Omnipoint 1850 & 2400 MHz
Test Circuit

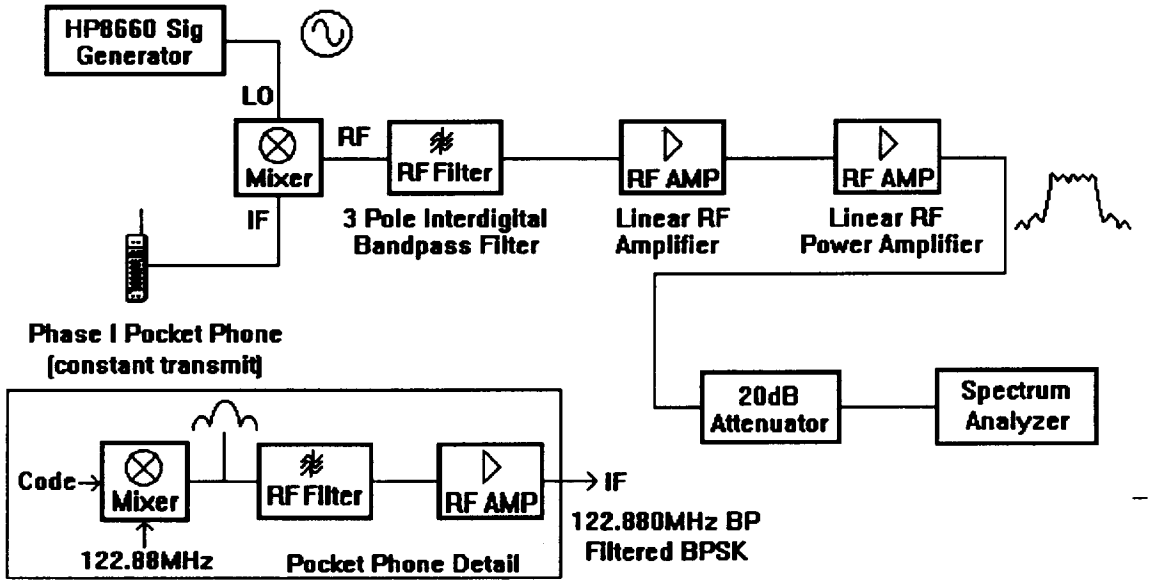
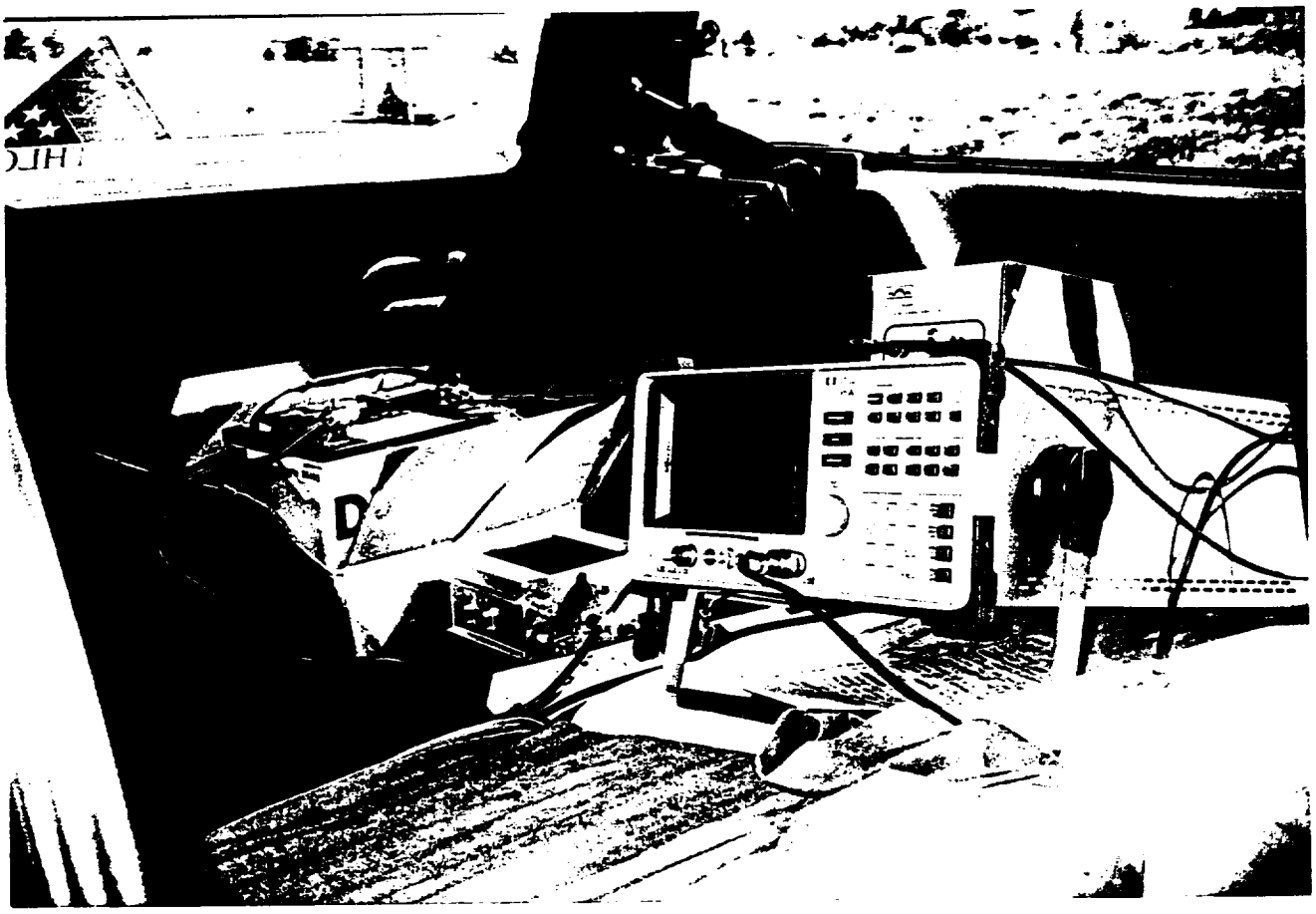
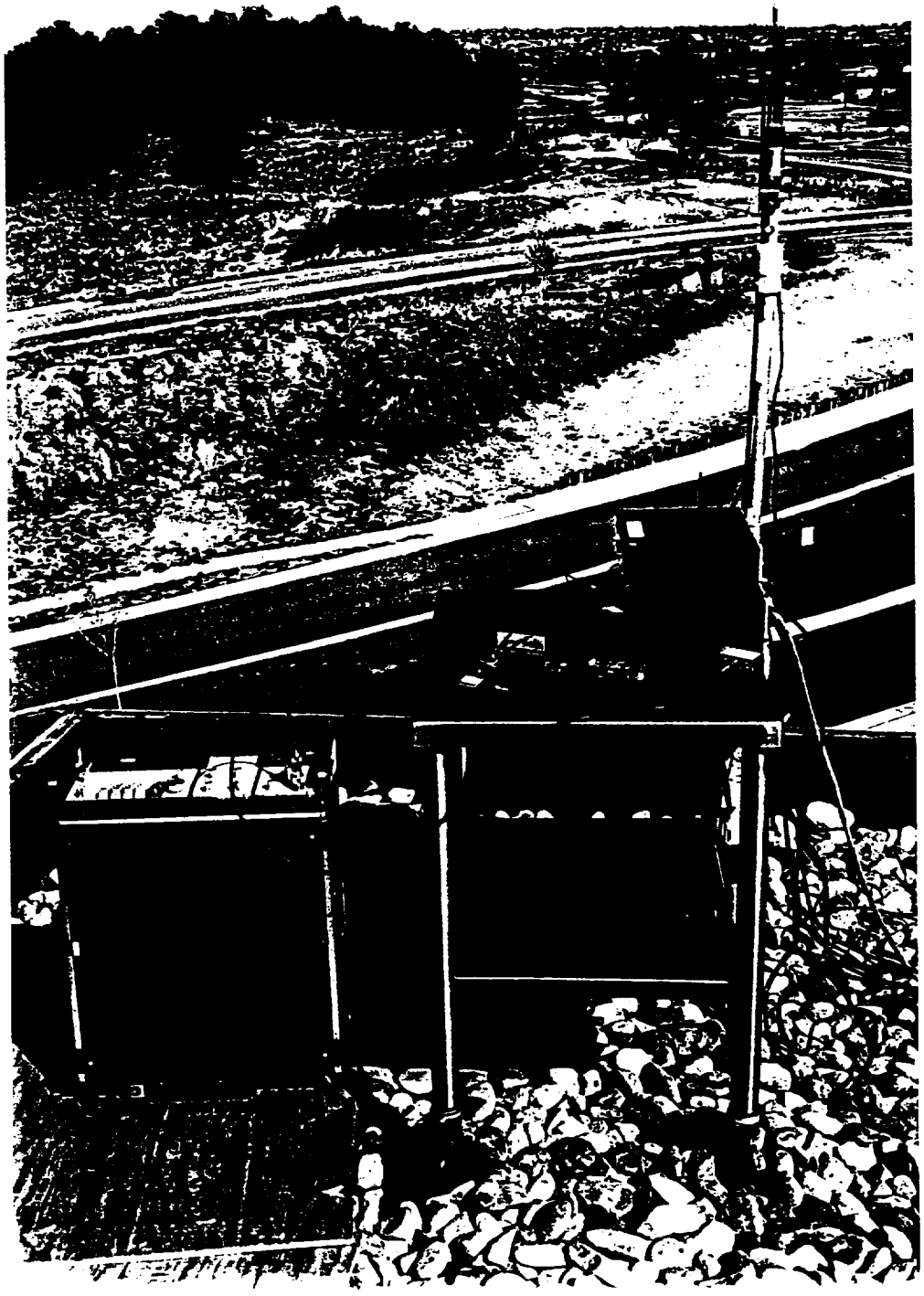


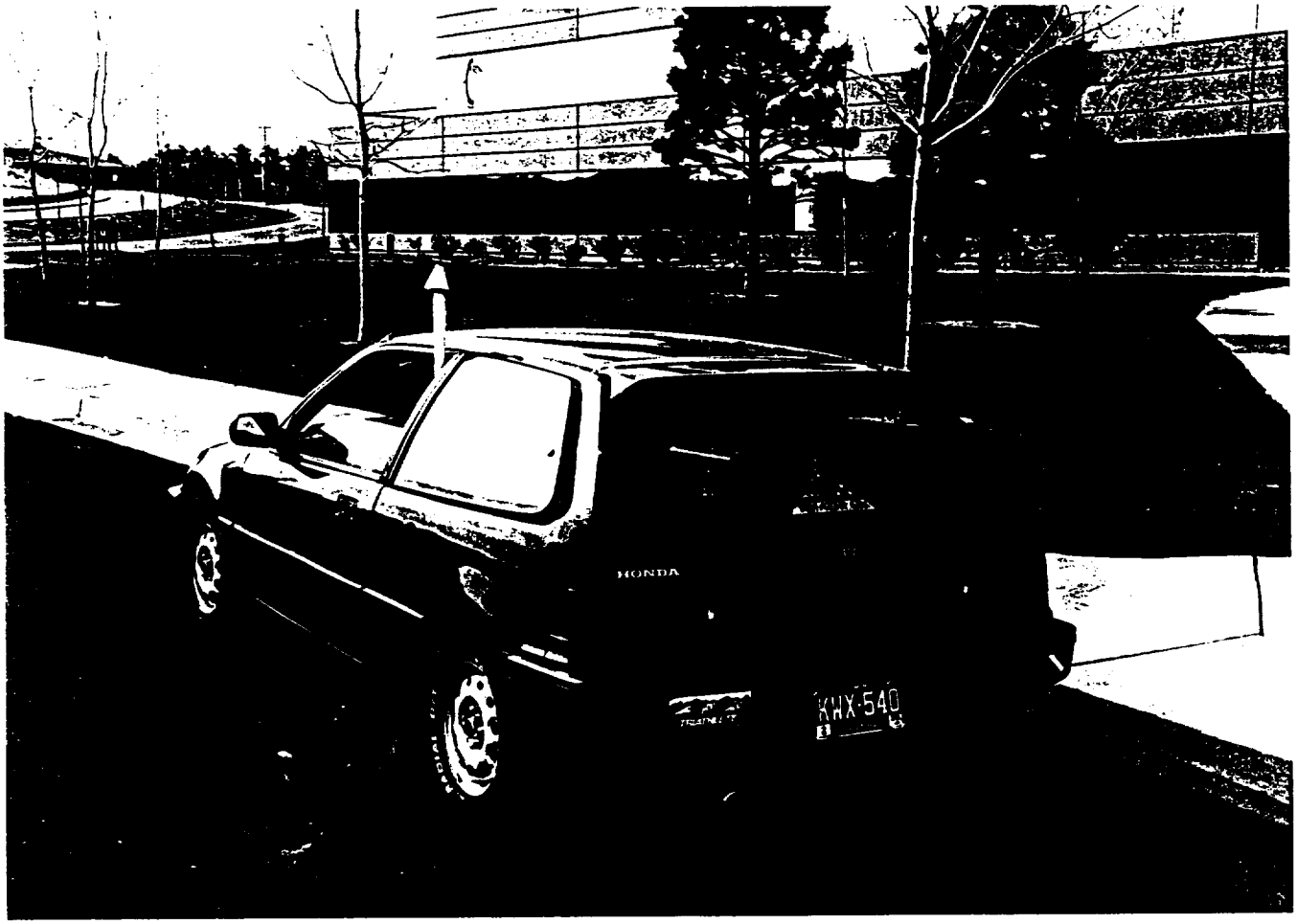
Figure 4.3-1



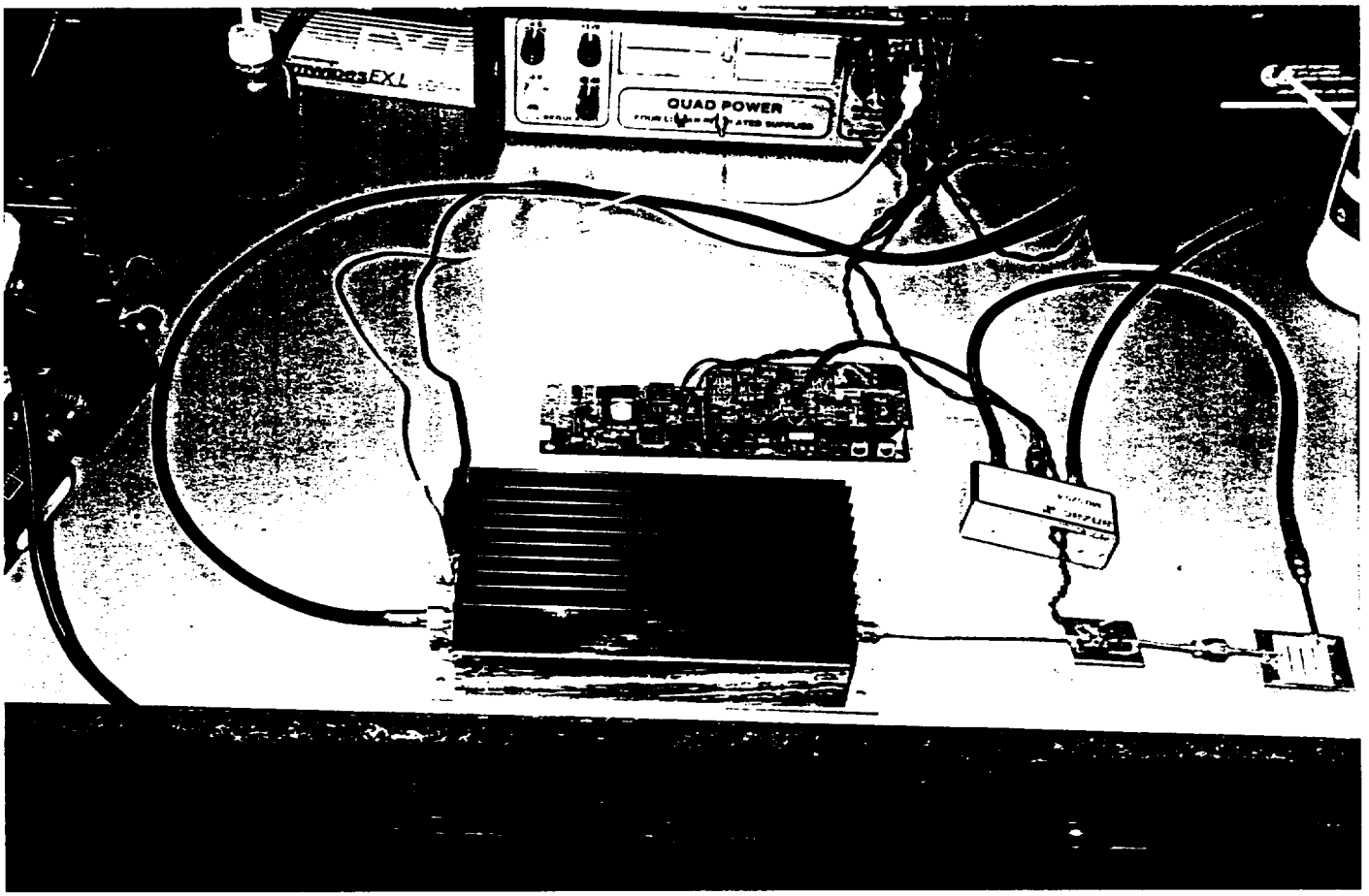
Test Set-up: Mobile Unit
Figure 4.3-2



Test Set-up: Base Unit
Figure 4.3-3



Test Set-up: Mobile Unit Vehicle
Figure 4.3-4



Test Set-up: Transmitter
Figure 4.3-5

Test Set-up: Transmitter
Figure 4.3-6

Omnipoint systems. Since it is a digital system, gradual degradation in perceived audio quality is generally not detectable. When the signal is degraded, the user is more likely to hear complete outages of the audio rather than a noisier signal. For this reason, Omnipoint's standard GOS is determined by the following standards:

Omnipoint Audio Grade of Service Standards

GOS1	Excellent (Clear audio quality)
GOS2	Good (Occasional bursty outages, otherwise clear audio)
GOS3	Fair (Audio generally understandable with effort, or clear audio may be obtained by decreasing mobility.)
GOS4	Poor (Unable to obtain link except in highly localized areas where mobile user must remain stationary.)
GOS5	Unusable (No link available, no audio)

When using an Omnipoint system, a mobile user can be located at a site defined as GOS3 or GOS4 due to the fact that the user doesn't have ubiquitous coverage and mobility throughout the area while maintaining a clear link. However, within a GOS3 or GOS4 area a link can commonly be obtained in a *highly localized* area. At those points where a link *can be obtained*, audio quality generally tends to be at the GOS1 level. For coverage plotting purposes, however, Omnipoint has established high standards that require that these localized GOS1 areas within a GOS3 or GOS4 area still be defined as lower quality, and are not considered "Covered Areas".

4.3.1 Indoor Propagation Effects

4.3.1.1 Conference Facilities

A major initial application for PCS services is to offer wireless pay phone services at convention and meeting facilities. Omnipoint has done extensive testing at selected conference facilities, and determined that a successful service is

both technically and economically viable. Included in the testing of these facilities were propagation studies at 900 MHz.

4.3.1.1.1 - Conference Facility No. 1

Figure 4.3-7 shows the floor plan for Conference Facility No. 1 with locations of test points and base station installations. This building is a single story structure of brick construction. It poses an unusual RF challenge in that its interior walls are 1 foot thick, with double steel doors to the conference rooms, providing a "secure" environment for sensitive meetings. This facility consists of a 52,000 square foot conference facility with rooms ranging from 135 to almost 5,000 square feet. The conference area is attached to a 26,000 square foot break area consisting of restaurants, bars, and lounges through an enclosed walkway. The entire facility, including courtyard, walkways, atriums and basement is approximately 148,000 square feet.

The Omnipoint system offers complete coverage of this facility with only three base stations, making for minimal installation costs. Figures 4.3-8 through 4.3-11 show coverage plots where the Omnipoint microcellular system base stations have been installed in order to cover the facility.

It can be seen from the sample spectral plots that multipath has a very destructive effect on received signals in this facility. (Figure 4.3-11a shows a typically deep fade at this facility.) In spite of these effects, the Omnipoint microcellular system performs flawlessly in the vast majority of the building. In a few spots the Grade of Service measurement drops to as low as GOS3.

Figures 4.3-12, 4.3-13, 4.3-14, & 4.3-15 show the raw data points as well as the results of our least squares regression analysis for each site. RMS propagation co-efficient and standard deviation is also indicated on each figure.

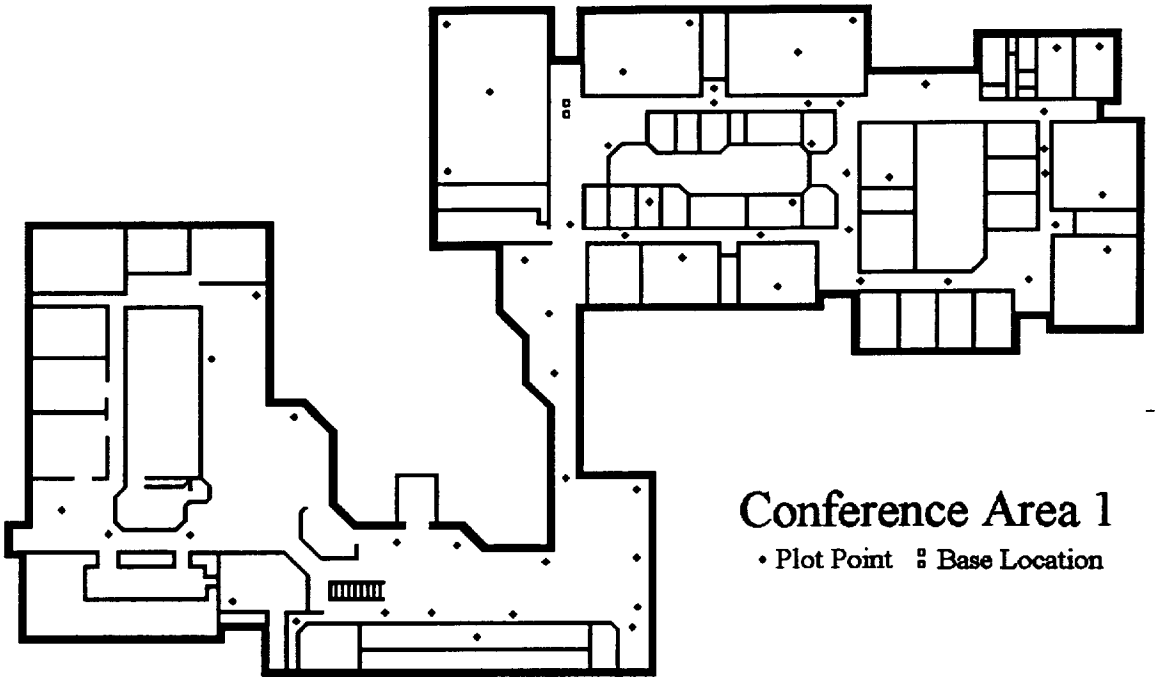


Figure 4.3-7

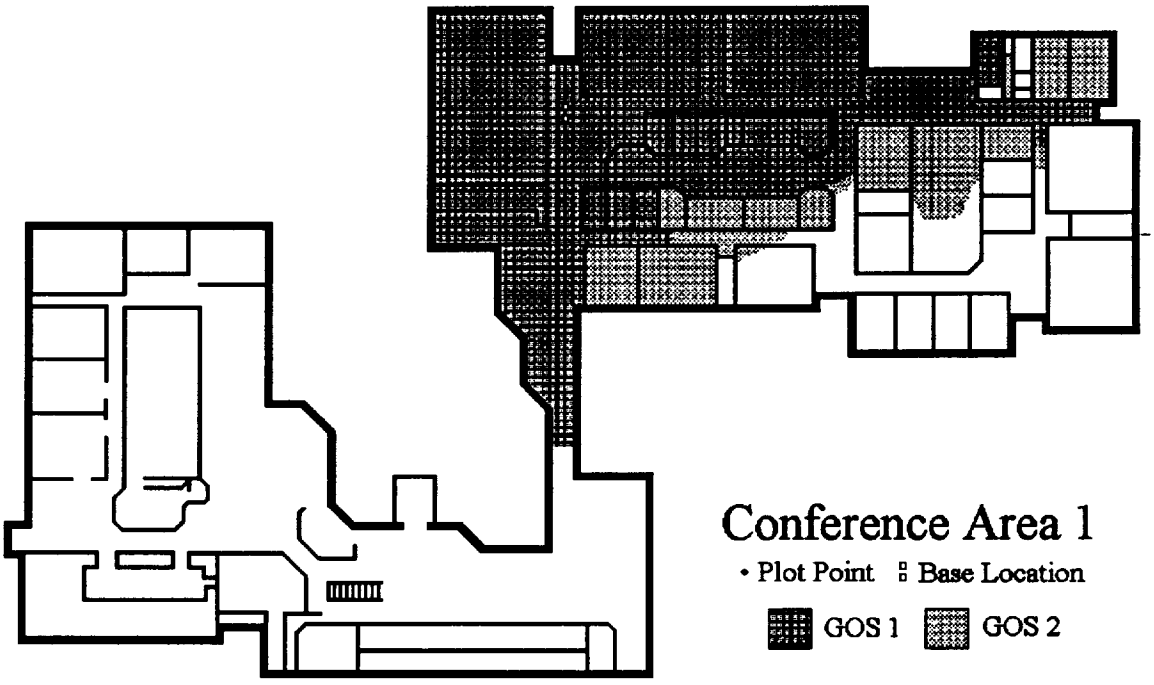


Figure 4.3-8

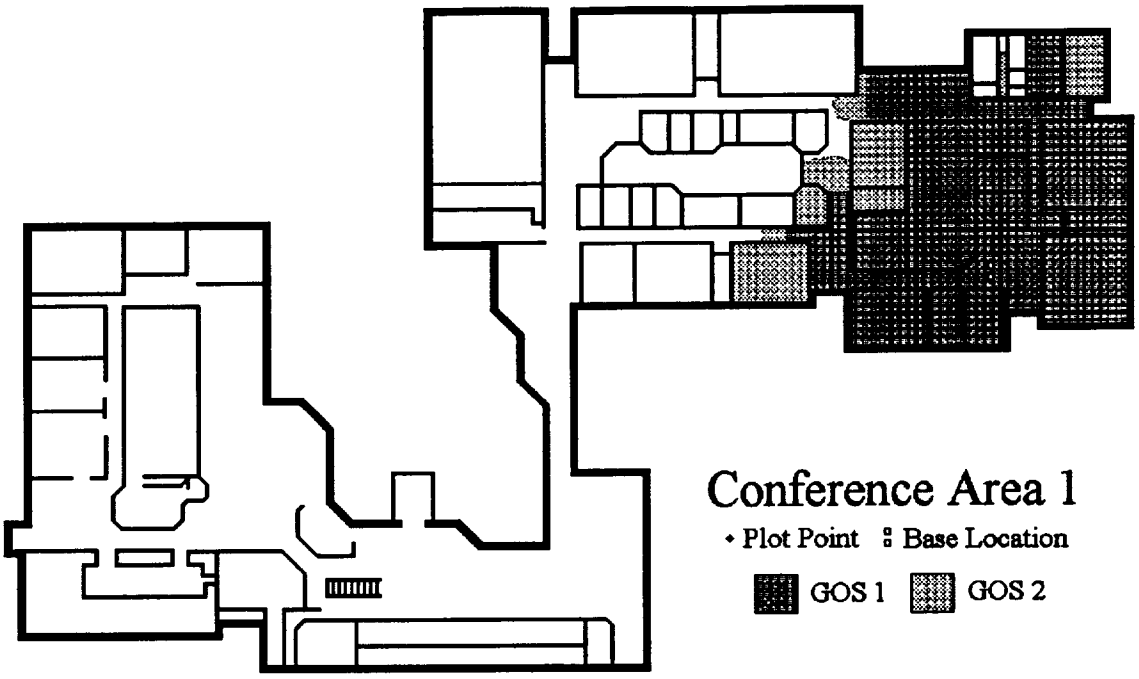


Figure 4.3-9

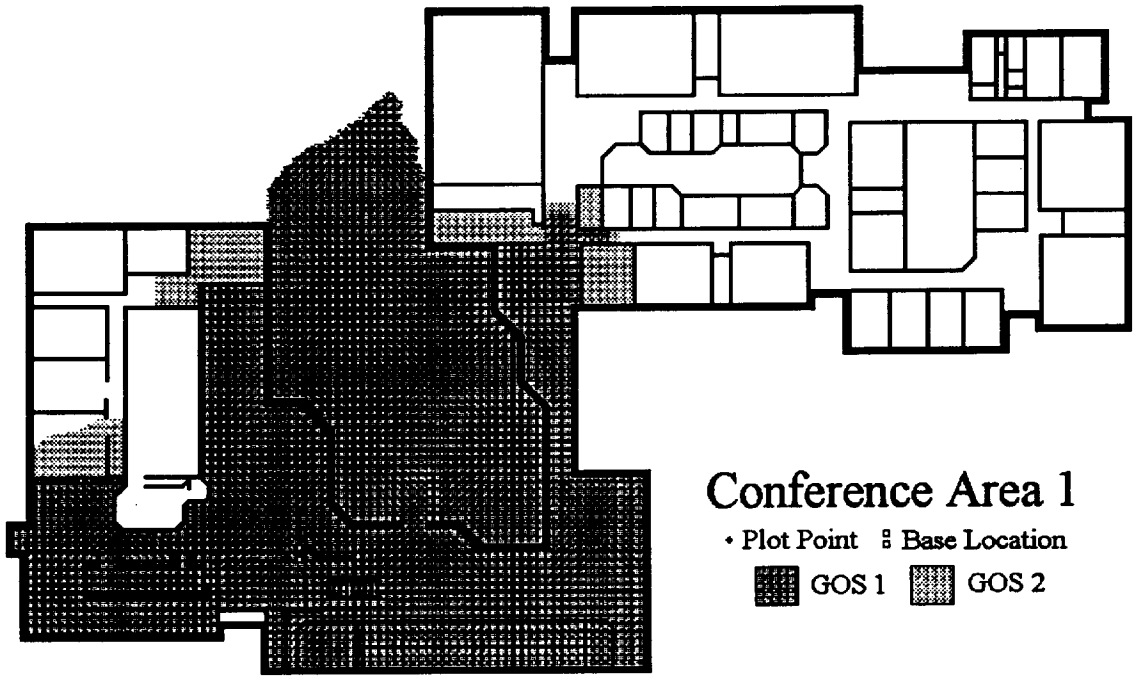


Figure 4.3-10

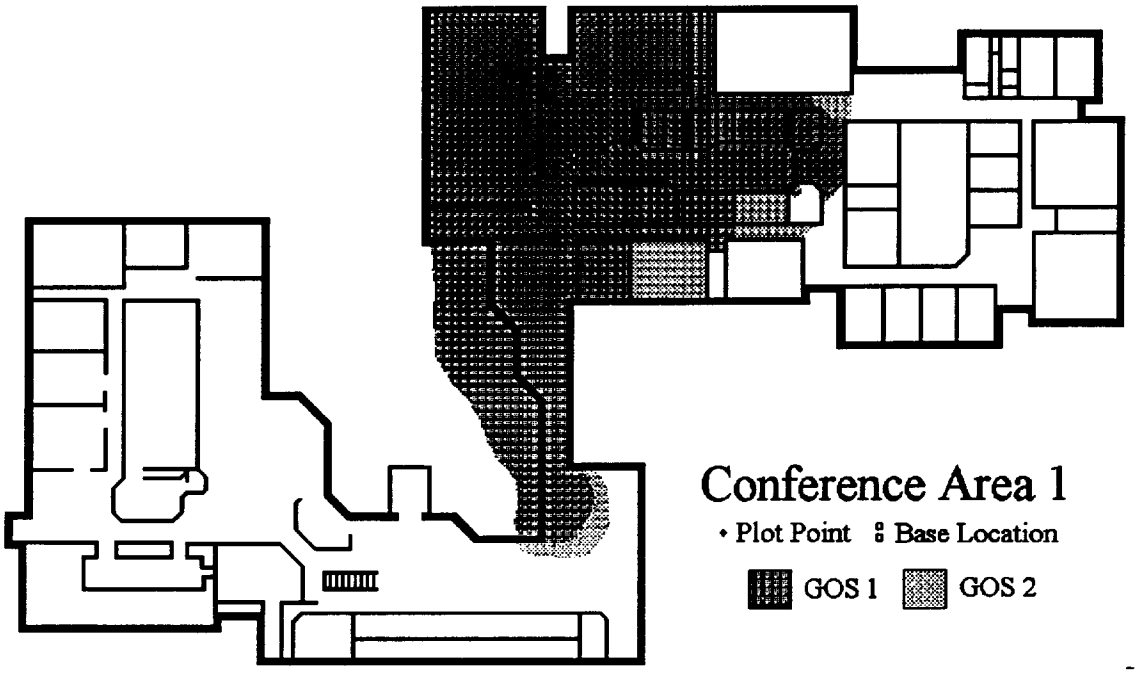


Figure 4.3-11

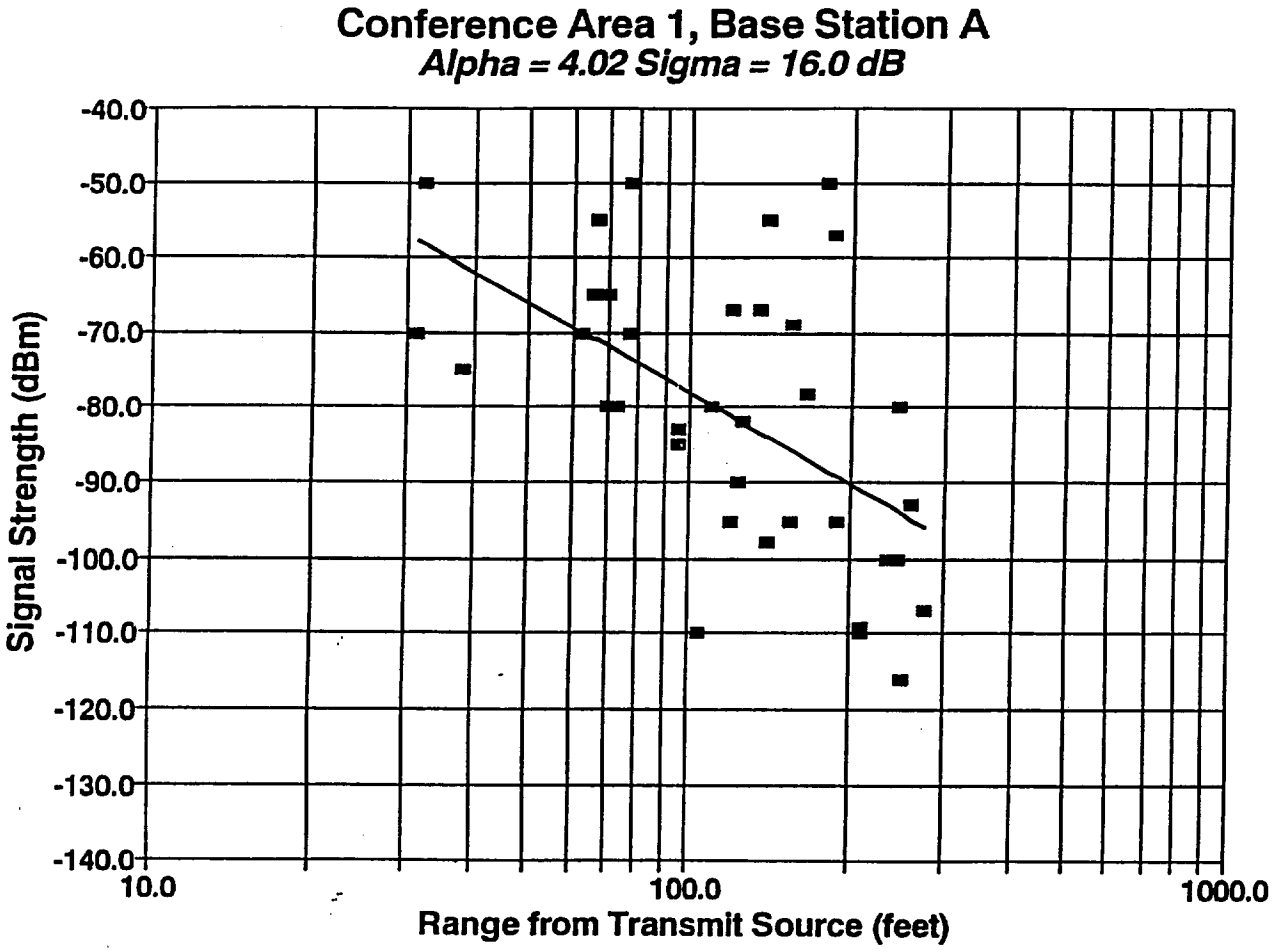

Conference Area 1, Base Station A
Alpha = 4.02 Sigma = 16.0 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-12

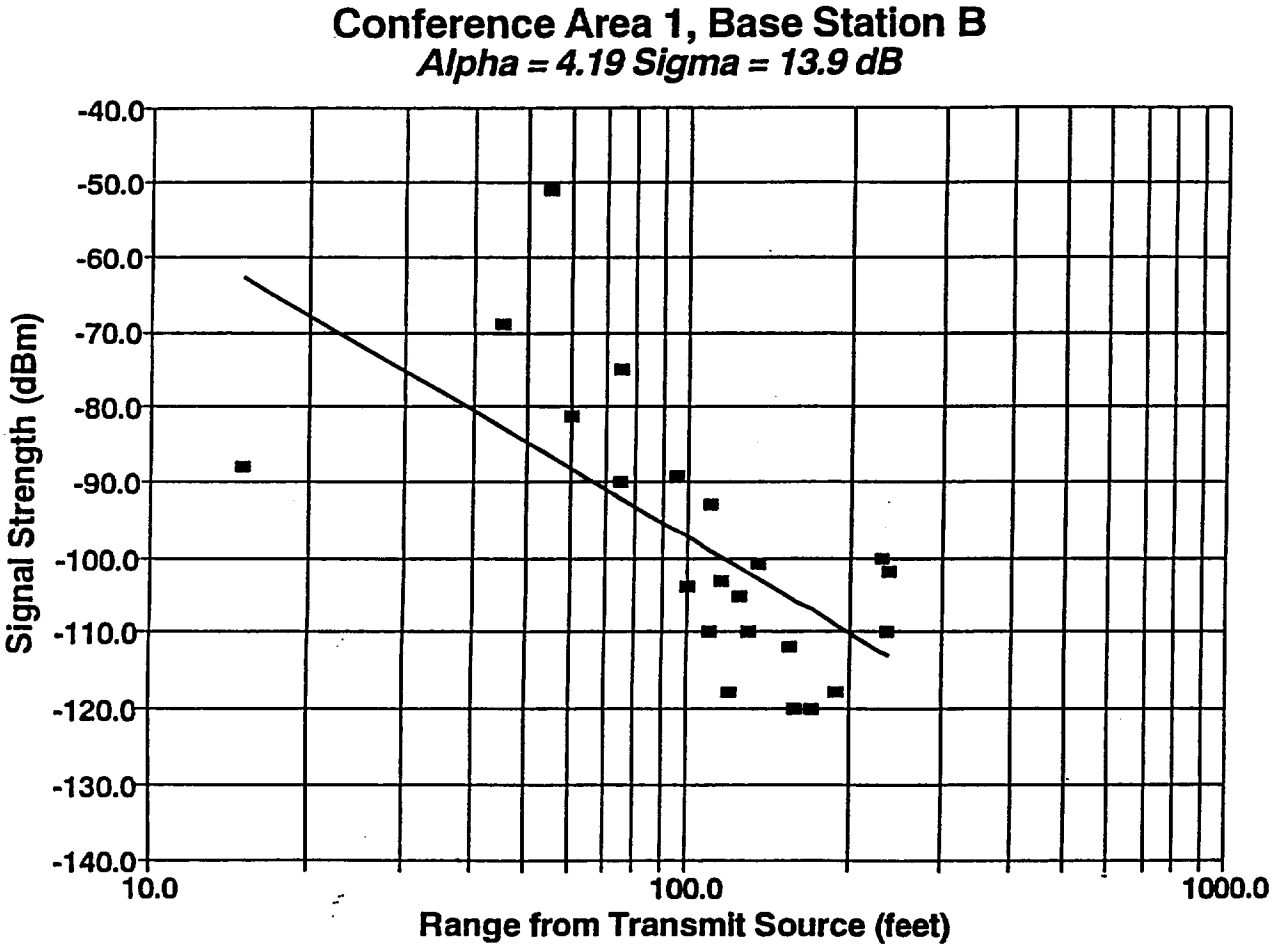

Conference Area 1, Base Station B
Alpha = 4.19 Sigma = 13.9 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-13

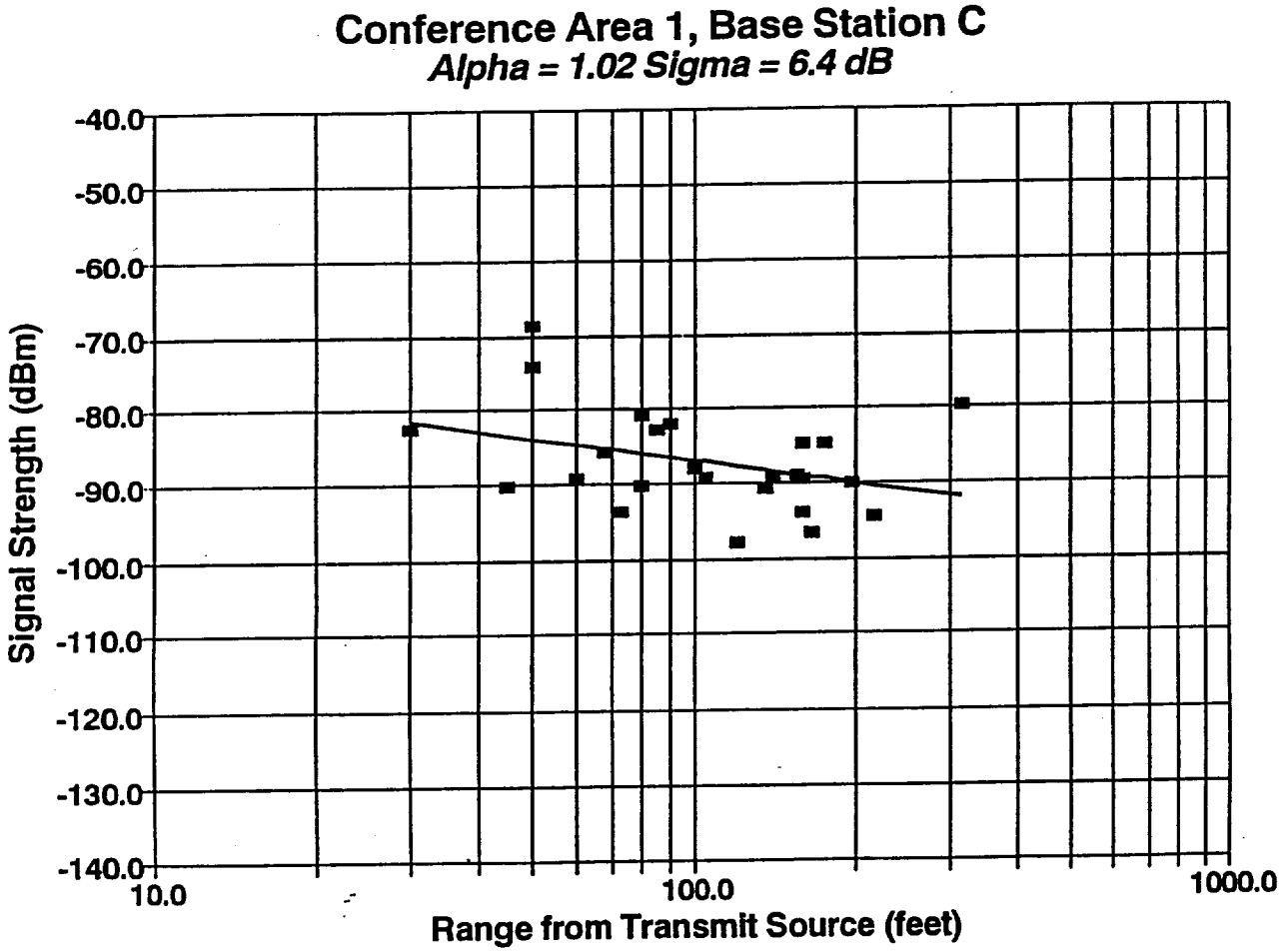

Conference Area 1, Base Station C
Alpha = 1.02 Sigma = 6.4 dB
Signal Strength (dBm)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-14

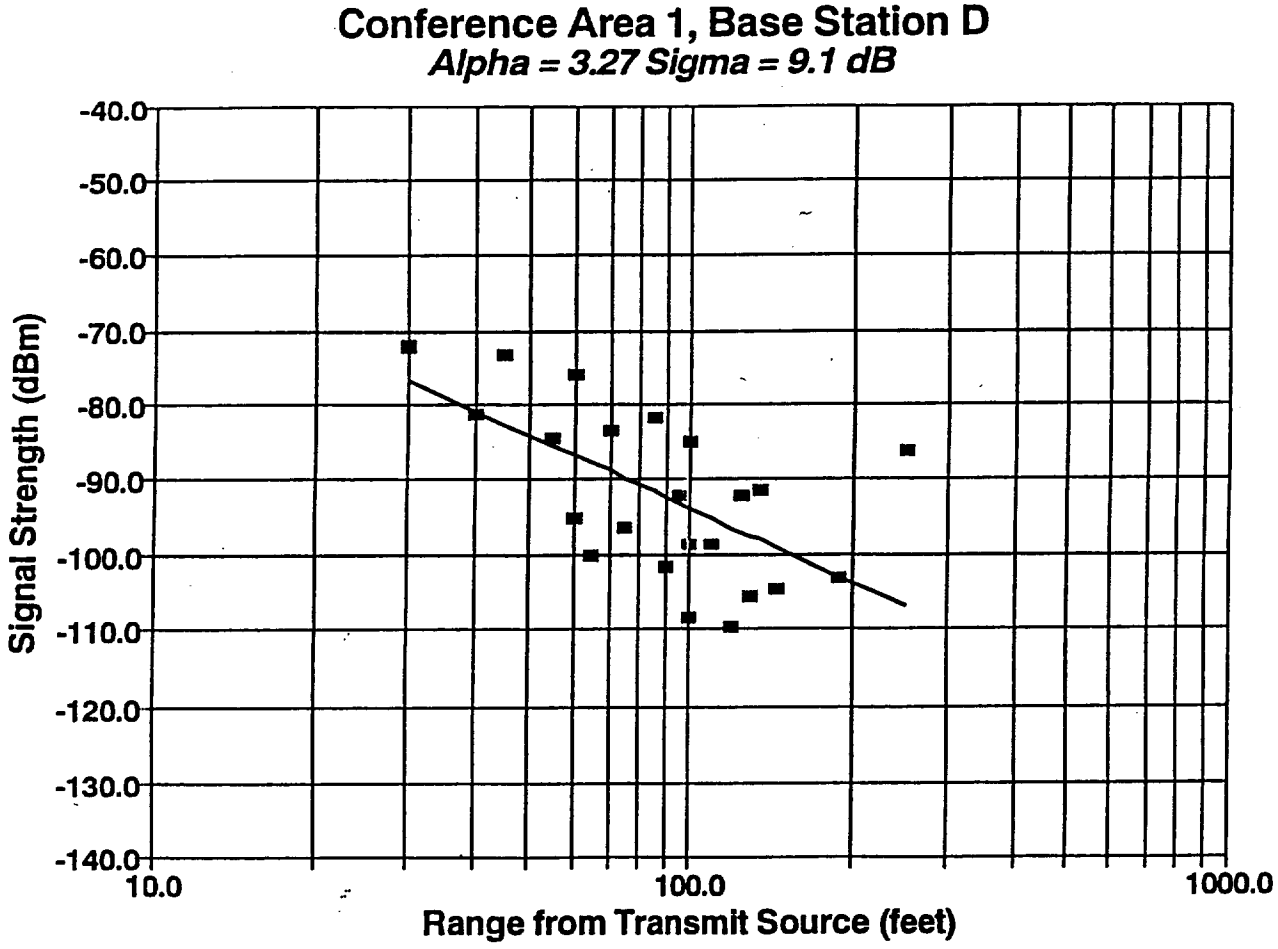

Conference Area 1, Base Station D
Alpha = 3.27 Sigma = 9.1 dB
Signal Strength (dBm)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-15

4.3.1.1.2 - Conference Facility 2

Conference Facility 2 consists of a modern meeting facility with movable walls which allow from one to twelve rooms, with maximum area of 10,000 square feet. It is a brick and structural steel facility with large windows surrounding the building on most sides. A lobby, administrative offices, and two restaurants fill the remaining area, bringing total available space to approximately 48,000 square feet on a single floor.

Figure 4.3-16 shows the test points taken in the survey of this facility, while figures 4.3-17 and 4.3-18 detail signal coverage with current generation Omnipoint microcellular system spread spectrum hardware. This installation requires only a single base station to provide ubiquitous coverage at GOS1 levels to the conference meeting area, but a second base has been installed at this facility in order to double the number of simultaneous users. If service requirements mandate coverage in the dining areas, a third base station will be installed in the Village Green restaurant.

Figures 4.3-19 & 4.3-20 show the raw data points as well as the results of our least squares regression analysis for each site. RMS propagation coefficient and standard deviation is also indicated on each figure.

4.3.1.2- Indoor Propagation Effects - Open-Air Indoor Facilities

If PCS is to be a truly public system, service will be required at all types of public gathering places. It is anticipated by many that service will therefore be required at "open-air indoor public facilities" places as hotels and sports areas. Many studies, including those done at Omnipoint, indicate that signal propagation in these types of buildings will follow free space models and vary wildly from more restrictive environments like office buildings or conference centers. As detailed above, multipath effects can differ from those encountered in more confined structures as well.

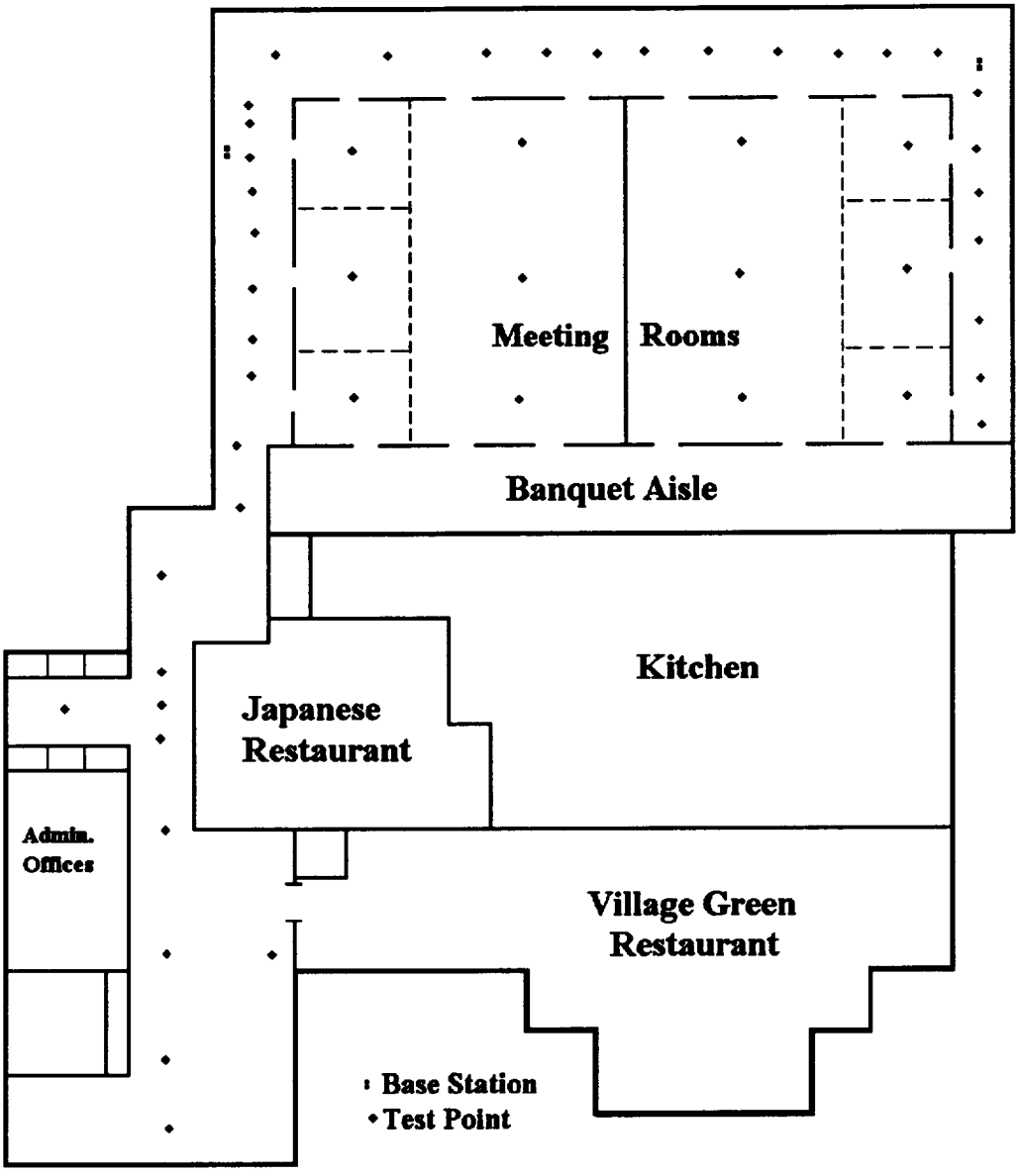

Meeting Rooms
Banquet Aisle
Kitchen
Japanese Restaurant
Admin. Offices
Village Green Restaurant
Base Station
Test Point

Figure 4.3-16

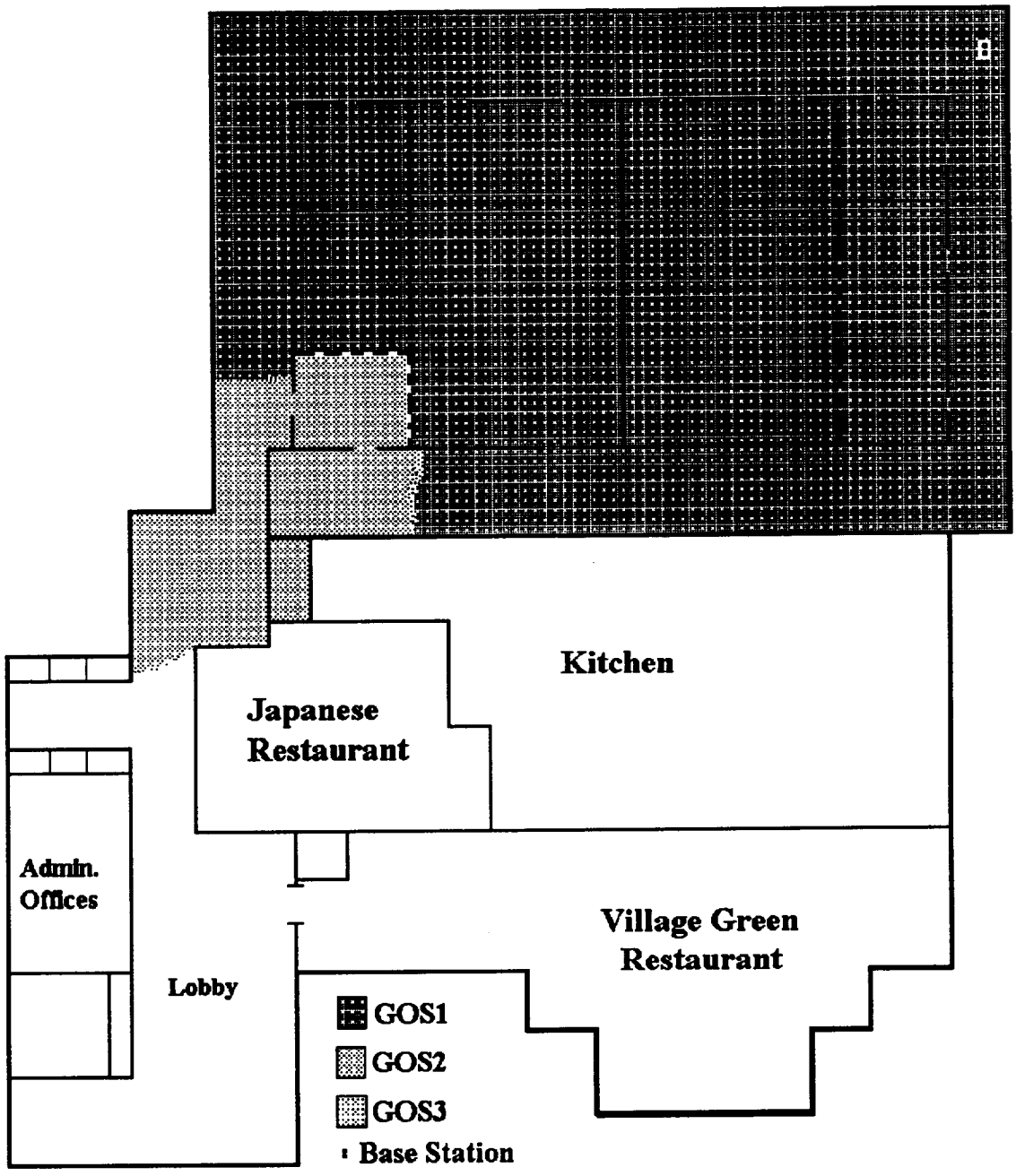

Kitchen
Japanese
Restaurant
Admin.
Offices
Lobby
Village Green
Restaurant
GOS1
GOS2
GOS3
Base Station

Figure 4.3-17

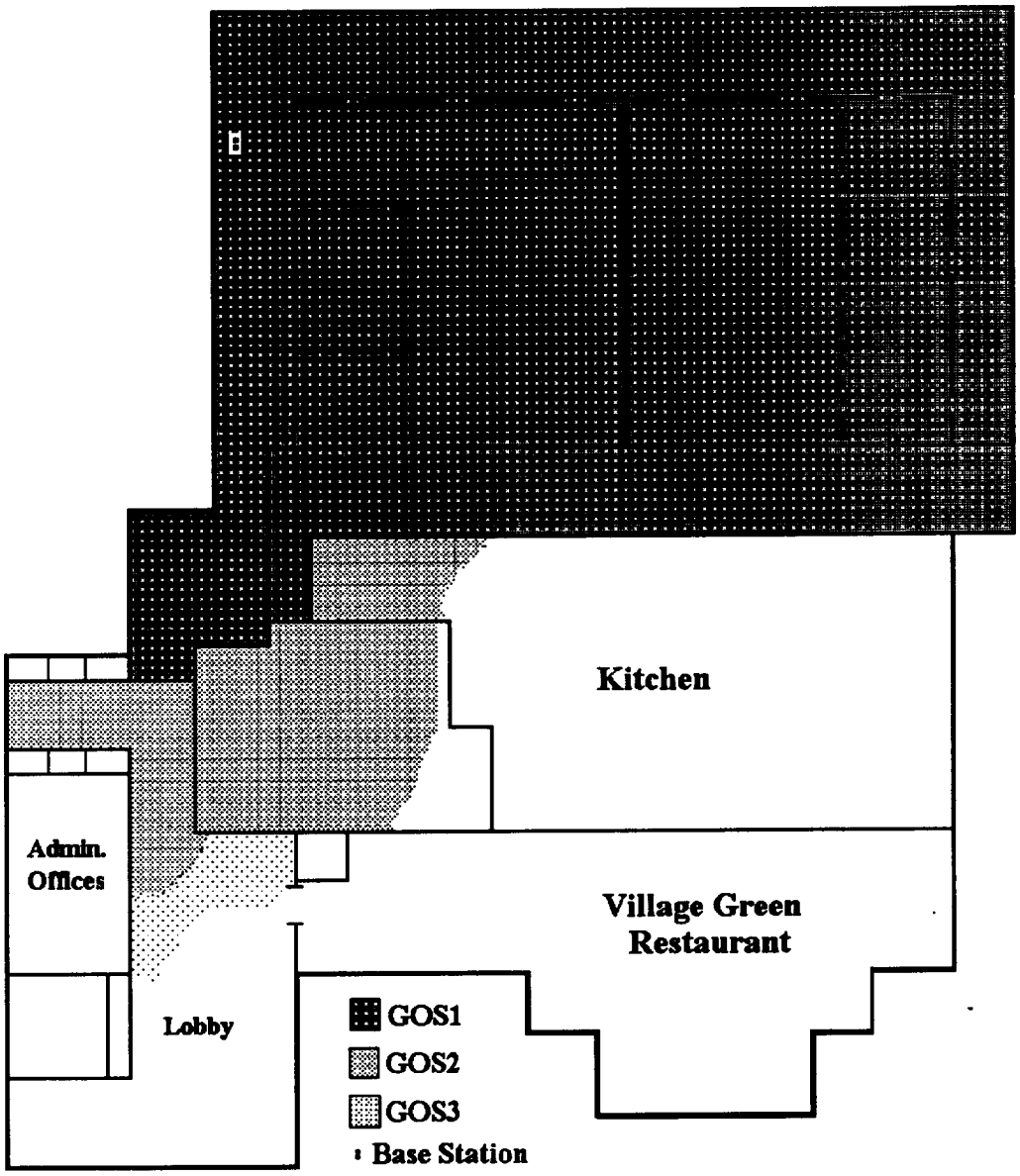

Kitchen
Admin.
Offices
Village Green
Restaurant
Lobby
GOS1
GOS2
GOS3
Base Station

Figure 4.3-18

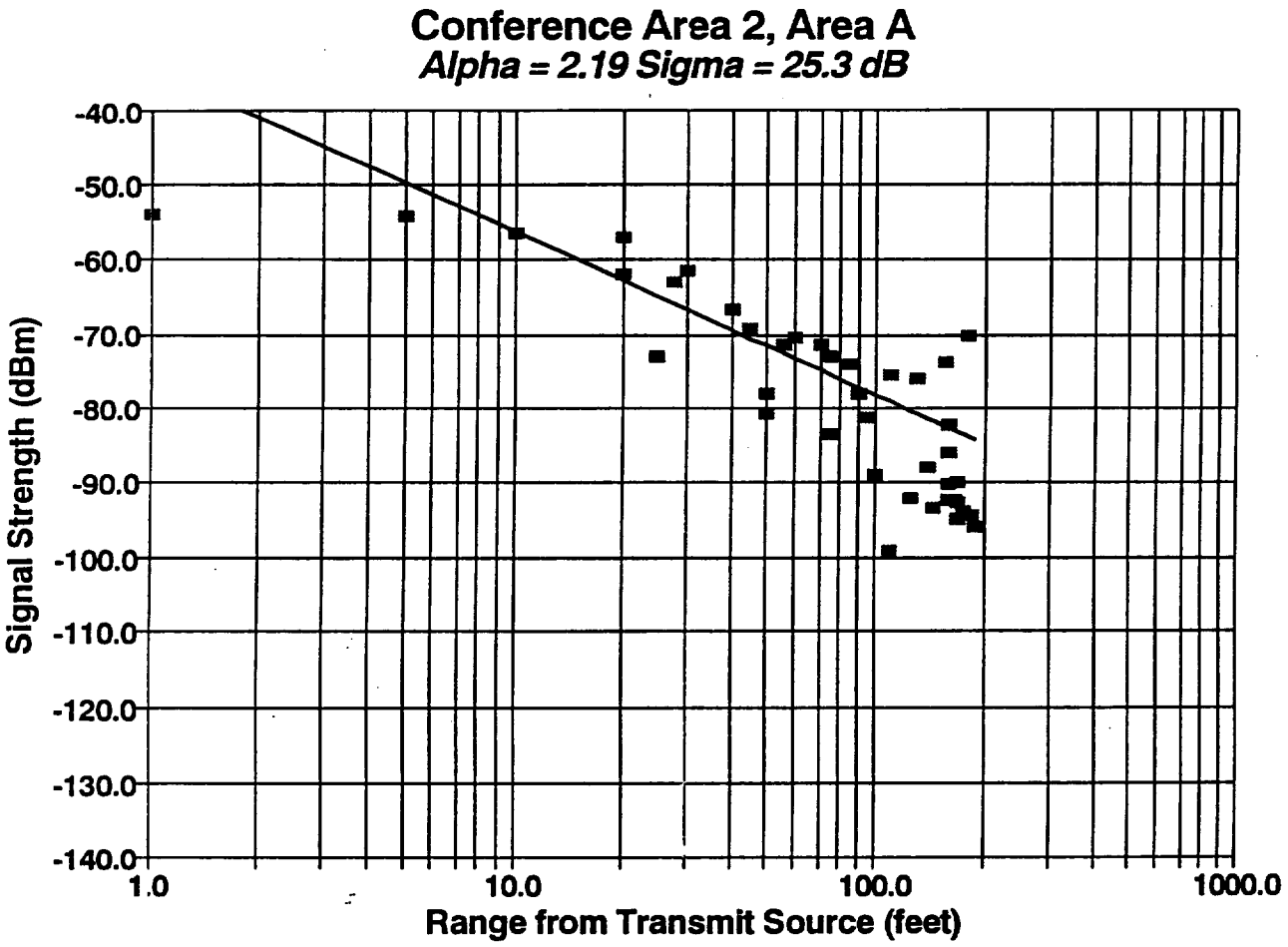

Conference Area 2, Area A
Alpha = 2.19 Sigma = 25.3 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
1.0
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-19

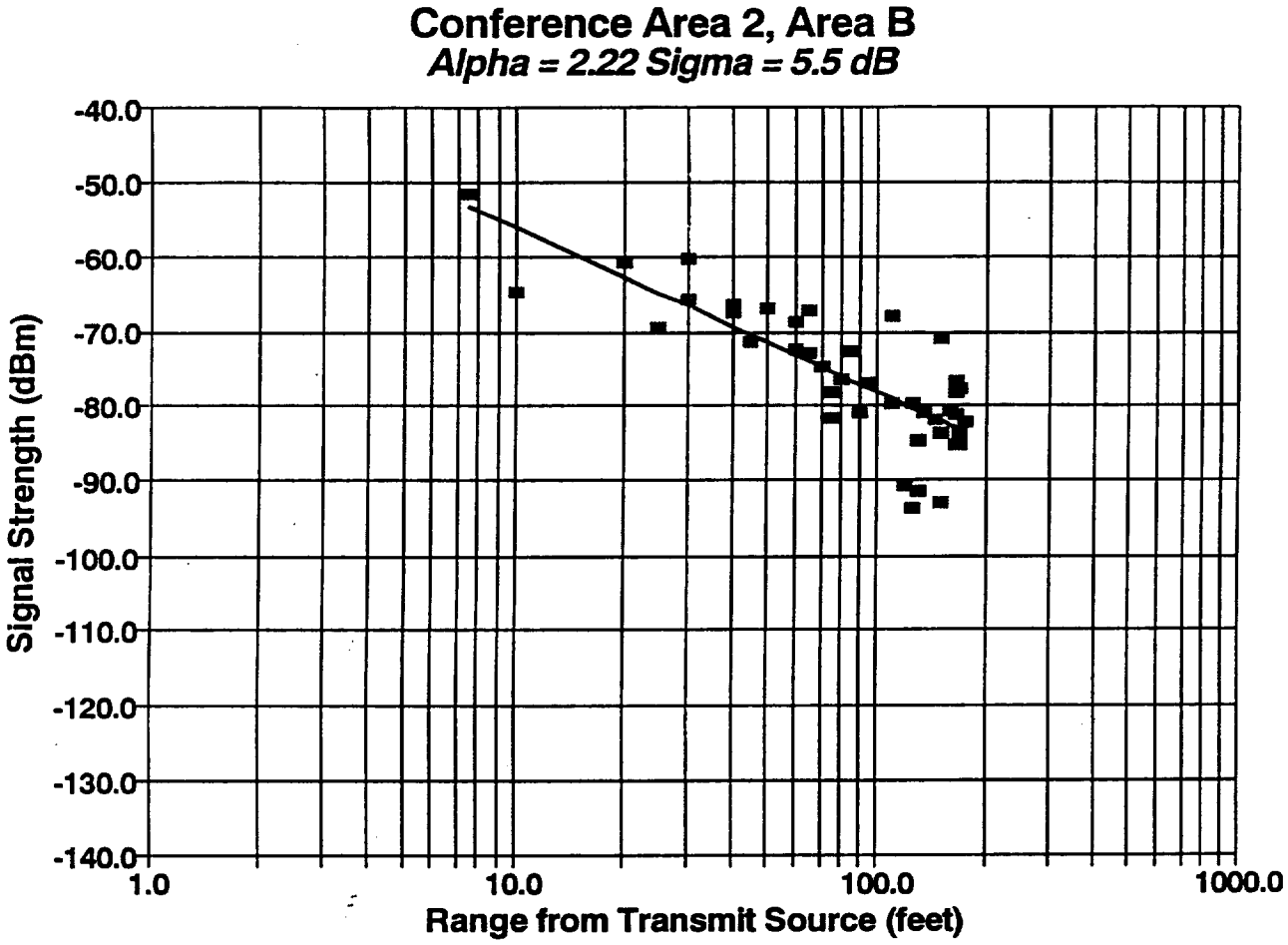

Conference Area 2, Area B
Alpha = 2.22 Sigma = 5.5 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
1.0
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-20

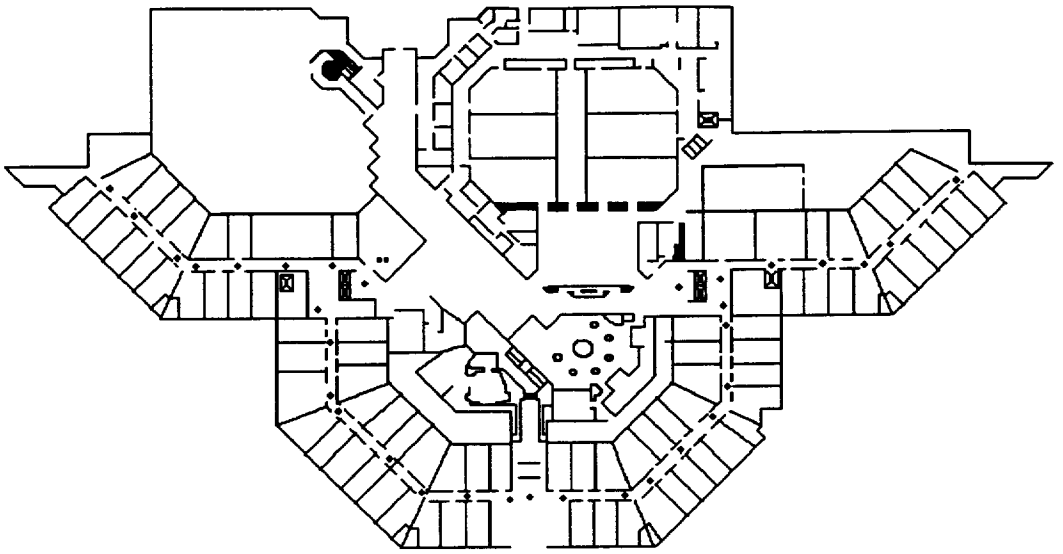
4.3.1.2.1 - Atrium Hotel

The first site selected for study as an open-air structure was a hotel facility that was designed for open spaces in a large four story atrium. This site is less than ten years old and constructed of brick and structural steel, as well as other common materials found in multi-story edifices of this type. It consists of a lobby/reception area with offices, an open two story pool/recreation area, and a gift shop. Adjacent to the lobby area on the main floor is the conference center, with rooms to accommodate gatherings requiring up to 9,300 square feet. The lobby and conference area open on one side to the atrium area, which is bounded on its other sides by the three floors of hotel rooms. The basement level, with adjacent meeting space under the lobby area, provides the lowest point in the Atrium, approximately 60 feet below the roof.

Figures 4.3-21 & 4.3-22 detail the test points taken on the first and second floors, respectively. Coverage plots on all floors were generated by performing the Grade of Service "Walk Test", with coverages for each shown in Figures 4.3-23, 4.3-24, 4.3-25, & 4.3-26 The base station was mounted on the third floor overlooking the atrium above the gift shop, and all tests were performed relative to this location.

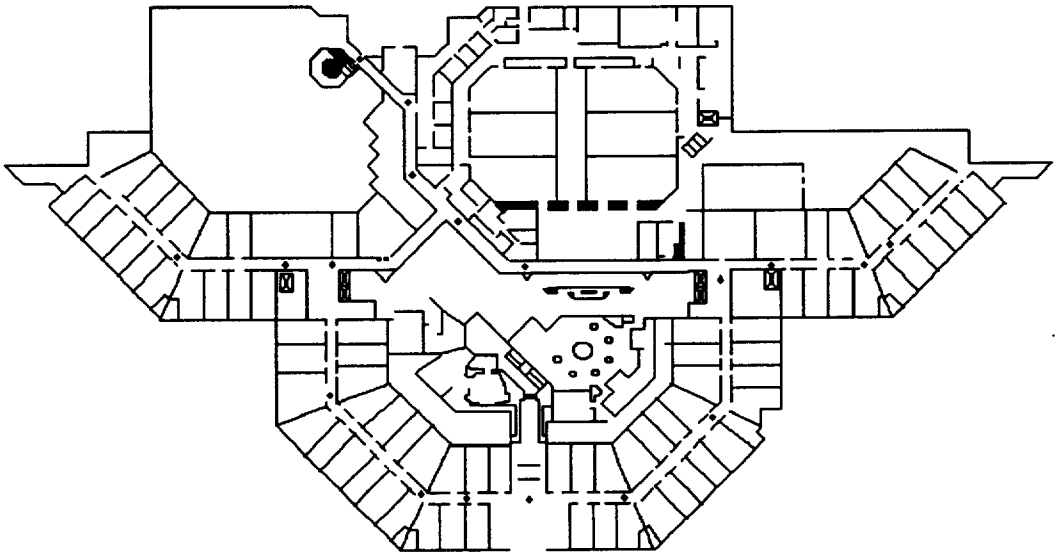
It can be seen from the figures that coverage varied slightly between all floor, with best performance (not surprisingly) on the third and fourth levels. Similar coverage characteristics for all the floors is explained by the open nature of the facility. It was the goal of this system to provide service to the public areas of the hotel, with coverage into the hotel rooms as a secondary priority. As requirements change to direct coverage into all hotel rooms, second and third base stations will be installed at the ends of both room wings. It should be noted that, while not detailed in the present drawings, the system performs with a GOS1 level of service outside of the building at ranges up to 200 feet away.

It is anticipated that more simultaneous users than that supplied by a single base station will be required. When these requirement arise, more base stations



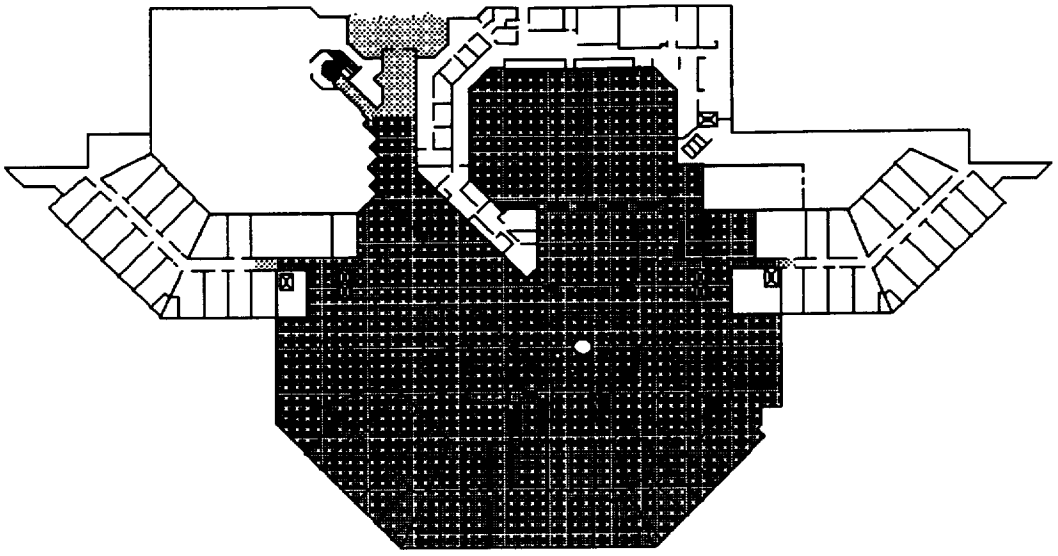
Atrium Hotel - 1st Floor
Test Points

Figure 4.3-21



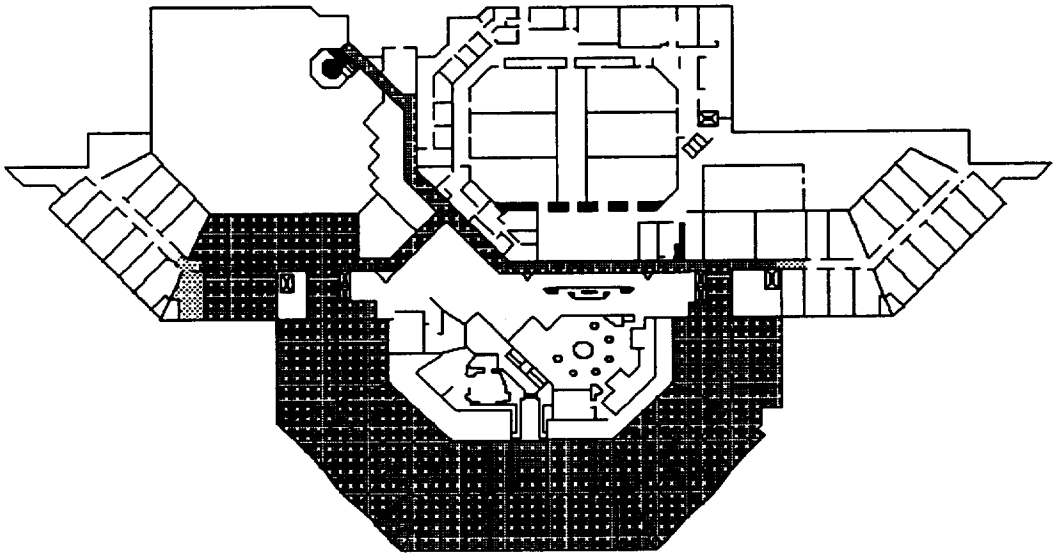
Atrium Hotel - 2nd Floor
Test Points

Figure 4.3-22



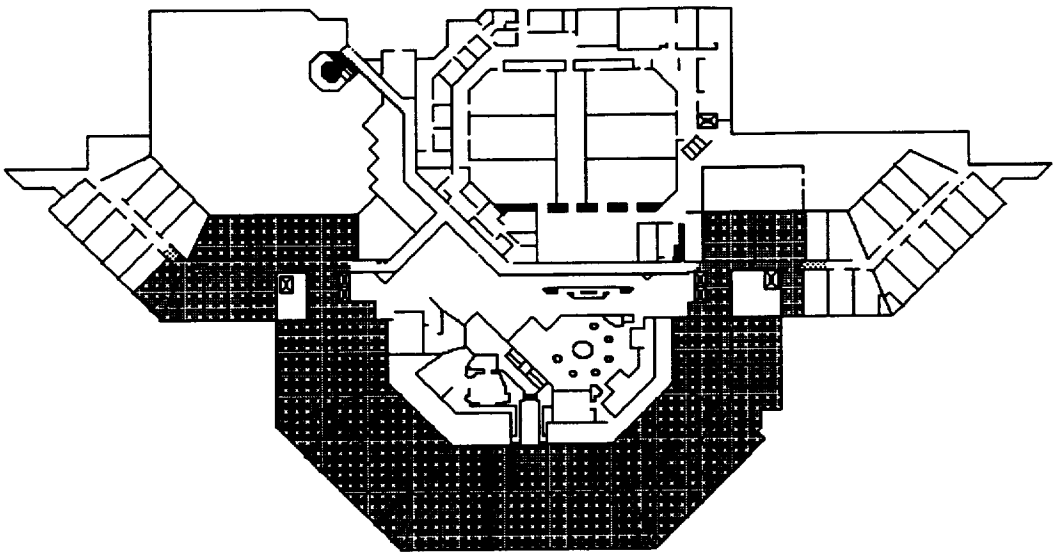
Atrium Hotel - 1st Floor
Coverage from 3rd Floor

Figure 4.3-23



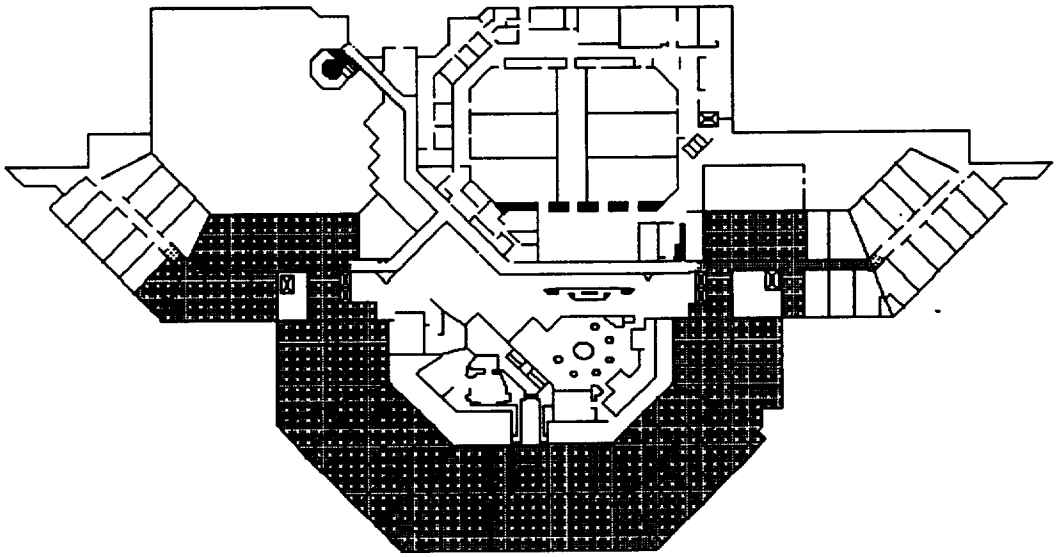
Atrium Hotel - 2nd Floor
Coverage from 3rd Floor

Figure 4.3-24



Atrium Hotel - 3rd Floor
Coverage From 3rd Floor

Figure 4.3-25



Atrium Hotel - 4th Floor
Coverage From 3rd Floor

Figure 4.3-26

may be installed at other locations in the atrium, taking advantage of the Omnipoint system frequency division multiplexing capabilities.

Figure 4.3-27 shows the raw data points as well as the results of our least squares regression analysis for each site. RMS propagation coefficient and standard deviation is also indicated on each figure.

4.3.1.2.2 - Multi-Use Arena

The second site chosen for open-air indoor propagation testing is a multi-use athletic arena. This is a single open building of approximately 260,000 square feet with space for a variety of activities. Its construction includes large steel spans peaking at approximately 100 feet from the arena floor, and covered with fiberglass panels, forming a dome structure.

Figure 4.3-28 shows that ubiquitous coverage over the entire structure has been achieved with a single base station. In this case, the base station was mounted near the roof, with two standard vertically polarized monopole antennas aimed down towards the arena floor. Again, as throughput requirements increase, more base stations will be added to this facility.

Figure 4.3-29 shows the raw data points as well as the results of our least squares regression analysis for this site. RMS propagation coefficient and standard deviation is also indicated.

4.3.1.3 - Commodities Exchange Site Survey

See Appendix B.

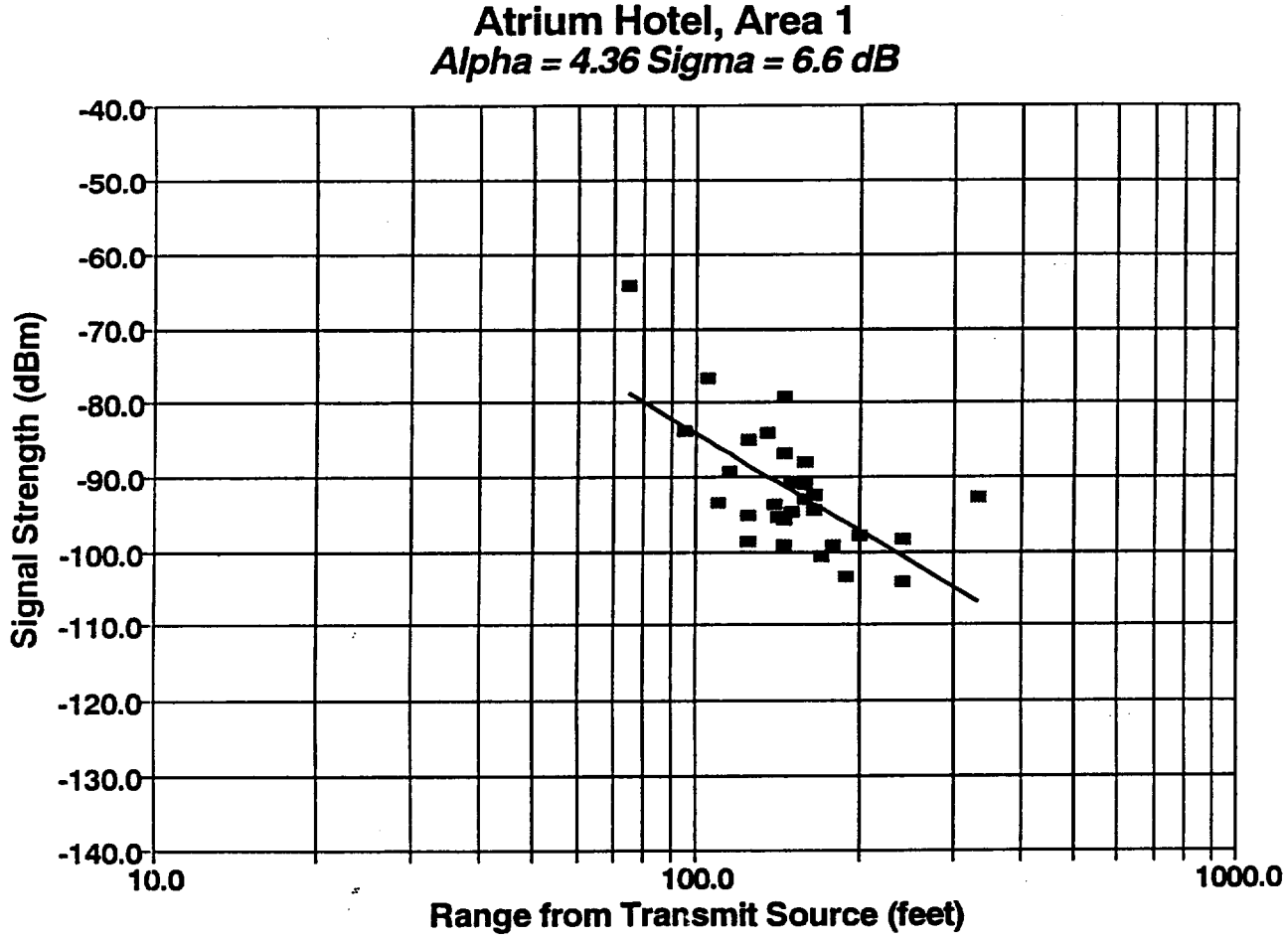

Atrium Hotel, Area 1
Alpha = 4.36 Sigma = 6.6 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-27

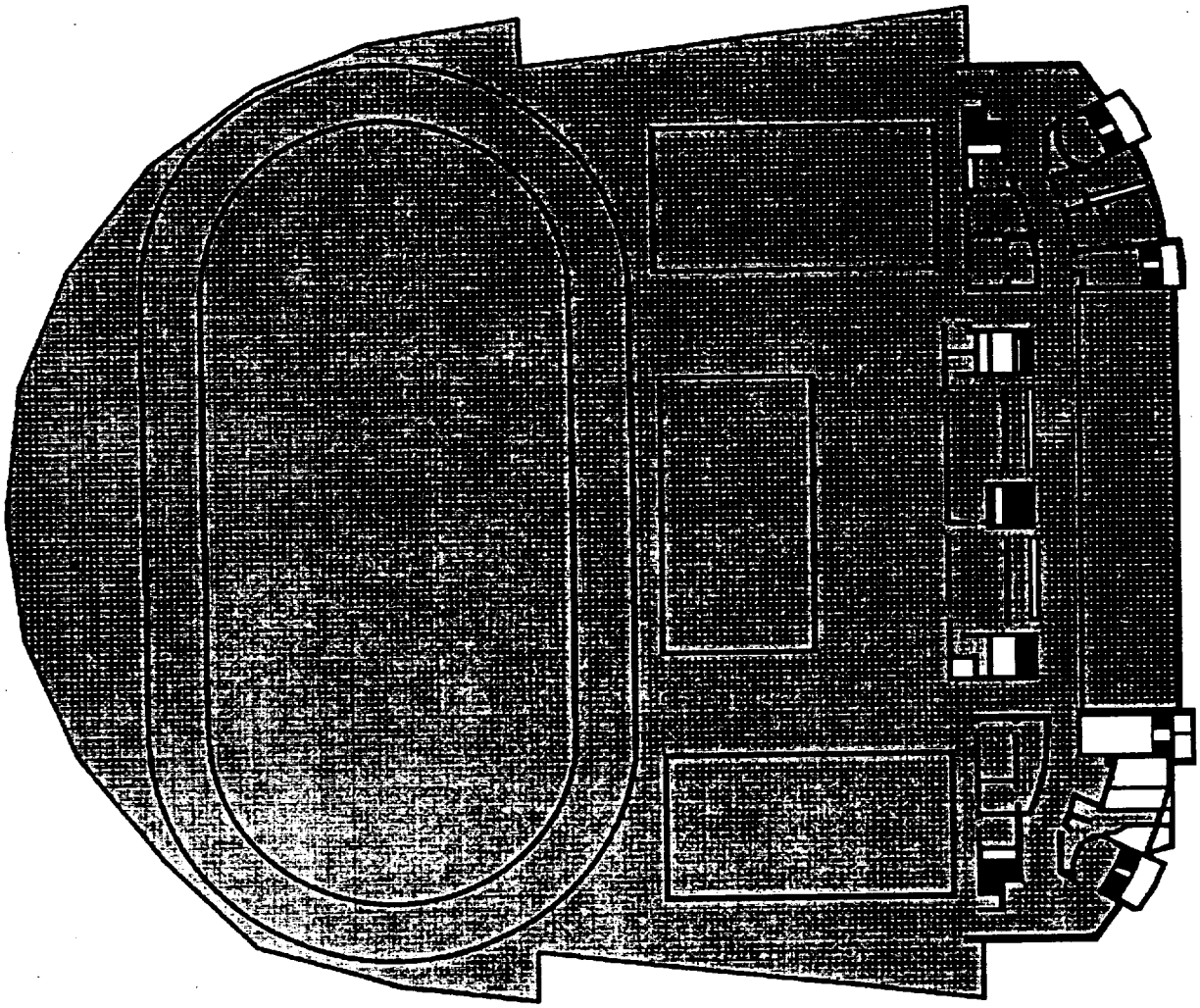


Figure 4.3-28
Coverage Plot: Multi-purpose Arena

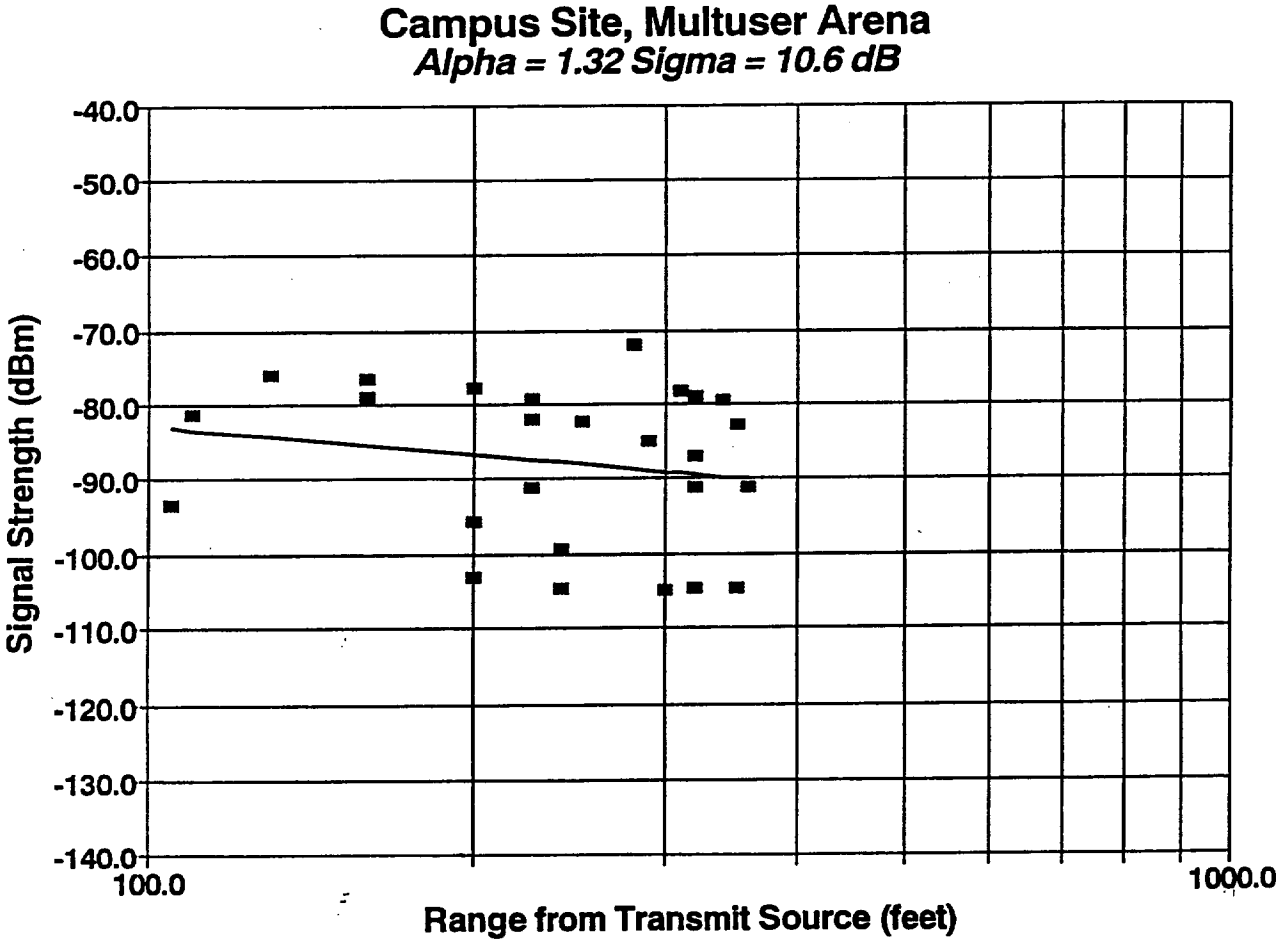

Campus Site, Multuser Arena
Alpha = 1.32 Sigma = 10.6 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-29

4.3.1.4 - Indoor Propagation Effects - Office Buildings

Likely the most important aspect of the Personal Communications System concept is the office environment. This is also of considerable importance to Omnipoint as any PCS system in the near future could involve licensing the 1.8 GHz band for public use (assuming allocation) and unlicensed operation in the 2.4 GHz band for office, commercial and residential uses.

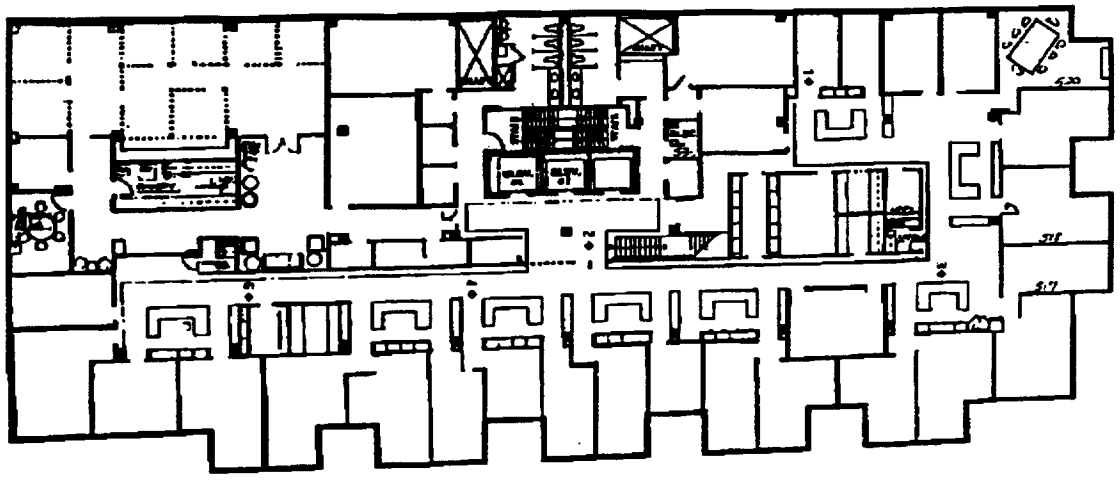
Omnipoint has focused its studies on two distinct office environments, including a multi-story urban structure in Washington DC and a low-rise (3 floors) suburban building in Colorado Springs, CO.

4.3.1.4.1 - Indoor Propagation Effects: High Rise Office Building

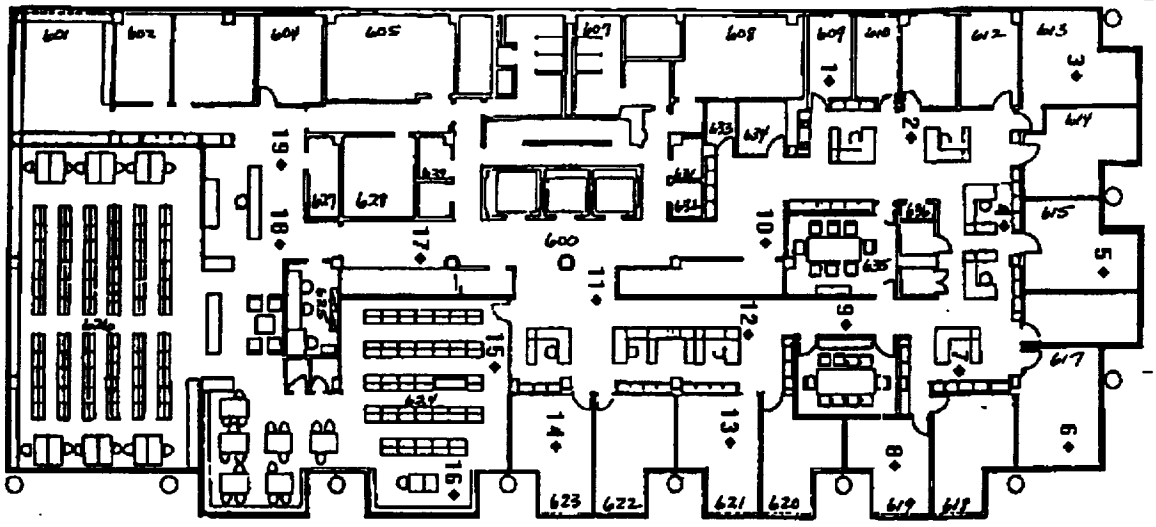
This location is a multi-story edifice less than ten years old of structural steel and brick construction, with approximate overall dimensions of 178 feet by 76 feet, yielding roughly 13,000 square feet per floor. Large windows surround the building on all sides, with elevator shafts in the middle, and interior walls of drywall construction mounted to steel studs. The floors under test are leased by a large legal firm, with offices on the outside walls surrounding a secretarial pool and common area in the middle, creating a semi-open environment.

For the tests conducted at this facility, a base station was placed on the seventh floor, and test plots were taken on the fifth through eighth floors. This yielded information on attenuation through floors, as well propagation effects out of the building through the windows and back in again on the other floors through the same path. Figures 4.3-30, through 4.3-33 detail where test plots were taken. Figures 4.3-34 through 4.3-37 show the service coverage the Omnipoint hardware provides from the seventh floor. It is seen that, as the tests are conducted further away from the base station, plot points and coverage decrease.

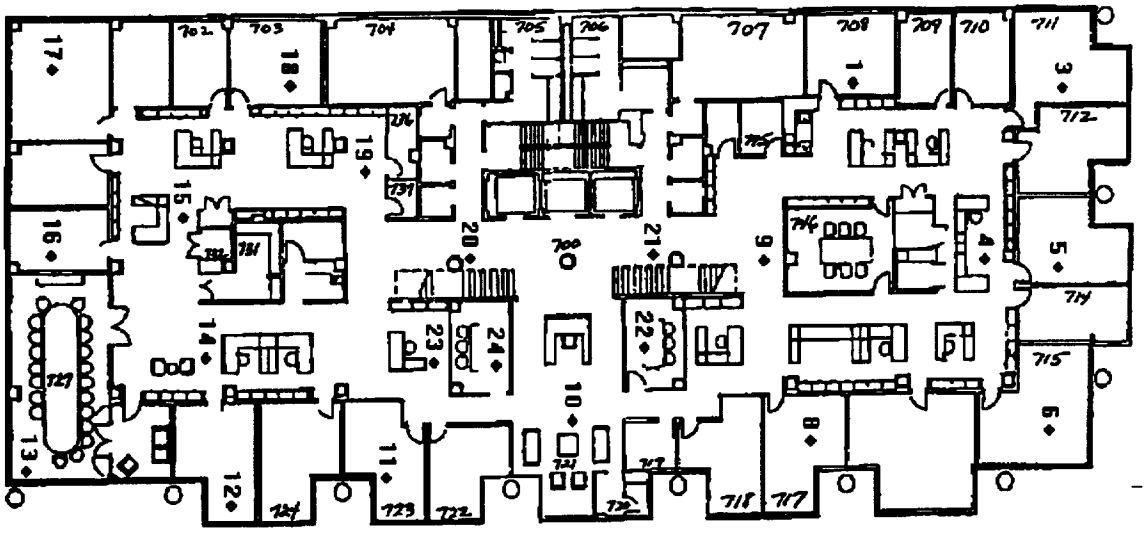
Table 4.3-1 shows estimated signal coverage at GOS quality ratings of 3 and above.



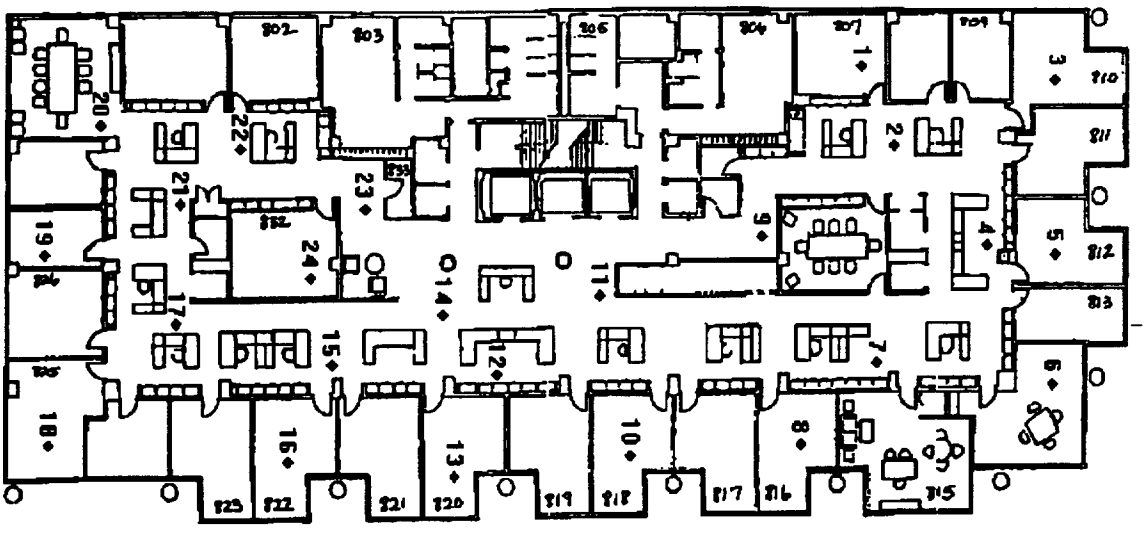
High Rise Office - 5th Floor
Test Points
Figure 4.3-30



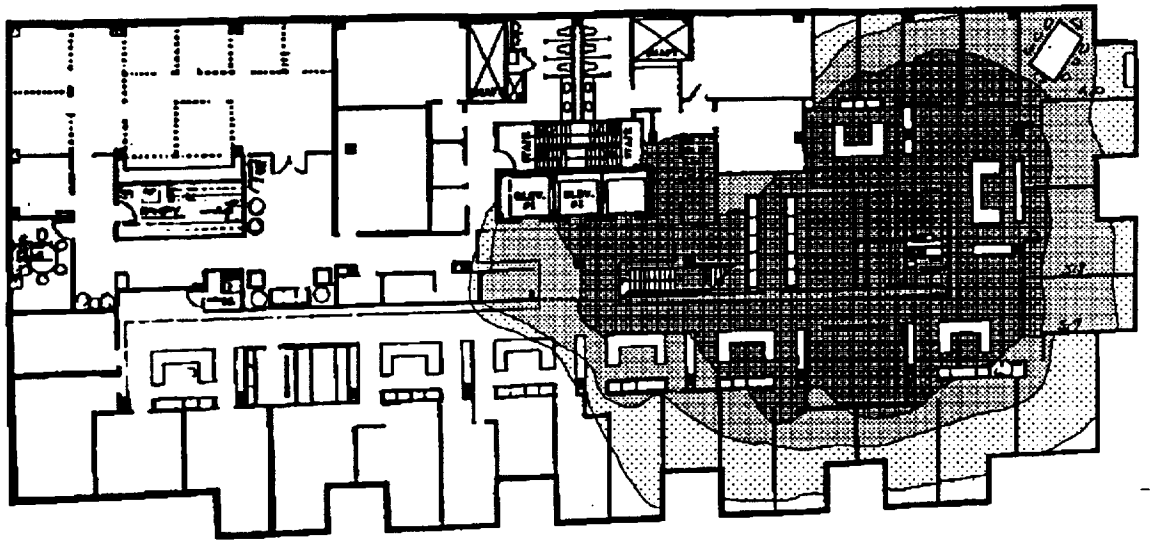
High Rise Office - 6th Floor
Test Points
Figure 4.3-31



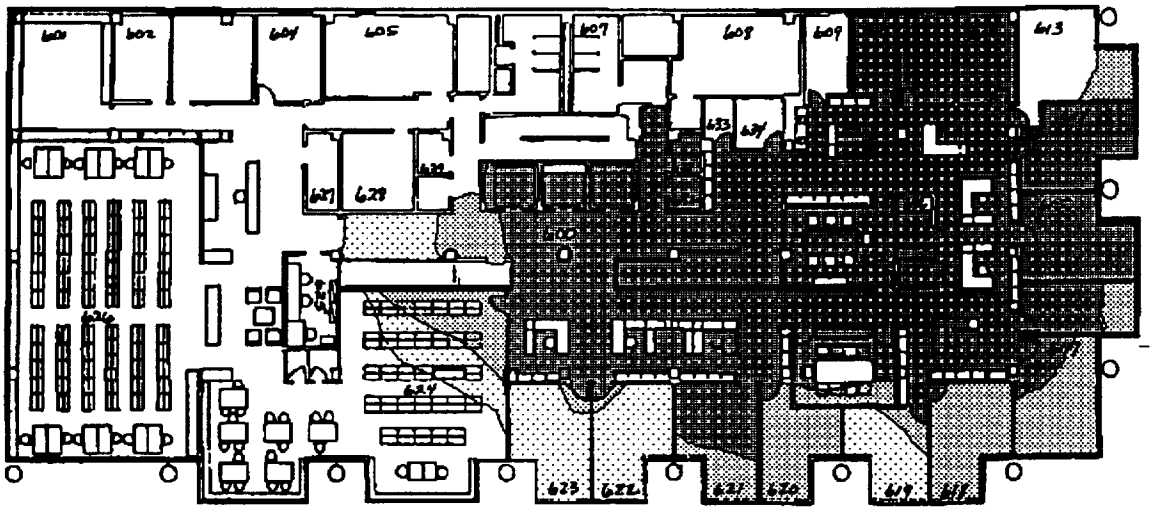
High Rise Office - 7th Floor
Test Points
Figure 4.3-32



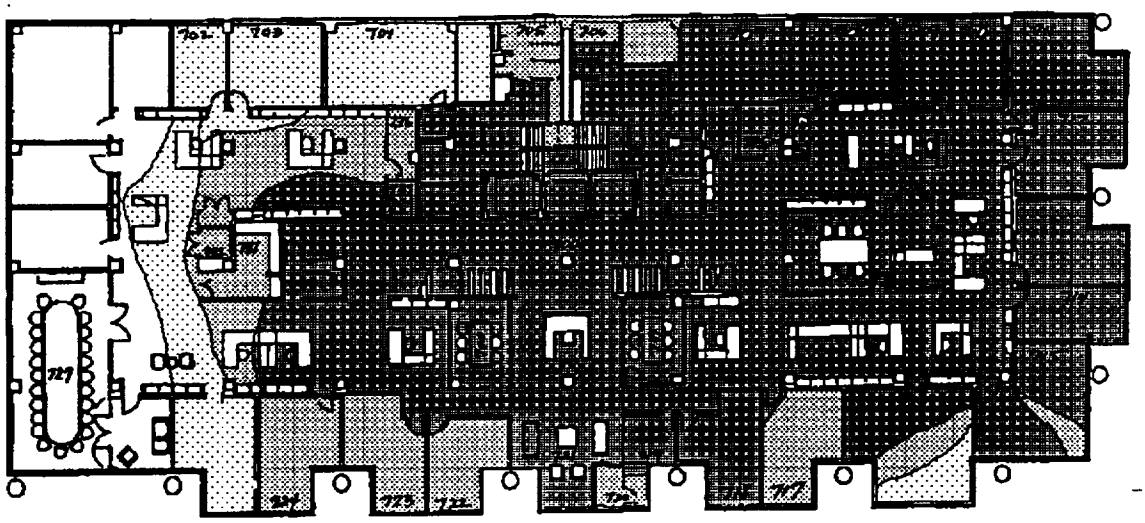
High Rise Office - 8th Floor
Test Points
Figure 4.3-33



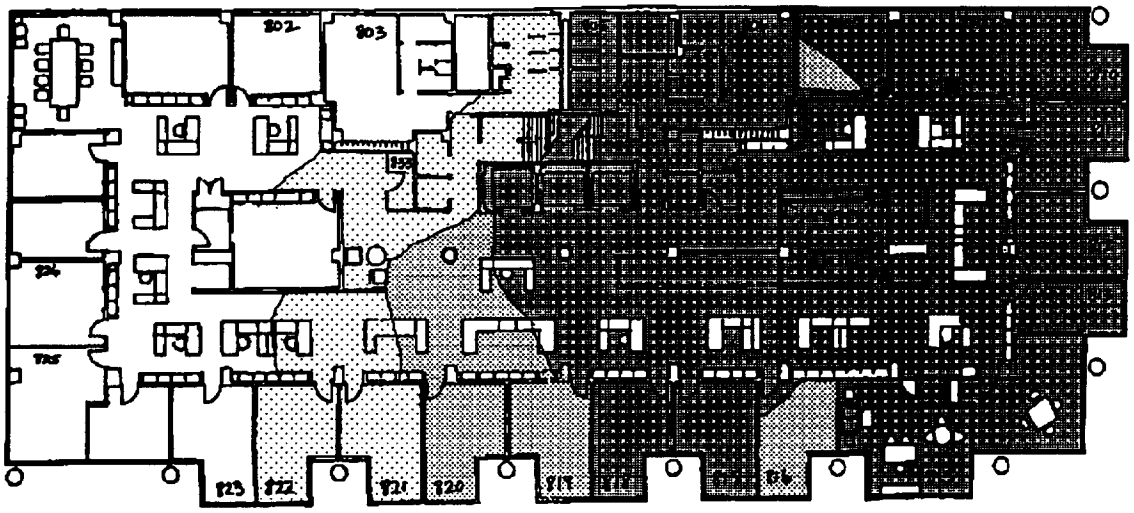
High Rise Office - 5th Floor
Coverage From 7th Floor
Figure 4.3-34



High Rise Office - 6th Floor
Coverage From 7th Floor
Figure 4.3-35



High Rise Office - 7th Floor
Coverage From 7th Floor
Figure 4.3-36



High Rise Office - 8th Floor
Coverage From 7th Floor
Figure 4.3-37

Table 4.3-1
GOS Coverage: Multi-story Office Building

Floor	GOS1	GOS2 & up	GOS3 & up
5	25%	33%	40%
6	33%	40%	52%
7	70%	80%	90%
8	50%	60%	70%

It is seen that, as the tests moved further away from the seventh floor base installation station, signal coverage unsurprisingly decreases. However, even from as many as three floors away, the system still allows GOS1 levels of service on approximately 25% of the floor, while signal levels of GOS1-GOS3 cover about 40%. Therefore, with a single base station, the Omnipoint PCTS will cover approximately 23,140 square feet over four floors with GOS1 quality, and up to 32,760 square feet with GOS3 and above quality in this particular site.

Figures 4.3-38 through 4.3-41 show the raw data points as well as the results of our least squares regression analysis for each site. RMS propagation coefficient and standard deviation is also indicated on each plot. Figure 4.3-42 summarizes all floors on a single regression plot.

4.3.1.4.2 - Low Rise Office Building

The second site chosen for office building propagation testing is the Omnipoint Corporate headquarters building in Colorado Springs, Colorado. This structure is a four year old three story Class A building. Besides the structural steel framework, the exterior of the building is covered with glass all around, with a pre-cast exposed aggregate facie between windows. Interior walls consist of drywall on steel studs. The building is separated into two wings of approximately 24,000 square feet on the ground level per wing with a common area linking them; Omnipoint occupies the West wing on the first floor.

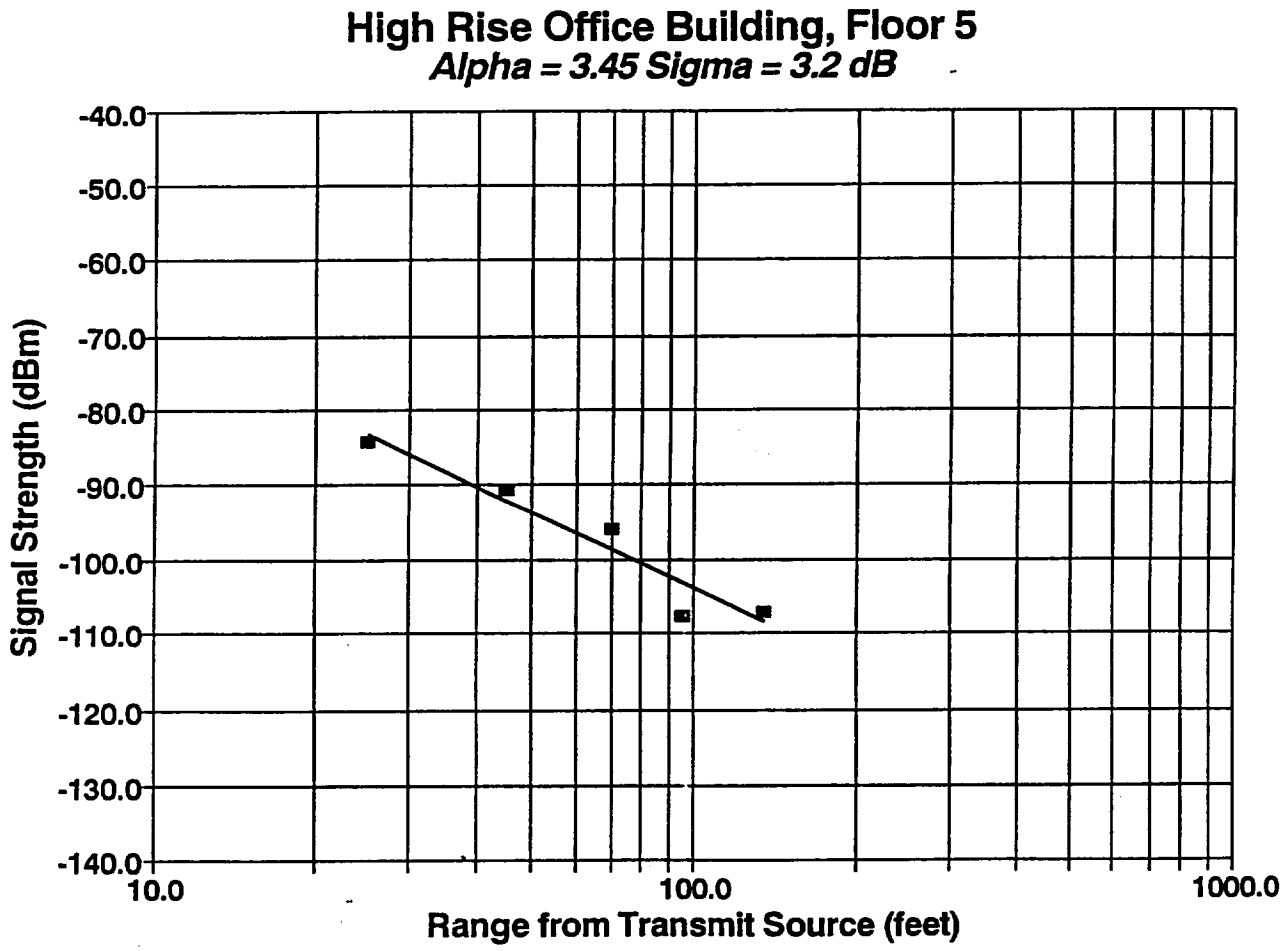

High Rise Office Building, Floor 5
Alpha = 3.45 Sigma = 3.2 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-38

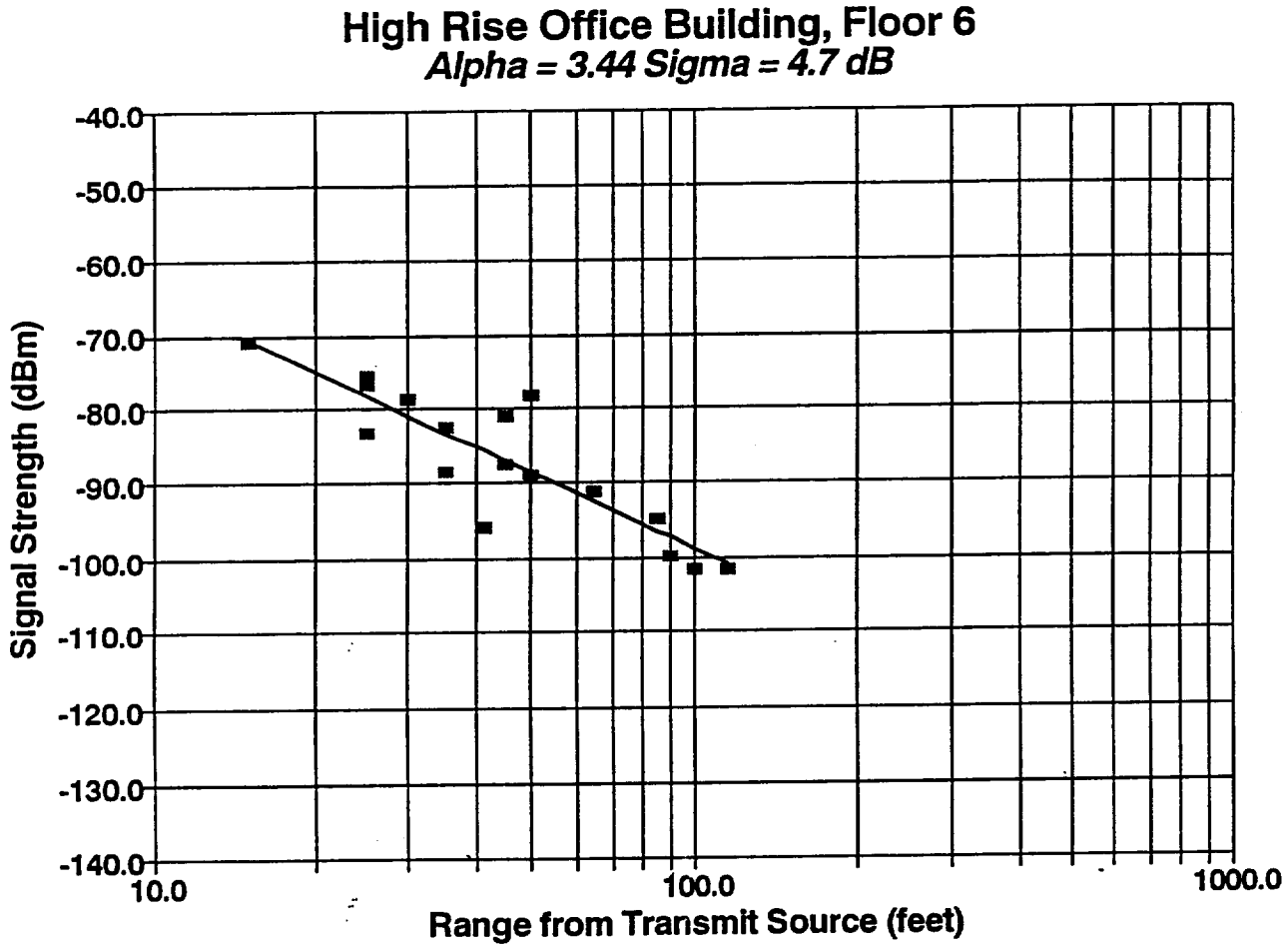

High Rise Office Building, Floor 6
Alpha = 3.44 Sigma = 4.7 dB
Signal Strength (dBm)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-39

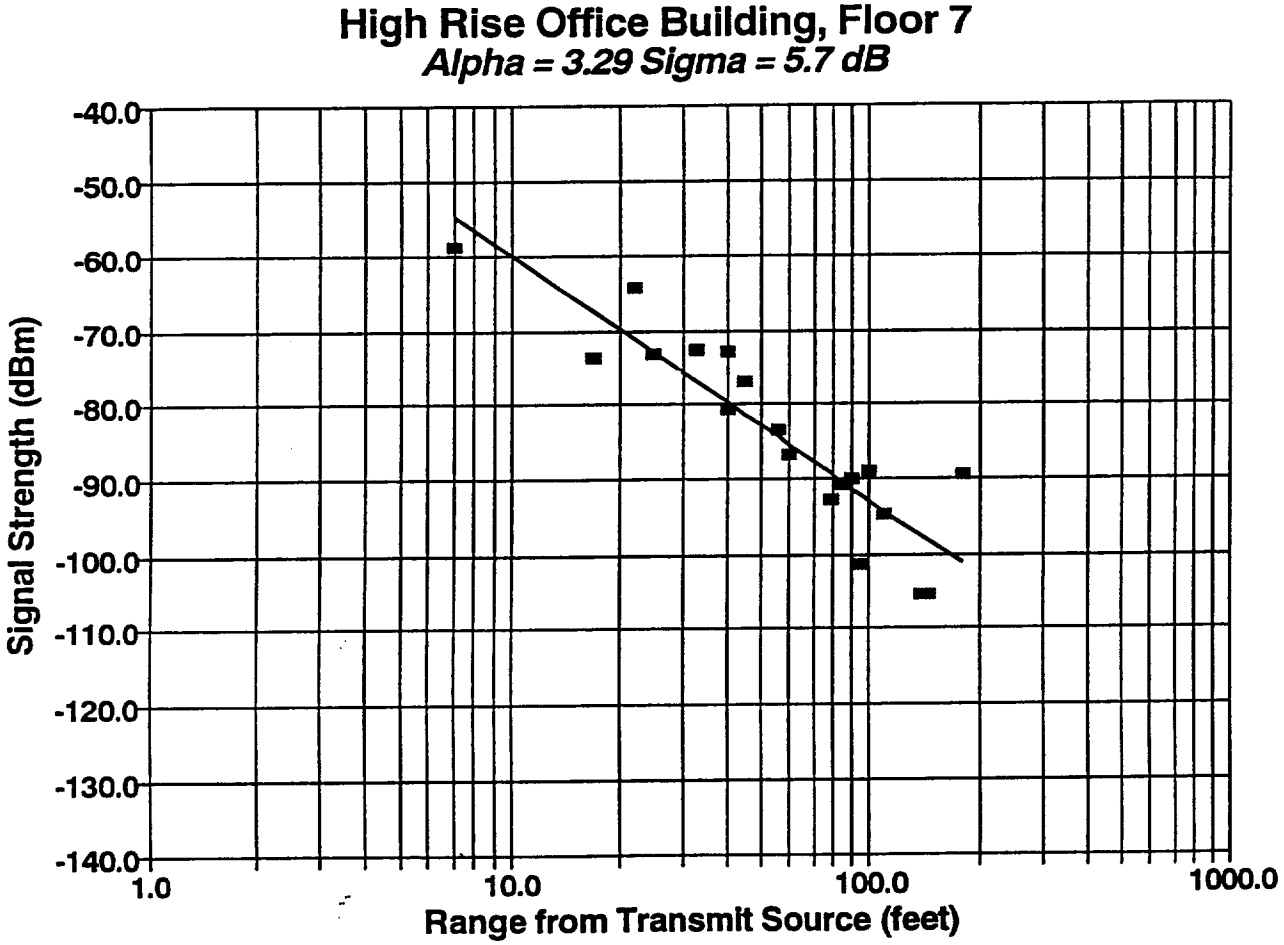

High Rise Office Building, Floor 7
Alpha = 3.29 Sigma = 5.7 dB
Signal Strength (dBm)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
1.0
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-40

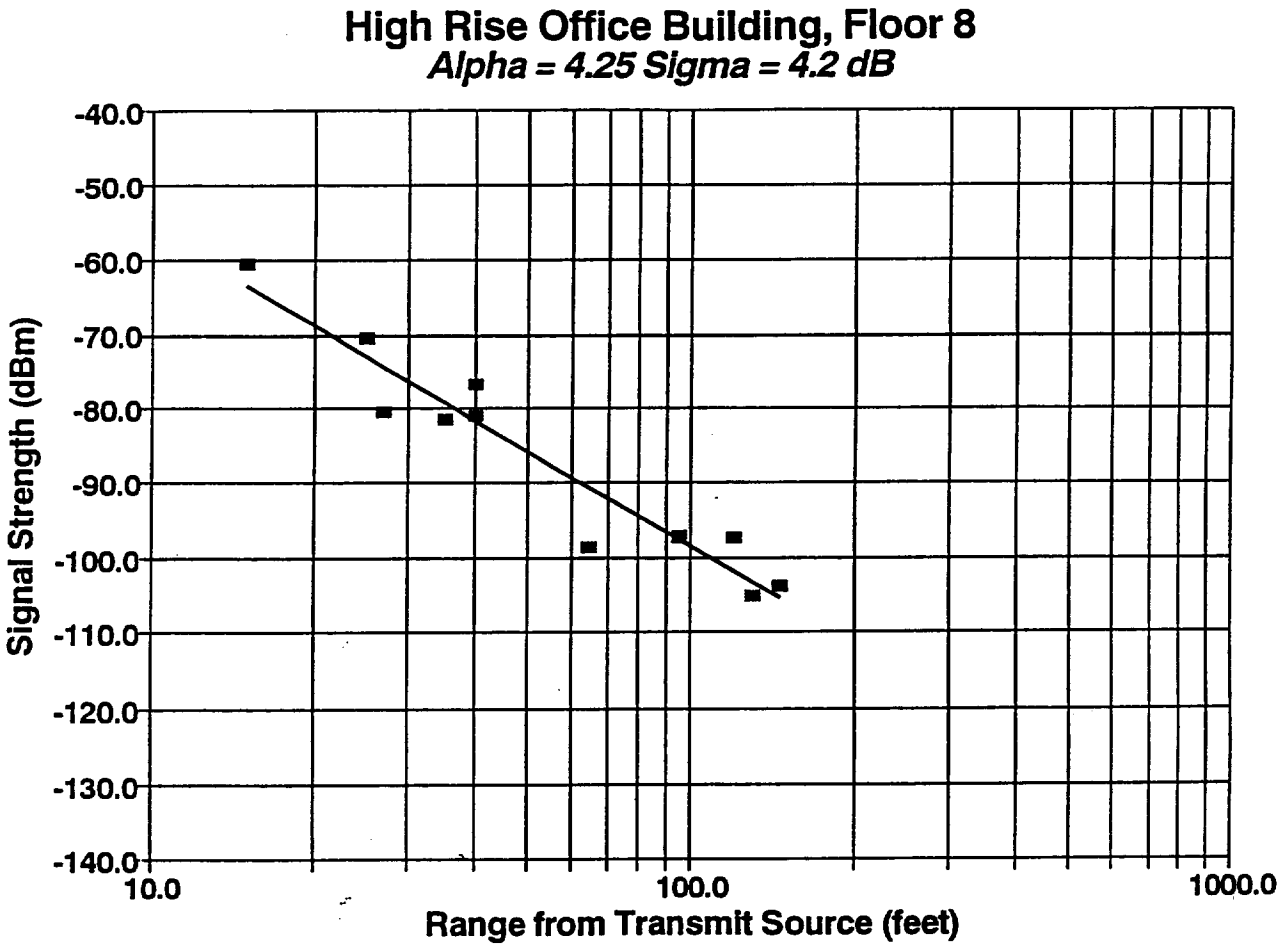

High Rise Office Building, Floor 8
Alpha = 4.25 Sigma = 4.2 dB
Signal Strength (dBm)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-41

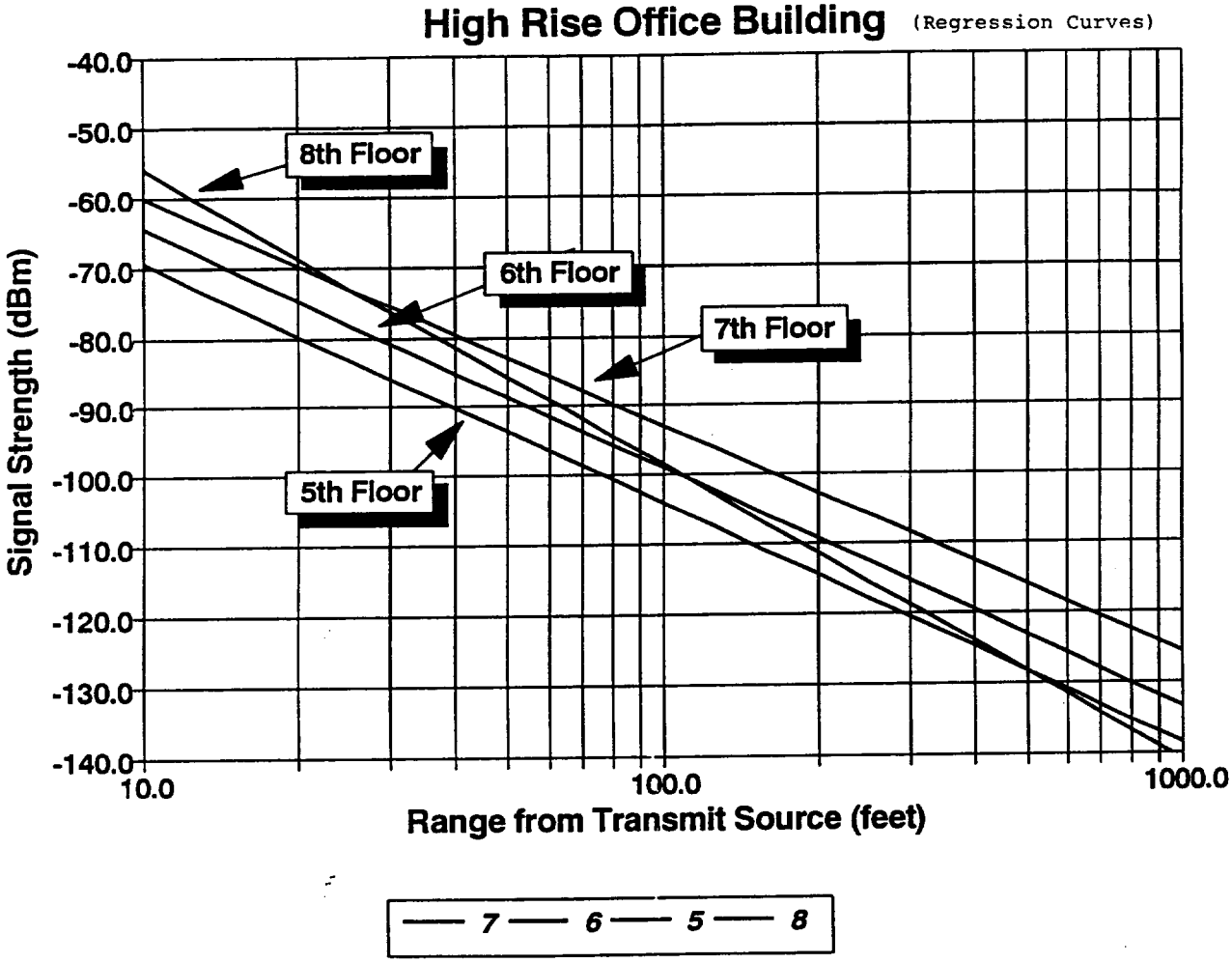

High Rise Office Building (Regression Curves)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
8th Floor
6th Floor
7th Floor
5th Floor
10.0
100.0
1000.0
Range from Transmit Source (feet)
7
6
5
8

Figure 4.3-42

In conducting tests at this facility, Omnipoint has access to the entire West Wing on the ground level, and access to all public area of the rest of the building. Most of the ground floor West Wing is finished office space, with a mixture of offices and technical production and R & D laboratories, which include several double shielded screen rooms.

Figures 4.3-43 through 4.3-45 show the layout of the building, with the plot points where the tests were conducted and coverage is supplied at different GOS levels. Unfortunately, without access to the entire building, coverage estimates on a square footage basis are not more than guesses. We will therefore restrict coverage specifications to the first floor where extensive propagation and coverage testing has been performed unhindered by lack of access.

With the base station placed in the Omnipoint Conference room, the antennas mounted at a height of approximately 8.5 feet and separated horizontally by six feet, coverage at GOS1 levels is approximately 25,300 square feet, and GOS2 and up levels covering approximately 32,400 square feet. With access to the other wing of the building, it is estimated, based on observations at myriad other sites, that coverage would likely extend on the range of 41,000 square feet for GOS1, and 58,000 square feet for GOS2 levels of service. With a second or third base station strategically placed throughout the facility, ubiquitous coverage will be supplied to the facility, with increased over-the-air capacity.

Figures 4.3-46 through 4.49 show the raw data points as well as the results of our least squares regression analysis for each site at 915MHz, 1.8GHz, and 2.4GHz. RMS propagation coefficient and standard deviation is also indicated on each figure.

4.3.2 Outdoor Propagation

Personal Communications Services cannot be offered without outdoor coverage, regardless of the band allocated to the service. Many Omnipoint

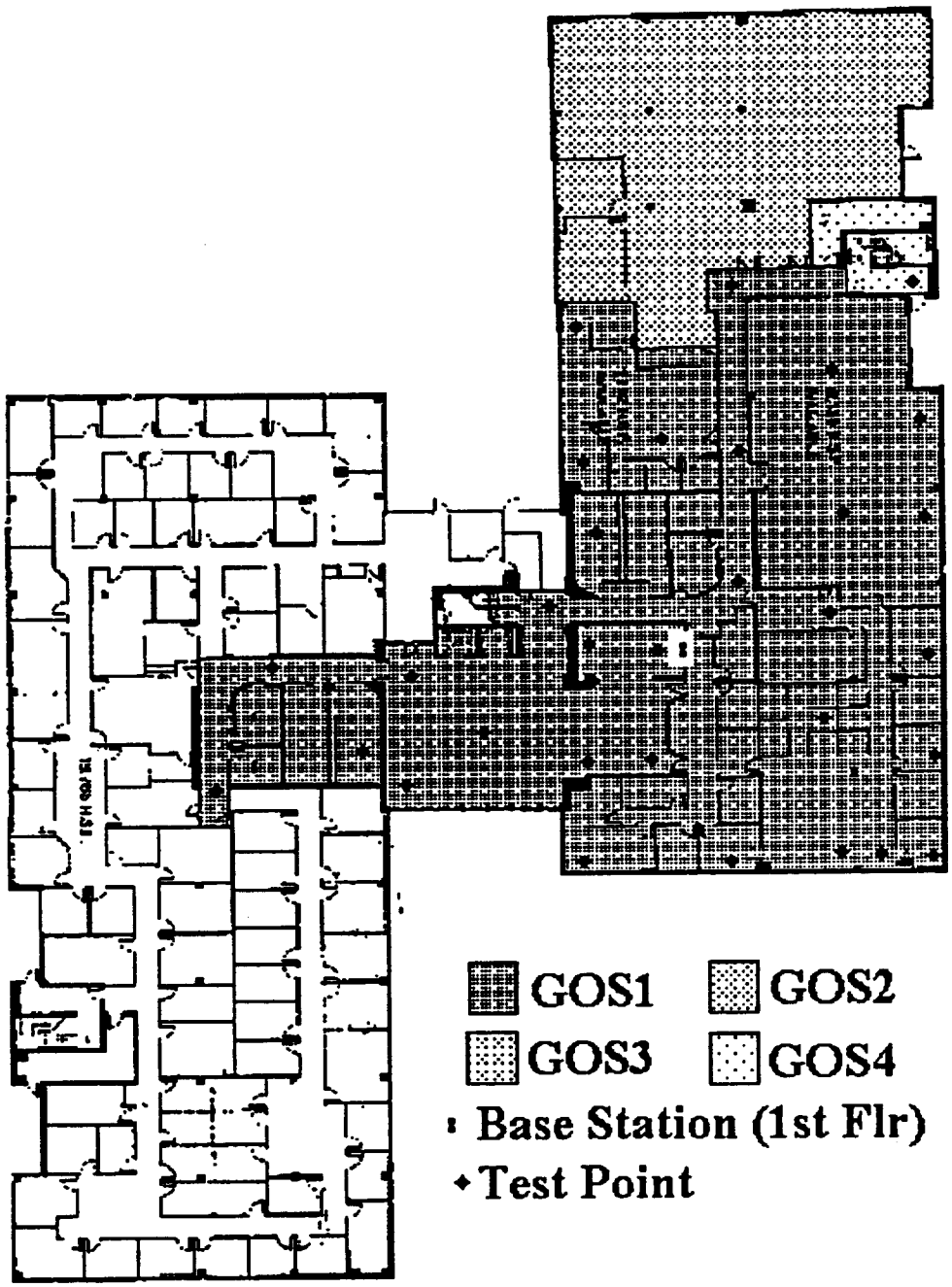


Figure 4.3-43

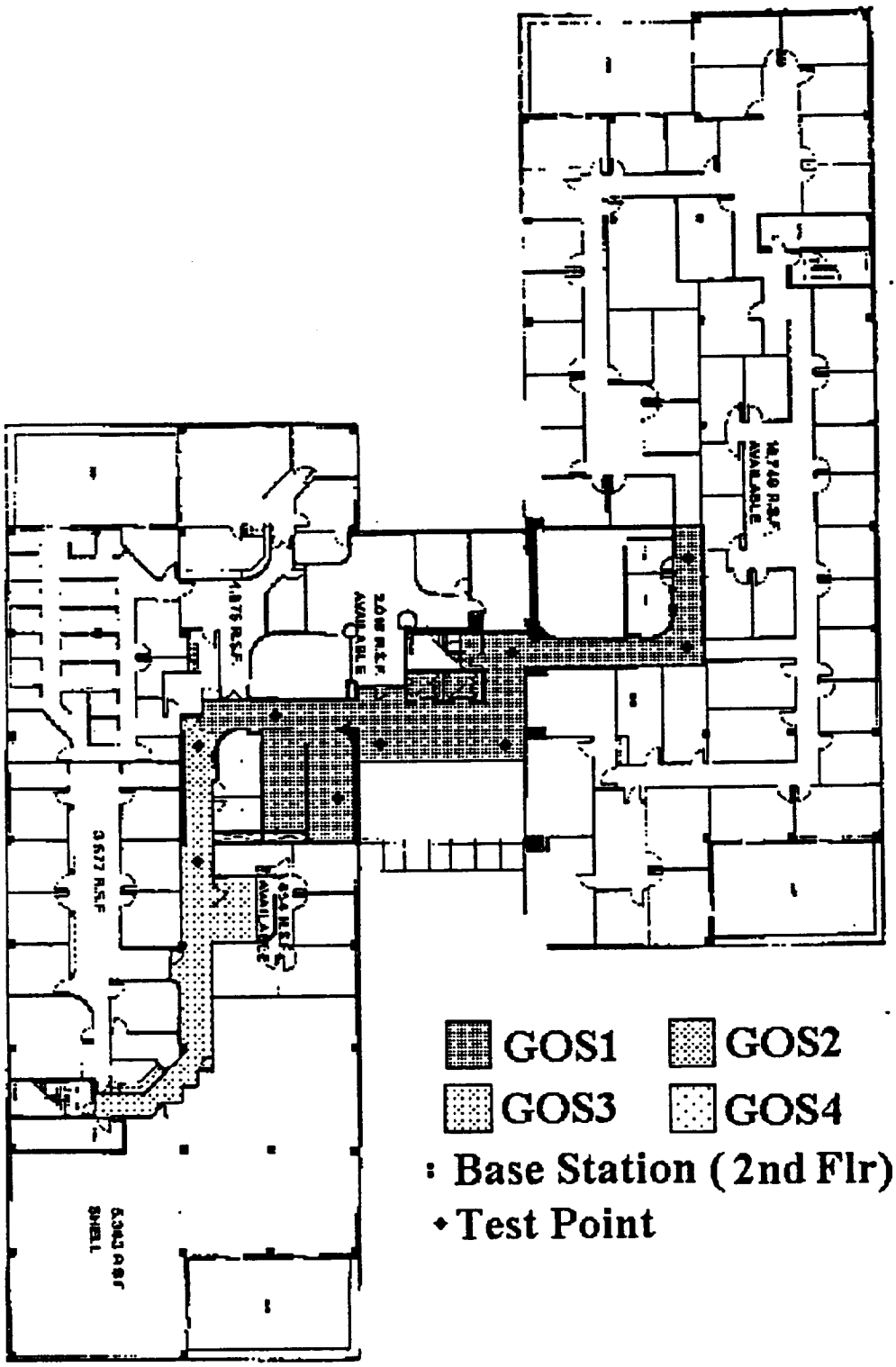


Figure 4.3-44

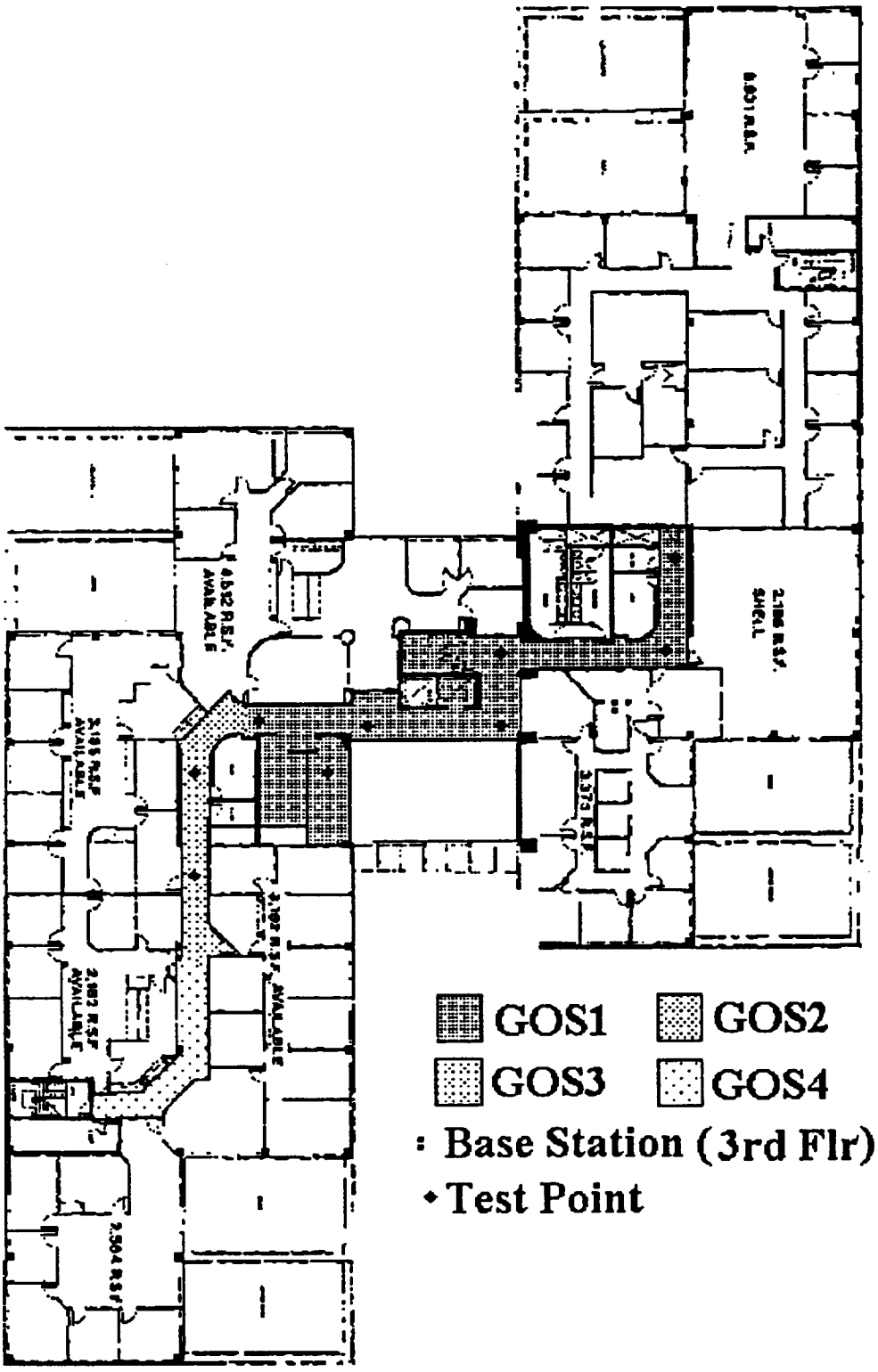


Figure 4.3-45

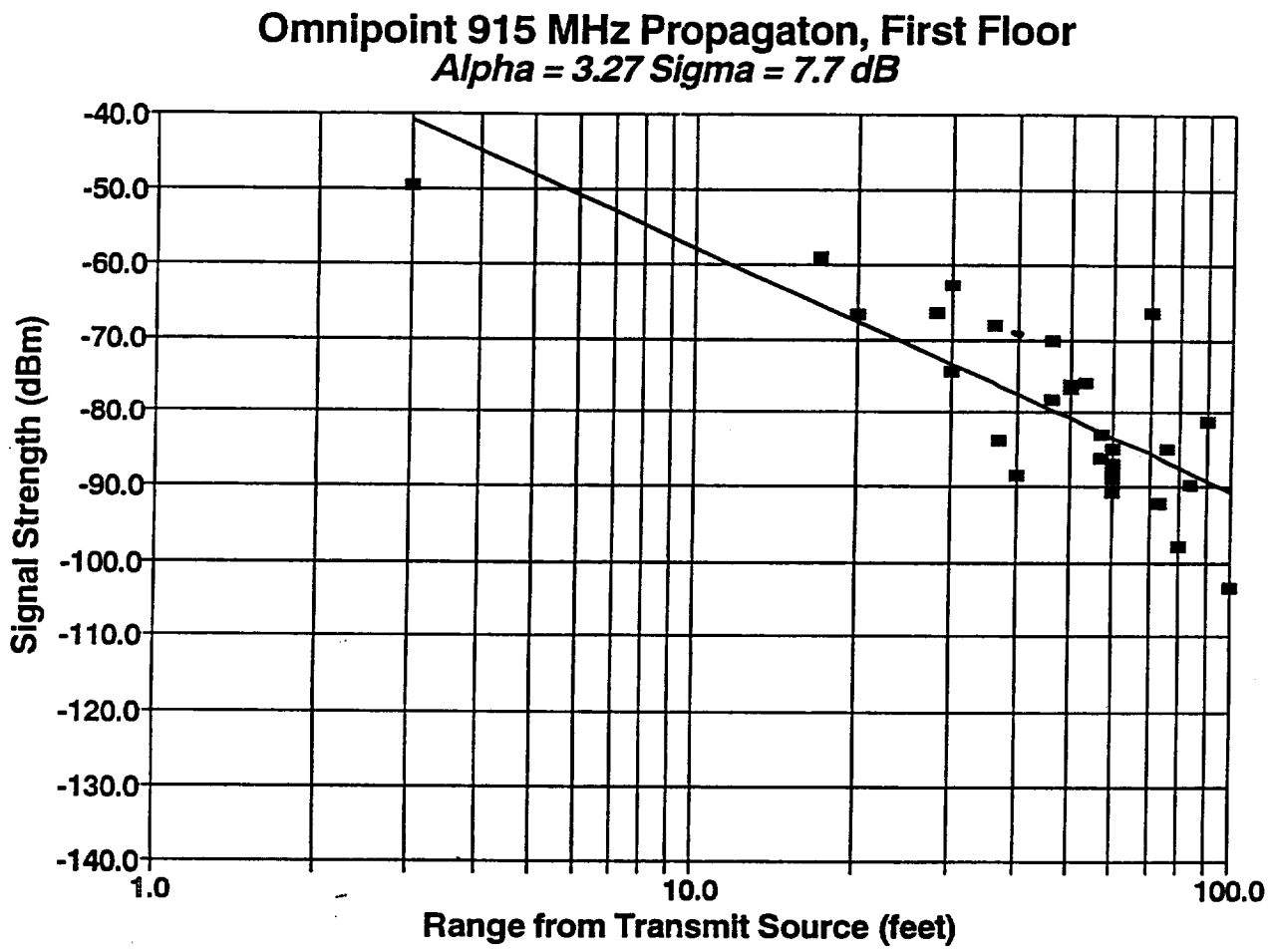

Omnipoint 915 MHz Propagaton, First Floor
Alpha = 3.27 Sigma = 7.7 dB
Signal Strength (dBm)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
1.0
10.0
100.0
Range from Transmit Source (feet)

Figure 4.3-46

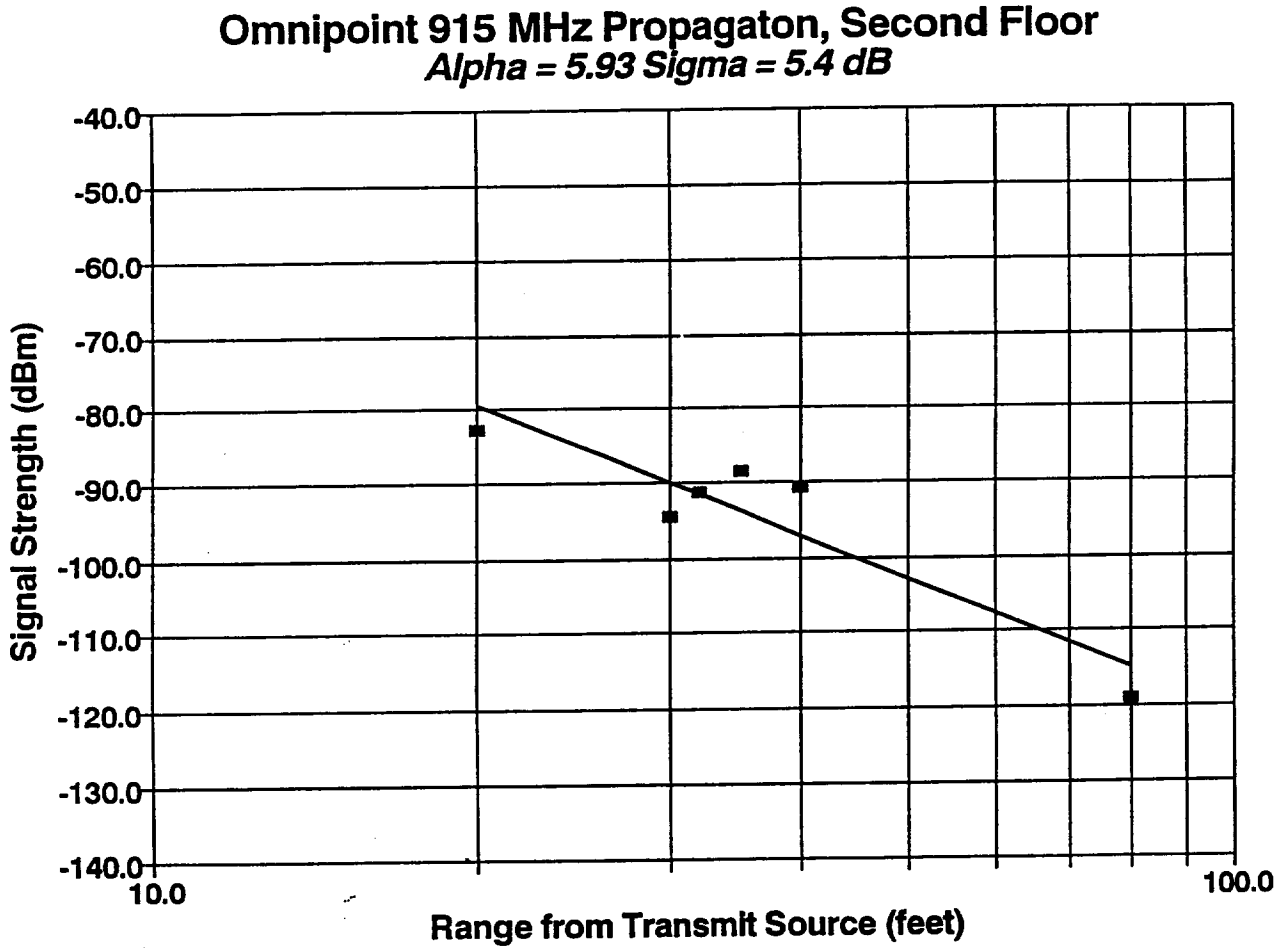

Omnipoint 915 MHz Propagaton, Second Floor
Alpha = 5.93 Sigma = 5.4 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
10.0
100.0
Range from Transmit Source (feet)

Figure 4.3-47

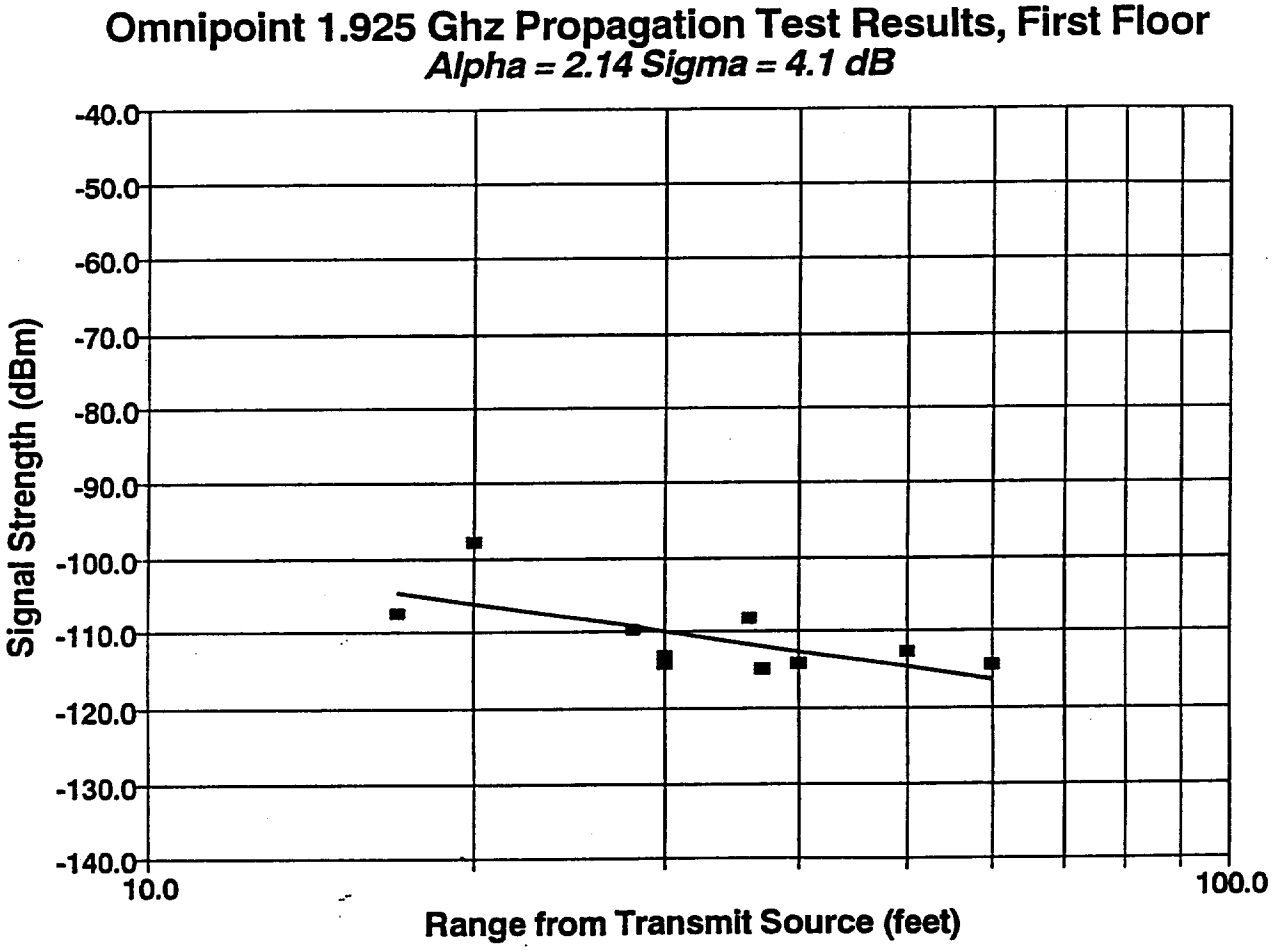

Omnipoint 1.925 Ghz Propagation Test Results, First Floor
Alpha = 2.14 Sigma = 4.1 dB
Signal Strength (dBm)
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
10.0
100.0
Range from Transmit Source (feet)

Figure 4.3-48

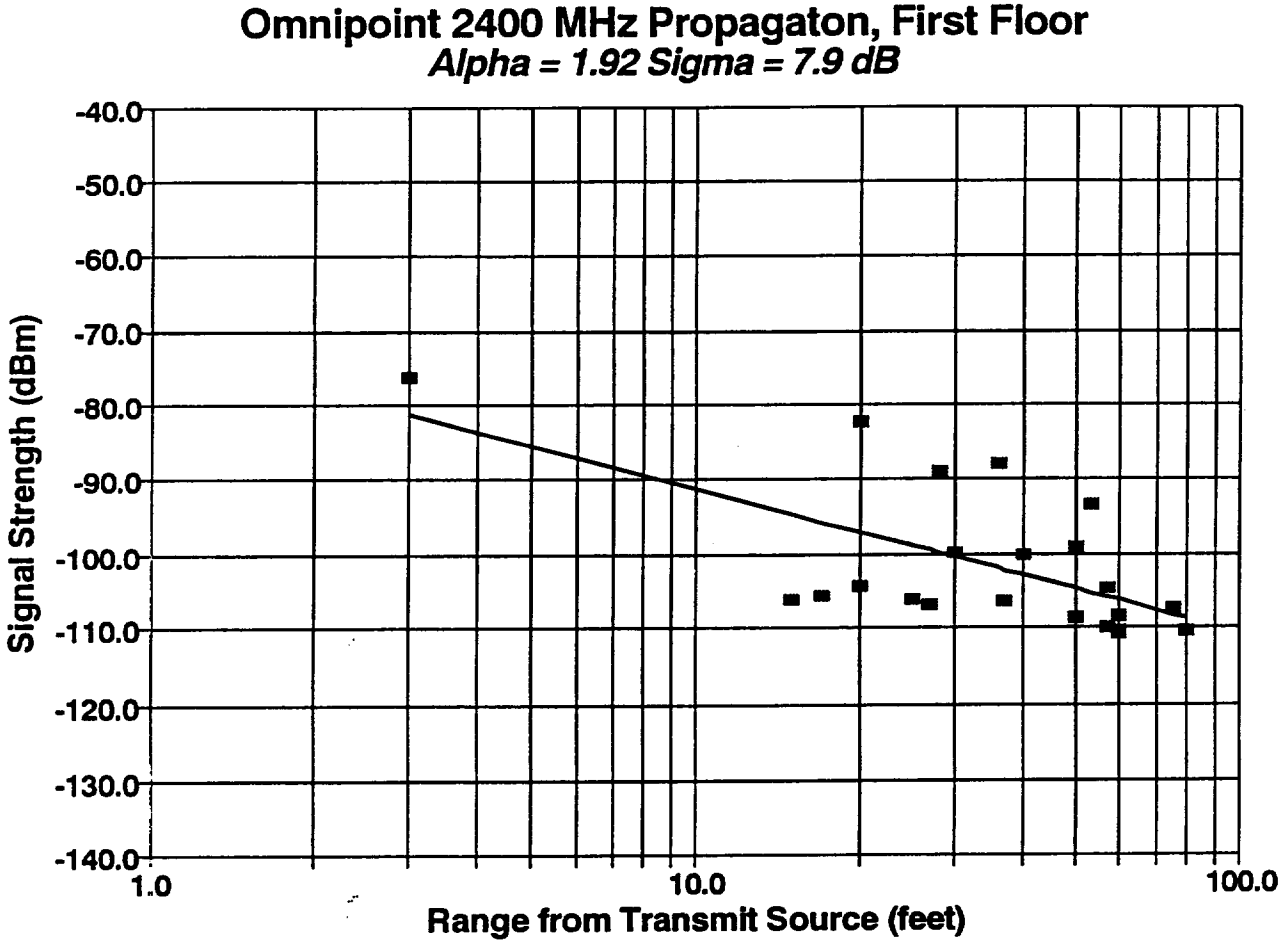

Omnipoint 2400 MHz Propagaton, First Floor
Alpha = 1.92 Sigma = 7.9 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
1.0
10.0
100.0
Range from Transmit Source (feet)

Figure 4.3-49

applications beyond indoor PCS require outdoor functionality, and Omnipoint hardware fulfills these requirements. The Omnipoint system has been tested at myriad sites, with details on three included here.

4.3.2.1 Campus Environments

Much has been said about the need to provide wireless service in large campus office facilities in order to accommodate the need for employees to roam between any number of buildings. Omnipoint has concentrated significant effort in studying this problem in order to understand radio effects in semi-open sites like these. Two studies are detailed here where different sites at the same facility were selected.

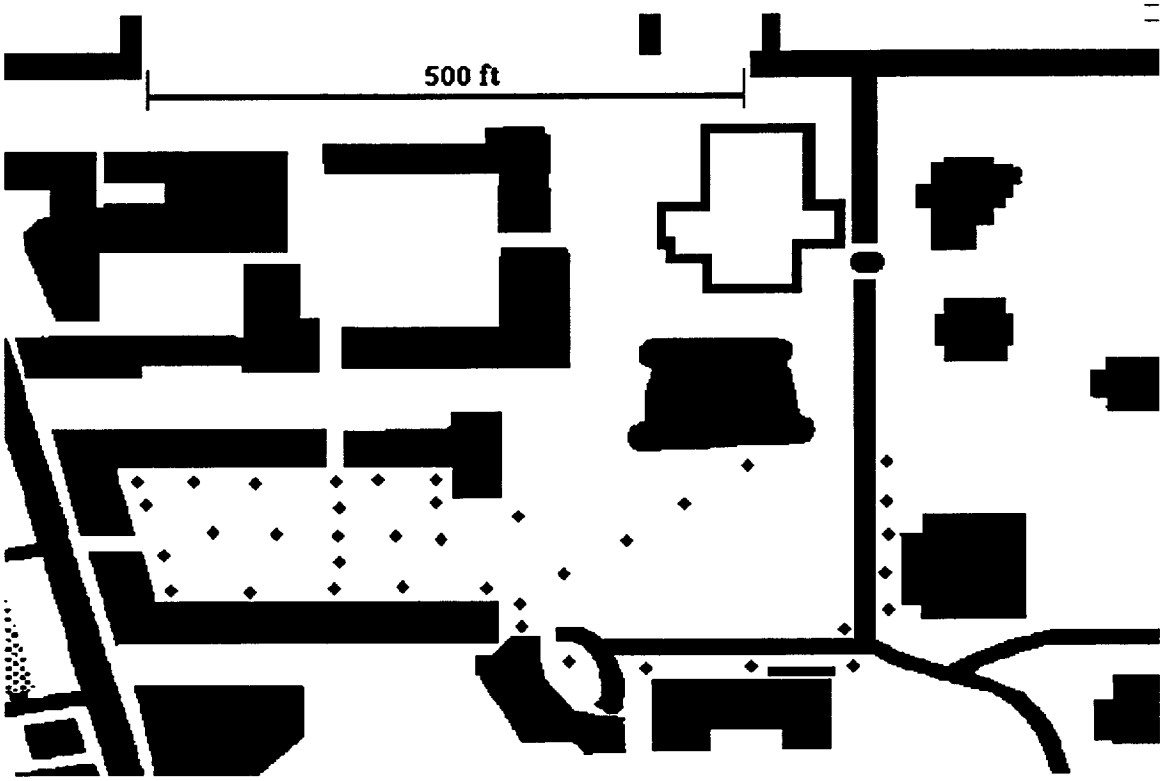
4.3.2.1.1 - Campus Site 1

The base station was mounted on the roof of a two story structure with the antennas mounted at approximately 25 feet from the ground, separated horizontally by 20 feet, aimed downwards and radiating primarily into the courtyard created by the building. Figure 4.3-50 shows the plot points taken in the test, and Figure 4.3-51 details the coverage zone at GOS1 and GOS2 levels. This site was somewhat open compared to Site 2, with two, three, and four story structures scattered about the building housing the base station.

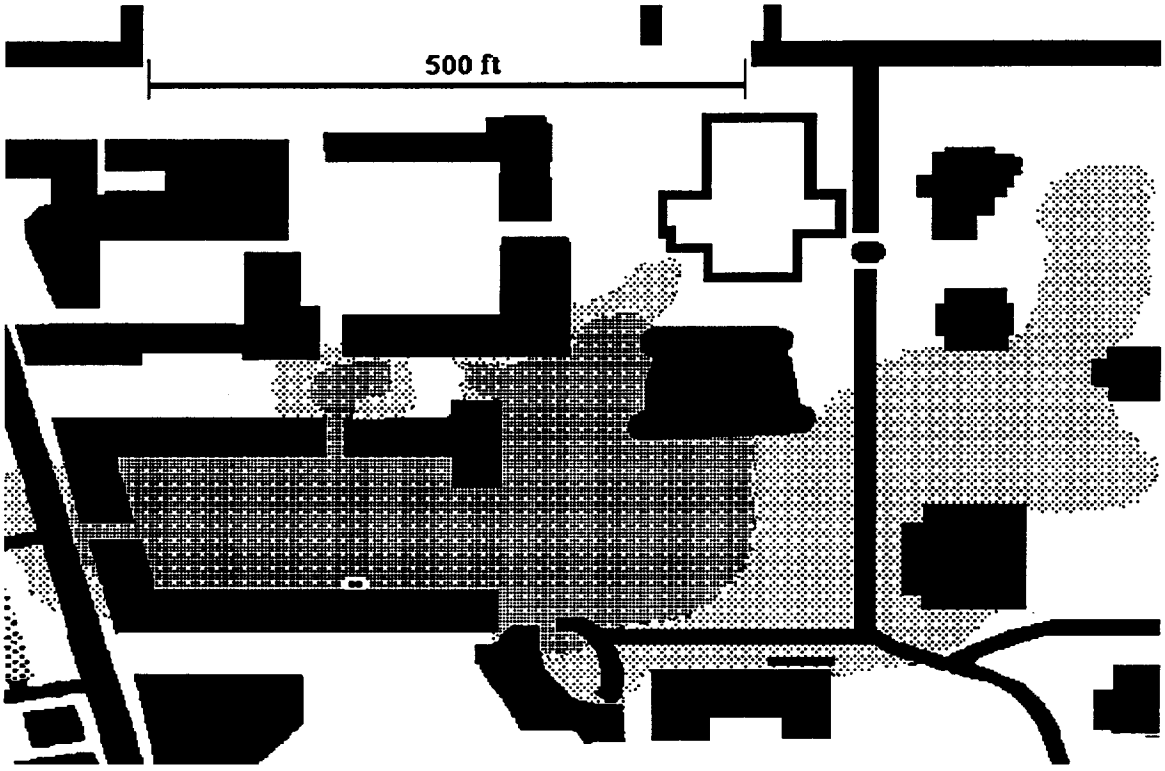
It can be seen in Figure 4.3-51 that GOS levels of at least 2 are supplied at ranges of up to 600 feet in a non-line of sight environment. Figure 4.3-52 show the raw data points as well as the results of our least squares regression analysis for each site. RMS propagation coefficient and standard deviation is also indicated on each figure.

4.3.2.1.2 - Campus Site 2

The installation building for Campus Site 2 is a three story structure with a fourth attic level. The base station antennas were mounted approximately 35 feet



Campus Site No. 1
Test Points
Figure 4.3-50



Campus Site No. 1
Coverage Plot
Figure 4.3-51

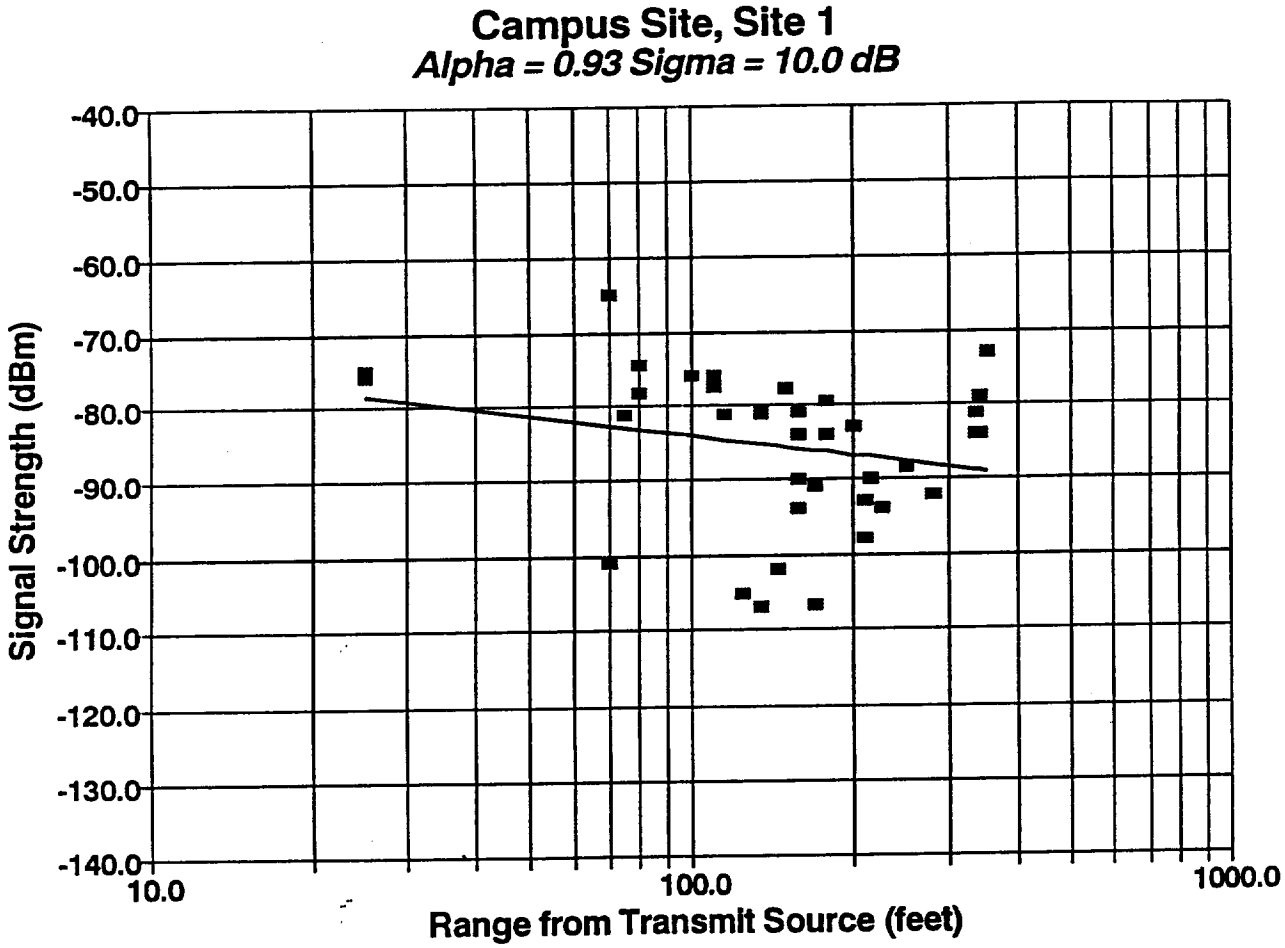

Campus Site, Site 1
Alpha = 0.93 Sigma = 10.0 dB
-40.0
-50.0
-60.0
-70.0
-80.0
-90.0
-100.0
-110.0
-120.0
-130.0
-140.0
Signal Strength (dBm)
10.0
100.0
1000.0
Range from Transmit Source (feet)

Figure 4.3-52