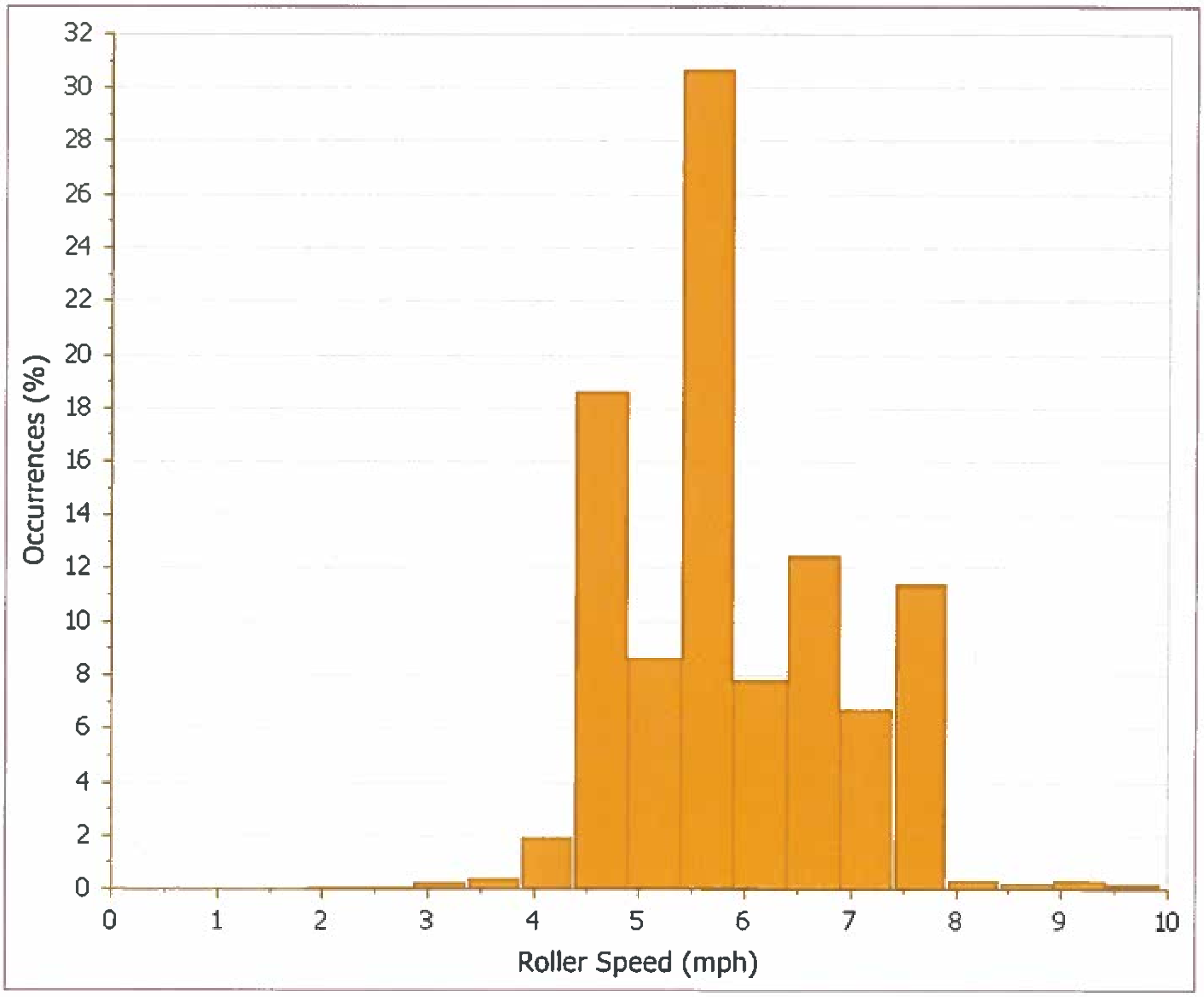
Statistic	Value
Mean	6
Standard Deviation	4
CoV (%)	67
Min	1
Max	18
Sample Size	78,455
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

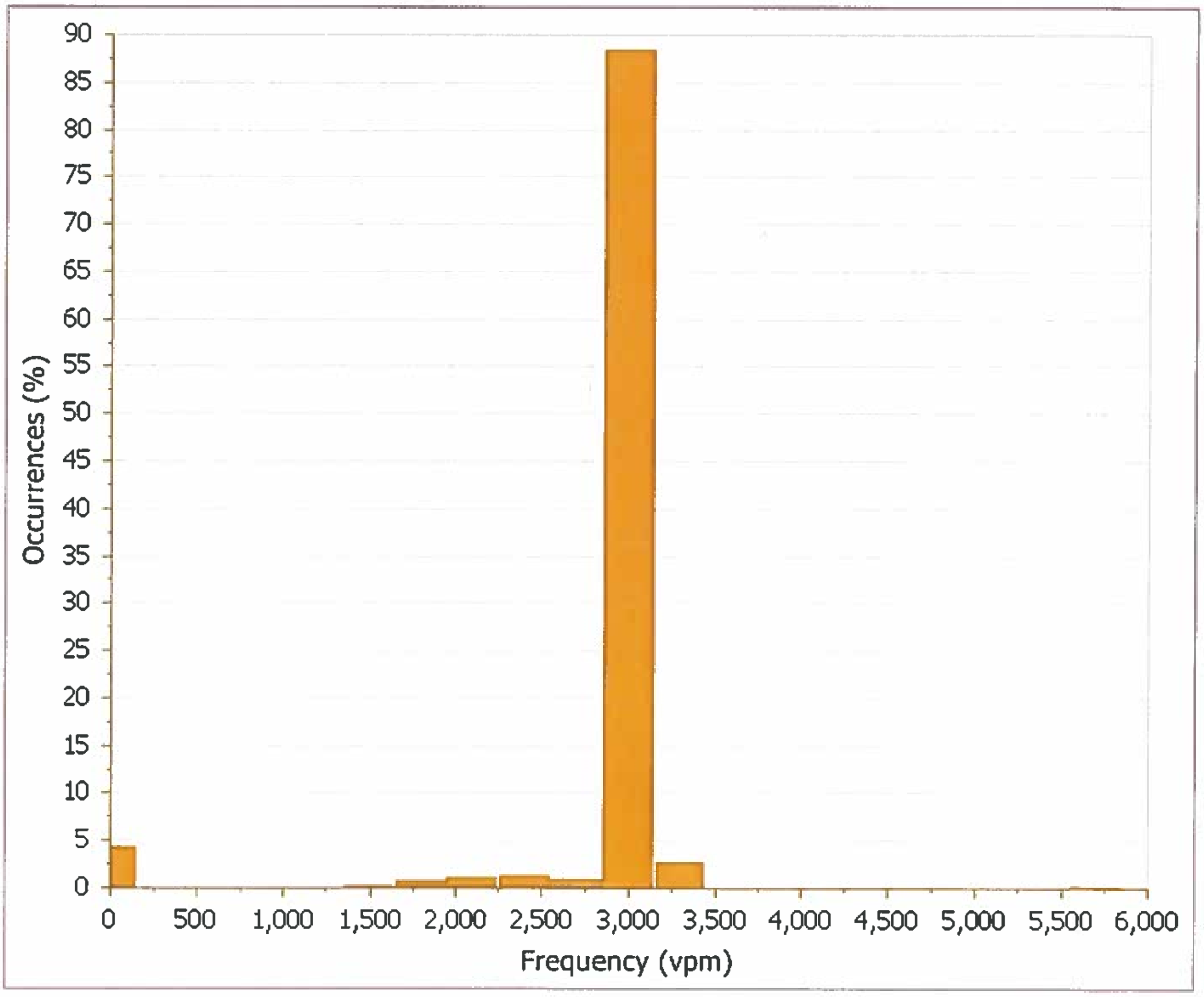
Statistic	Value
Mean (mph)	5.6
Standard Deviation (mph)	1.0
CoV (%)	18
Min (mph)	0.1
Max (mph)	10.2
Sample Size	78,455
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Frequency

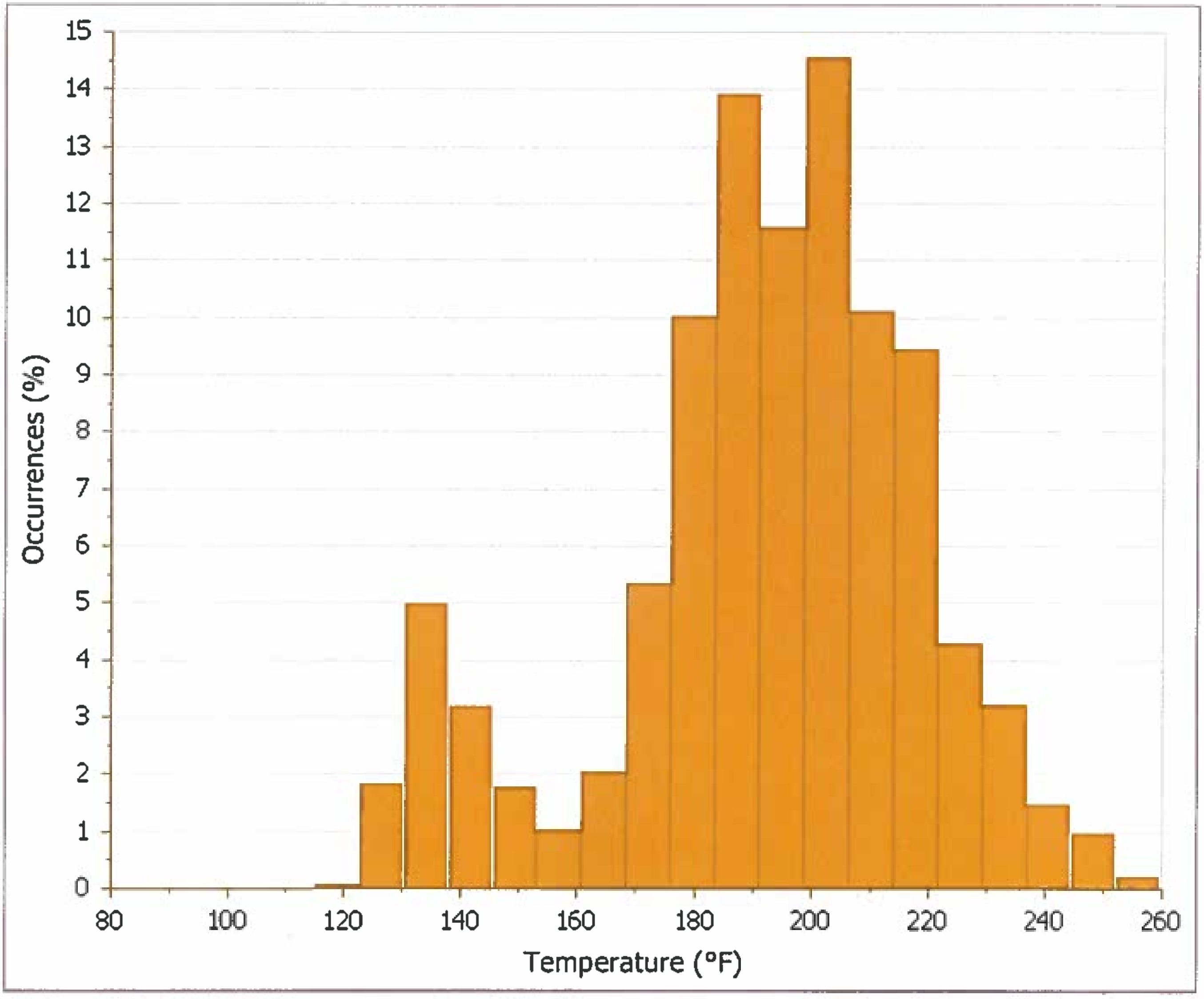
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,802
Standard Deviation (vpm)	647
CoV (%)	23
Min (vpm)	0
Max (vpm)	5,994
Sample Size	78,455
Target Status	Passed
% of Target Achieved	95.67



Final Coverage: Temperature

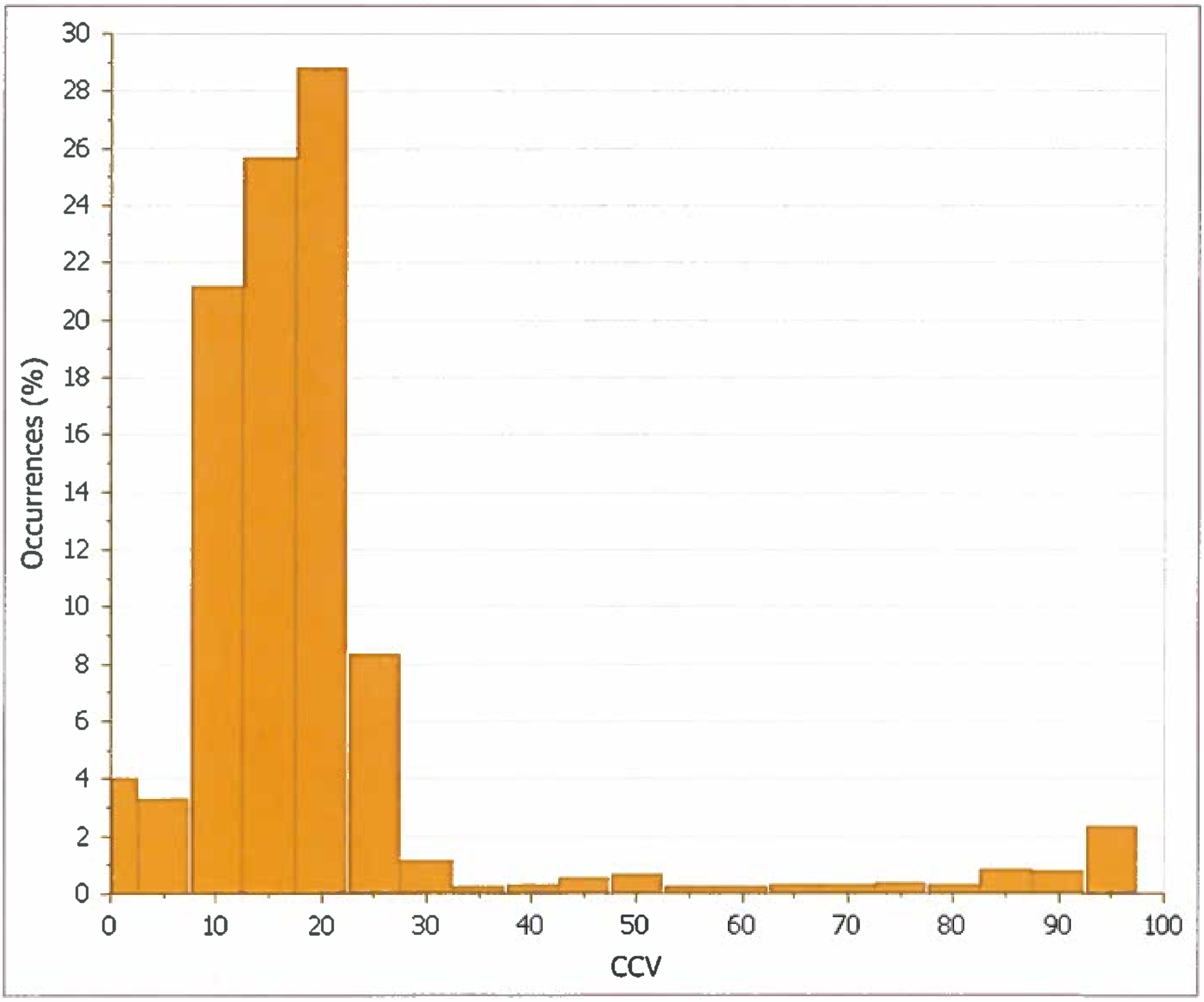
Statistic	Value
Mean (°F)	188.2
Standard Deviation (°F)	26.76
CoV (%)	14
Min (°F)	111.2
Max (°F)	263.5
Sample Size	78,455



Final Coverage: CCV

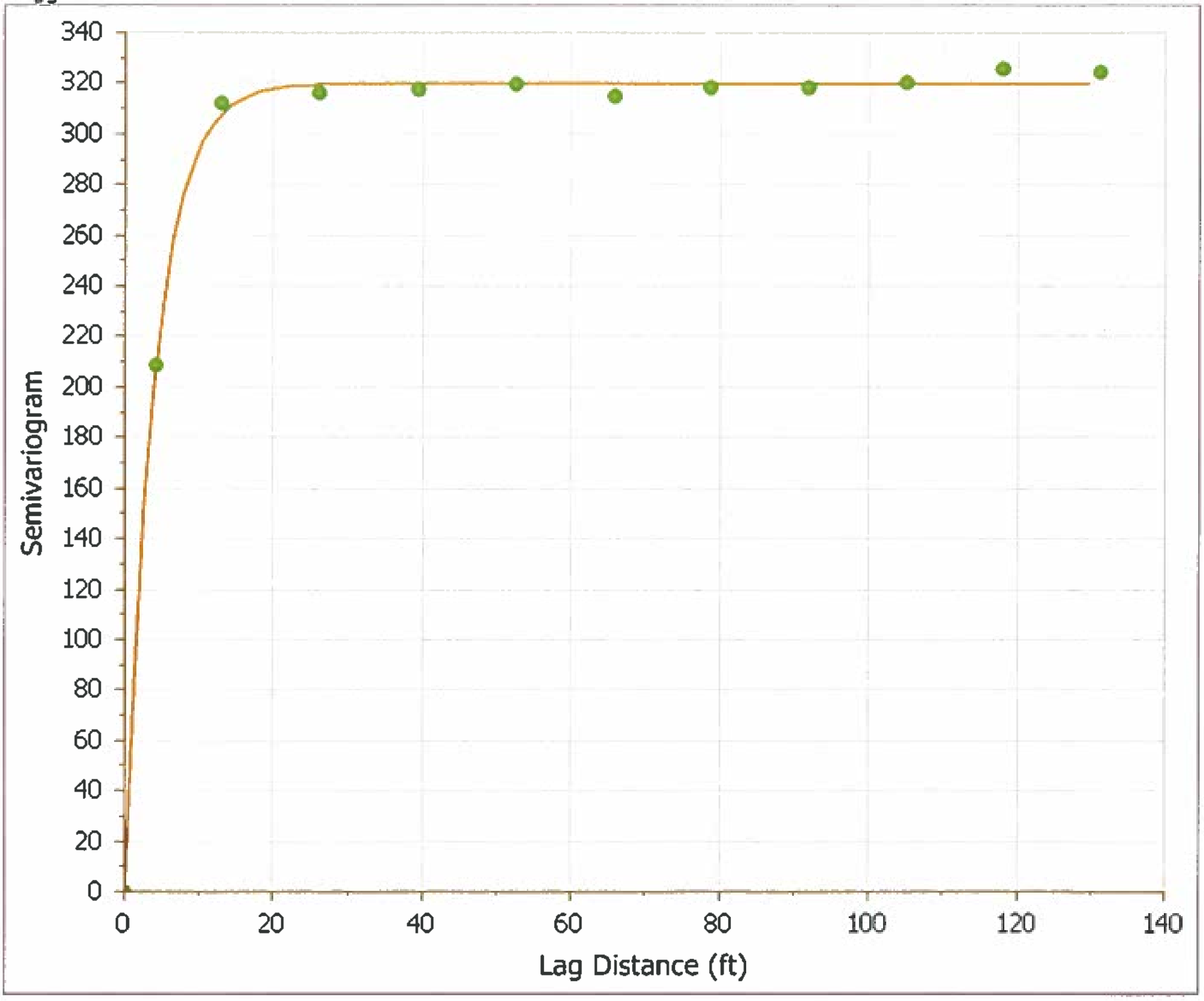
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	17.82
Standard Deviation	18.17
CoV (%)	102
Min	0.00
Max	100.00
Sample Size	78,455
Target Status	Passed
% of Target Achieved	95.99



Final Coverage: Semivariogram

Range (ft): 11.81
Sill: 303.52
Vertical Scale: 303.52
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130712-0810-35
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

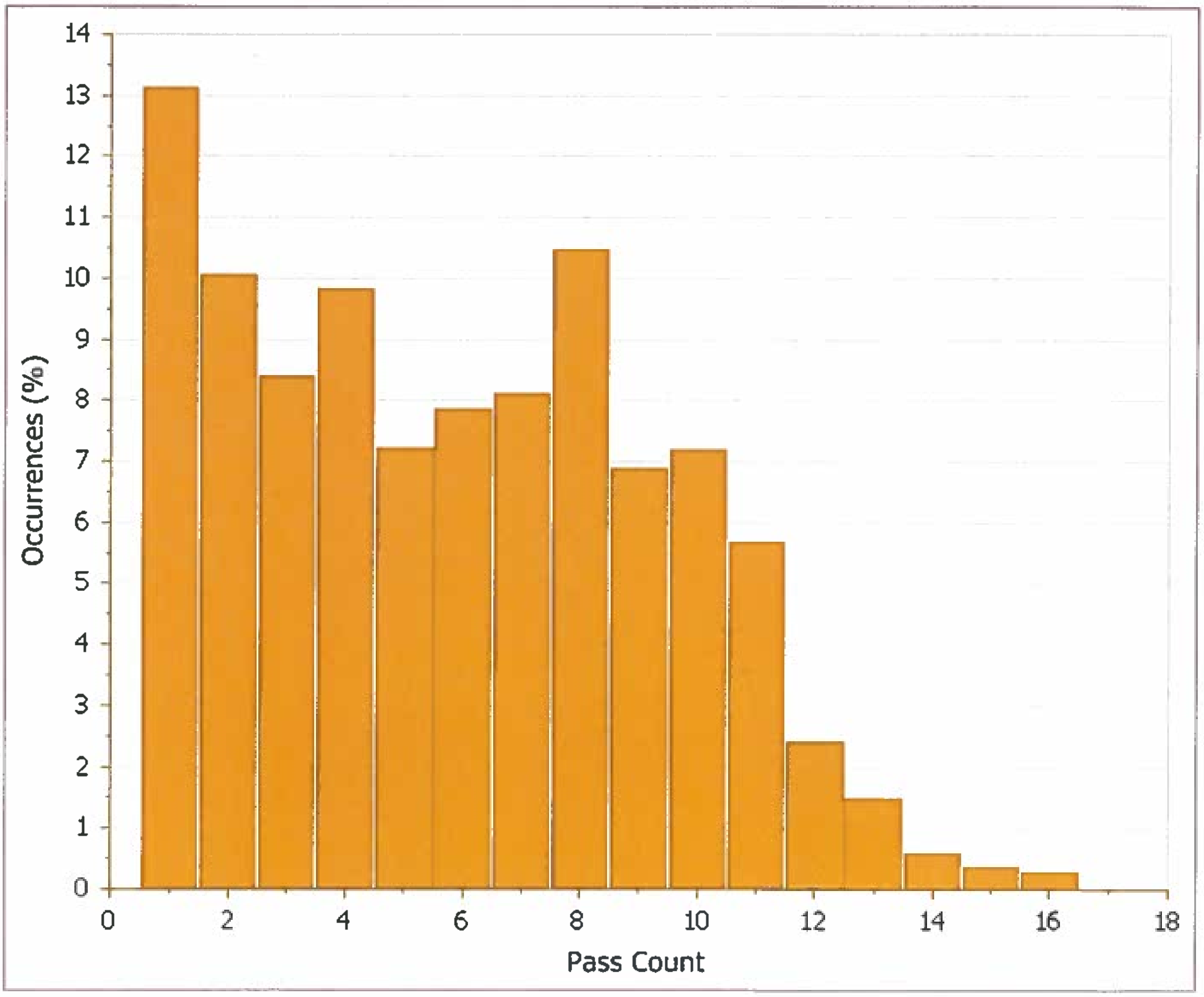
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

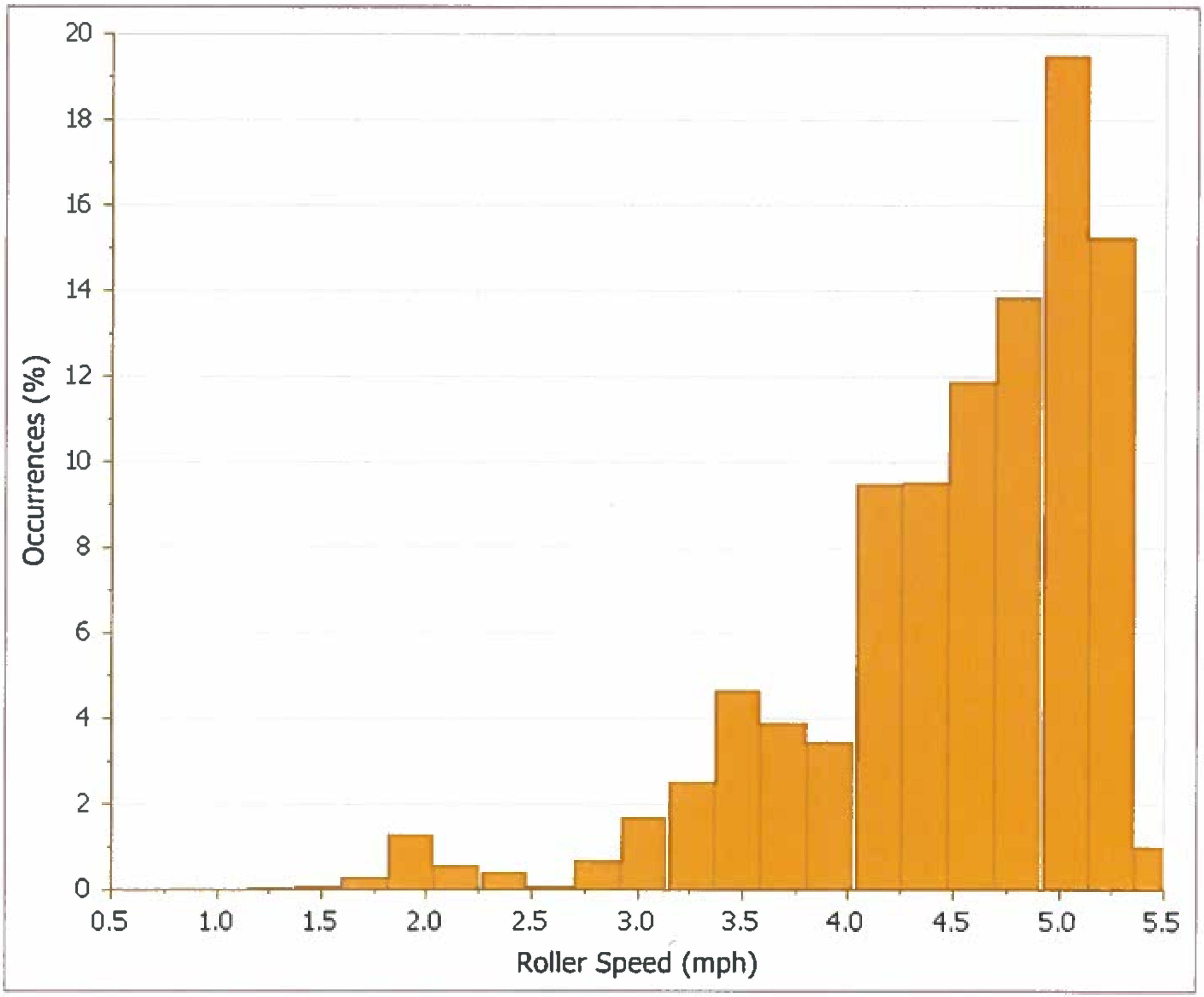
Statistic	Value
Mean	6
Standard Deviation	4
CoV (%)	60
Min	1
Max	16
Sample Size	16,423
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

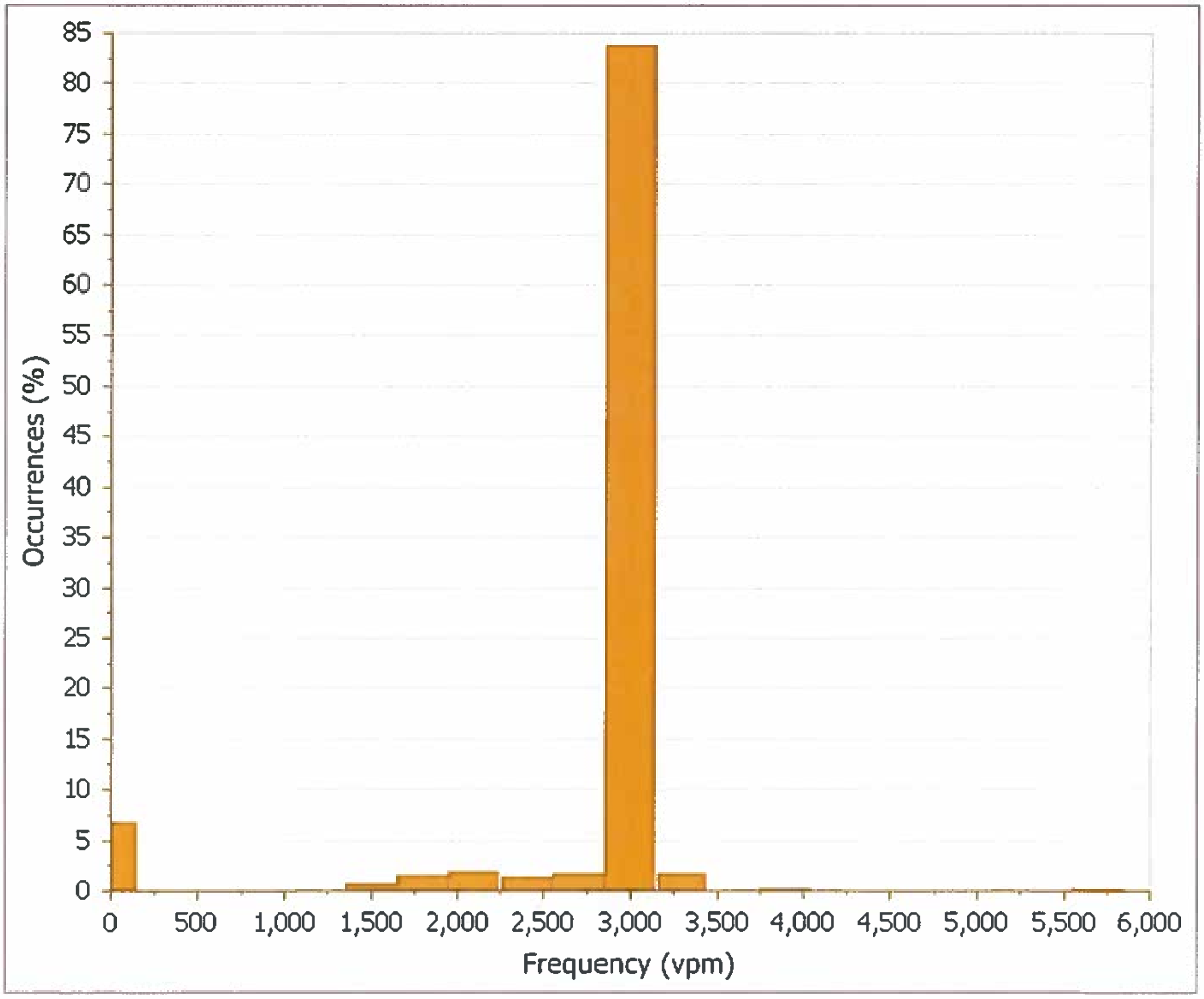
Statistic	Value
Mean (mph)	4.4
Standard Deviation (mph)	0.7
CoV (%)	16
Min (mph)	1.3
Max (mph)	5.7
Sample Size	16,423
Target Status	Passed
% of Target Achieved	99.95



Final Coverage: Frequency

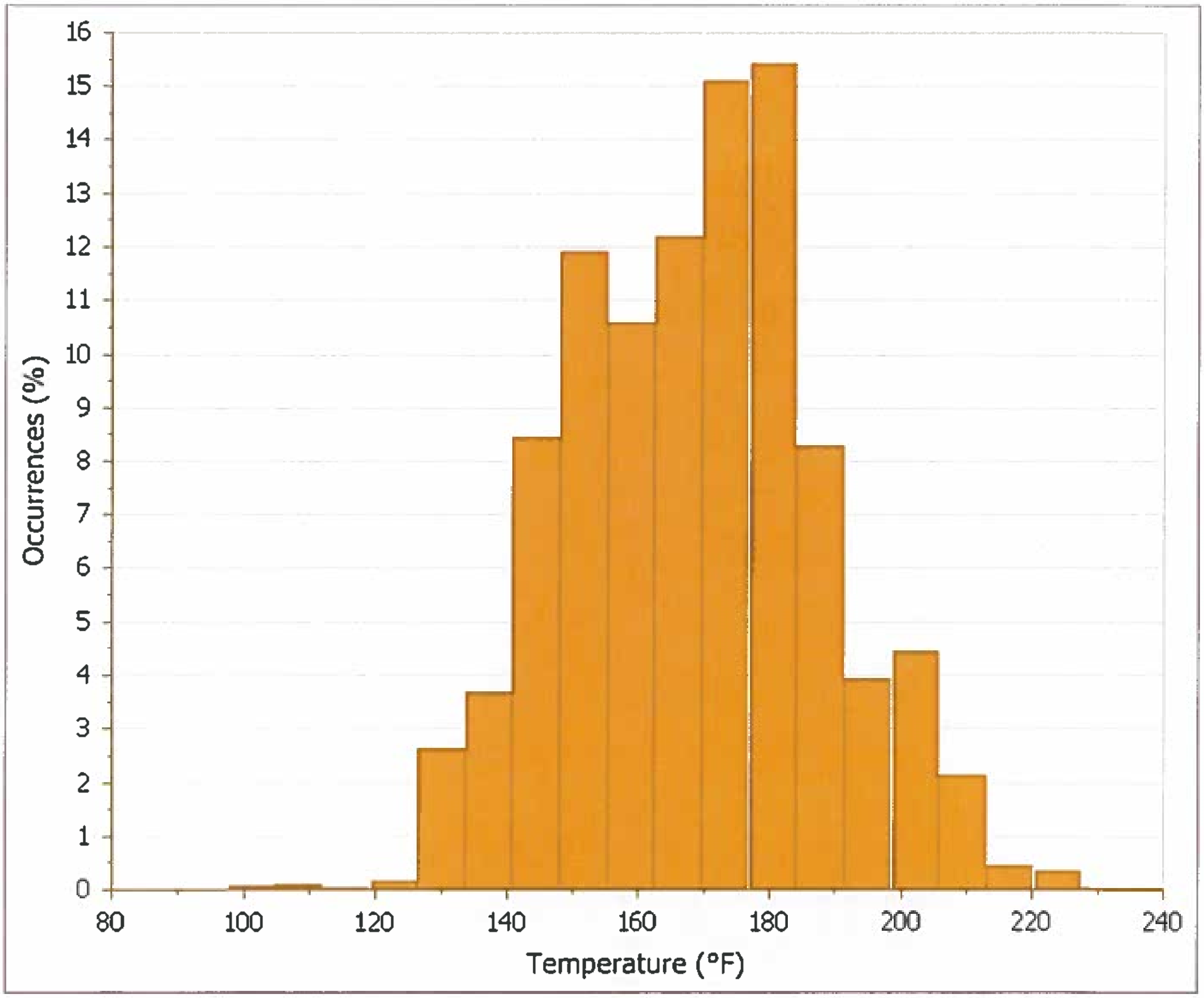
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,698
Standard Deviation (vpm)	785
CoV (%)	29
Min (vpm)	0
Max (vpm)	5,994
Sample Size	16,423
Target Status	Passed
% of Target Achieved	93.14



Final Coverage: Temperature

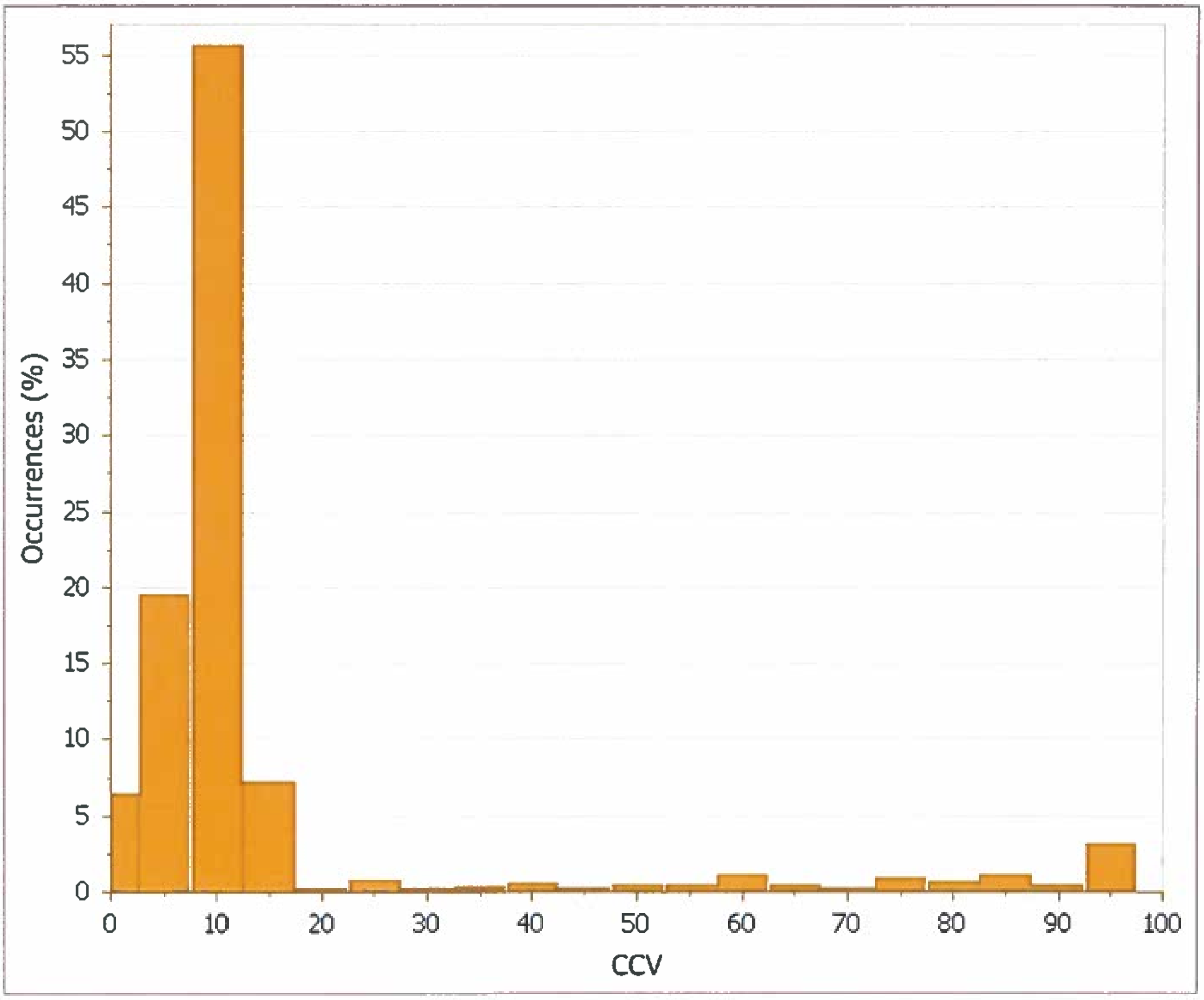
Statistic	Value
Mean (°F)	165.0
Standard Deviation (°F)	19.24
CoV (%)	12
Min (°F)	101.1
Max (°F)	245.4
Sample Size	16,423



Final Coverage: CCV

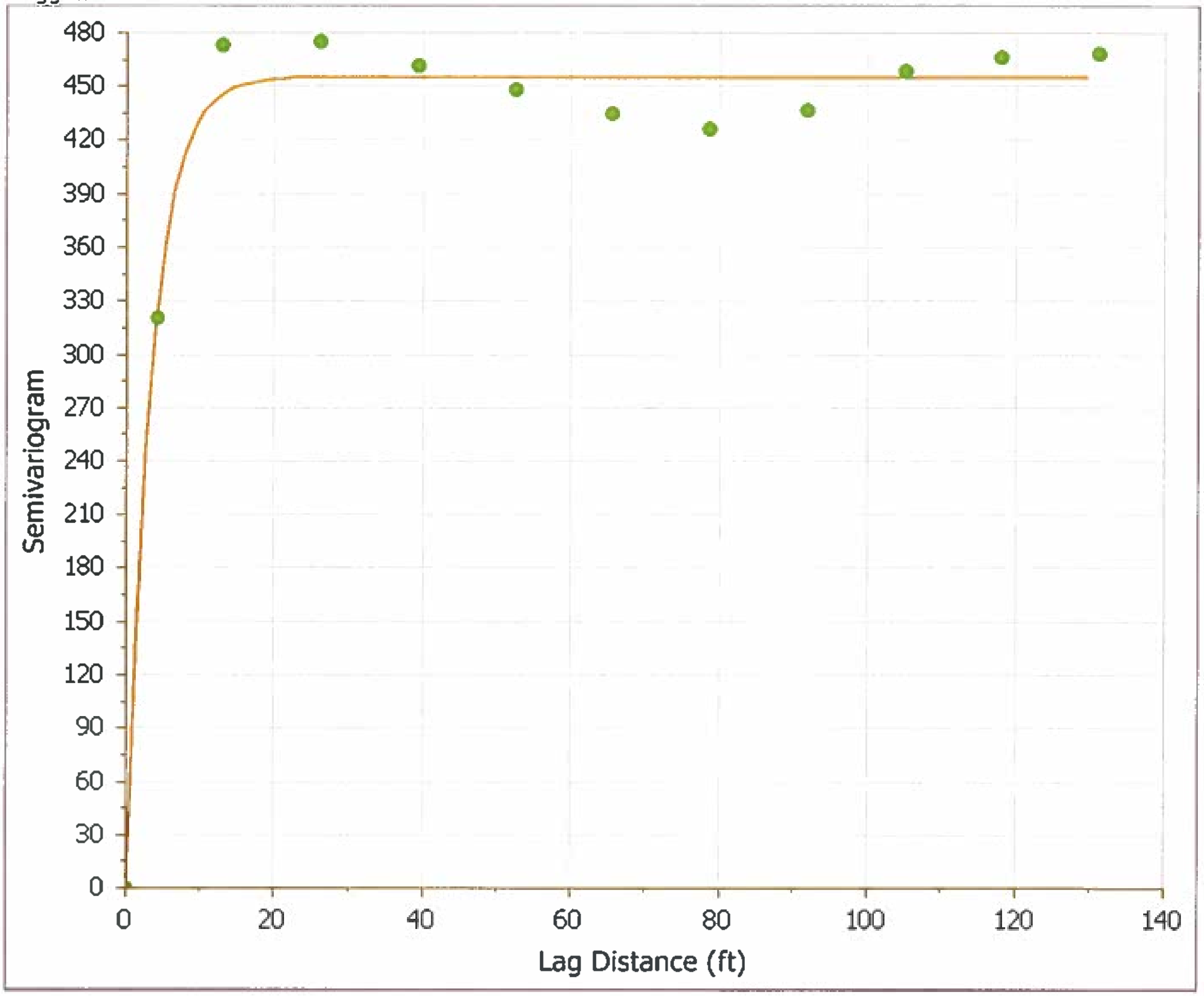
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	13.46
Standard Deviation	21.92
CoV (%)	163
Min	0.00
Max	100.00
Sample Size	16,423
Target Status	Passed
% of Target Achieved	93.61



Final Coverage: Semivariogram

Range (ft): 10.50
Sill: 435.65
Vertical Scale: 435.65
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130828-0715-40
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
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Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

Pass 17
Final Coverage: False

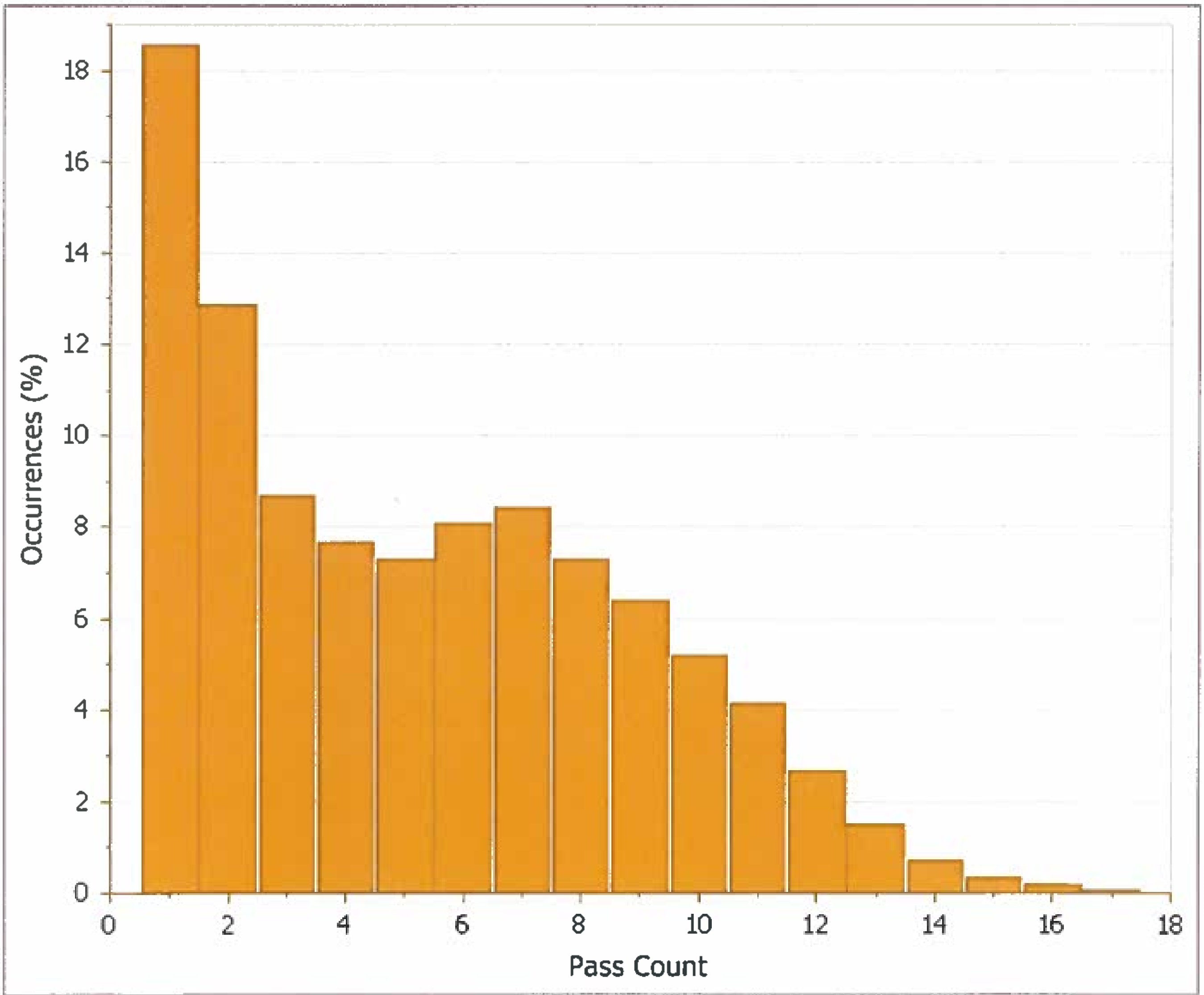
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

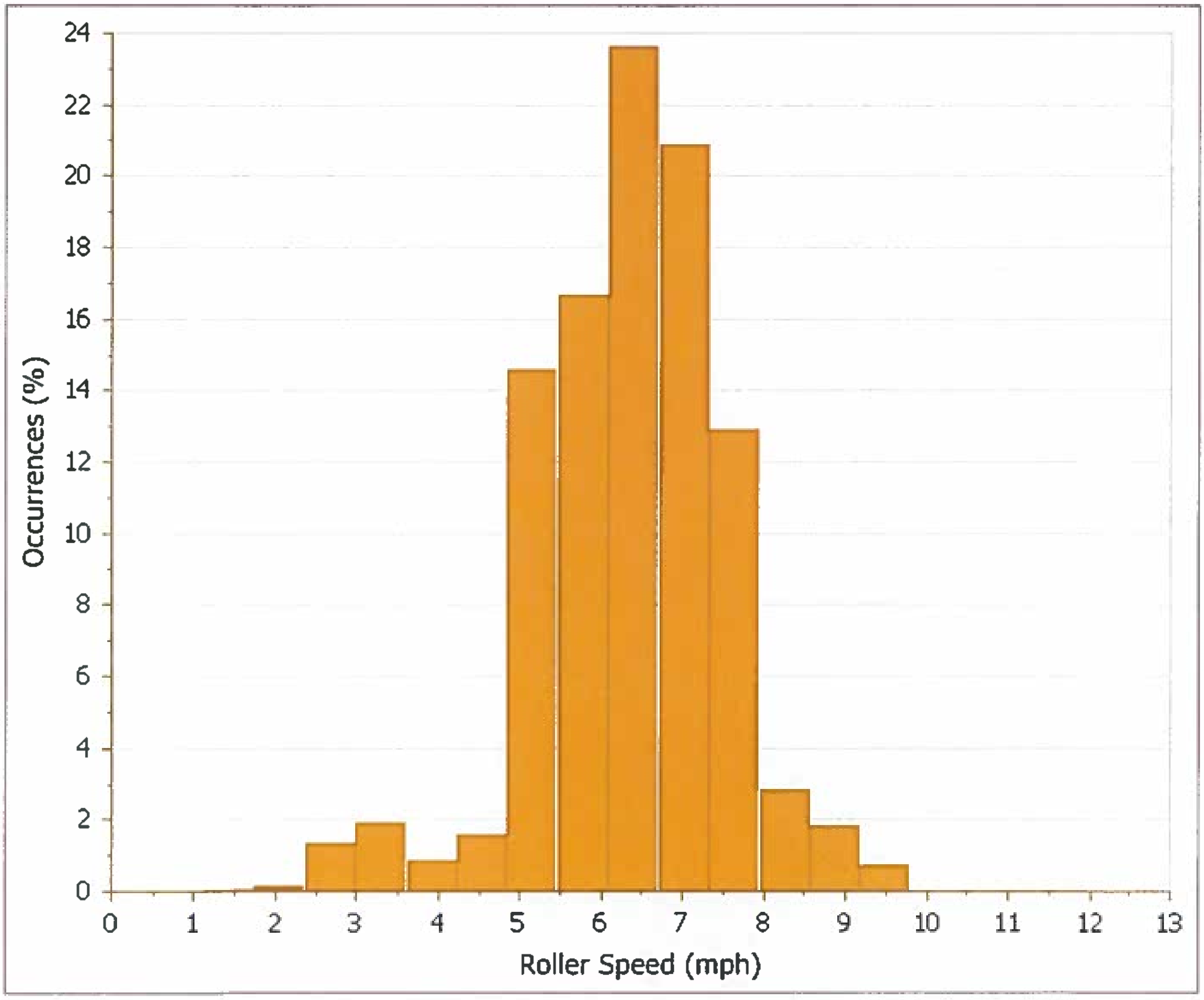
Statistic	Value
Mean	5
Standard Deviation	4
CoV (%)	68
Min	1
Max	17
Sample Size	68,553
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

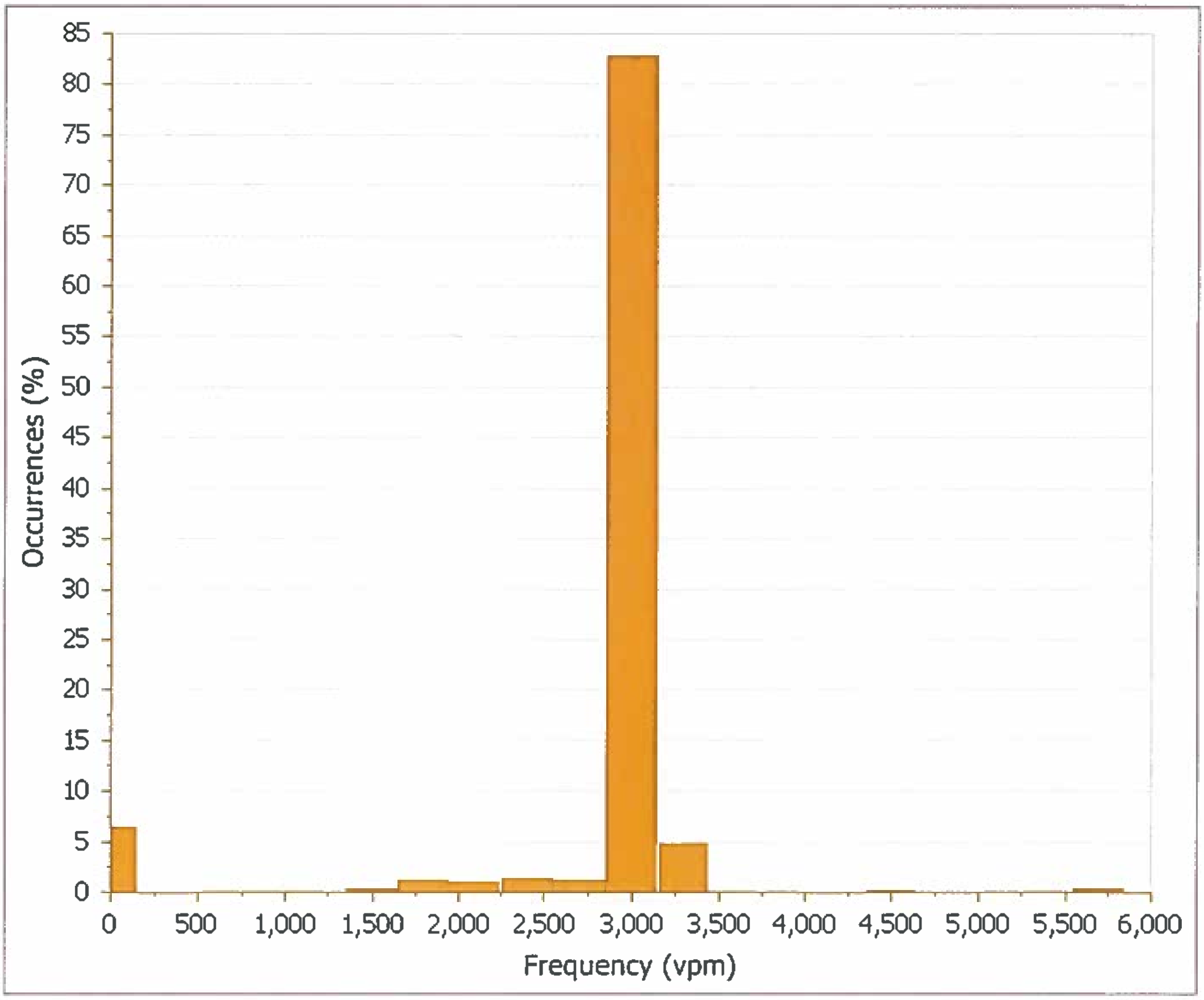
Statistic	Value
Mean (mph)	6.0
Standard Deviation (mph)	1.1
CoV (%)	19
Min (mph)	0.8
Max (mph)	13.2
Sample Size	68,553
Target Status	Passed
% of Target Achieved	99.98



Final Coverage: Frequency

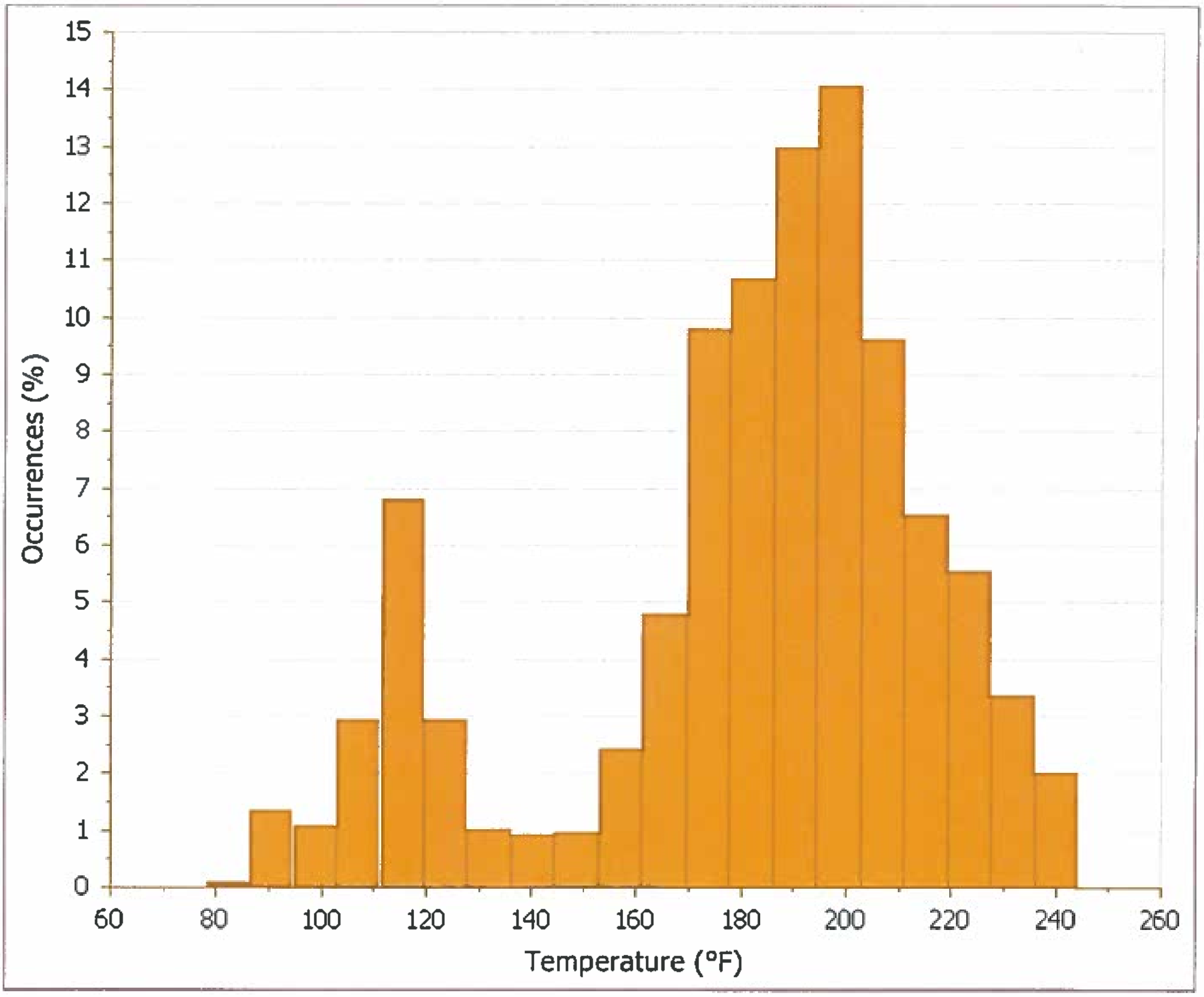
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,739
Standard Deviation (vpm)	772
CoV (%)	28
Min (vpm)	0
Max (vpm)	5,994
Sample Size	68,553
Target Status	Passed
% of Target Achieved	93.56



Final Coverage: Temperature

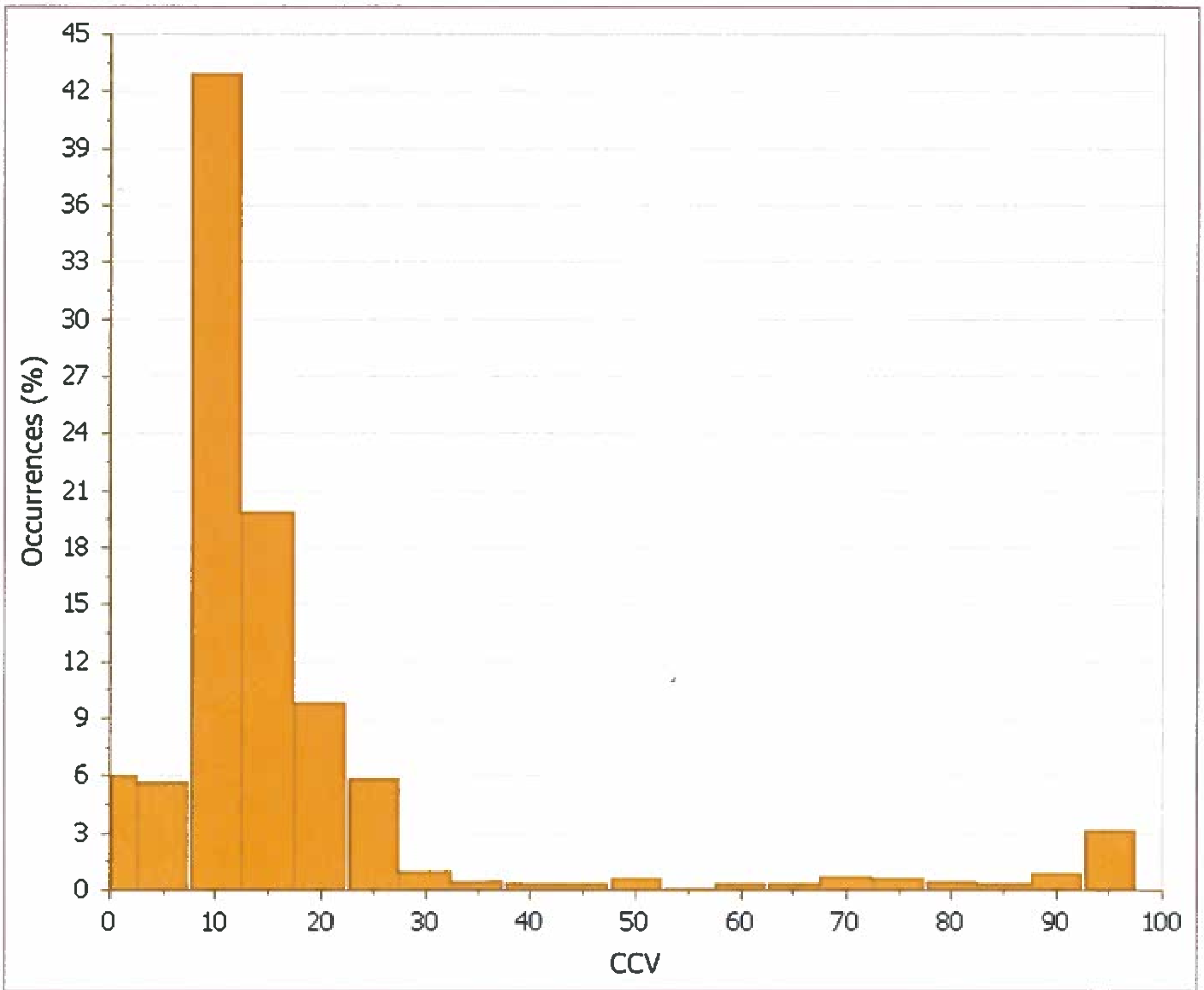
Statistic	Value
Mean (°F)	176.9
Standard Deviation (°F)	35.57
CoV (%)	20
Min (°F)	82.1
Max (°F)	248.4
Sample Size	68,553



Final Coverage: CCV

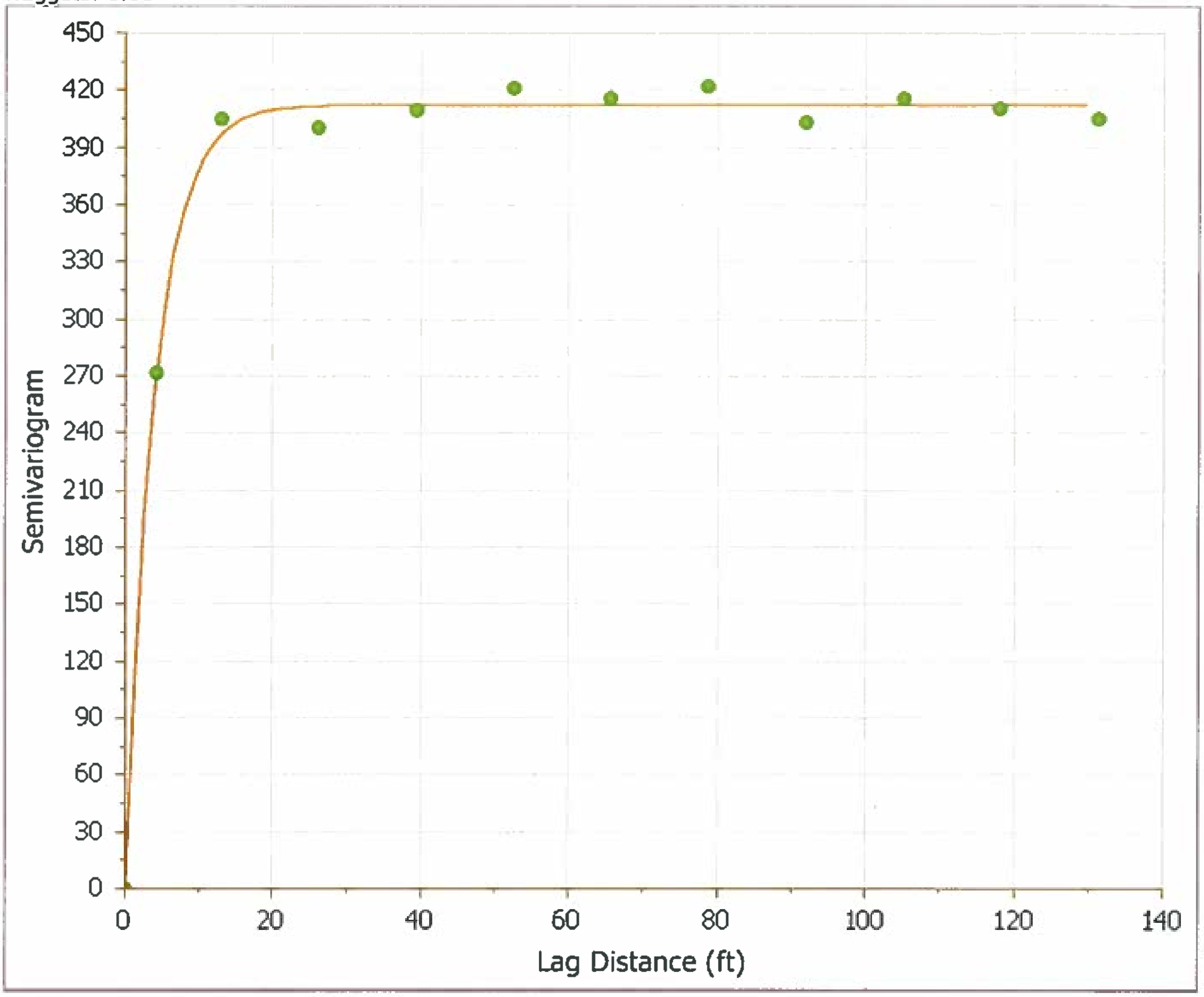
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	16.01
Standard Deviation	20.61
CoV (%)	129
Min	0.00
Max	100.00
Sample Size	68,553
Target Status	Passed
% of Target Achieved	94.01



Final Coverage: Semivariogram

Range (ft): 11.81
Sill: 391.84
Vertical Scale: 391.84
Nuggets: 0.00



Project Information

Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130829-0705-30
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

Pass 16
Final Coverage: False

Pass 17
Final Coverage: False

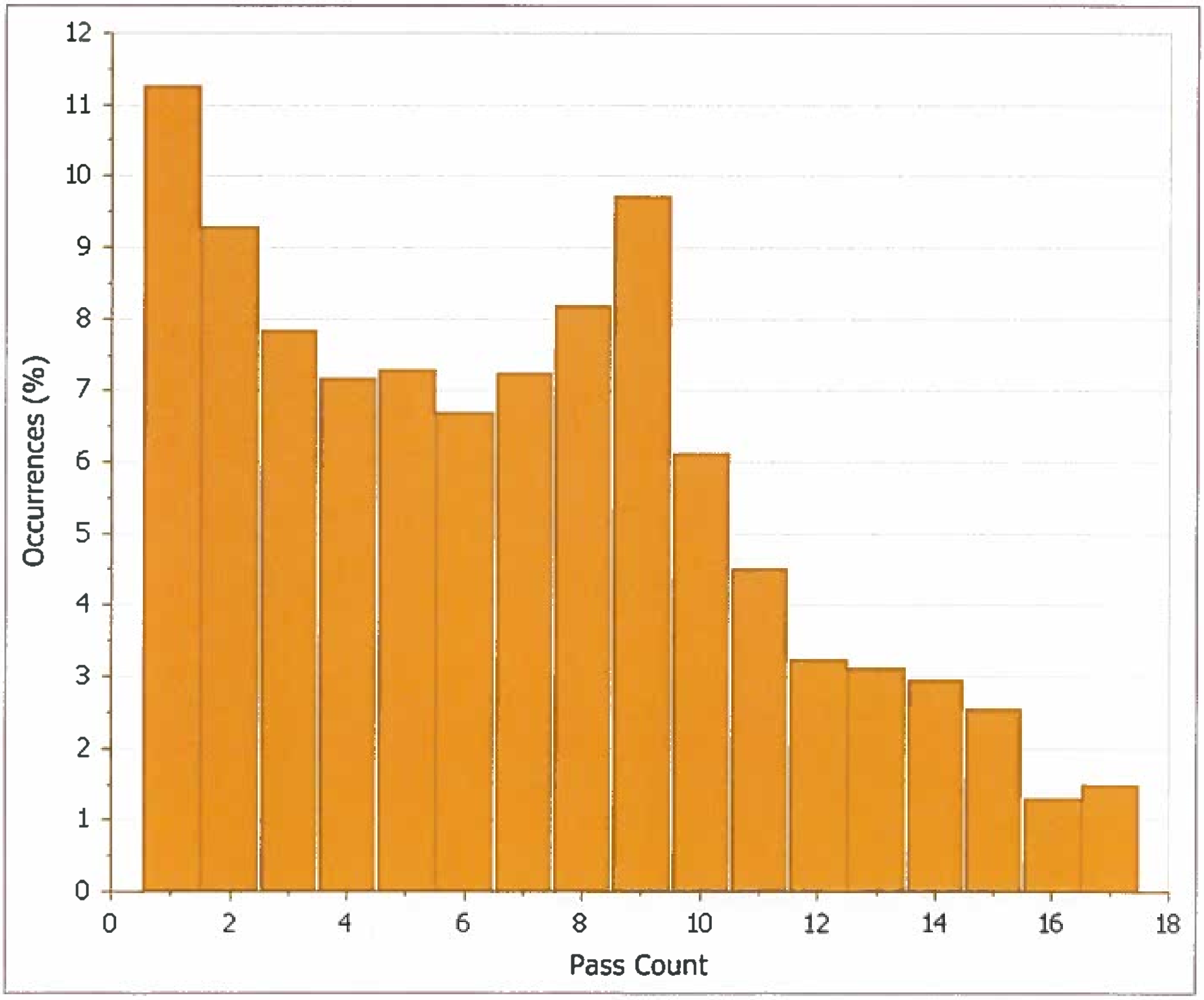
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

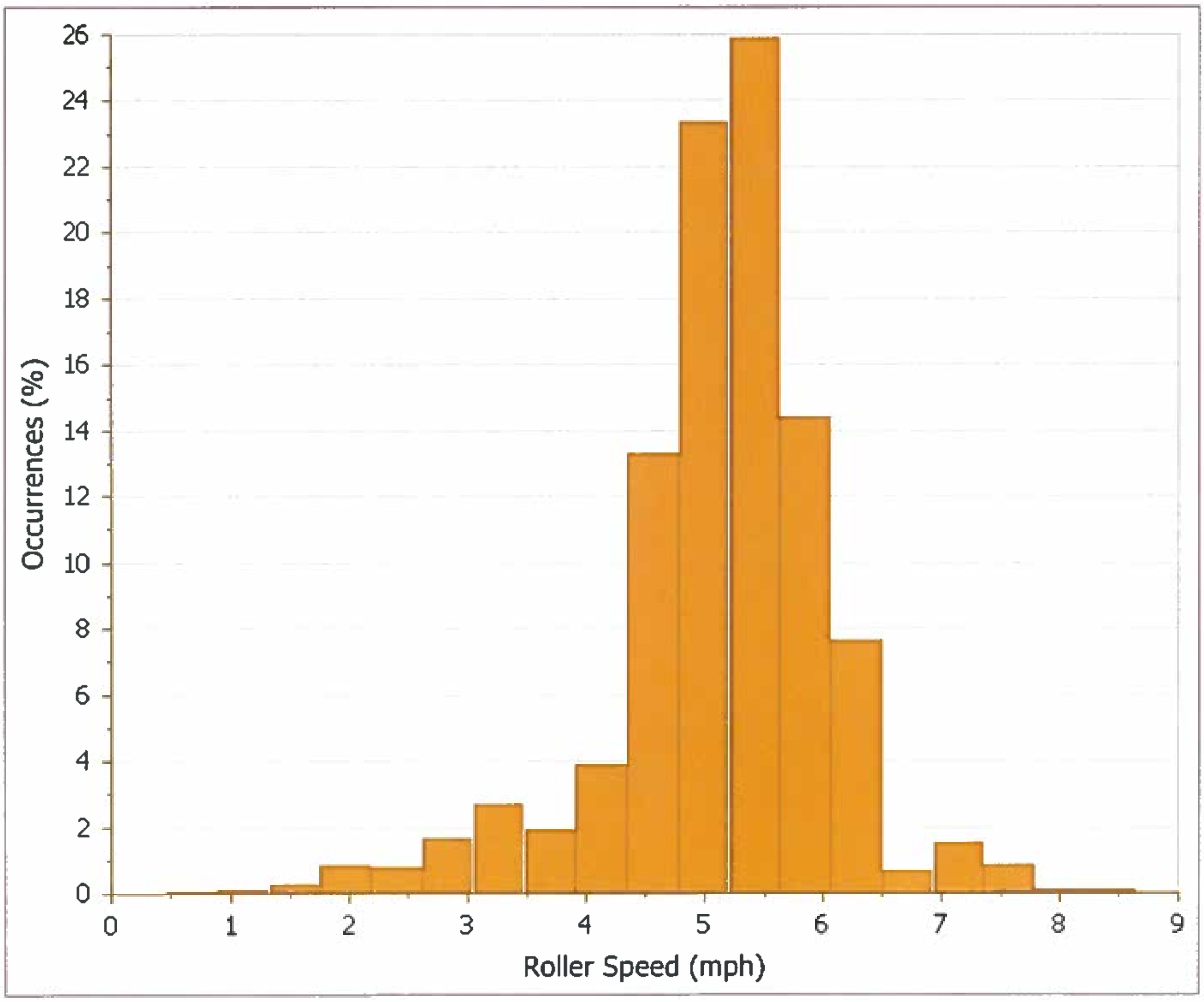
Statistic	Value
Mean	7
Standard Deviation	4
CoV (%)	62
Min	1
Max	17
Sample Size	42,366
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

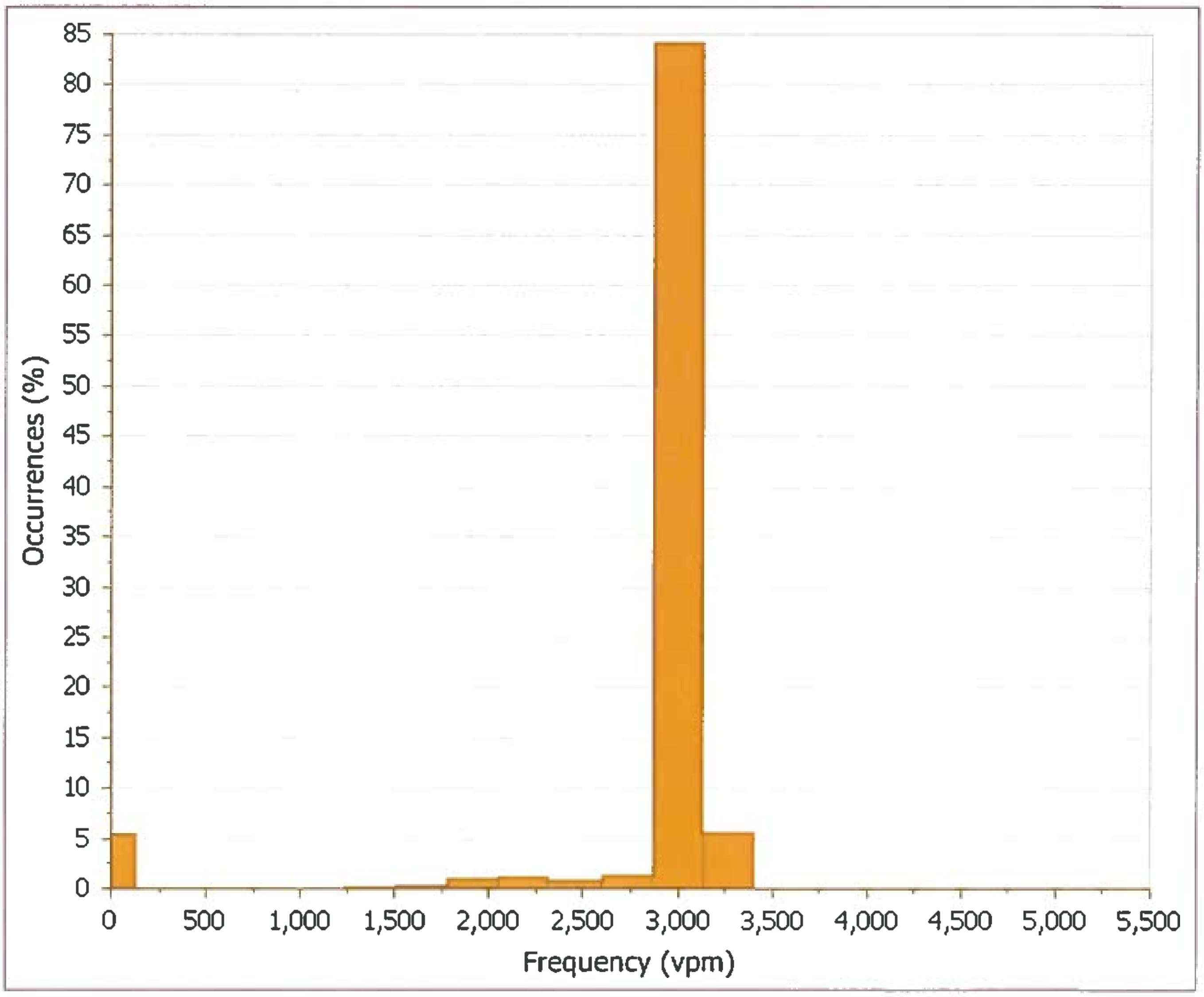
Statistic	Value
Mean (mph)	4.9
Standard Deviation (mph)	0.9
CoV (%)	19
Min (mph)	0.2
Max (mph)	8.9
Sample Size	42,366
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Frequency

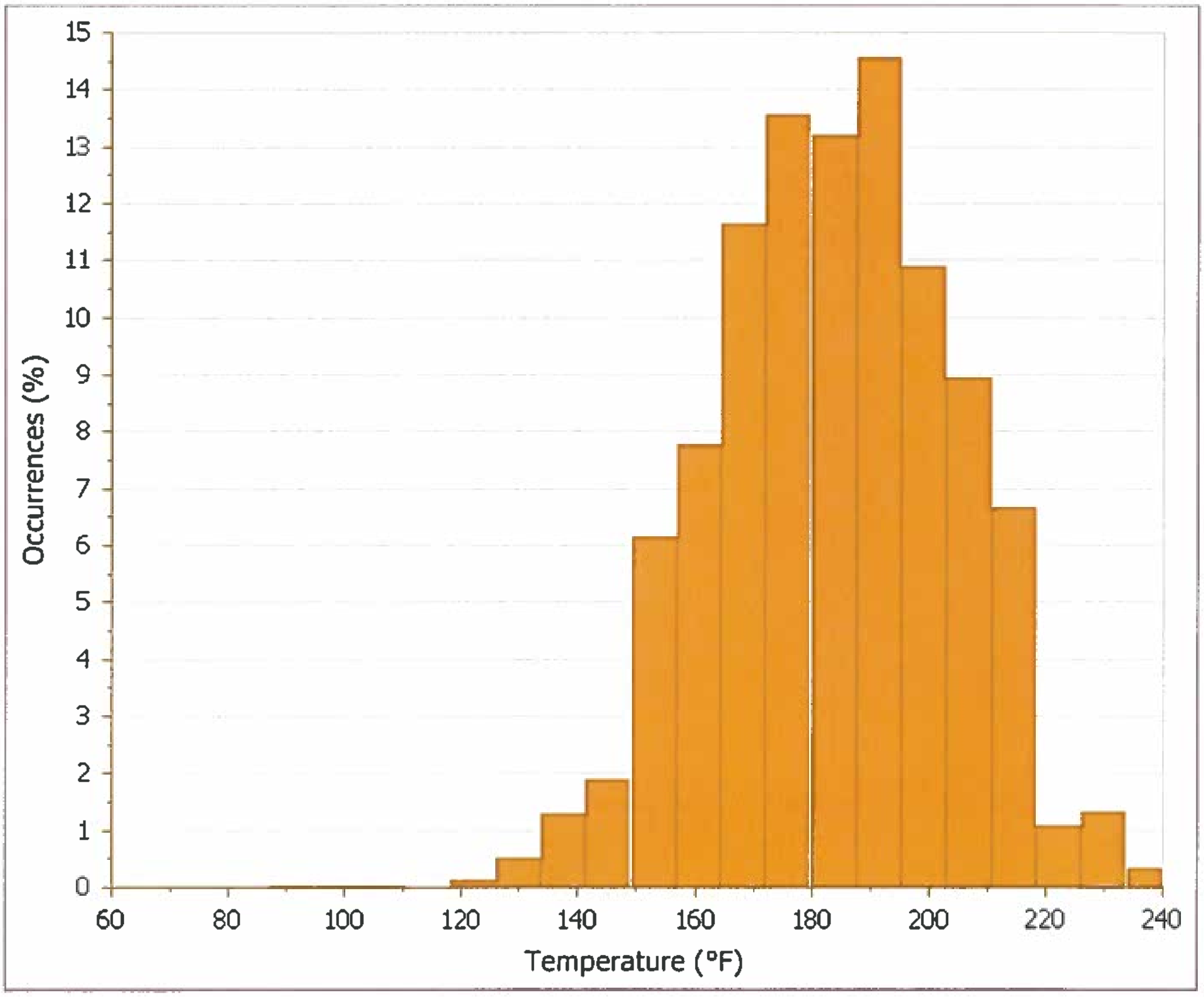
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,764
Standard Deviation (vpm)	693
CoV (%)	25
Min (vpm)	0
Max (vpm)	5,454
Sample Size	42,366
Target Status	Passed
% of Target Achieved	94.64



Final Coverage: Temperature

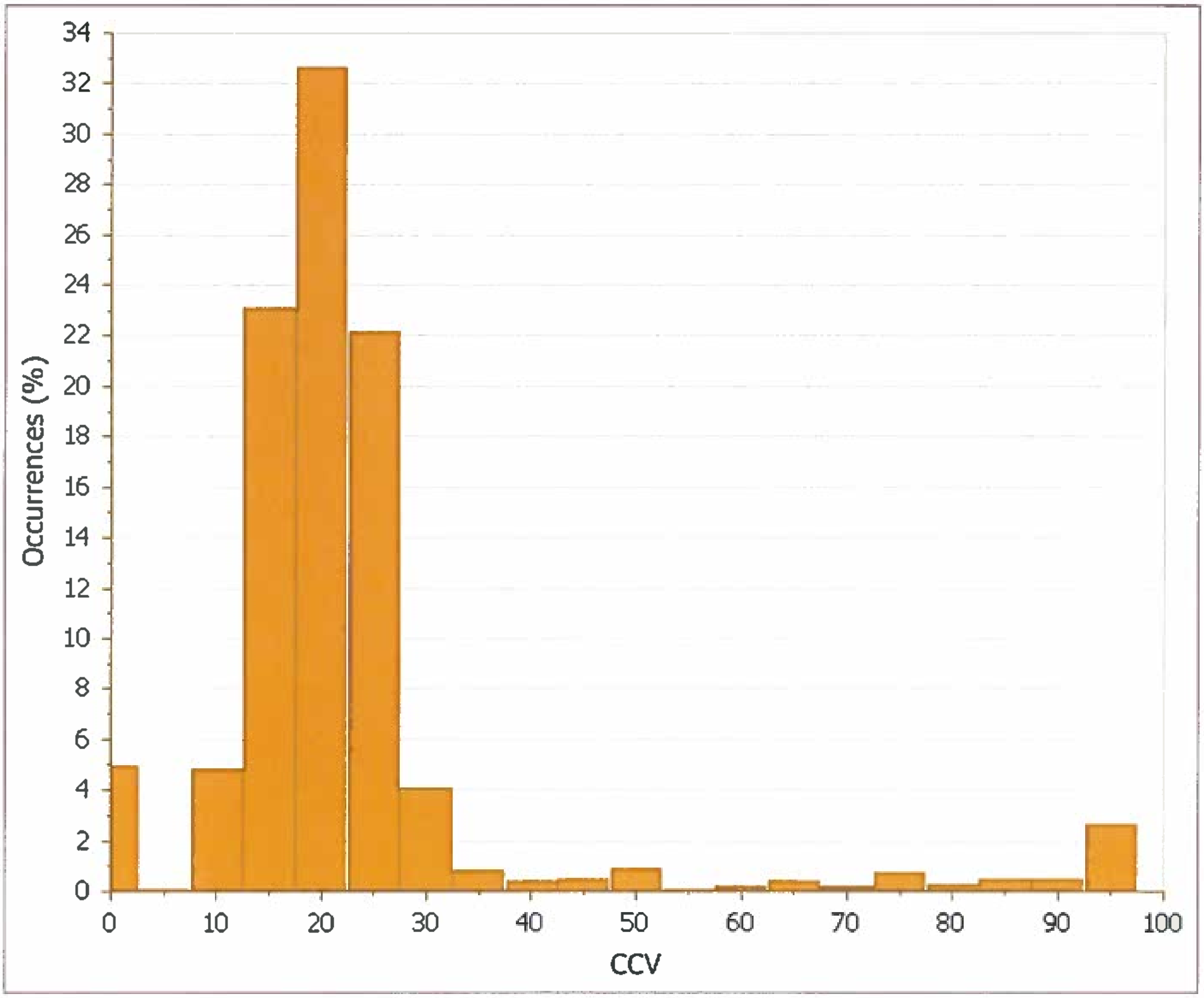
Statistic	Value
Mean (°F)	179.5
Standard Deviation (°F)	20.38
CoV (%)	11
Min (°F)	91.1
Max (°F)	245.4
Sample Size	42,366



Final Coverage: CCV

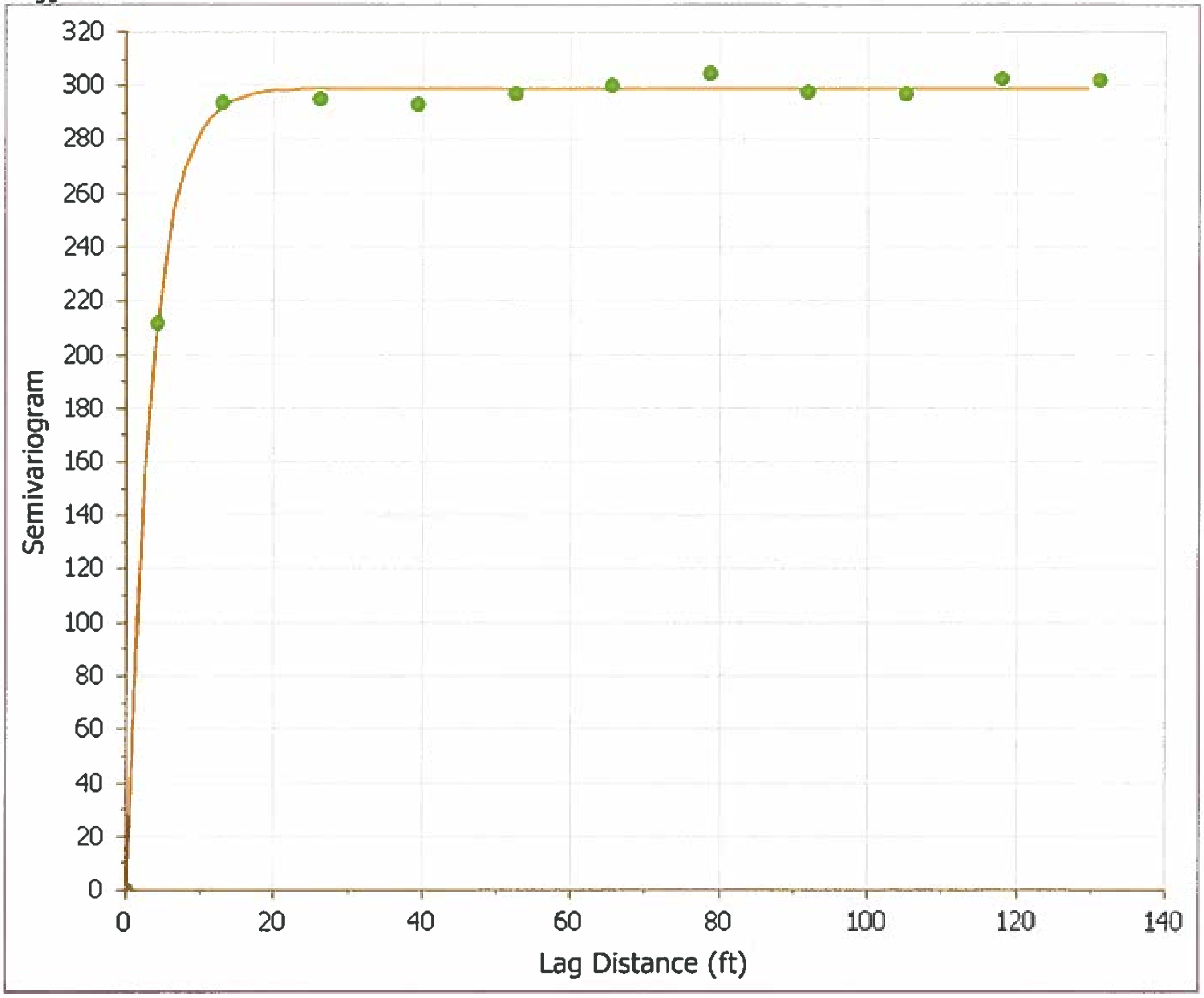
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	20.98
Standard Deviation	17.60
CoV (%)	84
Min	0.00
Max	100.00
Sample Size	42,366
Target Status	Passed
% of Target Achieved	95.01



Final Coverage: Semivariogram

Range (ft): 10.49
Sill: 284.74
Vertical Scale: 284.74
Nuggets: 0.00



Project Information
Drum Diameter: 0.00
Drum Width: 0.00
Hemisphere: North
Manufacturer: Sakai
Machine Weight: 0.00
Material Type: Asphalt
UTM Zone: 15
Original File: AREA_20130829-1429-42
State Plane Zone: 1702 - Louisiana South

File Information

Pass 01
Final Coverage: False

Pass 02
Final Coverage: False

Pass 03
Final Coverage: False

Pass 04
Final Coverage: False

Pass 05
Final Coverage: False

Pass 06
Final Coverage: False

Pass 07
Final Coverage: False

Pass 08
Final Coverage: False

Pass 09
Final Coverage: False

Pass 10
Final Coverage: False

Pass 11
Final Coverage: False

Pass 12
Final Coverage: False

Pass 13
Final Coverage: False

Pass 14
Final Coverage: False

Pass 15
Final Coverage: False

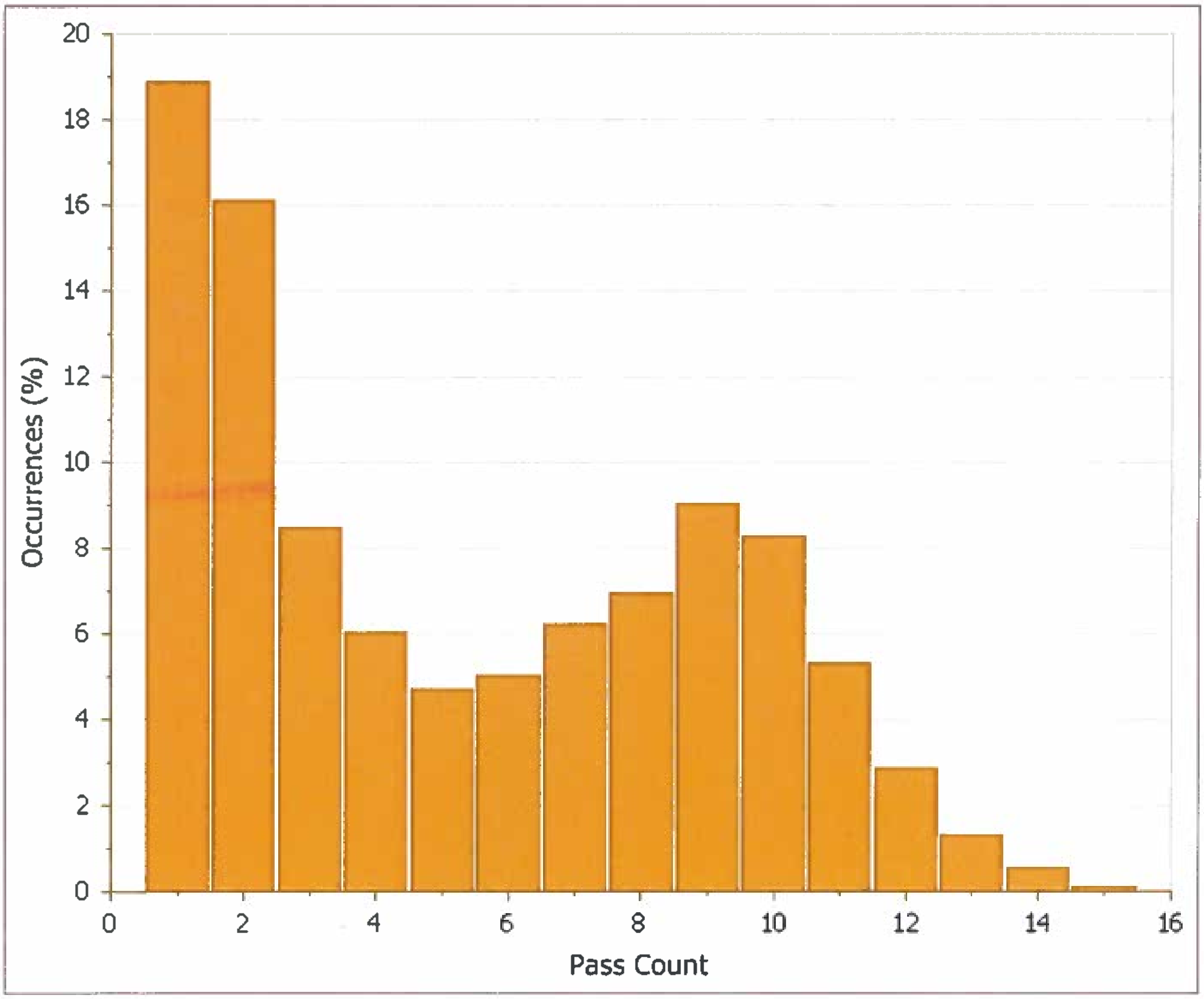
Final Coverage
Final Coverage: True

Analysis
Radius (ft): 3.28
Maximum Pass: 0
Linear Baselength (ft): 19.69

Final Coverage: Pass Count

Target Percentage (%): 0.00
Target Value: 0.00

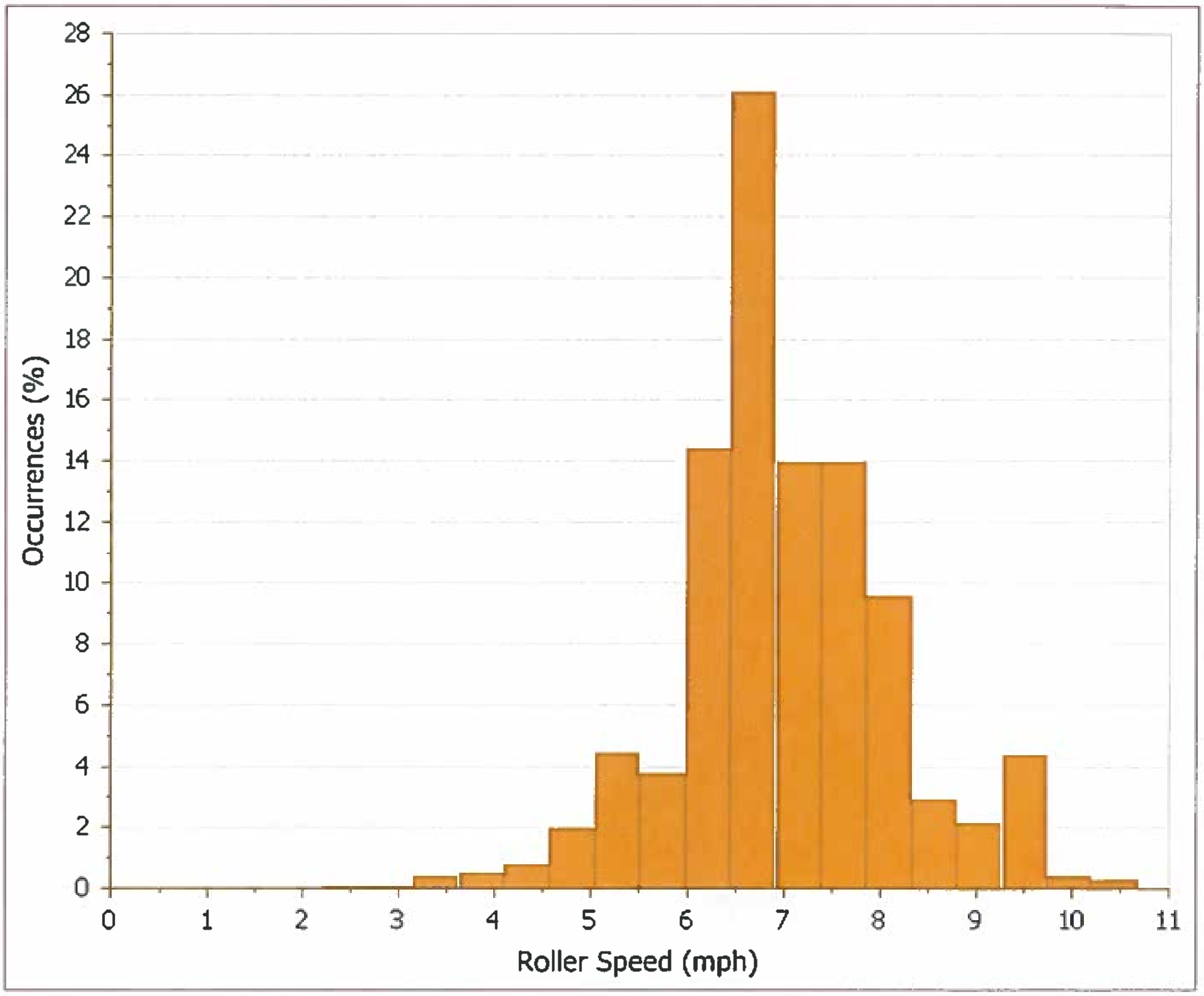
Statistic	Value
Mean	5
Standard Deviation	4
CoV (%)	69
Min	1
Max	15
Sample Size	74,955
Target Status	Passed
% of Target Achieved	100.00



Final Coverage: Roller Speed

Target Percentage (%): 0.00
Target Value (mph): 0.0

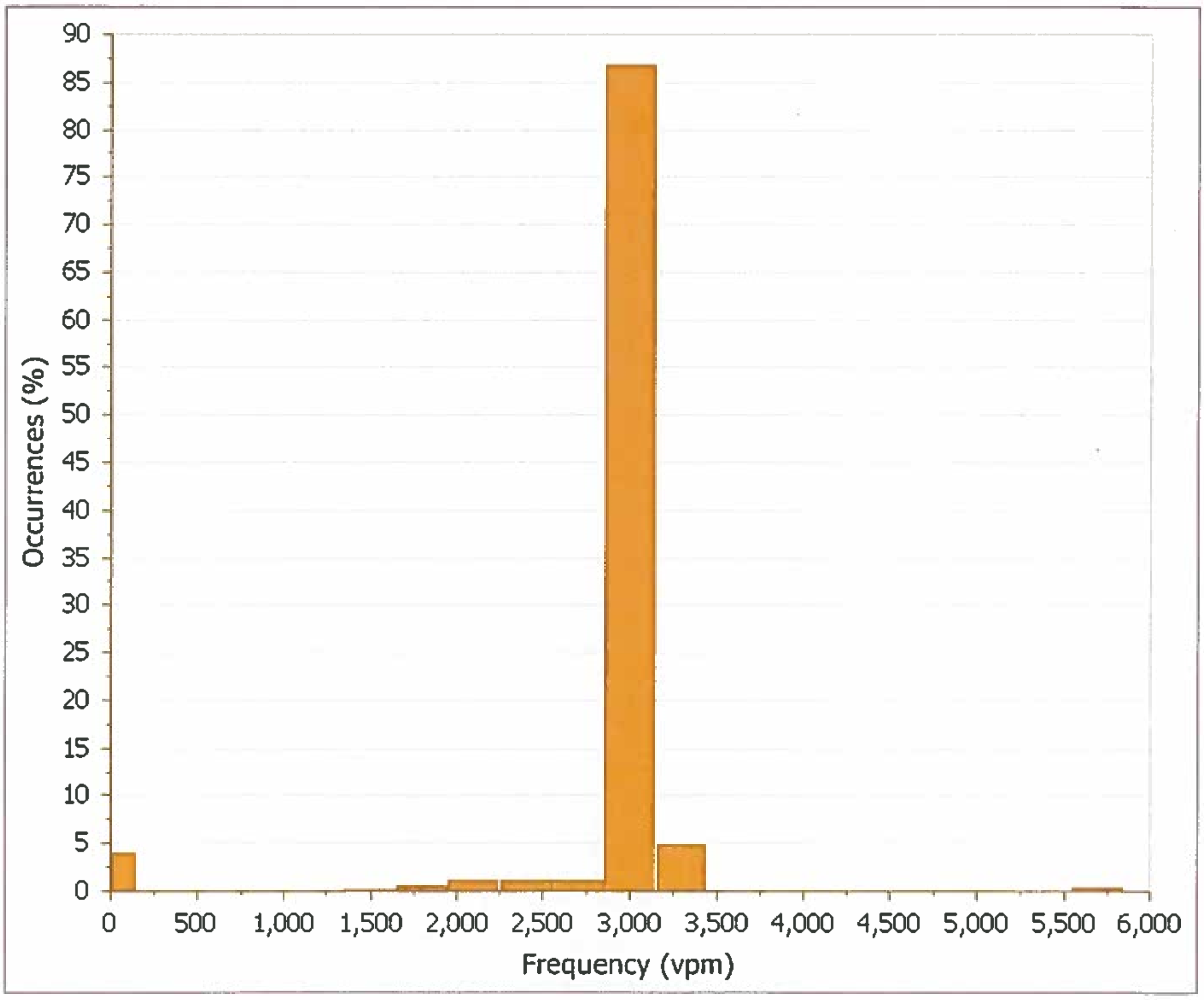
Statistic	Value
Mean (mph)	6.8
Standard Deviation (mph)	1.1
CoV (%)	16
Min (mph)	1.5
Max (mph)	10.9
Sample Size	74,955
Target Status	Passed
% of Target Achieved	99.99



Final Coverage: Frequency

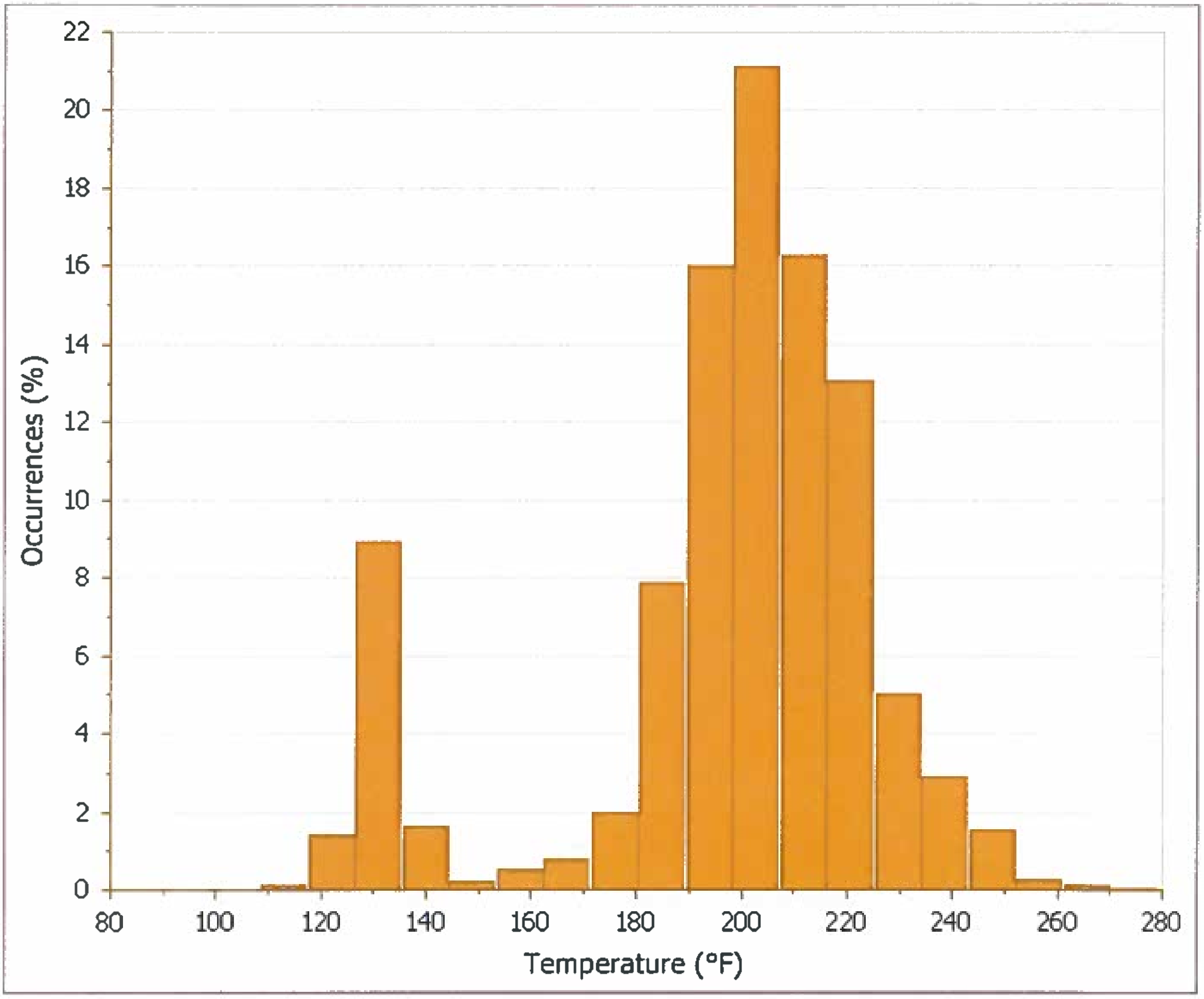
Target Percentage (%): 0.00
Target Value (vpm): 0

Statistic	Value
Mean (vpm)	2,823
Standard Deviation (vpm)	627
CoV (%)	22
Min (vpm)	0
Max (vpm)	5,994
Sample Size	74,955
Target Status	Passed
% of Target Achieved	96.08



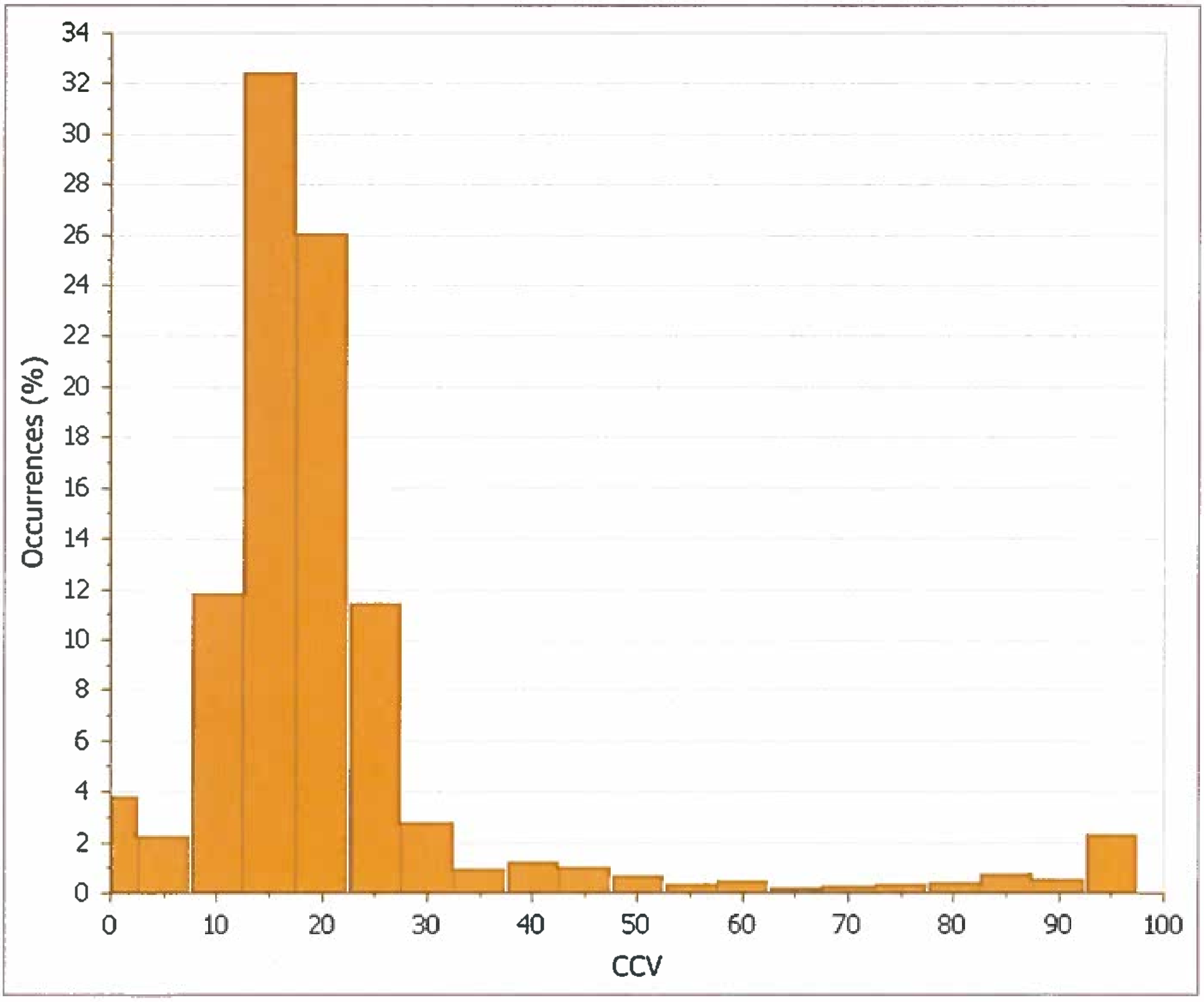
Final Coverage: Temperature

Statistic	Value
Mean (°F)	192.6
Standard Deviation (°F)	29.17
CoV (%)	15
Min (°F)	104.1
Max (°F)	283.5
Sample Size	74,955



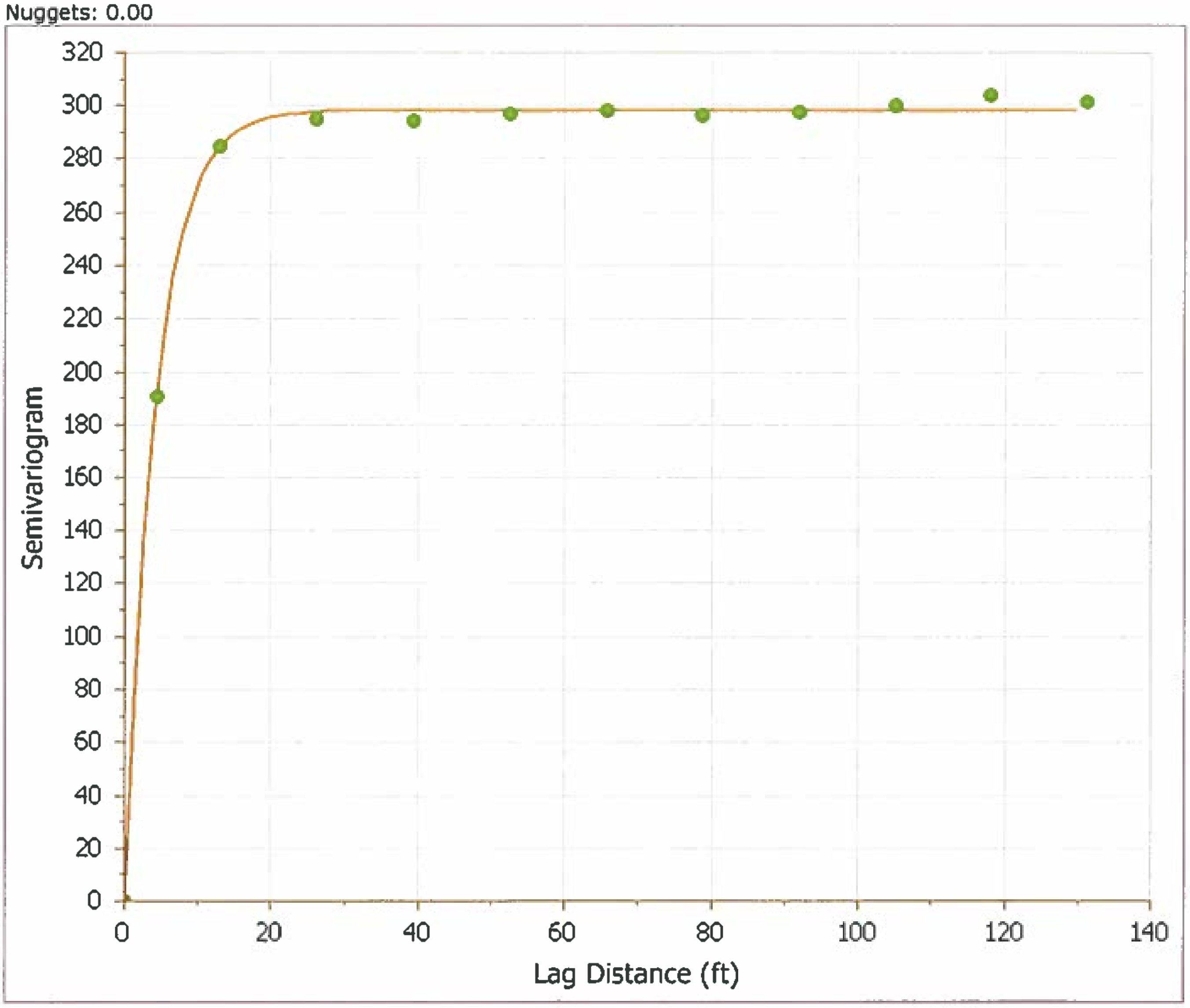
Final Coverage: CCV
Target Percentage (%): 0.00
Target Value: 0.00

Statistic	Value
Mean	19.14
Standard Deviation	17.64
CoV (%)	92
Min	0.00
Max	100.00
Sample Size	74,955
Target Status	Passed
% of Target Achieved	96.22



Final Coverage: Semivariogram

Range (ft): 11.81
Sill: 280.24
Vertical Scale: 280.24
Nuggets: 0.00



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