AMPS Noise Floor Study

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<u>TABLE OF CONTENTS:</u>

1. Executive Summary

The Advanced Mobile Phone System (AMPS) Noise Floor Study was performed in Verizon Wireless' cellular network within the surrounding Philadelphia, PA and New Jersey market area. A total of eighteen cell sites are included in the study. The cell sites are representative of normal sites within today's cellular markets types and signal levels. These sites are classified into four market type categories: Dense Urban, Urban, Suburban, and Rural.

The objective of the study is to provide *actual* field measurements of typical operating noise floor levels, as observed by the cell sites in two ways:
1. The distribution of operating noise floor measurements over a 24-hour period.
2. The operating noise floor level observed during day-time field tests.

The results of the 24-hour noise floor measurements, for the 18 cell sites, range from –119 dBm to –127 dBm, with an average of –126 dBm. Based on these results, "toll quality" AMPS calls can maintain service on these cell sites at very low levels. The minimum "toll quality" call signal level with 17 dB C/I, is –102 to –110 dBm, with an average of –109 dBm. The results of the day-time noise floor field tests range from –118 dBm to –128 dBm, with an average of –125 dBm.

The results of the AMPS Noise Floor Study show the low noise floor levels present in today's cellular networks. These levels are lower than systems have been in the past, due to trends in cellular system usage and cellular system design, which are further explained in section 6.1 of this report.

Based on the results of this study, the operating noise floor level for AMPS cellular systems is represented by –123 dBm for Dense Urban markets, –126 dBm for Urban markets, and –127 dBm for Suburban and Rural markets. These levels represent the operating noise floor for the 18 cell sites, averaged by market type and measured over a 24-hour period for a typical business day.

The results of this study are representative of AMPS cellular systems using typical cell site equipment. Cell sites using other equipment or technology, such as tower-top LNA, superconductor or smart antenna systems as described in section 6.2, offer cell site operating noise floor levels that are lower than the levels provided in this report.

2. Introduction

The purpose of this testing is to provide *actual* field measurements of typical operating cell site noise floor levels. This "operating noise floor" level is to include the thermal noise, ambient environment noise, co-channel and adjacent channel noise floor level, as observed by the cell site receiver. This is the operating noise floor level that is addressed by this noise floor study and report.

The cell sites included in this study are representative of normal sites within today's cellular market types and signal levels. A total of eighteen cell sites are included in the study. These sites are selected as representative sites within Verizon's Cellular B-side market within the surrounding Philadelphia, PA and New Jersey market area. These sites are classified into four market type categories: Dense Urban, Urban, Suburban, and Rural.

The wireless technology that is included in this testing is the Advanced Mobile Phone System (AMPS), as defined by the IS-553 wireless standard. The cell site equipment utilized by Verizon Wireless in this market is the Lucent Series 2 model. This cell site equipment type is very common for cellular sites, and its configuration and performance meet the industry standards for operation. (Digital wireless technologies are not included in this testing. The digital wireless technologies CDMA (IS-95), 3G-1xRTT, and TDMA are currently in operation within this cellular market.)

V-COMM developed the test plan, test methods, and test procedures to accomplish this AMPS Noise Floor Study. All field tests are performed at cell sites within Verizon's market. V-COMM coordinated test activities, reporting requirements, and cell site information with Verizon's regional performance and operations staff to accomplish this testing.

V-COMM is an independent wireless telecommunications engineering firm. Our team represents over 50 years of in-depth engineering experience in wireless telecommunications. We have provided our expertise to wireless operators in engineering, system design, implementation, expansion, system performance, optimization, and new technology evaluation. We have direct experience in all wireless technologies.

The test overview, procedures, results, analyses, and conclusions are provided in the following sections of this report.

3. Test Overview

The objective of this testing is to provide *actual* field measurements of typical operating noise floor levels, as observed by the cell site receiver. All test plans, methods, and procedures were developed with this objective.

To achieve this objective, the operating noise floor must be measured with the cell site's receiver performing the measurements. This will ensure the characteristics of the receiver under test matches the one performing the measurements. Using other receivers or test equipment to measure the noise floor can lead to different results, since their receiver characteristics may not match the cell site's receiver. For example, if a spectrum analyzer or receiver test equipment is used to measure the noise floor it may be more sensitive and utilize narrower resolution and intermediate frequency (IF) bandwidths than a typical cell site receiver. For this reason, the cell site receiver is utilized in this testing to measure the operating noise floor level of the cell site.

The cell site equipment type in this market is Lucent Series 2 model. The Lucent equipment has the ability to perform cell site receive measurements with the Power Level Measurement (PLM) function. For this study, the PLM is used to measure the distribution of operating noise floor levels over a 24-hour business day period, as observed by the cell site receiver. The PLM uses the receiver in the radio control frame (RCF) to perform the measurements. With Lucent's 15 dB receive path gain offset to the radio, all measurements will be referenced to the input of the cell site. The PLM Mode 2 function provides measurements of the operating noise floor level on an idle AMPS channel and records signal levels into 3.125 dB bins. With this resolution, the measured data is within +/- 1.562 dB of the center of the bin. The signal level of each bin is referenced at the center value. The accuracy of the receiver measurements is given by Lucent as approximately +/- 1 dB. To confirm this level of accuracy, tests are performed in the field at the 18 cell sites with calibrated test equipment. The PLM 50% threshold is provided in Table 5.1, as the median operating noise floor for the cell site, over the 24-hour period.

The following field tests are performed at the 18 cell sites:

<u>Field Test #1</u>
Verify the accuracy of the measurements reported by the cell site radio, using a calibrated signal generator connected to the cell site receive system. Include levels within the dynamic range of the receiver and to the lowest signal level that can maintain a call on the cell site, without muting the receiver. This level is approximately to 2 dB above the noise floor. The purpose of this test is to confirm the accuracy of the measurements provided by the 24-hour PLM data.

<u>Field Test #2</u>
Using a calibrated signal generator connected to the cell site receive system, observe the lowest signal level that can maintain an AMPS call on the cell site, with no audio

muting. At this level, the call is maintained with the cell site receiver decoding SAT correctly and continuously, without interruption and without muting the receiver. At this level, the signal-to-operating-noise-floor level (S/N) is estimated to 2 dB. If the signal is decreased below this level, the cell receiver will begin to lose the ability to decode the 6 kHz SAT (Standard Audio Tone - used to maintain calls), and will begin to mute the audio tone. Typically, 1 dB below this no muting test call signal level, the audio begins to mute approximately 5-10% of the time; 2 dB below this level the audio mutes approximately 50-60% of the time; and the call drops when the SAT Fade Timer is expired (typically 10 seconds). During this call test in the field, V-COMM estimates the cell site's operating noise floor is 2 dB below this no muting call signal level. The purpose of this test is to establish lowest signal level that can maintain an AMPS call on the cell site, with no audio muting. From this level, we are able to estimate the cell site's operating noise floor level, during the day-time field tests between 9:00 am and 3:00 pm.

Field Test #3

Using a spectrum analyzer connected to the cell site receive system, after the 45 dB preamplifier, record a snapshot of the average noise floor level observed. This is the operating noise floor level of the spectrum analyzer, which is generally lower than the cell site receiver, since the resolution bandwidth is narrower. The purpose of this test is to support the estimated field test operating noise floor level, for the cell sites with noise floors above the equipment's system noise floor.

In field tests #1 and #2, the signal generator is connected to the –50 dB port of the 1st direction coupler in the cell site's receive system, within the antenna interface frame (AIF). The measured offset from this coupler port to the input of the cell site, and the test cable loss, are used to reference all signal levels to the input of the cell site. The results of field test #1 indicate the accuracy of the measurements recorded by the cell site receiver are within Lucent's +/- 1 dB threshold, for 12 of the 18 sites tested. For 6 of the 18 sites, the test results indicate an offset is required to bring their accuracy in accordance with this +/- 1 dB threshold. (These six receivers, site # 5-8, 11 and 16, measure almost 3 dB lower than the calibrated signal reference levels, and therefore their PLM data provided in this report, is increased by this 3 dB offset, to bring their accuracy in-line with the other receivers.)

In field test #3, the spectrum analyzer is connected to the output of the 1 to 9 splitter at the top of the radio channel frame (RCF) in the cell site receive system. The measured offset from this port to the input of the cell site, and the attenuation of the test cable, is used to reference all signal levels to the input of the cell site. These readings were generally lower than the PLM measurements by a few dB, since the resolution bandwidth of the analyzer was narrower than the cell site receiver's bandwidth. For sites with the highest operating noise floors, the analyzer's measurements yielded similar results. For example, the analyzer measured the average noise floor of the Dense Urban Cell 85 to –119 dBm, which has a –118.5 dBm for the 50% PLM value and –118 dBm for the "Estimated Noise Floor During Test" value.

All field tests and PLM measurements are performed under normal cell site and antenna system configuration. No changes were made to the cell site or antenna systems to perform these tests. Both receive diversity systems remain connected to the antennas during all tests.

The test results of the PLM and field tests are provided in "Test Results" section of this report. The operating noise floor of the 18 sites are provided in two ways:

1. The distribution of operating noise floor measurements taken by the 24-hour PLM.
2. The operating noise floor observed during field testing, as estimated by the minimum call level that can maintain an AMPS call with no SAT muting.

Section 4 of this report provides the test procedures in more detail.

3.1. Overview of Test Equipment

This section lists the test equipment that was utilized during this AMPS noise floor testing. The test equipment was checked and verified before using in the field. The HP 8921A test equipment was within its current calibration period; it was calibrated within the prior 12-month period. The test cables and cell site offsets reference to the cell site input port were measured and recorded during testing.

Test Equipment:

1. HP 8921A Communications Test Set -- Signal Generator / Spectrum Analyzer
2. Lucent Power Level Measurements (PLMs)
3. Lucent RF Call Trace
4. Nokia 2160 cellular telephone, in AMPS mode
5. Landline telephone
6. Miscellaneous test cables, connectors, and hardware.

Two functions of the HP 8921A test set were utilized. The signal generator function was used for field tests #1 and 2 to inject a signal into the cell site receive system and maintain an AMPS call for the duration of the test. The spectrum analyzer function was used for field test # 3 to record a snapshot of the average operating noise floor level observed for the AMPS channel and receiver utilized in field tests #1 and #2, during the test period. The test period was approximately 1 ½ hour per cell site, during the day-time weekday hours between 9:00 am and 3:00 pm. The signal level accuracy of the calibrated HP 8921A Signal Generator, is specified by HP as within +/- 1 dB. V-COMM checked the signal accuracy with another calibrated spectrum analyzer (HP 8591) for various frequencies and signal levels across the cellular band, and observed the HP 8921A signal level was within 0.2 dB of the HP 8591.

The Lucent Power Level Measurement (PLM) Mode 2 function was used to measure and record the operating noise floor over a 24-hour period, as observed by the cell site receiver, on the specific site/sector/channel that was seized during the field testing. The resolution of the Lucent PLM measurements is approximately 3 dB, since it uses 3.125 dB bin sizes. The center value of the bin is the reference value for the bin, and represents data collected within +/-1.562 dB of the center value of the bin.

The Lucent RF Call Trace was used in field tests #1 and #2, to record the cell site receive signals of the AMPS call that was maintained during the testing, as measured by the cell site receiver. Lucent's receive path gain of 15 dB, allows these measurements to be referenced to the cell site input, and is compared to the injected calibrated signal levels to verify the accuracy of the measurements reported by the AMPS receiver. The resolution of the Lucent RF Trace measurements is reported in 1 dB increments.

Lucent's RF Trace and PLM Mode 2 records the cell site receive signal levels with the cell site's voice channel radio receiver. The accuracy of the cell site receiver measurements is approximately +/- 1 dB, as provided by Lucent.

A Nokia 2160 cell phone was used to initiate the AMPS test call to a landline telephone. The signal generator was used to seize and maintain the call using a modulated carrier with a 1 kHz tone (2.9 kHz deviation) and a 6 kHz SAT (2 kHz deviation) to represent typical cellular AMPS voice channel characteristics.

The cell site landline telephone was used to receive and maintain the AMPS cellular telephone call for the duration of the test. The engineer used the landline telephone to monitor the audio tone of the AMPS telephone call throughout the test.

Miscellaneous test cables, connectors, and hardware were used to connect the HP8921A to the cell site equipment.

3.2. Signal Level Reference Points

All signal levels that are listed in this report are referenced to the input to the cell site. Lucent references this as the J1 port. This reference is the antenna side connector of the very first element in the cell site receive system; which is the same reference as the equipment side of the antenna jumper cable, that connects to the transmission line. All signal level units are in dBm (decibels, relative to 1 milliwatt).

All measurements performed by the cell site receiver are offset by Lucent's receive path gain (15 dB for Series 2 cell sites), to reference the input of the cell site. Lucent's RF Trace and PLM measurements are performed by the AMPS radio receiver and use this offset to reference the input of the cell site. During field tests #1 and #2, the signal generator injected calibrated signal levels into the cell site receive system, at the –50 dB coupler port. For these tests, an offset was used to reference the input of the cell site, which takes into account the loss in the test cable and the path offset to the J1 port.

During field test #3, the spectrum analyzer measured the average operating noise floor of the cell site from the output of the 1 to 9 splitter, at the top of the radio channel frame (RCF). The receive path offset was measured to this point, to reference the level measured to the input of the cell site.

3.3. Cell Site Selection

The cell sites included in this AMPS Noise Floor Study were selected to be representative of normal sites within today's markets types, and to exhibit typical operating signal and noise floor characteristics. A total of eighteen cell sites are included in the study. The sites are located within the surrounding Philadelphia, PA and central New Jersey market areas.

The 18 sites are classified into 4 market type categories: Dense Urban, Urban, Suburban and Rural. V-COMM selected these sites after reviewing over 200 sites within Verizon's local market area to determine the sites that would be representative of normal sites with typical surrounding signal and noise floor levels, antenna elevations, and antenna configurations, for each market category. In this market, Verizon's cell sites are 3-sectored sites, which is the most common antenna site configuration for cellular systems. The cell site antenna orientation is north, southeast, and southwest, for sectors alpha, beta, and gamma (A, B, G) respectively.

Cell site information for the 18 cell sites is provided in the table below. This information includes the site #, market type, cell ID, sector tested, location, cell type, ground elevation, antenna height elevation, antenna type, and antenna down-tilt.

Table 3.1 Cell Site List

The table below contains the data pertaining to the configuration, cell site type, location and antenna system information, for the 18 cell sites that were included in this AMPS Noise Floor Study

Site	Classification	ECP	CELL	Sector Tested	County, State	GE (ft)	ANT TIP HT (ft)	Antenna Type	Downtilt (degrees)
1	Dense Urban	5	54	Alpha	Center City, Philadelphia, PA	40	180	EMS-FV901210	10
2	Dense Urban	5	58	Gamma	Center City, Philadelphia, PA	40	110	ALP-9012-DIN	8
3	Dense Urban	5	85	Gamma	Center City, Philadelphia, PA	21	156	ALP-6014-N	10
4	Urban	5	80	Gamma	Philadelphia, PA	80	150	SCP-9012	0
5	Urban	5	63	Gamma	Philadelphia, PA	80	75	ALP-6014-N	8
6	Urban	5	65	Gamma	Philadelphia, PA	28	100	ALP-6014-N	5
7	Urban	5	78	Alpha	Philadelphia, PA	80	155	ALP-8013-DIN	4
8	Urban	5	57	Alpha	Philadelphia, PA	19	75	ALP-11011-N	0
9	Suburban	2	87	Beta	Gloucester, NJ	35	157	ALP-8013-N	0
10	Suburban	2	106	Beta	Camden, NJ	70	110	ALP-8013-DIN	2
11	Suburban	7	70	Alpha	Bucks, PA	283	140	ALP-9212-DIN	0
12	Suburban	8	66	Gamma	Delaware, PA	292	125	ALP-6014-N	4
13	Suburban	5	79	Alpha	Delaware, PA	365	130	ALP-8013-N	5
14	Rural	6	52	Beta	Cumberland, NJ	104	110	SCP-9012	0
15	Rural	7	50	Gamma	Montgomery, PA	239	118	ALP-8013-DIN	0
16	Rural	7	42	Gamma	Lehigh, PA	630	182	ALP-8013-DIN	0
17	Rural	7	53	Gamma	Montgomery, PA	388	200	ALP-9212-DIN	0
18	Rural	7	102	Alpha	Bucks, PA	331	136	ALP-8013-DIN	0

Notes
1. The Dense Urban sites are in "Center City", within the Philadelphia county.
2. Cell Type is a standard Lucent Series 2 cell site, the classic version (not the Series 2m or 2mm).
3. GE - Ground elevation, above mean sea level.
4. ANT TIP HT - Antenna tip height, above the ground level. This is reference to the top of the antenna.
5. ECP - Executive Cellular Processor, or Mobile Telephone Switching Office (MTSO).

Below, are two geographic maps depicting the locations of the 18 cell sites. The sites are represented with different colors and shapes, to reference each market type.

Figure 3-1 Map of Cell Sites Tested

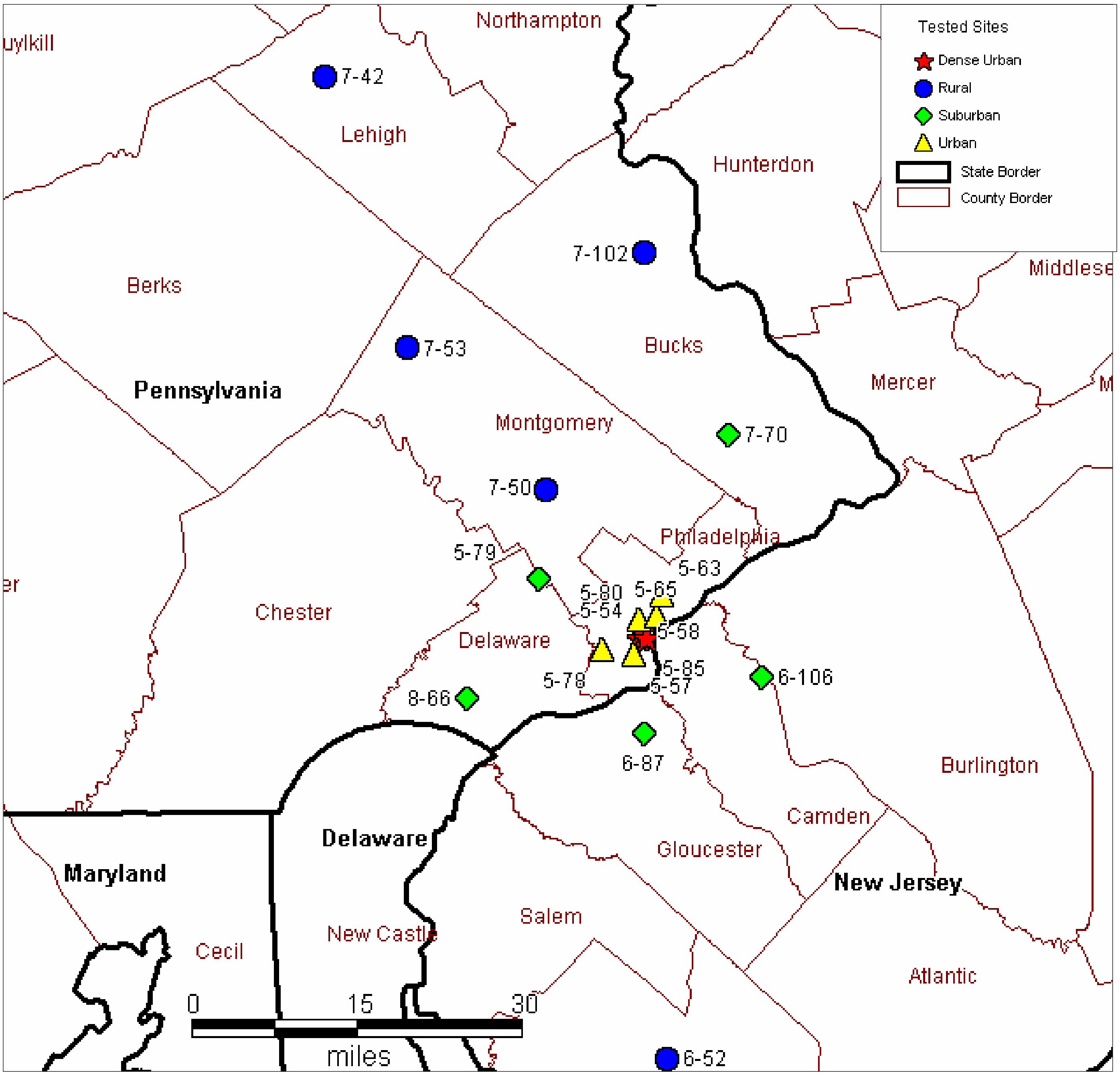
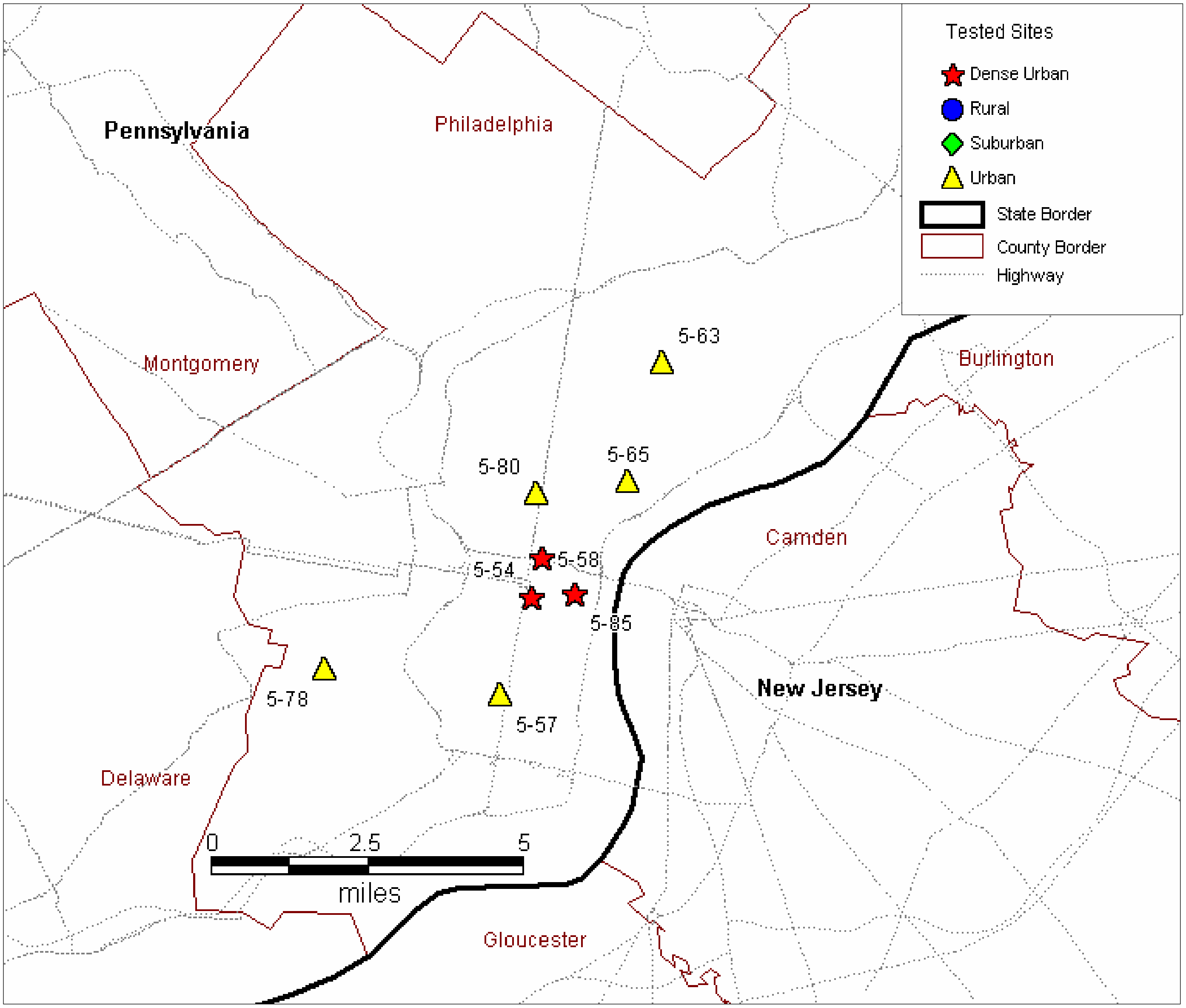


Figure 3-2 Zoom in Map of Cell Sites Tested



4. Test Procedures

4.1. Test Coordination

V-COMM worked with Verizon Wireless' regional performance and operations staff to execute this AMPS Noise Floor Study within the Philadelphia, PA and New Jersey market area. For each of the 18 sites tested, coordination of the required AMPS PLM and RF Traces settings, test mobile ID number (MIN), field engineering contact information, test meeting times, test plan activities and other cell site information was performed. The field tests were performed at each of the 18 cell sites on a typical business day, between the hours of 9:00 am to 3:00 pm. The field tests were performed within the months of December 2001, and January 2002.

4.2. Test Procedures

Upon arrival to the site, the HP 8921A Signal Generator was immediately powered up to allow for a minimum of a half-hour warm-up period, prior to testing. Then, using a test coaxial cable, the signal generator was connected to the –50 dB port of the directional coupler, for one receive diversity path. The switched diversity algorithm in the cell site's receiver selects this diversity since it is stronger than the background noise level on the other diversity. A cellular AMPS telephone call was made from the test mobile to the cell site landline telephone, and seized the desired AMPS voice radio and sector to be tested. The Nokia test phone displayed the channel number and SAT in the phone's test mode screen #1. The AMPS radio that was captured during this call, was located within the Radio Channel Frame (RCF) and the engineer verified that channel was within the desired sector to be tested. This transmit light on the radio was monitored during the test to verify the call was maintained. In addition, the audio was monitored on the landline phone, to verify the call was maintained on the cell site and for the duration of the test, once the signal generator captured the call.

The signal generator was used to capture this test call, by setting the generator to the same reverse channel frequency and supervisory audio tone (SAT) as the cellular AMPS telephone call. The battery was pulled off the cell phone (to prevent a termination signal being sent) and the signal generator was immediately turned on to maintain the call on the channel and cell site. Once the call was verified to remain on the radio channel for a 1 minute period, field tests #1 and #2 were performed. Both field tests use the signal generator modulating 2 tones:

1. The SAT to maintain the call (at either 5970, 6000, or 6030 Hz for SAT 0, 1, or 2; and a deviation of 2 kHz).

2. An audio tone to model typical voice channel characteristics (at 1 kHz frequency and 2.9 kHz deviation). The 1 kHz tone is also used to monitor the call, by listening on the landline phone.

Field Test #1

Using the calibrated signal generator connected to the –50 coupler port, with the proper offsets to reference the input of the cell site, a strong signal level was input into the cell site receive system. At the same time, the RF Call Trace was scheduled on the respective mobile phone number that started the test call, and measures the calibrated signal level over the duration of the test. The injected level was varied below this level, in 10 dB and then 1 dB increments, for fixed periods of time, to allow the RF Trace to provide consistent measurements for each signal level. This was continued all the way to the minimum signal level that would maintain the AMPS call on the channel with no audio muting of the receiver, as observed on the landline telephone.

The duration of this test was approximately 1 hour. The RF Trace data from this test was compared to the calibrated signal levels, to verify the accuracy of the AMPS radio receiver that was captured during the test. After this testing, the PLM was scheduled to measure the operating noise floor, over a 24-hour period, for the same radio channel receiver that was captured during this testing. The 50% PLM results are included in the "Test Results" section of this report and the individual site PLM graphs are included in the appendix of this report.

Field Test #2

Field test #2 takes place at the end of field test #1. The minimum signal level that can maintain an AMPS call with no audio muting is observed. This level is observed by decreasing the signal level 1 dB at a time, while listening to the audio tone on the landline telephone. At this minimum test call signal level, the operating noise floor during test can be estimated with the signal to noise ratio of approximately 2 dB.

At this level, the cell site receiver is able to maintain an AMPS call with 0% audio muting over a period of time of approximately 5 minutes. The call is maintained with the cell site radio receiver decoding SAT correctly and continuously, without interruption and without muting the receiver. The signal-to-operating-noise-floor level (S/N) is estimated to approximately 2 dB. If the signal is decreased below this level, the cell receiver will begin to lose the ability to decode the 6 kHz SAT (Standard Audio Tone - used to maintain calls), and will begin to mute the audio 1 kHz tone. Typically, 1 dB below this no muting "Minimum Test Call" signal level, the audio begins to mute approximately 5-10% of the time; 2 dB below this level the audio mutes approximately 50-60% of the time; and the call drops when the SAT Fade Timer is expired (typically 10 seconds). For this call testing, V-COMM estimates the cell site's operating noise floor is 2 dB below the no muting "Minimum Test Call" signal level.

To verify the approximate 2 dB S/N ratio provided above, two additional field tests were performed. The test results of these two tests support this S/N conclusion. Both tests involve similar test setups as used above. In the first test, using a strong signal the signal generator switches its output carrier on/off every 10 seconds to maintain a call on the site without dropping the call. This allows the cell site radio to measure the operating noise floor with the Lucent RF Call Trace function. The operating noise floor would be represented in the measured data, in alternating 10 second periods. The RF Trace has a measurement interval of 2 seconds and a resolution of 1 dB. In the second test, the signal generator performed a standard 12 dB SINAD audio test (Signal plus Noise and Distortion), with a 1 kHz tone and 8 kHz deviation. Lucent stated that the 12 dB SINAD point on their equipment is achieved with 4 dB S/N. The test results indicate the signal level to achieve 12 dB SINAD on the cell site was approximately 4 dB above noise floor, and approximately 2 dB above the “no muting” minimum call signal level test results. In conclusion, the results of both tests support the 2 dB S/N used in the test procedure above.

Field Test #3

Field test #3 takes place after field tests #1 and #2 are completed. The HP 8921A is set to its spectrum analyzer mode. The spectrum analyzer is connected to the cell site receive system, at the output port of the 1 to 9 splitter, at the top of the radio channel frame (RCF). The measured offset from this port to the input of the cell site, and the test cable loss, are used to reference the signal levels to the input of the cell site.

A snapshot of the average operating noise floor level is recorded during this test on the same radio receiver channel that was captured during field tests #1 and #2 above. The engineer verifies the radio channel is idle before taking these measurements. The results of these readings were equal to or lower than the estimated noise floor field tests, since the resolution bandwidth of the analyzer was narrower than the cell site receiver’s bandwidth.

5. Test Results

The AMPS Noise Floor Test Results are provided in Table 5.1. Included are the results from the field tests and 24-hour PLM measurements. For each of the 18 sites, the operating noise floor level is provided in two ways:

1. The distribution of operating noise floor measurements recorded by the 24-hour PLM. The individual PLM graphs for each site are provided in the appendix of this report. The PLM 50% threshold is the median operating noise floor for the cell site, over the 24-hour period.
2. The operating noise floor level observed during field testing, as estimated by the minimum test call signal level, that can maintain an AMPS call with no SAT muting.

In addition, Table 5.1 contains the minimum signal level that a “toll quality” AMPS call can be received by the cell site, with a carrier to interference (C/I) ratio of 17 dB (above the 50% PLM noise floor level). In the presence of considerable signal fading, an additional fade margin may be required. However, most cellular systems utilize diversity receive path systems, which mitigates the effects of signal fading.[1]

The results of the 50% PLM operating noise floor measurements, recorded over a 24-hour period by the cell site receiver for the 18 cell sites are –119 dBm to –127 dBm, with an average of –126 dBm. The 50% PLM operating noise floor levels, averaged per market type, for Dense Urban, Urban, Suburban and Rural sites are –123.4, –126.2, –127 and –127 dBm, respectively.

The estimated operating noise floor results, for day-time field tests within the 9:00 am - 3:00 pm time period, for the 18 cell sites are –118 dBm to –128 dBm, with an average of –125 dBm. The estimated field test operating noise floor levels, averaged per market type, for Dense Urban, Urban, Suburban and Rural sites are –121.7, –124.4, –126.4 and –126.6 dBm, respectively.

The minimum “toll quality” AMPS call signal level with a 17 dB C/I above the 50% PLM level, for the 18 cell sites are –102 dBm to –110 dBm, with an average of –109 dBm. The minimum “toll quality” AMPS call signal level, averaged per market type, for Dense Urban, Urban, Suburban and Rural sites are –106.4, –109.2, –110 and –110 dBm, respectively.

[1] Cellular base stations typically utilize diversity receive systems to mitigate the effects of signal fading. These systems utilize switched diversity receive or maximum ratio combining methods. As measured by Nokia in field tests, these systems provide between 2.7 to 5.7 dB of mean signal improvement depending on the radio environment and antenna used, over cellular systems not employing such equipment. Diversity receive systems providing link budget improvements up to 5.7 dB will mitigate the need for network fade margins in the same amount, or to approximately 5.7 dB. (This network fade margin assumes 8 dB standard deviation, 76% cell edge reliability, and approximalety 90% area coverage availability.)

The test results indicate very low cell site operating noise floor levels for the 50% PLM and Estimated Noise Floor During Test levels. The estimated noise floor during testing took place between 9:00 am and 3:00 pm, and the 24-hour PLM measurements includes the entire day-time and night-time periods for a typical weekday. The individual site PLM graphs are provided in the appendix of this report. These graphs show the distribution of operating noise floor levels over the 24-hour period, which includes system busy-hours (ie. 4:00 pm to 6:00 pm), where the cell site operating noise floor is higher than the 50% PLM values.

The AMPS Noise Floor Test Results are provided in Table 5.1 below. Included are the results from the field tests and 24-hour PLM measurements.

Table 5.1 AMPS Noise Floor Test Results

SITE	Market Type Classification	ECP	Cell	County, State	Minimum Test Call Signal (dBm) [1,2]	Est. Noise Floor During Test (dBm) [1,3]	Noise Floor Measurement PLM 50% (dBm) [1,4]	Min. Toll Quality Call Level, with 17 dB C/I (dBm) [1,5]
1	Dense Urban	5	54	Center City, Philadelphia, PA	-124	-126	-124.7	-108
2	Dense Urban	5	58	Center City, Philadelphia, PA	-119	-121	-127.0	-110
3	Dense Urban	5	85	Center City, Philadelphia, PA	-116	-118	-118.5	-102
4	Urban	5	80	Philadelphia, PA	-121	-123	-127.0	-110
5	Urban	5	63	Philadelphia, PA	-124	-126	-125.5	-108
6	Urban	5	65	Philadelphia, PA	-124	-126	-126.0	-109
7	Urban	5	78	Philadelphia, PA	-123	-125	-125.5	-108
8	Urban	5	57	Philadelphia, PA	-120	-122	-126.9	-110
9	Suburban	2	87	Gloucester, NJ	-126	-128	-127.0	-110
10	Suburban	2	106	Camden, NJ	-124	-126	-127.0	-110
11	Suburban	7	70	Bucks, PA	-124	-126	-127.0	-110
12	Suburban	8	66	Delaware, PA	-126	-128	-127.0	-110
13	Suburban	5	79	Delaware, PA	-122	-124	-127.0	-110
14	Rural	6	52	Cumberland, NJ	-124	-126	-127.0	-110
15	Rural	7	50	Montgomery, PA	-125	-127	-127.0	-110
16	Rural	7	42	Lehigh, PA	-125	-127	-127.0	-110
17	Rural	7	53	Montgomery, PA	-125	-127	-127.0	-110
18	Rural	7	102	Bucks, PA	-124	-126	-127.0	-110
				Average	-123.1	-125.1	-126.2	-109.2

Table 5.2 AMPS Noise Floor Test Results, Averaged by Market Type

Market Type Classification	Average per Classification			
	Minimum Test Call Signal (dBm) [1,2]	Est. Noise Floor During Test (dBm) [1,3]	Noise Floor Measurement, PLM 50% (dBm) [1,4]	Min. Toll Quality Call Level, with 17 dB C/I (dBm) [1,5]
Dense Urban	-119.7	-121.7	-123.4	-106.4
Urban	-122.4	-124.4	-126.2	-109.2
Suburban	-124.4	-126.4	-127.0	-110.0
Rural	-124.6	-126.6	-127.0	-110.0

Notes for Tables 5.1 and 5.2:

1. All signal level units are in dBm, referenced to the input to the cell site. Lucent references this as the J1 port. This reference is the antenna side connector of the very first element in the cell site receive system; which is the same reference as the equipment side of the antenna jumper cable, which connects to the transmission line.

2. Minimum Test Call Signal (dBm) - This is the minimum signal level that the cell site receiver is able to maintain an AMPS call, with 0% audio muting over a period of time of approximately 5 minutes, during testing. The test call occurred between the weekday hours of 9:00 am to 3:00 pm. The test call used a modulated 1 kHz audio tone, with 2.9 kHz deviation, to represent average voice channel characteristics. At the minimum test call level, the call is maintained on the cell site and SAT is decoded properly and continuously, without interruption or muting. At this level, the signal-to-operating-noise-floor level (S/N) is estimated to 2 dB. If the signal is decreased below this level, the cell receiver will begin to lose the ability to decode the 6 kHz SAT (Standard Audio Tone - used to maintain calls), and will begin to mute the audio tone.

3. Est. Noise Floor During Test (dBm) - This is the estimated cell site operating noise floor, that is computed from the "Minimum Test Call Signal" level. This is 2 dB below the "Minimum Test Call Signal" level. See previous note for further explanation.

4. Noise Floor Measurement, PLM 50% (dBm) - This is the cell site's 50% median operating noise floor level, as measured over a 24-hour weekday period. This is provided by the Lucent Power Level Measurement (PLM) Mode 2 function, which measures the operating noise floor level on an idle AMPS channel and records signal levels into 3.125 dB bins. With

this resolution, the measured data is +/- 1.562 dB. The signal level of each bin is referenced to the center of the bin. The PLM 50% threshold is provided as the median operating noise floor, from the cumulative probability series. Linear interpolation is used for values that are contained between 2 data points. If the 50% cumulative probability occurs within the lowest bin, the –128.6 dBm bin, linear interpolation cannot be performed and the upper edge of the bin is used, which is –127.0 dBm.

5. Min. Toll Quality Call Level, with 17 dB C/I (dBm) - This is the minimum signal level that a "Toll Quality" AMPS call can be made on the cell site, with a carrier-to-interference ratio of 17 dB. This level is computed by adding 17 dB to the "Noise Floor Measurement, PLM 50%" values.

6. Analysis of Test Results and Noise Floor Issues

6.1. Cell Site Operating Noise Floor in Today's Cellular Networks

The test results indicate that very low operating noise floor levels exist in today's cellular AMPS networks. The noise floor is lower than it has been in the past. Over the past years, cellular networks have experienced a quieting affect to their operating noise floors for a variety of reasons. Some of these reasons are provided below.

Cellular Portable Phones – Cellular portable phones are the most prevalent phones in the market, representing close to 100% of the cellular phones that exist today. In the past, cellular car phones were more common. The AMPS cellular car phone transmits maximum power at 3 watts, into a 3 dB gain antenna, and the AMPS portable phone only transmits maximum power at 0.6 watts, into a 0 dB gain antenna. This is approximately an 10 dB reduction in signal strength of the cellular phones, which translates to lower signal and operating noise floor levels seen by the cellular base stations. In addition, portable phones used inside cars experience additional attenuation, due to the placement of the phone's antenna within the car (especially when used with a headset, with the phone on the seat or in a cradle). This attenuates the signal path by an additional 5 to 10 dB.

In-building Cell Phone Usage – The percentage of people using cell phones inside buildings has increased over the past years. This trend has the affect of dramatically lowering the signal and operating noise floor seen by cellular base stations. The decrease in signal and noise levels from in-building cell phone users are approximately 10 to 30 dB, due to the signal attenuation of the building structure.

Cell Sites Using Sector Antennas – The most common cellular base station antenna today is the 3-sectored panel antenna. The panel antenna improves the performance of cellular systems by achieving more gain in the intended 120 degree sector coverage area, and more protection from interference in the other 240 degrees. This allows the cell site to achieve lower operating noise floor conditions, from nearby co-channel and adjacent channel interference. The sector antenna's interference noise floor reduction will be in the range of 5 to 30 dB, depending on the antenna's horizontal beam-width pattern. In addition, the interference noise floor can be lower in cases when the antenna is mounted on a water tank or building wall, which further attenuates the interference from these directions. In the past, omni-directional antennas were more common than they are today. Omni-directional antennas have gain in all directions (360 degrees) and consequently experience higher noise floor levels.

Mature Cellular Networks – The use of cellular service has increased dramatically over the past years. Cellular networks have matured and evolved to meet this growing demand. Mature cellular systems exhibit the following trends in network design.

1. Smaller cell sites with lower antenna elevations (closer to the height of the clutter of trees and buildings). This lowers the operating noise floor of the cell site, and increases system capacity. Smaller cell sites allow mobile phones to operate at lower power levels, which in turn lowers the interference levels received by the co-channel and adjacent channel cell sites.
2. Downtilting antennas are commonly used in mature cellular systems to lower the cell site's interference noise floor.
3. Narrow horizontal beam-width antennas are used to reduce the cell site's interference noise floor, by limiting the interference that can be seen from the edges of the sector antenna. Antennas with horizontal beam-width of 60 to 80 degrees are becoming more common in mature systems.
4. The cell site Voice Mobile Attenuation Code (VMAC) parameter is utilized by some cellular systems, to lower the maximum allowable AMPS mobile phone power, which in turn reduces the surrounding cellular system's interference noise floor.

The above trends in cellular system usage and network design have contributed to lowering the cell site's operating noise floor. The results of this AMPS Noise Floor Study exhibit this trend.

6.2. Other Technology and Cell Site Equipment

Cell sites included in this study use standard and typical cell site equipment. Many cellular operators use other technology and cell site equipment, which have different noise floor characteristics. Examples of other technology and cell site equipment that offer lower operating noise floors than the standard AMPS cell site equipment, are provided below.

<u>Tower-top Low-Noise Amplifiers (TLNA)</u> - offer cellular systems lower system noise figures (by approximately 2 dB), which allows the cell site to exhibit a lower operating noise floor.

<u>Superconductor receive filter and preamplifier equipment</u> - offer cellular systems lower system noise figures (by approximately 1 to 2 dB), which allows the cell site to exhibit a lower operating noise floor.

<u>Smart antenna technology utilizing micro-sector antennas</u> - exhibit lower operating noise floor levels, due to the interference protection provided by the antenna's horizontal beam-width characteristics. Typical horizontal beam-width specification for this application is 30 degrees.

<u>Smart antenna technology utilizing adaptive array antenna systems</u> - exhibit lower interference noise floor levels, due to interference reductions provided by interference nulling and canceling algorithms.

Narrow-band AMPS (NAMPS) cell site equipment - this cell site equipment was offered by Motorola years ago and still exists in some cellular networks today. The cell site radio equipment for NAMPS uses a 10 kHz bandwidth, as compared to the standard AMPS 30 kHz bandwidth. With 1/3 the bandwidth, the NAMPS receiver has a thermal noise floor that is 4.7 dB below the AMPS receiver, which allows it to exhibit lower noise floor conditions.

Six-sectored cell sites - may exhibit lower operating noise floor levels, due to interference protection provided by the antenna's horizontal beam width characteristics. Typical horizontal beam width specifications for this application is 50 to 60 degrees. This application is not common, but may exist in some cellular systems today.
(If the six-sector network design is used in conjunction with a frequency reuse of N=4, then system interference levels will not decrease, due to increased co-channel usage.)

6.3. Cell Site Equipment System Noise Floor

The cell site's *system* noise floor is the lowest noise level that can be achieved by the cell site receive system. It is represented below in two separate analyses. The first method uses the thermal noise floor plus the equipment's system noise figure, and the second uses the Signal plus Noise and Distortion (SINAD) measurement to compute the equipment's system noise floor. The noise floor level varies across some radio receivers and cell sites. Included in these analyses are approximate values and assumptions for the characteristics that contribute to the system noise floor.

Method #1
The first method uses the thermal noise floor plus the equipment's system noise figure to calculate the cell site *system* noise floor.

Cell Site System Noise Floor = Thermal Noise Floor + System Noise Figure

System Noise Figure – The cell site receive system begins at the input to the cell site (J1 port) and ends at the radio. The system noise figure is equal to the noise contributions all the devices in this path, however it is primarily controlled by the front end of the receiver. The front end consists of receive system filters, couplers and the preamplifier. As provided by Lucent, a typical system noise figure for the Series 2 cell site is 3.7 dB. Lucent's manufacturing guaranteed noise figure is 5 dB, which is a conservative, maximum value. The minimum value can be lower than the typical; however Lucent did have this information available. For this analysis, the typical value for the Series 2 cell site *system* noise figure is used, which is 3.7 dB.

Thermal Noise Floor – The thermal noise floor is calculated with the formula = kTB, where k is Boltzmann's constant k = 1.37 x 10^{-23} joules/Kelvin, T is the temperature in Kelvin, and B is the bandwidth of the receiver. Using 290 degrees K room temperature, the thermal noise floor is –129.2 dBm, –130.2 dBm, and -130.6 dBm for receiver bandwidths of 30 kHz, 24 kHz and 22 kHz, respectively. Depending on the actual bandwidth characteristics of the AMPS cell site receiver, its thermal noise floor will vary slightly. The AMPS cellular standard uses 30 kHz bandwidth channel spacing to define the AMPS channel's nominal bandwidth,[2] however the signal level at +/- 15 kHz from the center of the carrier is sufficiently lower to meet the receiver adjacent channel rejection specifications and improve receiver sensitivity. In addition, the AMPS cell site receivers must have bandwidth characteristics wide enough to demodulate voice signals (typically 300 to 3 kHz), SAT tones (6 kHz) and Signaling tones (10 kHz) such as power control and handoff messages.

Lucent did not specify the actual bandwidth characteristics of its cell site receivers, however they performed receiver band pass measurements on the AMPS Series 2 cell site receiver.[3] V-COMM analyzed these measurements for the actual receiver bandwidth characteristics, and concluded the actual bandwidth is approximately 24 kHz. For this analysis, the AMPS receiver is assumed to operate with the bandwidth characteristics of 24 kHz. With this receiver bandwidth characteristic, the Lucent Series 2 cell site's thermal noise floor is –130.2 dBm.

Cell Site Equipment's *System* Noise Floor – With a thermal noise floor of –130.2 dBm and typical noise figure of 3.7 dB, the cell site's *system* noise floor is –126.5 dBm.

Method #2

The second method uses the Signal plus Noise and Distortion (SINAD) audio measurement to compute the equipment's system noise floor. The cell site's *system* noise floor is computed with the signal to noise (S/N) ratio that is required to achieve 12 dB SINAD (referenced in audio) on the Lucent Series 2 AMPS cell site receiver. As provided by Lucent, this S/N ratio is 4 dB (referenced in RF). V-COMM performed measurements at the Series 2 cell site, and measured the 12 dB SINAD level to –123 dBm.[4] With this signal level and S/N ratio above, the cell site *system* noise floor is equal to –127 dBm.

As provided in the two analyses above, the cell site *system* noise floor is estimated to approximately –127 dBm. Comparing the –127 dBm *system* noise floor level to the lowest readings in the test results, we observe that the lowest readings are at or slightly below this level. However, the cell site receiver should not be able to distinguish signals

[2] The transmitted emissions of analog cellular signals are attenuated by approximately 24 to 28 dB, at its nominal channel bandwidth (i.e. +/- 15 KHz from its center frequency).

[3] Lucent conducted measurements on a series II cell site AMPS radio in its laboratory. For these tests, an unmodulated signal reference was injected into the AMPS radio at various offset frequencies from the radio channel's center frequency, to determine the receiver's actual pass band characteristics.

[4] The SINAD performance of cell site equipment may vary slightly from site to site. In another test, at a different Lucent Series 2 AMPS cell site, V-COMM measured the 12 dB SINAD reference point to –122 dBm. Utilization of external LNA configurations (ie. Tower-top) or superconductor filters will improve and lower these system noise floor and sensitivity figures further, by approximately 2 dB (i.e. to –124 dBm). These levels are referenced to the input to the cell site. These low receive sensitivity levels allow cellular operators (and AirCell, since they reuse the same AMPS cell site equipment) to serve calls to very low signal levels. At the Marlboro AirCell site, AirCell sets the lower end of its DPC power box equal to –120.5 dBm, which results in a C/N of approximately 6 to 6.5 dB at the lower end of the power box, with an equipment noise floor of –126.5 to –127 dBm.

or noise below its system noise floor level. Some possible reasons for this occurrence are provided below.

1. Some radio receivers may be more sensitive than others and some receive paths may have lower noise figures than others, which improves the cell site system noise floor. This allows the radio to distinguish signals and noise levels that are lower than the assumptions indicate in the analyses above.
2. The resolution of PLM measurement uses 3.125 dB bin sizes, and records data within +/- 1.562 dB from the center of the bin. For example, the lowest bin is centered at –128.6 dBm, and it records data from –130.2 to –127.0 dBm. The –127 dBm value is within its +/- 1.5 dB bin resolution.
3. The accuracy of the PLM and RF Trace measurements are approximately within +/- 1 dB, and the differences above are within its measurement tolerance.
4. The accuracy of the signal generator is +/- 1 dB, and the differences above are within its measurement tolerance.

In another observation, it is observed that that the suburban and rural cell sites tested exhibit very low cell site operating noise floor levels that approach the cell site equipment's *system* noise floor level, for a good percentage of the day. The operating noise floor increases above this level at other times during the day, but this occurs for shorter periods of time. The distribution of operating noise floor levels over a 24-hour period are provided in the PLM graphs in the report's appendix section.

7. Conclusion

The results of the AMPS Noise Floor Study show very low noise floor levels present in today's cellular networks. These levels are lower than systems have been in the past, due to trends in cellular system usage and cellular system design (see section 6.1).

The results of the 24-hour noise floor measurements, for the 18 cell sites, range from –119 dBm to –127 dBm, with an average of –126 dBm. With 17 dB C/I, "toll quality" AMPS calls can maintain service to very low levels at these cell sites, from –102 to –110 dBm, with an average of –109 dBm. The results of the day-time noise floor field tests range from –118 dBm to –128 dBm, with an average of –125 dBm.

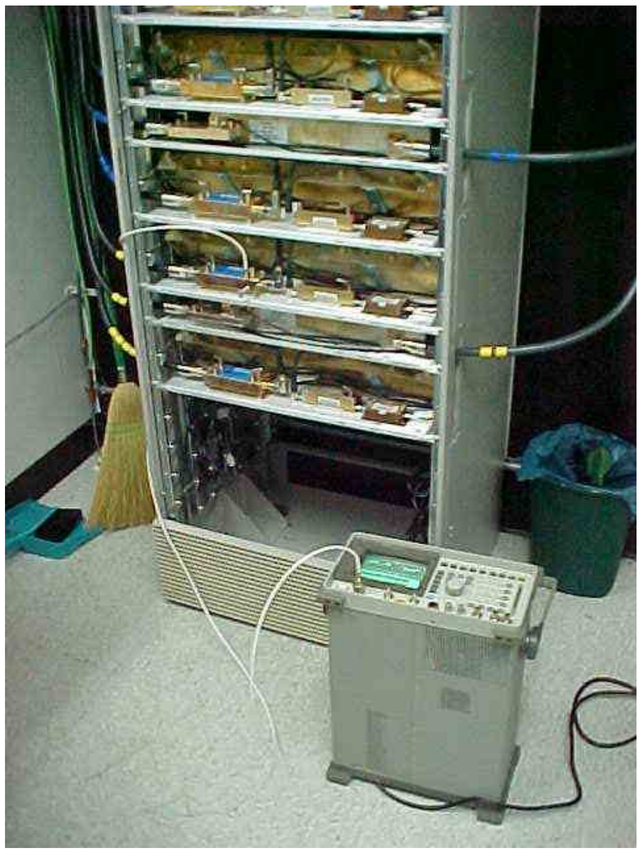
Based on the results of this study, the operating noise floor level for AMPS cellular systems is represented by –123 dBm for Dense Urban markets, –126 dBm for Urban markets, and –127 dBm for Suburban and Rural markets. These levels represent the operating noise floor for the 18 cell sites, averaged by market type and measured over a 24-hour period for a typical business day. AMPS cellular systems using other cell site equipment, such as tower-top LNA, superconductor or smart antenna technology described in section 6.2, offer cell site operating noise floor levels that are lower than the levels provided in this report.

In addition, the test results indicate the following conclusions:

1. The operating noise floor levels for the Rural and Suburban sites indicate similar and very quiet noise conditions. With the current market trends (in-building cell phone users and the maturity of cellular systems), Suburban site noise floors conditions have approached the Rural site conditions.
2. The operating noise floor levels for the Rural and Suburban sites approach the cell site's *system* noise floor levels between 55% to 98% of the 24-hour business day period.
3. The operating noise floor levels for the Urban and Dense Urban sites are higher than the Suburban and Rural sites, by 1 dB, and 4 dB, respectively, based on the 50% PLM measurements.
4. The 50% PLM noise floor level shows a correlation to the estimated noise floor level during testing. When comparing the average of these the two levels, it shows the estimated day-time field test noise floor 1 dB higher. This is expected due to the elevated noise floors that occur during busier day-time periods, and the PLM measurements are averaged over a longer 24-hour period.

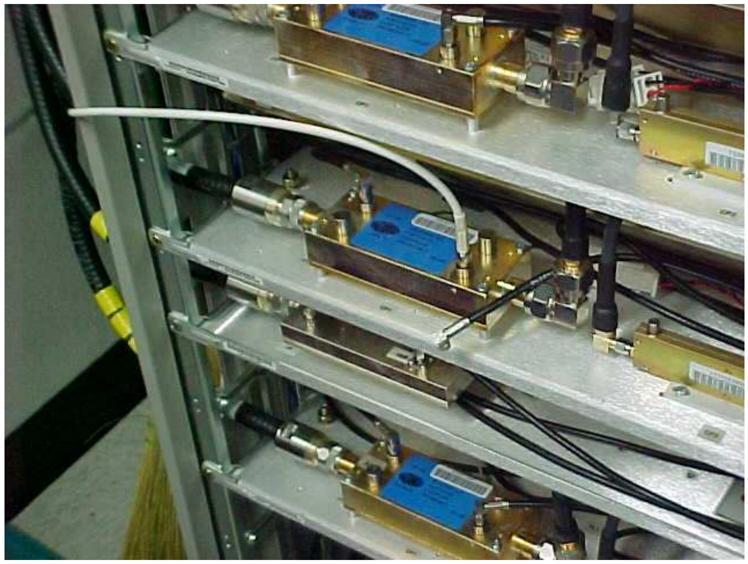
8. Appendix

8.1 Pictures of Test Setup



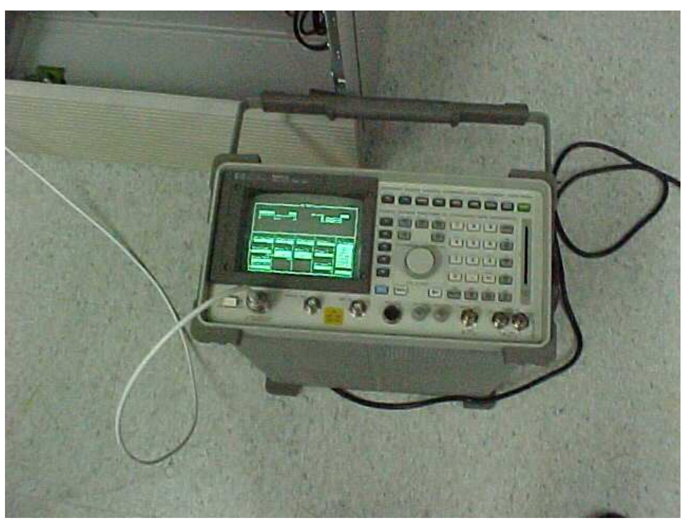
Picture 1 -- Test Setup

This photo illustrates the connection of the HP 8921A Signal Generator to the -50 dBm receive coupler port, which was used for calibrated signal level injections during field tests #1 and #2. This coupler is the 1st element in the cell site's receive path, within the Lucent Series 2 cell site antenna interface frame (AIF).



Picture 2 – Receive Coupler Port

This is a close-up photo of Picture 1, showing the test cable connected to the–50 dB receive coupler.



Picture 3 -- Cell Site Analyzer

This is a photo of the HP 8921A Signal Generator / Spectrum Analyzer used to perform the AMPS Noise Floor field tests #1, #2 and #3.

8.2 PLM Graphs of Cell Sites

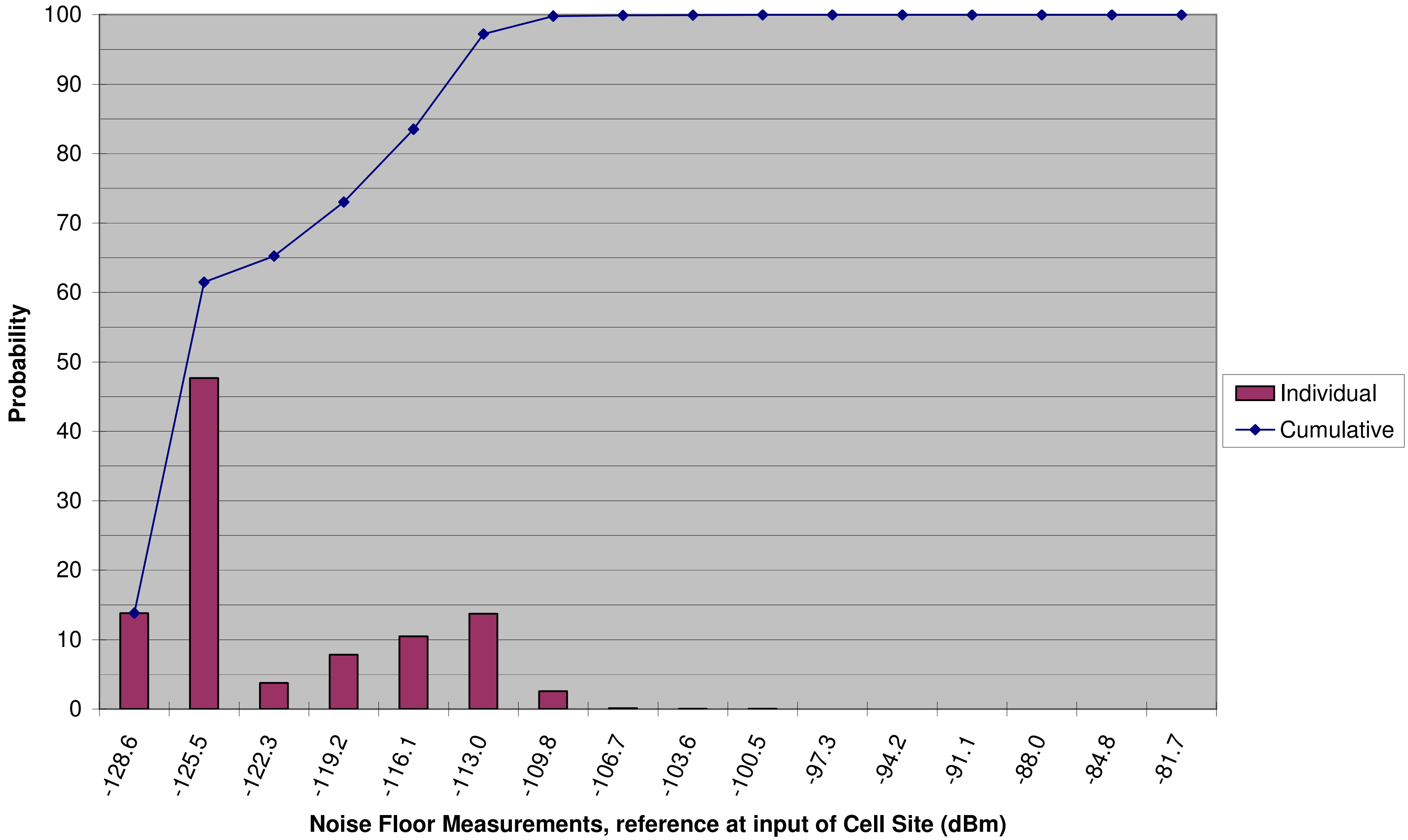
The following 18 pages contain the PLM graphs of the 18 cell sites included in the AMPS Noise Floor study. The PLM graph represents the cell site's operating noise floor level distributions over a 24-hour period, as recorded by the Lucent PLM function. The PLM function records the noise floor measurements on an idle AMPS channel with the cell site receiver. The Lucent PLM measurements are collected into "bins" that are 3.125 dB in width. The reference value of each bin is the center value of the bin, and is represented by the x-axis value on the graphs. With this bin size and reference, each bin includes measured data that is 1.562 dB above and below the reference value. For example, the measured data contained within the 1st bin, at the –128.6 dBm level, includes data that is greater than –130.2 dBm and less than –127.0 dBm.

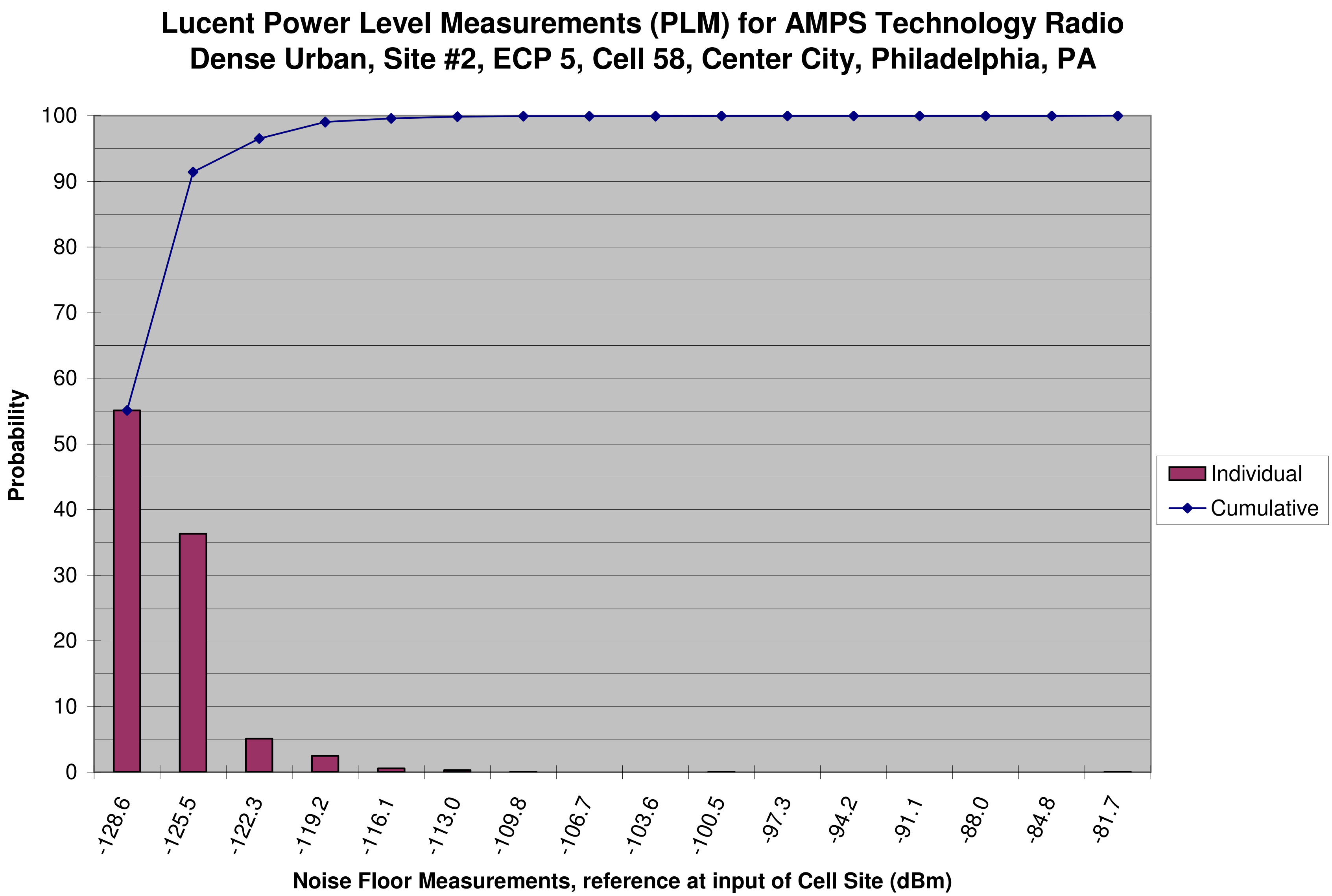
The PLM graphs contain the Individual Probability and Cumulative Probability distributions. The Individual Probability is the probability of occurrence of an individual bin or data point. The reference value of this data is represented by the average value of the bin, which is the center of the bin. The Cumulative Probability is the probability of occurrence of an individual bin, plus the accumulation of all prior bins starting from the minimum value on the x-axis. The reference value of this data is represented by the upper value of the bin, since all the data within the bin must be included. The upper value of the bin is 1.562 dB above the center value of the bin.

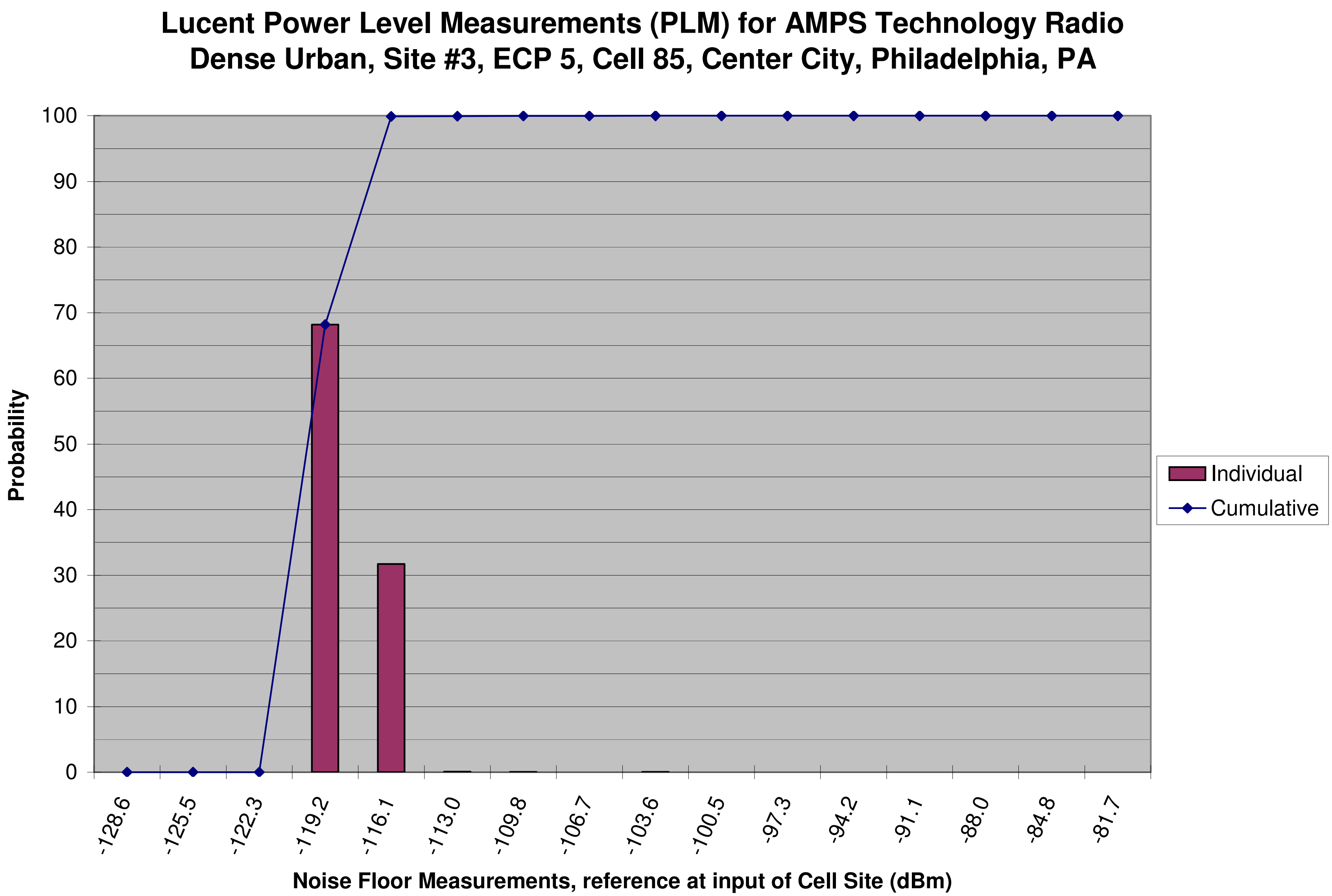
Two examples for the 1st PLM graph are as follows. Site #1 has an operating noise floor level that occurs at the –125.5 dBm level 48% of the time. The –125.5 dBm level is the average for the bin; it includes signals measured from –127.0 dBm to –123.9 dBm. In addition, 61% of the time the operating noise floor level is below –123.9 dBm. This is the cumulative probability, which is referenced to the upper value of the bin. This upper value is equal to –123.9 dBm, which is derived from –125.5 dBm + 1.562 dB.

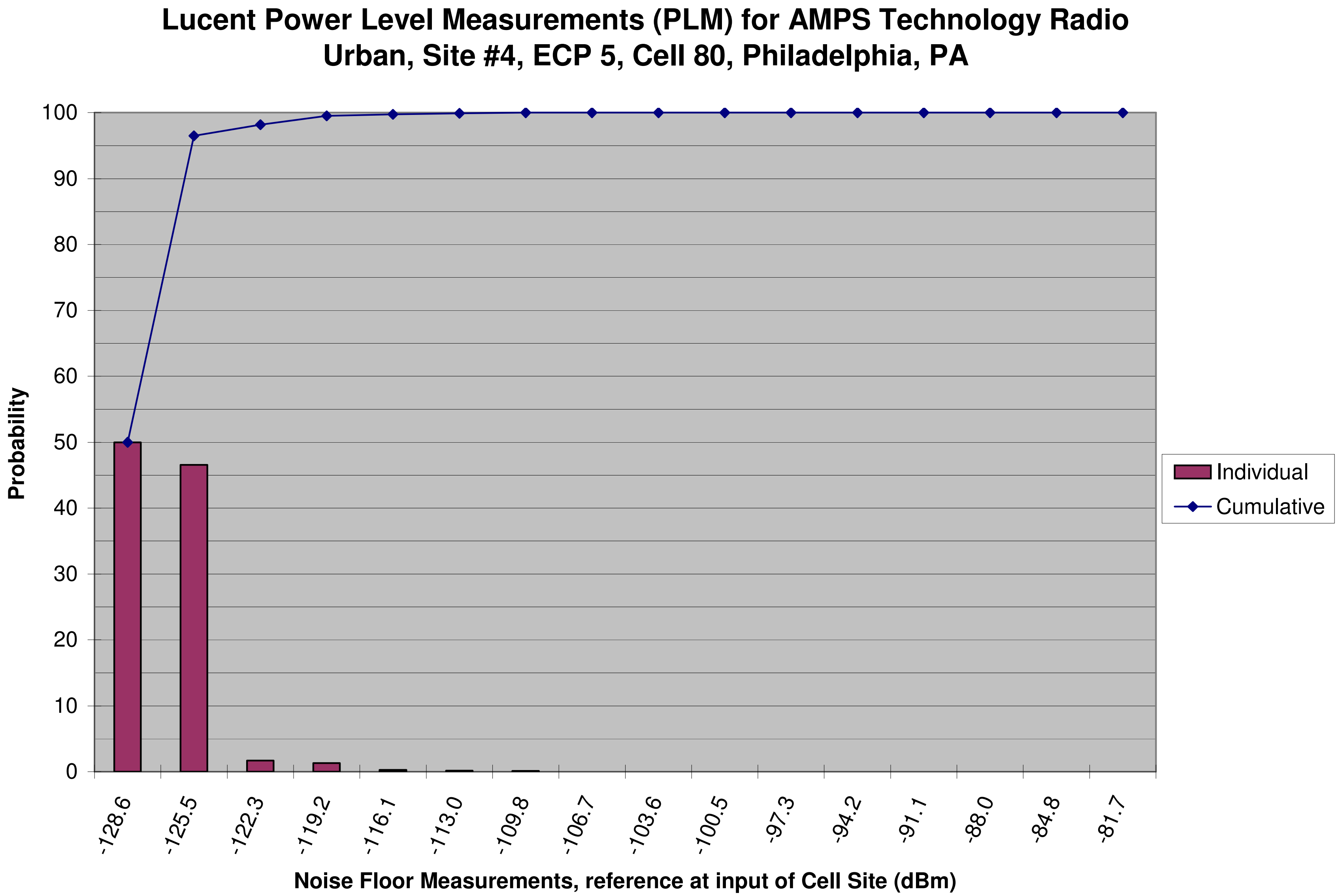
The AMPS Noise Floor Test Results in Table 5.1, includes the PLM 50% threshold as the median operating noise floor for the cell site. The PLM 50% noise floor is calculated from the cumulative probability series. Linear interpolation is used for values that are contained between 2 data points. If the 50% cumulative probability occurs within the lowest bin, the –128.6 dBm bin, linear interpolation cannot be performed and the upper edge of the bin is used, which is –127.0 dBm.

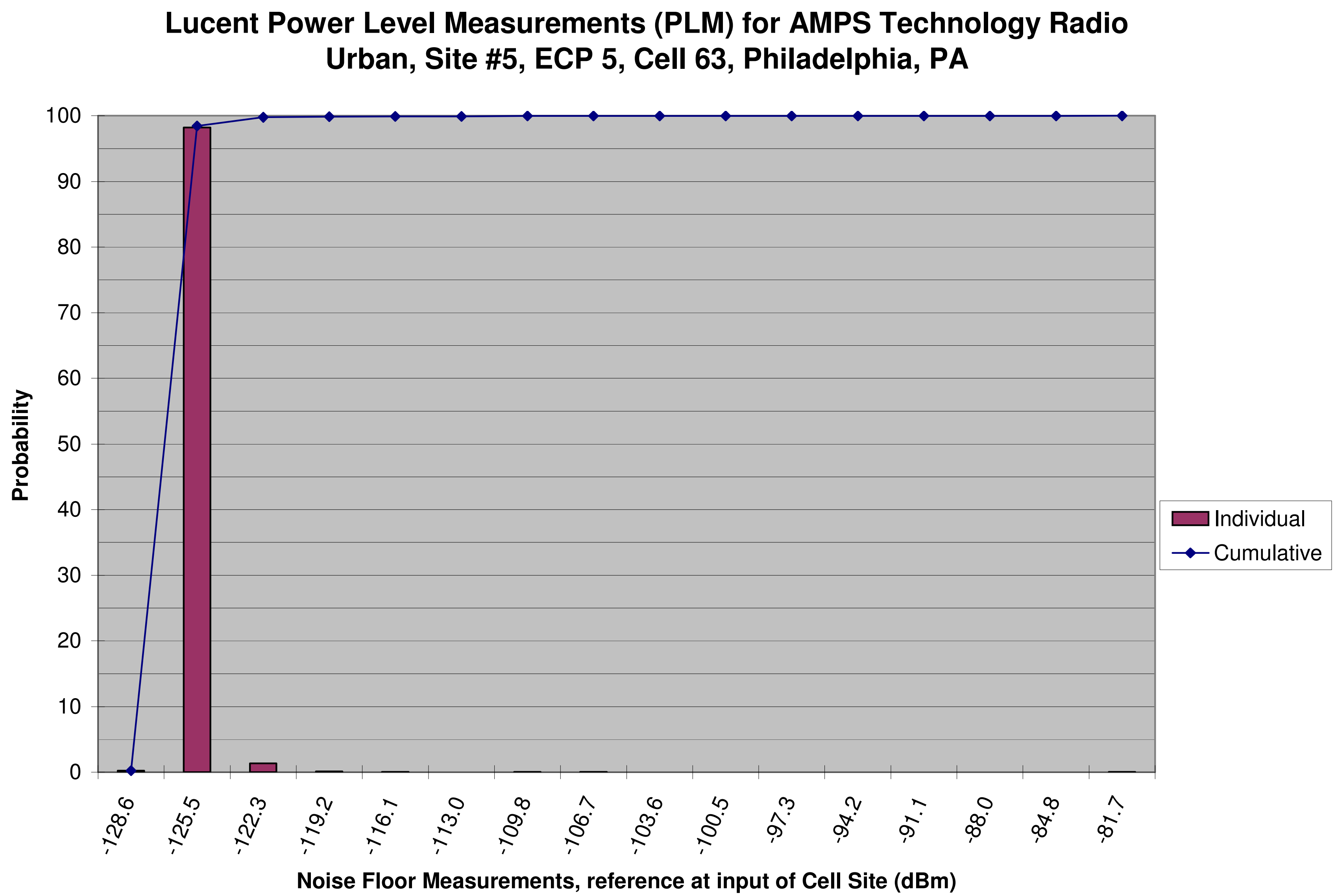
Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Dense Urban, Site #1, ECP 5, Cell 54, Center City, Philadelphia, PA

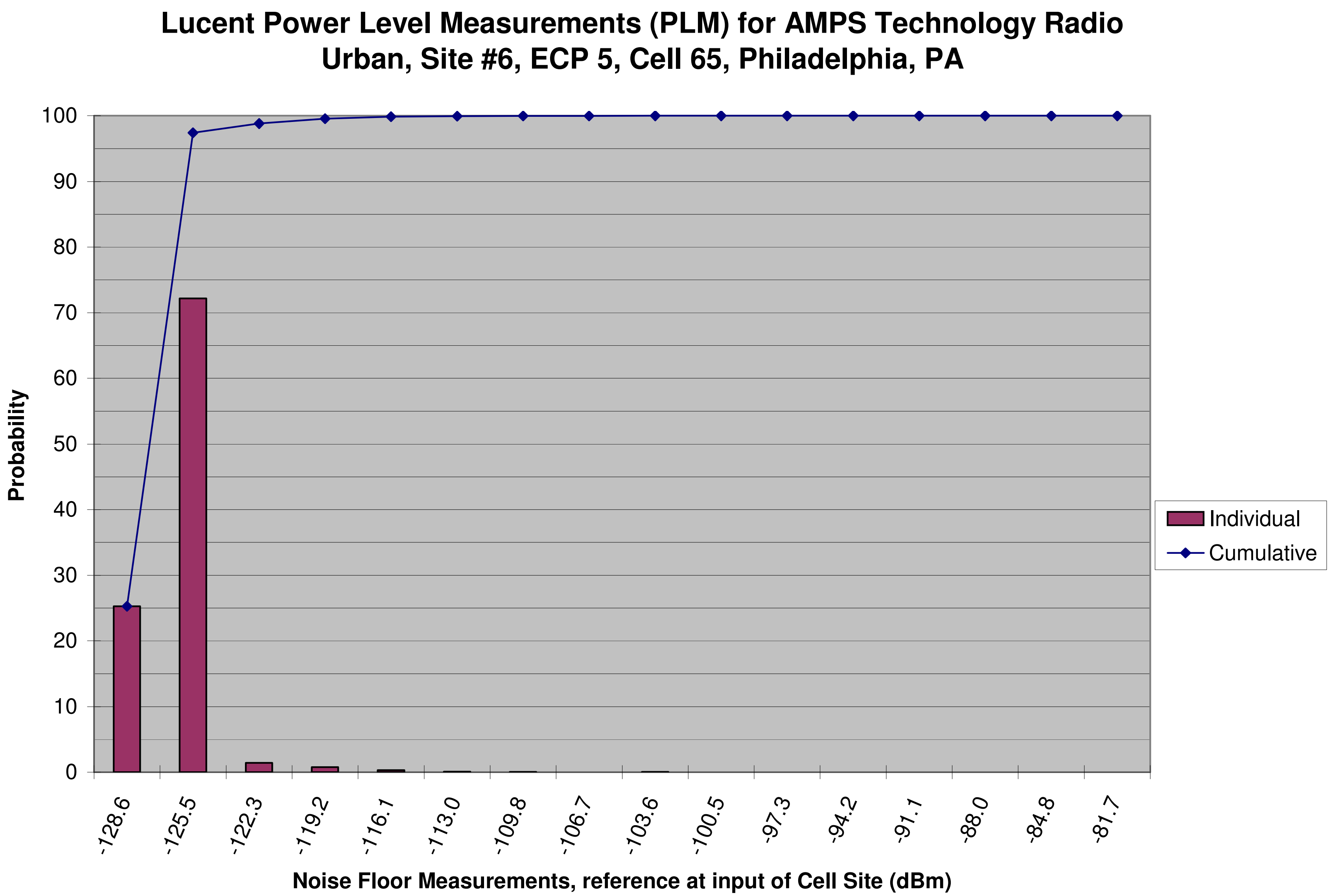


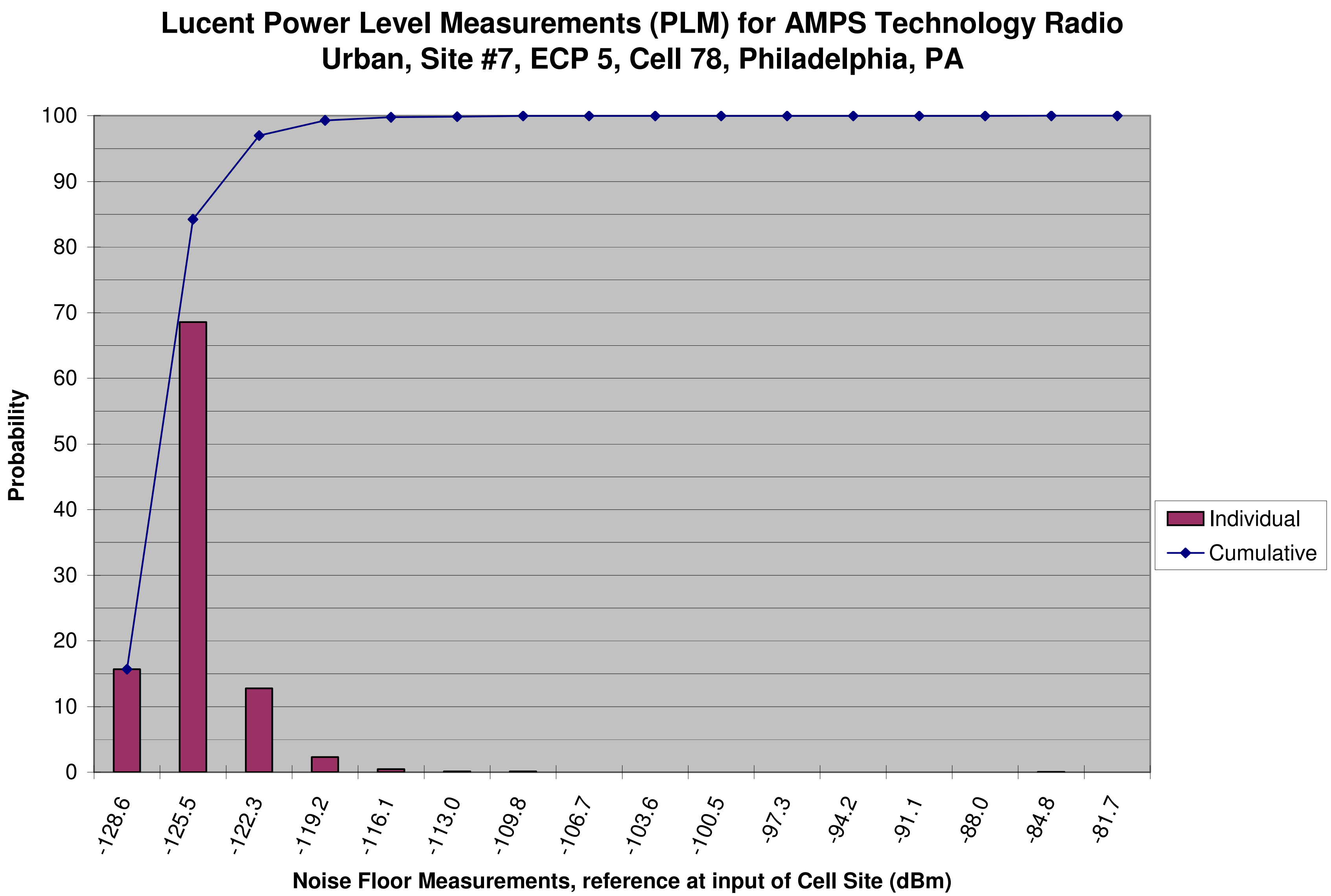

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Dense Urban, Site #2, ECP 5, Cell 58, Center City, Philadelphia, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

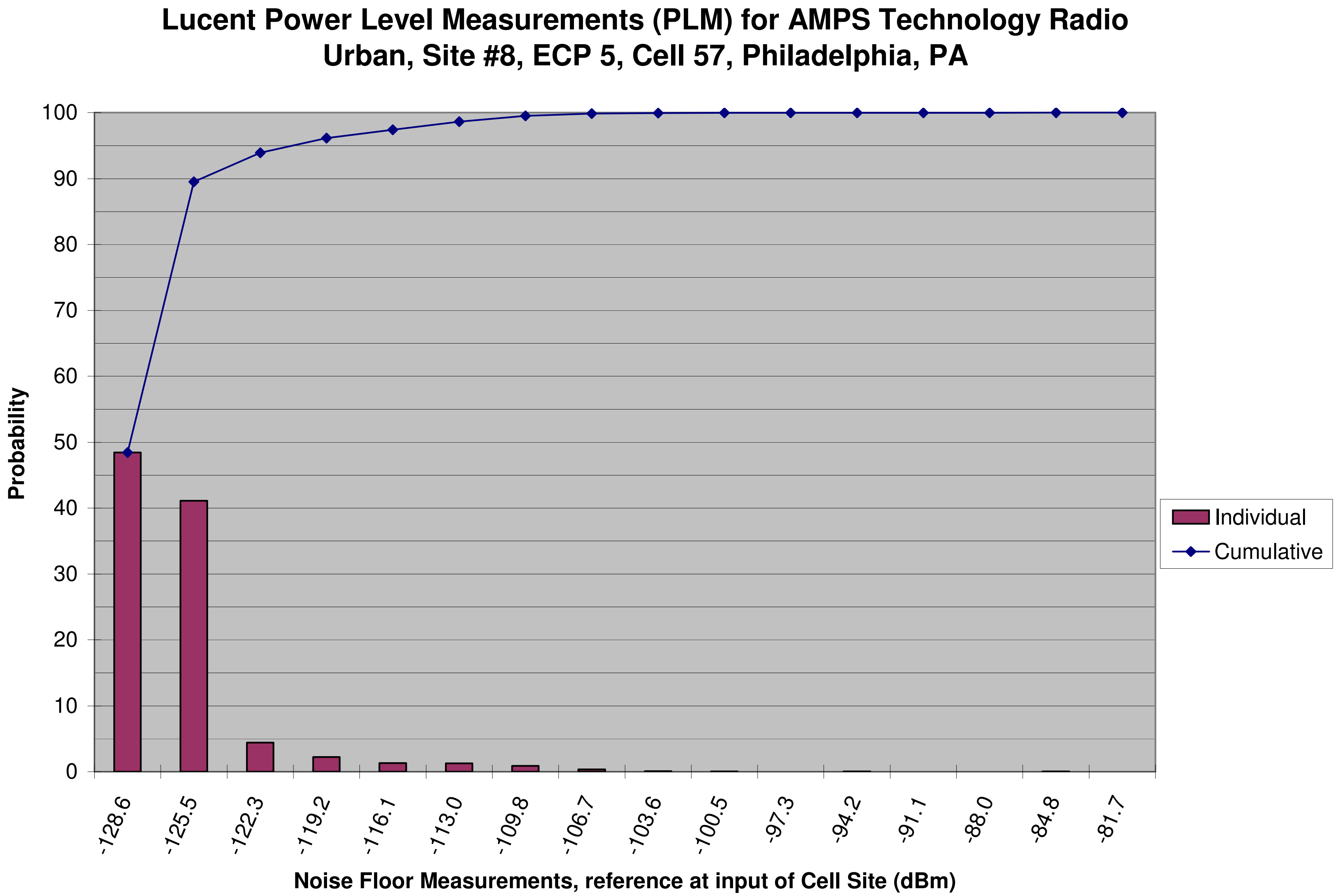

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Dense Urban, Site #3, ECP 5, Cell 85, Center City, Philadelphia, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

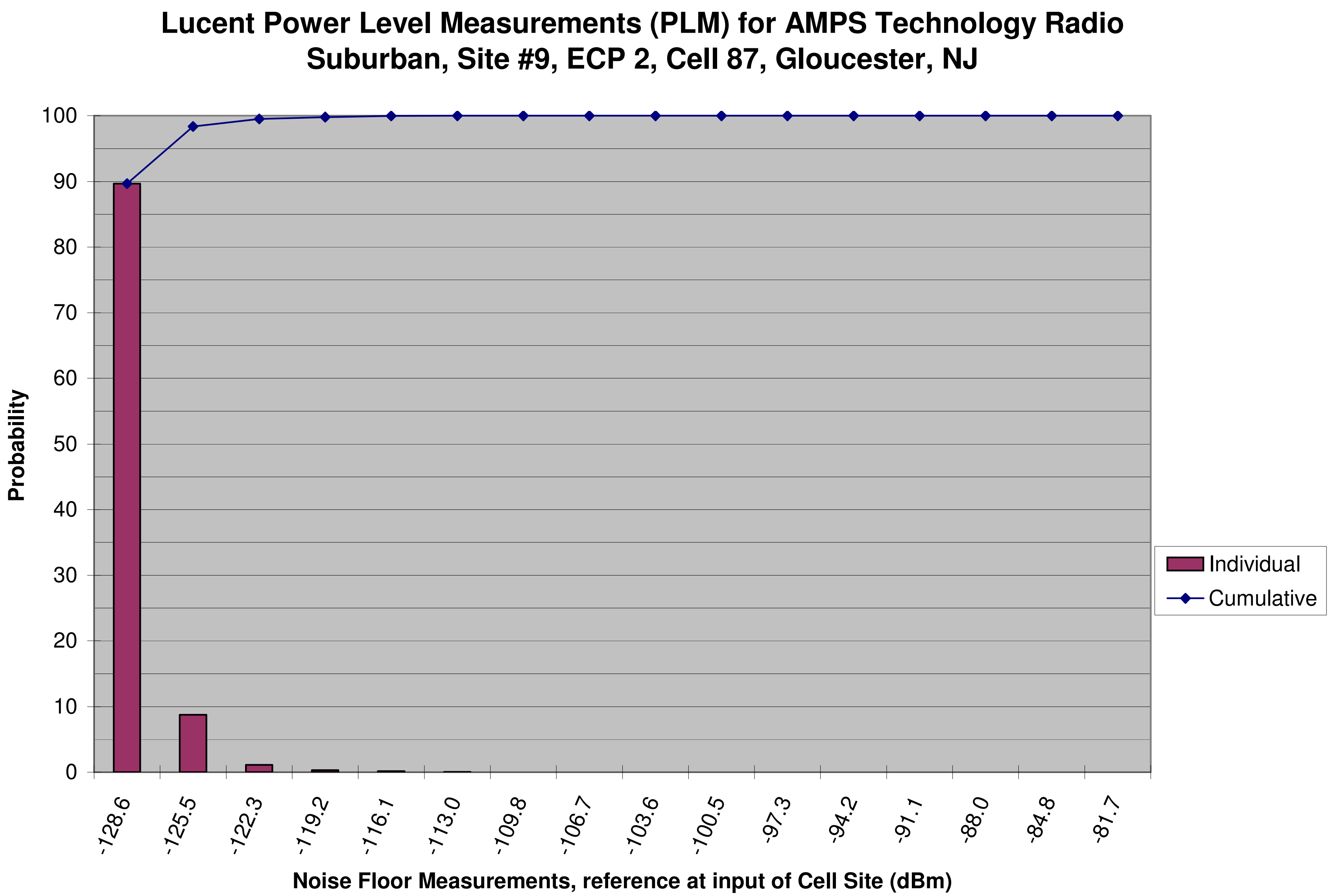

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Urban, Site #4, ECP 5, Cell 80, Philadelphia, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

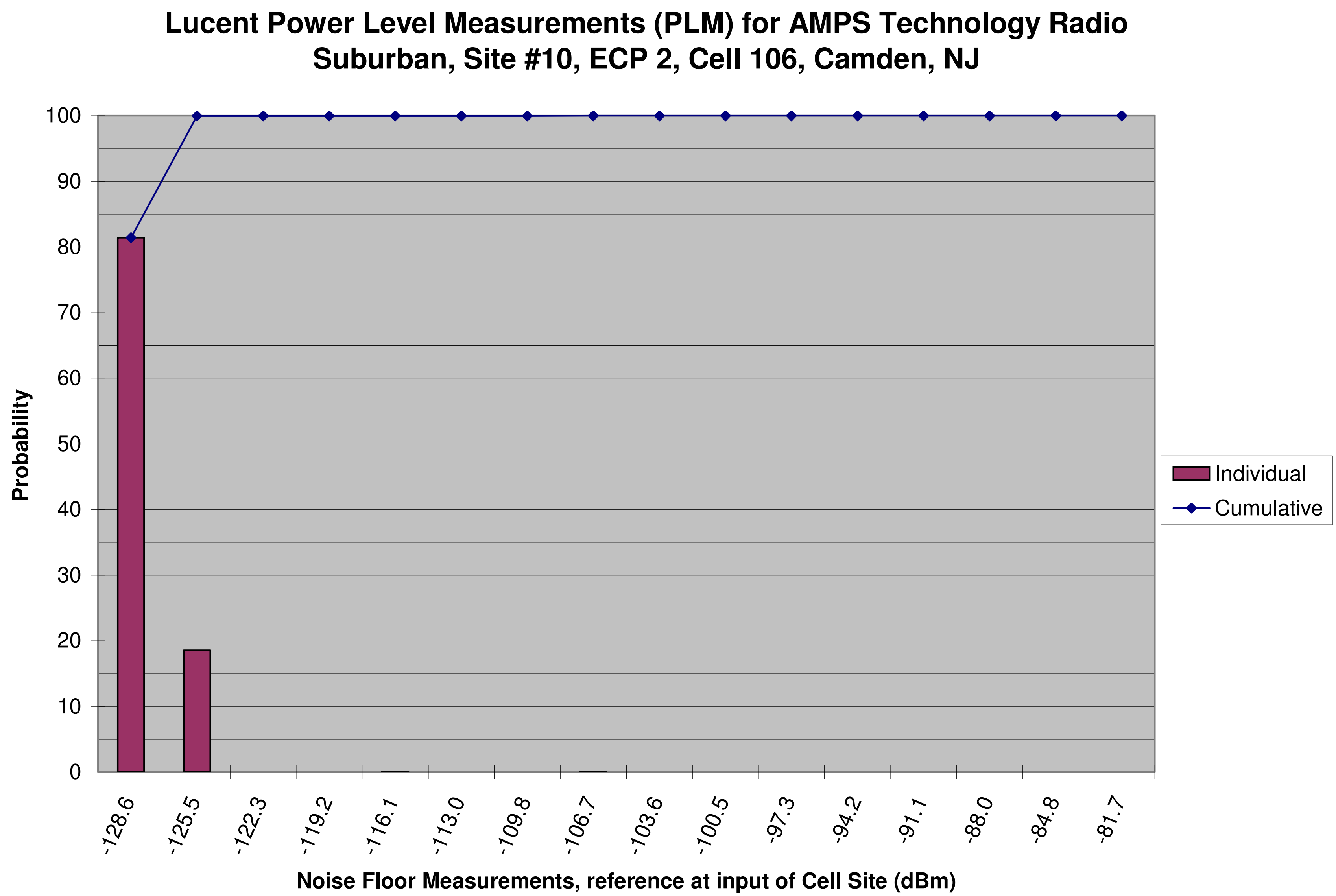

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Urban, Site #5, ECP 5, Cell 63, Philadelphia, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

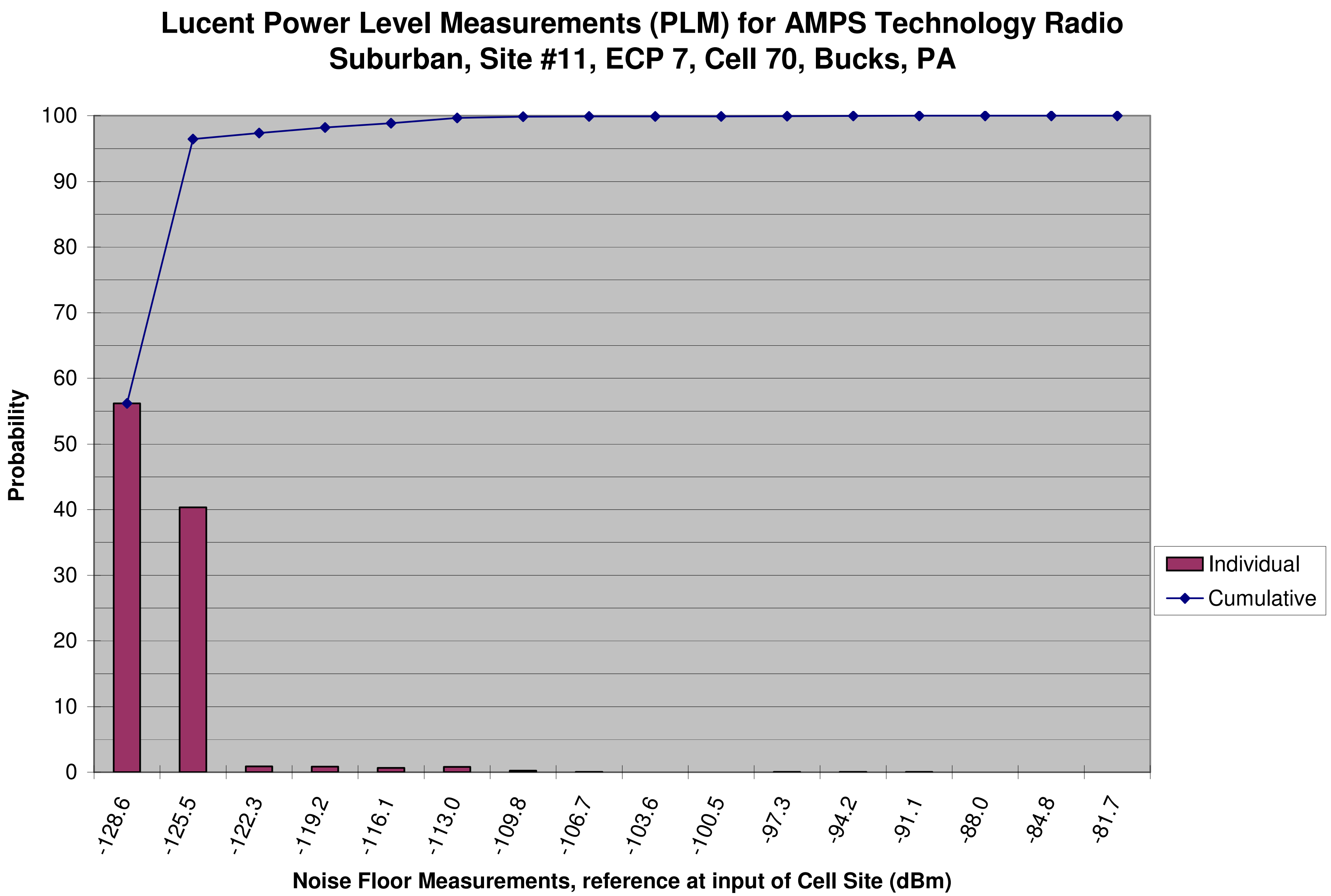

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Urban, Site #6, ECP 5, Cell 65, Philadelphia, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

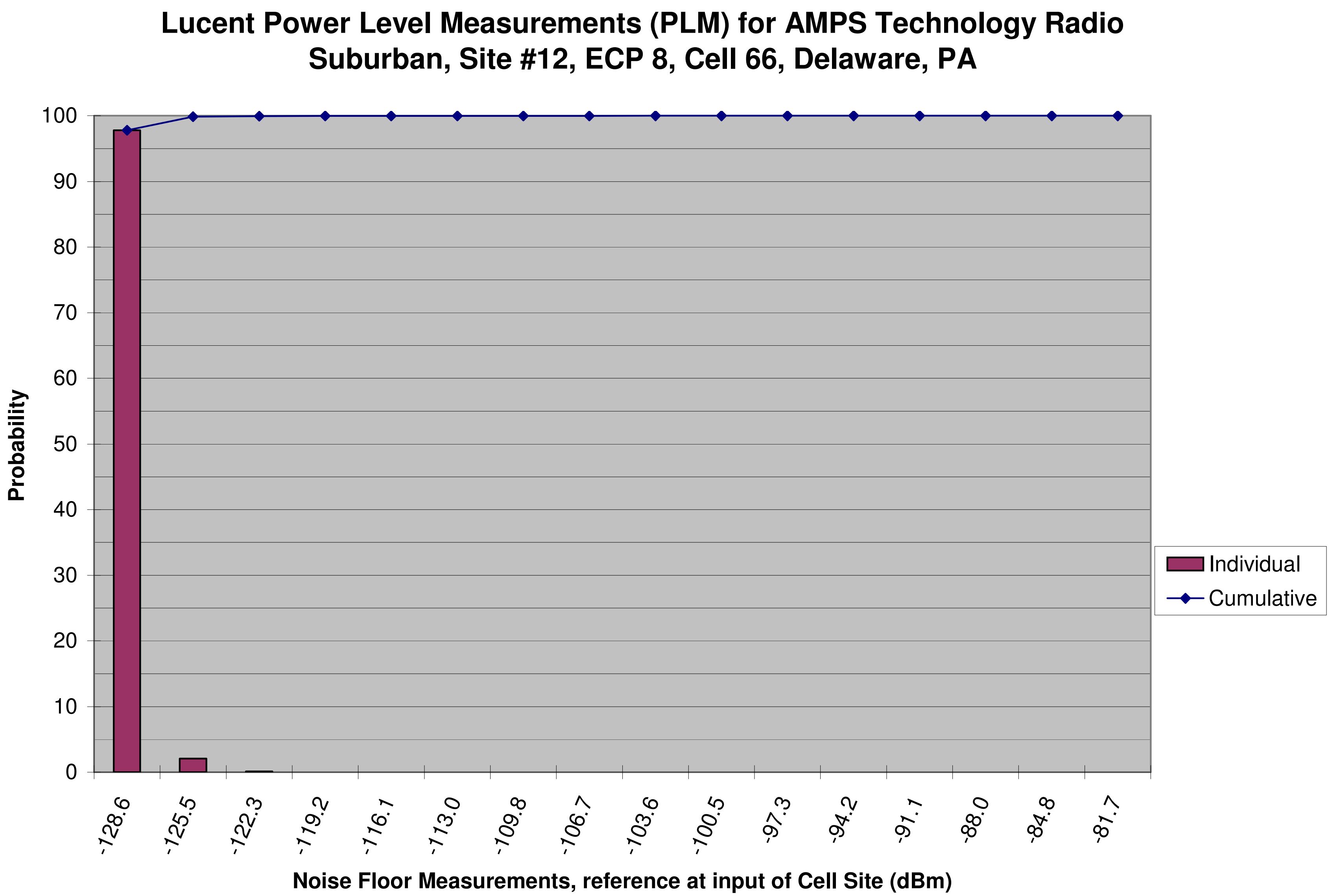

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Urban, Site #7, ECP 5, Cell 78, Philadelphia, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

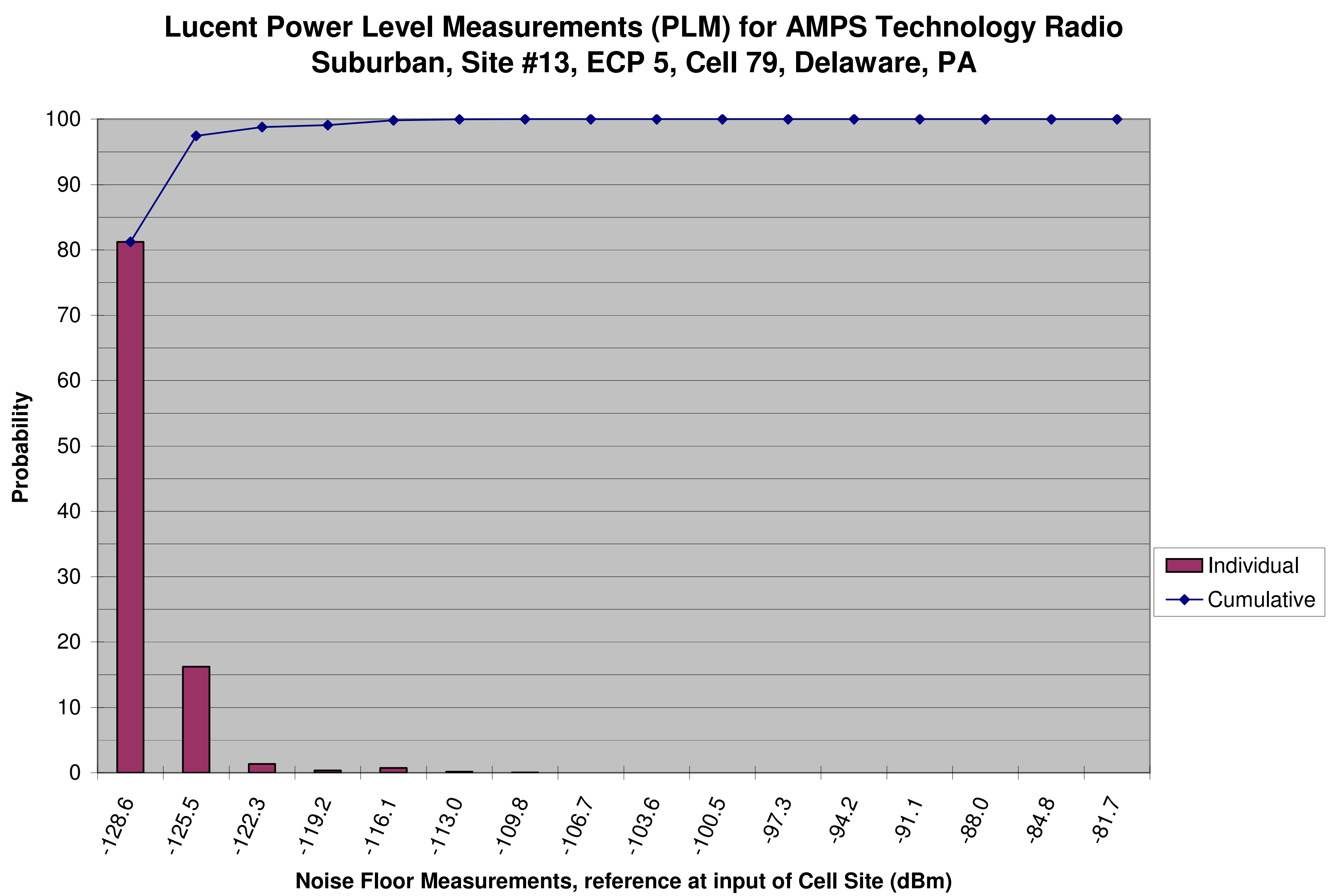

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Urban, Site #8, ECP 5, Cell 57, Philadelphia, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative


Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Suburban, Site #9, ECP 2, Cell 87, Gloucester, NJ
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

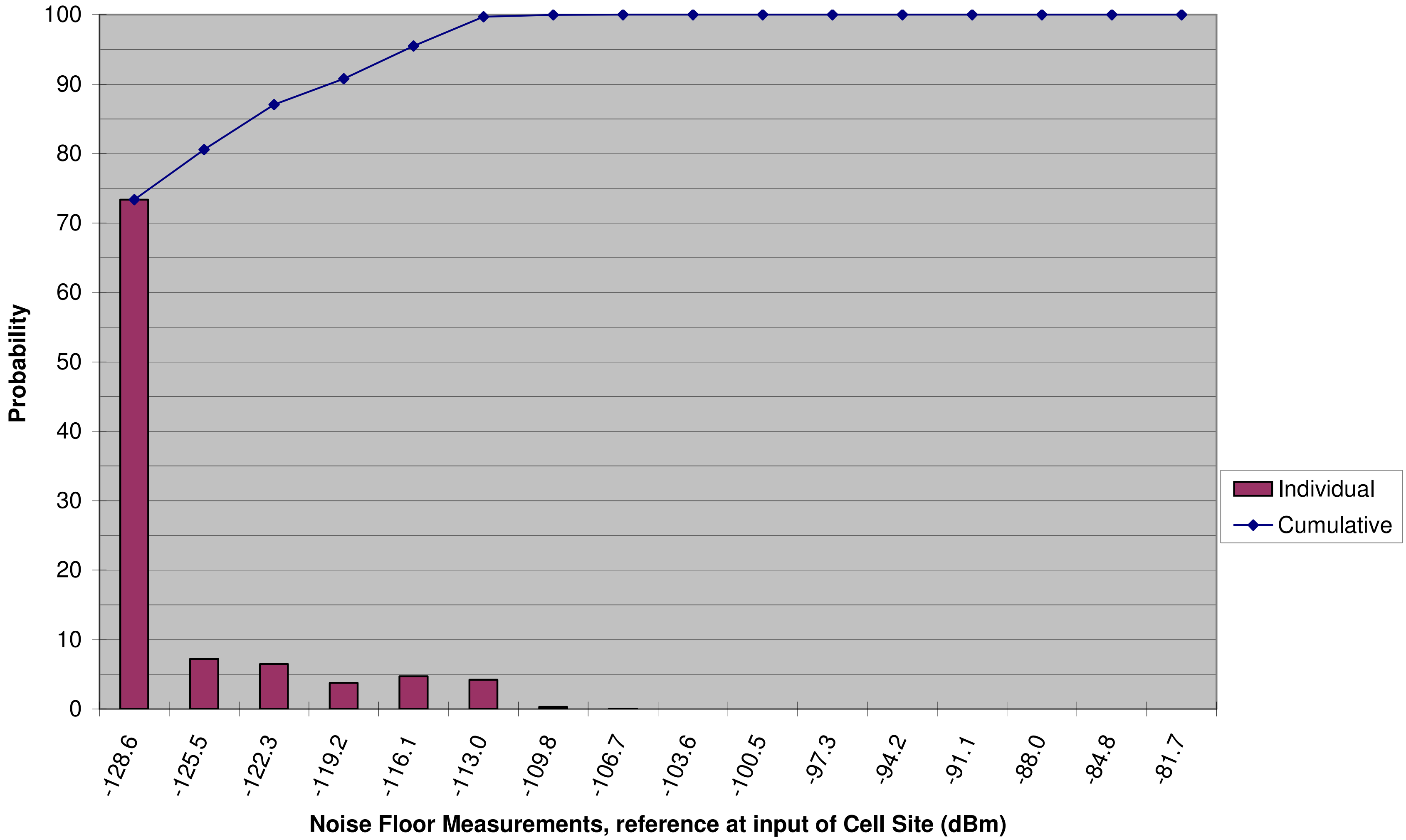

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Suburban, Site #10, ECP 2, Cell 106, Camden, NJ
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

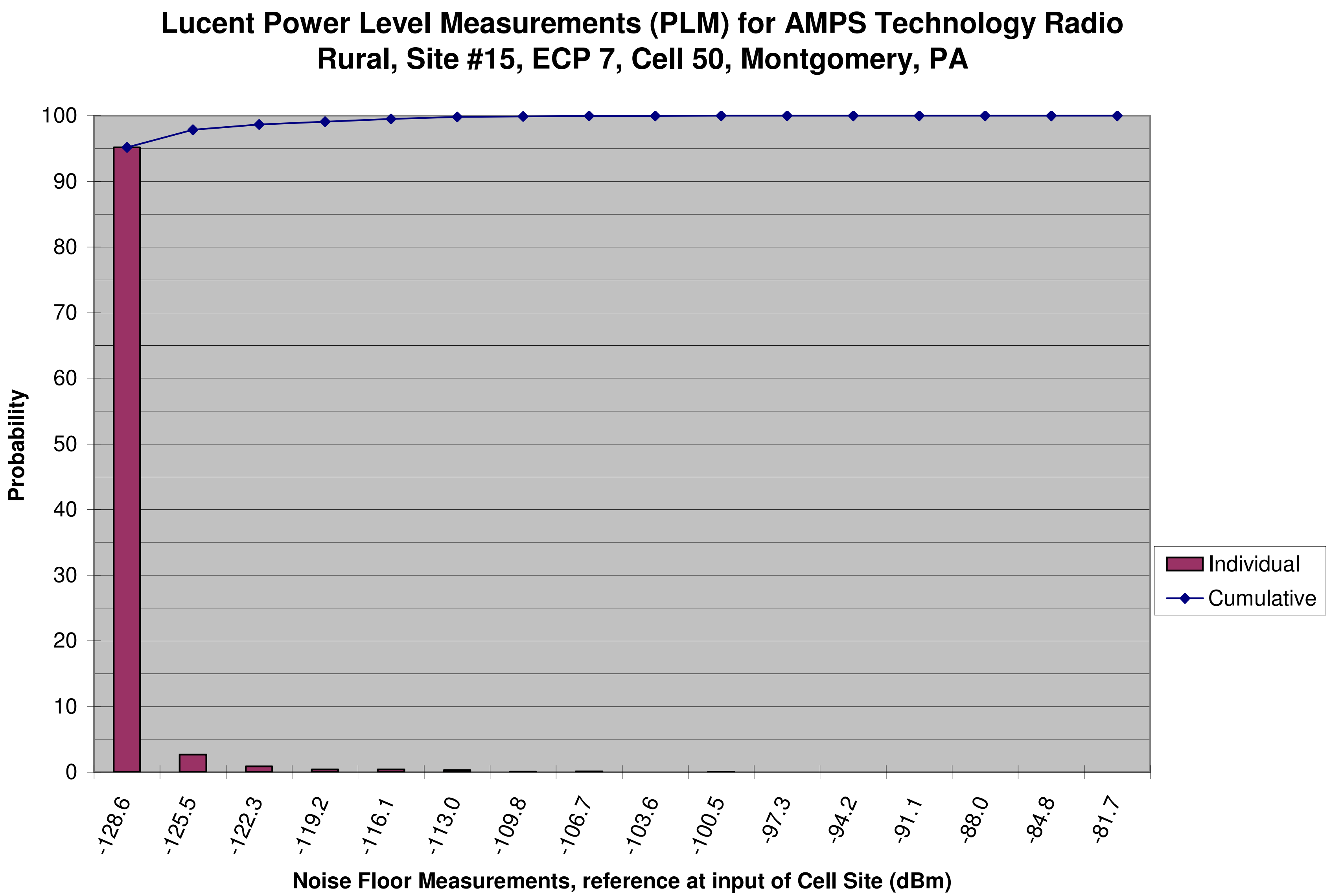

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Suburban, Site #11, ECP 7, Cell 70, Bucks, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

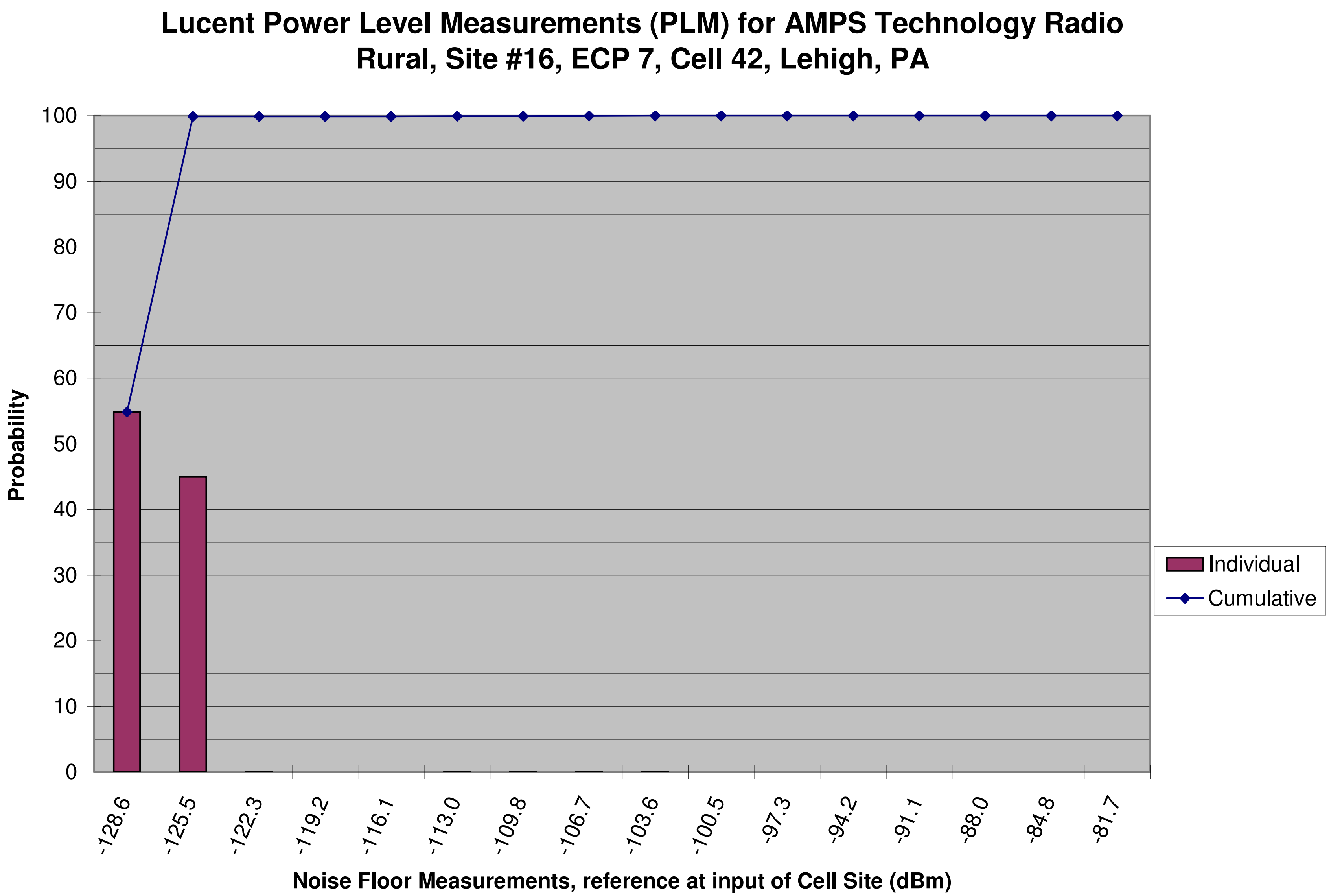

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Suburban, Site #12, ECP 8, Cell 66, Delaware, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

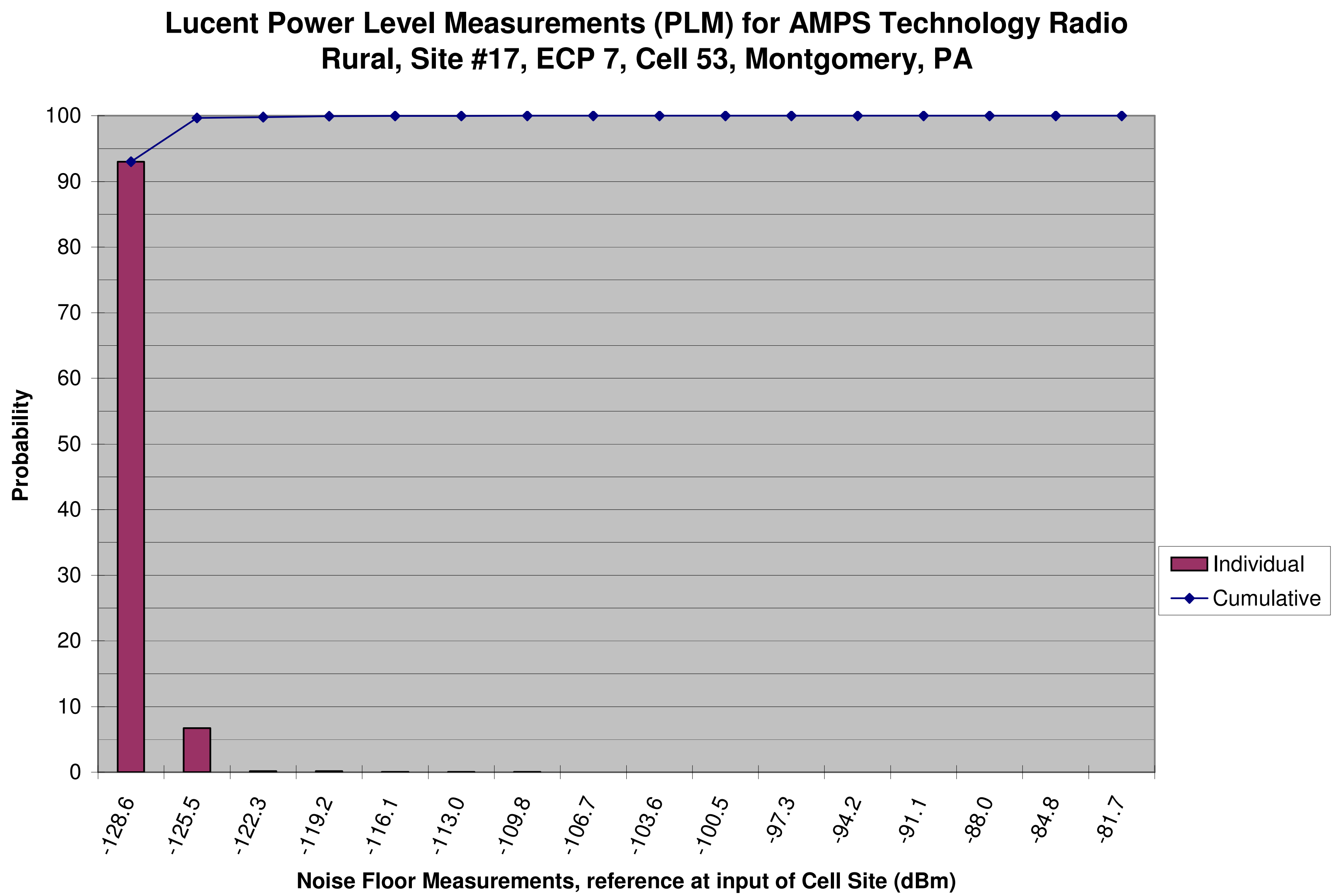

Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Suburban, Site #13, ECP 5, Cell 79, Delaware, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative

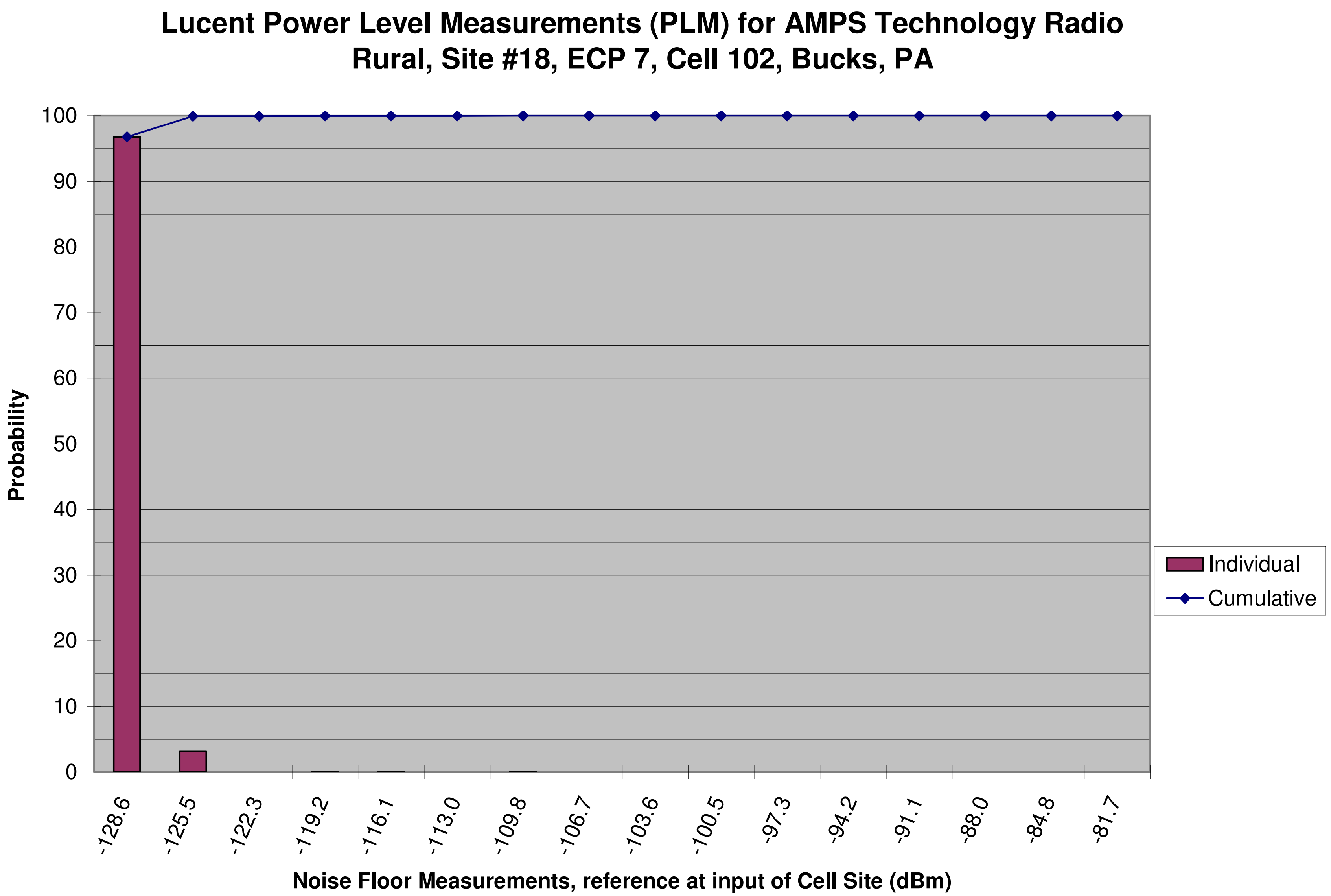
Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Rural, Site #14, ECP 6, Cell 52, Cumberland, NJ




Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Rural, Site #15, ECP 7, Cell 50, Montgomery, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative


Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Rural, Site #16, ECP 7, Cell 42, Lehigh, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative


Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Rural, Site #17, ECP 7, Cell 53, Montgomery, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative


Lucent Power Level Measurements (PLM) for AMPS Technology Radio
Rural, Site #18, ECP 7, Cell 102, Bucks, PA
Probability
100
90
80
70
60
50
40
30
20
10
0
-128.6
-125.5
-122.3
-119.2
-116.1
-113.0
-109.8
-106.7
-103.6
-100.5
-97.3
-94.2
-91.1
-88.0
-84.8
-81.7
Noise Floor Measurements, reference at input of Cell Site (dBm)
Individual
Cumulative