



# **Resource Review and Design Recommendations**

## **Public Safety Communications System Assessment and Design**

Broome County, New York

Report

June 28, 2012



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- Appendix A - Broome County VHF High-Band Frequency Search**
- Appendix B - Broome County UHF Frequency Search**
- Appendix C - Microwave Connectivity**



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## **1 Overview**

This report contains resource findings as well as design recommendations for the future Broome County radio system based on the recommendation during the review of required enhancements. The report first focuses on reviewing the key resources; spectrum sites and interconnects, available. The report also reviews the different solutions, given the resources available and the required enhancements. The system proposed will provide Broome County with a public safety radio system that will meet its future operational needs.



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## **2 System Design**

### **2.1 Overview**

In the previous report, Blue Wing reviewed the system design options. Blue Wing has provided recommendations for the system to achieve the operational enhancements desired. The recommendations below provide a brief summary of the system enhancement review found in the Operational Enhancement Report.

### **2.2 Systems**

#### **2.2.1 Voice**

For the voice system, based the desired channels required, the upgrade plans focus around providing UHF Project 25 Phase 1 voice system. Project 25 trunked is a full-featured technology and provides the features required operationally by the County. First and most importantly, Project 25 trunking is the only technology can provide the talk paths required with the number of channels available to the County. Project 25 provides robust security and a full feature set. Most of the data capabilities of Project 25 are dated and, in general, commercial services provide a much better option. The Project 25 trunked solution is available with linear transmitters that allow the transmitter sites to be spaced 12-15 miles apart. The only significant downfall of the technology is that Project 25 trunked is the least competitive marketplace and has the highest priced radio infrastructure and subscriber equipment. Project 25 does allow the County to be eligible for grants.

#### **2.2.2 Data**

In the last 10 years, almost all public safety agencies have migrated to the commercial cellular/PCS air card for wide area data operations. A number of agencies use local controlled hot spots to provide Wi-Fi connectivity. Data was not reviewed beyond the recommendation to use commercial and localized Wi-Fi services.

#### **2.2.3 Paging**

For paging, Blue Wing feels the County should take a strong look at an alphanumeric paging system. Blue Wing understands the institutional preference to tone/voice paging, but feels careful consideration should be given to alphanumeric paging.



### 2.3 Enhanced System Feature Sets

The County has evaluated the use of Project 25 features including UID, emergency, text and status messaging, and AVL. It is recommended that the basic data capabilities of P25 not be implemented because of poor functionality and cost. The desired features by service group are indicated in the right side columns.

System Features and Service Requirement	Analog Conventional Features	Digital Project 25 Features	Broome Law Enforcement	Broome Fire	Broome EMS
Caller Recognition					
Unit ID (UID)	Yes	Yes	Yes	Yes	Yes
Emergency	Yes	Yes	Yes	Yes	Yes
Caller Location					
AVL	No	Yes	Yes	No	Yes
Messaging					
Status Messaging	Yes	Yes	No	No	No
Text Messaging	No	Yes	No	No	No
Security					
Voice Security					
Encryption	No	Yes	Yes	No	No
Scrambling	Yes	No	No	No	No
Data					
19.2K Data	No	Yes	No	No	No
Broadband Data Applications	No	No	Yes	No	Yes

Table 2-1: Enhanced System Feature Sets

### 2.4 Talk Paths

Blue Wing has worked with the County and created detailed talk path plans. These plans provide the basis for communications response. They are based on the current best practices in which all users remain on the communications channel until directed to another channel by the dispatcher. The talk path plans provide deterministic method for assigning resources for a response. This area of change generally causes the greatest area of change and resistance for the end-users. The table below outlines the County's needs. The following outline the number of talk paths required to support the communications plans above. Based on these requirements the system could not be supported via conventional channels and would be required to implement a trunked system to meet the requirements.



Group	Repeater	Simplex
Law Enforcement		
Communications	4	
Administration	3	
Tactical	3	
Ground		2
Fire/EMS		
Paging	1	
Communications	3	
Tactical	5	
Ground		5
Total	19	9

Table 2-2: Talk Path Requirements

## 2.5 Interoperability Solutions

Blue Wing recommends the use of the National Interoperability Channels. All radios should be programmed with the channels. Only the Calling channels are recommended to be installed at the sites. The County should initially choose its top 3-5 sites in which to install the repeater channels. It is recommended that all three bands VHF, UHF and 800 MHz calling channels are installed.

The County should include the ability to interconnect one or more direct communications talk paths to the bordering county dispatch centers. This would include between the Broome County PSAP in Binghamton and with other PSAPs in adjacent counties. This would greatly enhance the ability to cross patch multiple County communications talk paths and allow for efficient handling and transfer of border incidents. The use of 45.88 MHz should be preserved as the frequency is used commonly throughout New York State.





## 3 Spectrum

### 3.1 Spectrum Status

Blue Wing reviewed spectrum bands for use for the County radio system. The major factors in band selection were propagation performance and spectrum availability. The spectrum bands reviewed were VHF high-band and UHF. VHF low-band and 800 MHz were not the preliminary focus of the study because of interference and propagation characteristics.

#### 3.1.1 VHF Low-Band

VHF low-band was eliminated for numerous reasons. The most important reason is the continued and growing noise floor in VHF-low band. VHF low-band is affected from many localized noise sources such as AC conversion and various RF mixing devices. These non-predictable noise sources have increased over the years and make the band a poor performing spectrum today with degrading performance in the future. In addition, VHF low-band does not have a digital roadmap; it will most likely remain analog and will not be eligible for federal grants. The feature set provided for VHF low-band band will remain limited and will not provide the features desired by the County. VHF low-band, although providing very good mobile coverage, works poorly in the portable environment both wide area and in-building. VHF low-band provides interoperability with numerous Counties in New York that surround Broome County. However, this environment is changing and over the next 1-3 years the majority of the surrounding counties will have migrated from VHF low-band.

#### 3.1.2 VHF High-band

VHF high-band is one of the two preferred bands for the County system. The propagation characteristics are the most favorable in the County's hilly terrain. VHF high-band also has a Project 25 offering, and there are numerous federal, state and surrounding County agencies that operate at VHF high-band. VHF high-band is unfortunately the most difficult to license because of congestion and given the number of channels required for the County it would not be possible to operate the system with a VHF high-band solution. VHF high-band would be the preferred frequency to operate paging from because of its favorable propagation characteristics in hilly terrain.

#### 3.1.3 UHF Band

The UHF band is also one of the preferred bands for the County system. The propagation characteristics are slightly less favorable than VHF high-band, but



still better than 800 MHz. The UHF band also has a Project 25 offering, and there are numerous counties in the region are using or will be migrating to UHF. The UHF band is slightly easier to license than VHF-high band, but it's still a challenging band.

#### **3.1.4 800 MHz**

The 800 MHz band was not seriously considered as a solution because of the poor propagation characteristics in terrain such as Broome County.

### **3.2 New Spectrum Availability**

Blue Wing completed an extensive review of the frequencies in Broome County. Blue Wing reviewed the VHF high-band, UHF and 800 MHz spectrum.

#### **3.2.1 VHF High-band**

After a review of the VHF high-band spectrum, it was found that there was no additional VHF spectrum that could operate throughout the County to allow the County to operate a wide-area simulcast system. Blue Wing does recommend the County try to license the currently used VHF high-band frequency for Western Broome Fire as a potentially county-wide frequency for paging. The results are found in Appendix A.

#### **3.2.2 UHF**

It was found that there was UHF spectrum available through two sources. The first source was FCC Part 90 public safety spectrum and the second source was through the purchase of FCC Part 22 paging spectrum. The procurement of FCC Part 22 paging spectrum has been also completed with other counties in the area such as Cortland County, Madison County and Onondaga County. Blue Wing has begun the preliminary licensing of the FCC Part 90 public safety spectrum and has done the preliminary negotiations with the various spectrum holders for the FCC Part 22 paging spectrum. It is recommended that before Broome County proceed with creating an RFP that there is a clear method to determining and ensuring that the UHF spectrum required for the system is available. The results are found in Appendix B and C with the total 11 wide-area frequencies and one mobile only frequency. The costs for the frequencies which are Part 22 are still under discussion. The frequencies available via the findings would be sufficient for the UHF plan. A repeater pair may needed to provide additional mobile only frequencies to support ground operations.



Pending FCC Frequencies	Status	Comment
453/458.4000	Pending 06/2012	Presently licensed at certain sites.
453/458.7250	Pending 12/2011	Presently licensed at certain sites.
453/458.8375	Pending 06/2012	New license.
453/458.8750	Pending 06/2012	Presently licensed at certain sites.
460/465.2875	Pending 12/2011	New license.
465.2625, Mobile Only	Pending 12/2011	New license.
454.3000	Pending	EA Licensed
454.4250	Pending	EA Licensed
454.4750	Pending	EA Licensed
454.5250	Pending	EA Licensed
454.5750	Pending	EA Licensed
460.2875	Pending	EA Licensed

Table 3-1: UHF Potential Frequency List

**3.2.3 800 MHz**

800 MHz spectrum was not reviewed because of the number of sites required to provide the required coverage.



## 4 Sites

### 4.1 Existing Sites

Blue Wing inventoried the County's and existing tower sites in and adjacent to Broome County for possible collocation. Blue Wing reviewed the tower sites to determine the risks associated with the various tower site solutions. In general, unless there was a significant coverage issue which only a specific site could address, Blue Wing focused on locating towers in areas in which towers already existed or would in preliminary review not cause significant impact to the community. Blue Wing attempted to utilize existing infrastructure as much as possible to reduce the time and cost of implementing the new system. If a new site was required, Blue Wing attempt to place the sites on Broome County land and/or other friendly sites as identified with Broome County. However, in general, there were very few situations in which the County land was located in close proximity. In addition, because cost and flexibility in managing RF resources, it was determined that if possible the County would own all the sites and tower resources. In determining the propagation required for the County, Blue Wing attempted to use as few as sites as possible to provide the propagation required. During the pre-RFP preparation, Blue Wing will work closely with Broome County to determine the best candidate sites to ensure an expedient zoning process. Blue Wing highly recommends beginning the site acquisition phase of the project before letting the RFP to ensure the majority of the sites and the system design remain constant.

The figure below contains a pictorial representation of existing Broome County tower locations

The location of the towers is shown below. Towers are not labeled for clarity. Multiple towers may exist in close proximity to each other rendering the map unreadable. The details of the sites are found in the supporting Excel documents and are best reviewed via ArcMap as needed.



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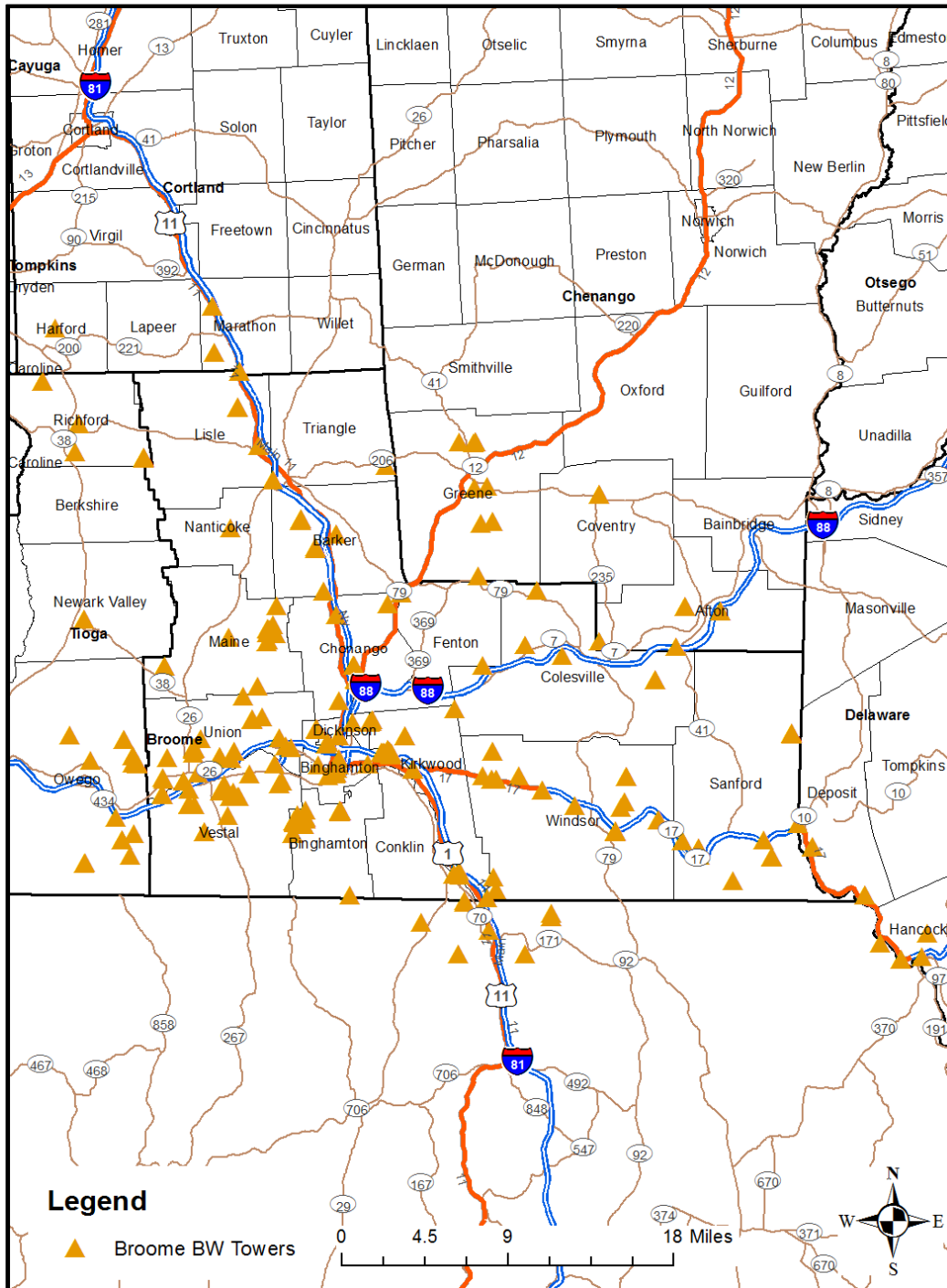


Figure 4-1: Broome County - Tower Locations



## 5 Coverage

### 5.1 Goals

Two-way voice communications shall support the effective two-way communications between mobile vehicular units and the communications center. The wide area two-voice signal shall be simulcast from all towers at the same time, and the best received signal at the base station shall be chosen (voted) to be heard by the dispatchers. All of the design parameters were met or close to met by the design. In general, Blue Wing has found that the coverage predictions provide a conservative view of the coverage capabilities. The following are the design parameters for coverage in the Binghamton Metro Area and Broome County.

#### 5.1.1 Binghamton Metro Area

The coverage requirement for the Binghamton Metro area as defined by the contour below shall be 95% Portable On-street Coverage with 95% reliability. The required voice quality shall be DAQ of 3.4 or better.

#### 5.1.2 Greater Broome County

The coverage requirement for the greater Broome County area shall be 95% mobile coverage/90% portable coverage with 95% reliability. The required voice quality shall be DAQ of 3.4 or better.

### 5.2 Predictions

Propagation predictions for Broome County are created for a proposed trunked P25 Phase 1 UHF radio system. The sites, propagation parameters, and the propagation predictions for County area coverage are detailed in this document.

#### 5.2.1 System Sites

Propagation predictions for Broome County are created for a proposed P25 Phase 1 UHF radio system. The sites, propagation parameters, and the propagation predictions for County area coverage are detailed in this document.

The sites and parameters employed in the propagation predictions for the radio system are given in Table 5-1. Optional sites are denoted by "(O)". The coordinates for existing sites have been reviewed by Blue Wing for accuracy and antenna heights are estimates.



Site	Latitude (NAD83)	Longitude (NAD83)	Estimated Antenna Height (Feet)	Antenna	ERP (Watts)
Andrews Road	42-04-54.90	76-01-07.20	90	Omni	100
Deposit	42-04-00.60	75-27-16.00	180	Omni	100
Doraville	42-10-20.30	75-34-27.50	148	Omni	100
Dunbar	42-06-49.50	75-44-38.60	180	Omni	100
Ely Park	42-07-09.70	75-55-10.20	50	Omni	100
Gulf Summit	42-01-39.70	75-30-47.90	180	Omni	100
Hawkins	42-12-24.70	75-45-43.50	180	Omni	100
Ingraham Hill	42-03-43.00	75-56-34.50	70	Omni	100
Kirkwood	42-02-40.00	75-48-00.00	90	Omni	100
Lester (O)	42-02-52.40	75-44-02.20	180	Omni	100
Lisle Park	42-23-05.60	76-01-06.70	164	Omni	100
Maine	42-12-09.10	76-01-36.50	148	Omni	100
N. Sanford	42-07-44.90	75-25-46.20	180	Omni	100
Old State Road	42-08-11.10	75-52-33.20	100	Omni	100
Pease Hill	42-17-49.00	75-57-02.00	180	Omni	100
Popple Hill	42-20-36.90	76-07-03.90	180	Directional	100
Port Crane (O)	42-10-21.00	75-50-52.00	30	Omni	100
Round Top	42-05-21.10	76-04-16.10	60	Omni	100
Sanford	42-08-05.50	75-30-31.60	180	Omni	100
Tuscarora (O)	42-03-43.00	75-34-12.00	180	Omni	100
Union	42-09-00.70	76-02-07.20	80	Omni	100
Vestal	42-00-08.50	76-02-00.20	180	Omni	100
Vestal (O)	42-02-59.00	76-02-53.00	164	Omni	100
Windsor	42-04-33.00	75-36-20.70	180	Omni	100
911 Center	42-07-55.50	75-54-59.90	90	Omni	100

Table 5-1: Sites and Parameters

### 5.2.2 UHF Propagation Predictions

The major UHF propagation parameters employed are given in Table 5-2.

Parameter	Value
Propagation Model	Longley-Rice v1.2.2
Mode	Mobile
Location, Time, Situation	50%
Land Use Land Clutter	TSB-88
Study Point Spacing	~300 Feet
Technology	P25 Phase 1 Linear Simulcast



Parameter	Value
Mobile Antenna Height	2 Meters
Mobile Antenna System Gain	-1.2 dB
Delivered Audio Quality (DAQ)	3.4
Reliability	95%
Mobile Area Study Type	Received power at remote (Talk Out)
Mobile Faded Signal Level Threshold (Talk Out)	-109 dBm
Mobile Confidence Margin 1	8 dB
Capture Ratio	10 dB
Delay Spread	66 μsec
Portable Area Study Types	Received power at best base from remote (Talk In)
Portable Antenna Height (Talk In)	1.8 Meter
Portable Antenna Loss (Talk In)	-6.1 dBd
Portable Transmit Power	3 Watts
Base Station Receive System Gain	2.4 dB
Portable Confidence Margin 1	4 dB

Table 5-2: UHF Propagation Parameters

### 5.2.3 UHF Mobile Propagation Plots

The simulcast propagation plots for mobile talk out operations for the UHF radio system are shown in the Figures that follow. Coverage percentages for the County are given in Table 5-3.

Operation	Area Coverage (%)
Mobile Talk Out	98.4
Talk Out (TDI)	1.7

Table 5-3: Mobile Talk Out County Area Coverage Percentage

In the Figures sites that are transmitting are shown in yellow. Received signals levels > -109 dBm are shown in blue, and areas of non-capture with a delay spread > 66 μsec are shown as red (which looks purple when overlaid on areas of blue).

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1 Confidence margin includes reliability, environmental noise, antenna system, and miscellaneous adjustments.



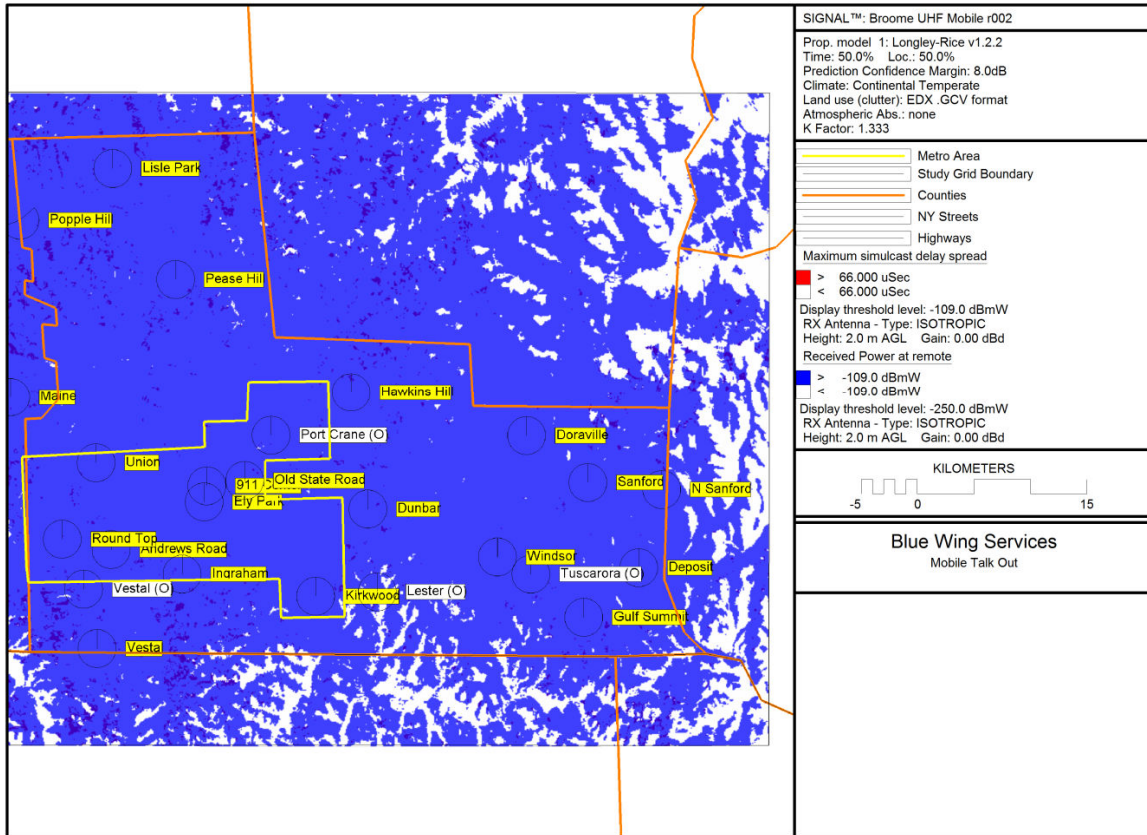


Figure 5-1: Mobile Talk Out County Coverage

The following Figure is a close-up view of the area around Binghamton known as the Metro Area.

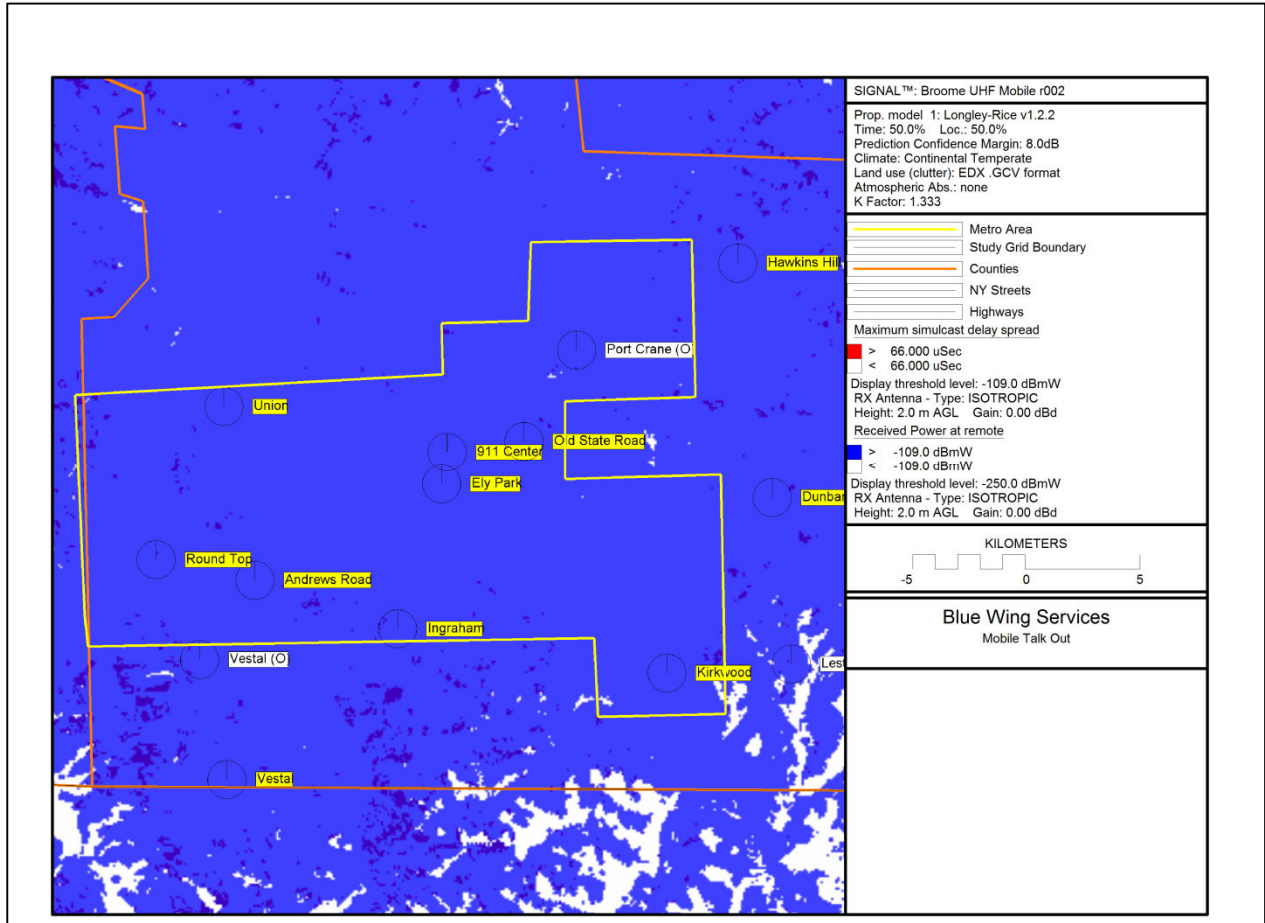


Figure 5-2: Mobile Talk Out Metro Area

### 5.2.4 Portable Coverage

The propagation plots for portable talk in (weakest communication path) operations are shown in the Figures that follow. Sites that are transmitting are shown in yellow. Coverage percentages for the County are given in Table 5-4.

Operation	Area Coverage (%)
Portable Talk In With Optional Sites	87.1
Portable Talk In Without Optional Sites	83.4

Table 5-4: Portable Talk In County Area Coverage Percentage



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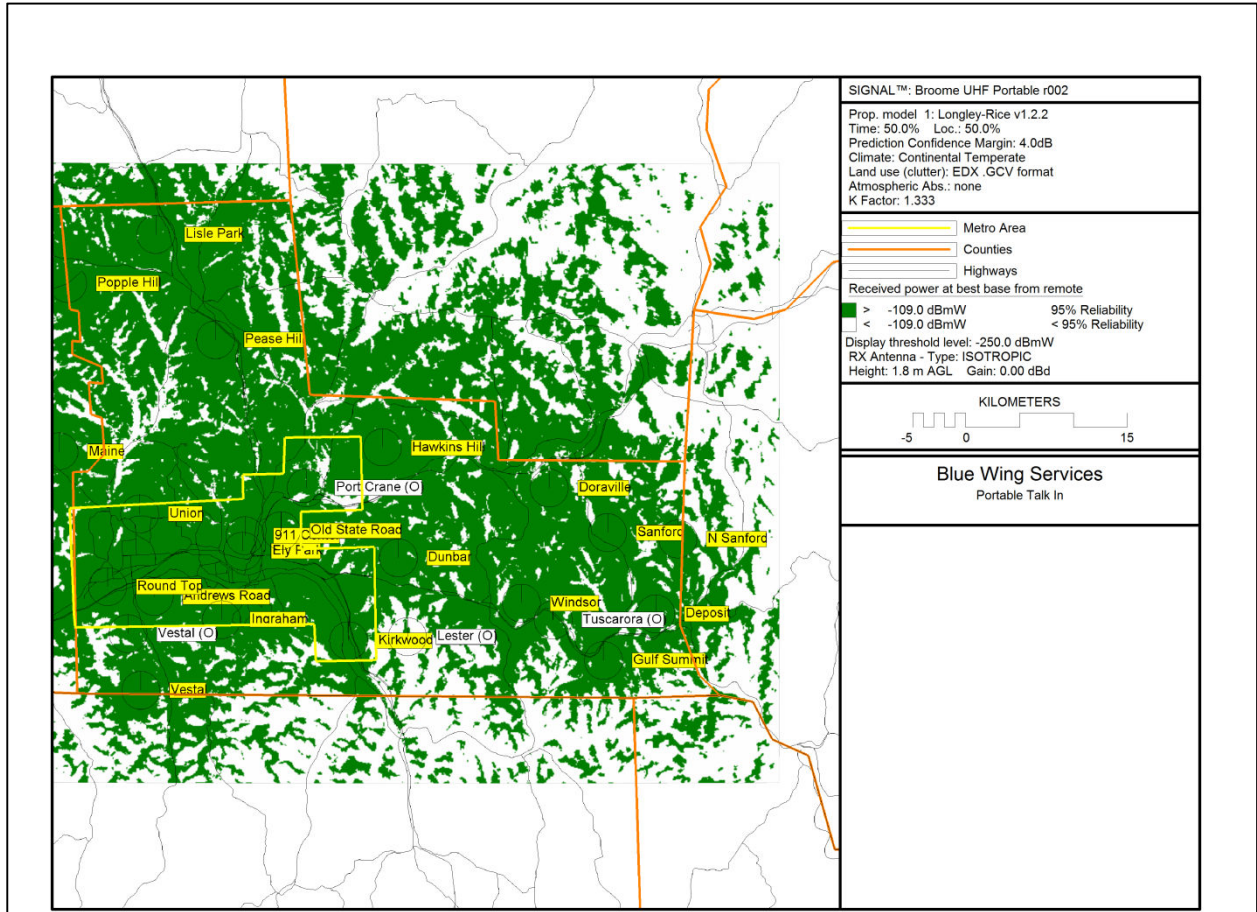


Figure 5-3: Portable Talk In County Coverage Without Optional Sites

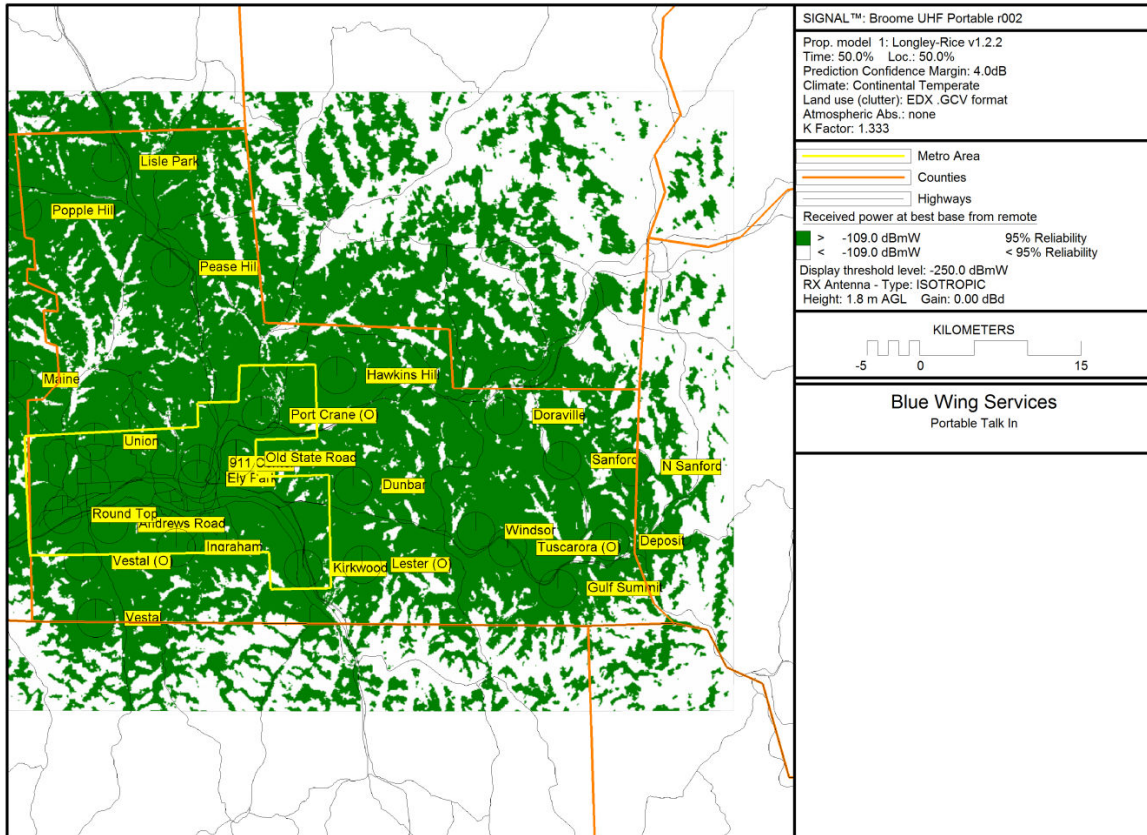


Figure 5-4: Portable Talk In County Coverage With Optional Sites

### 5.2.5 Portable Coverage Metro Area

An area around Binghamton has been identified as requiring 95% portable in street coverage. The area is known as the Metro Area and shown in Figure 5-5.

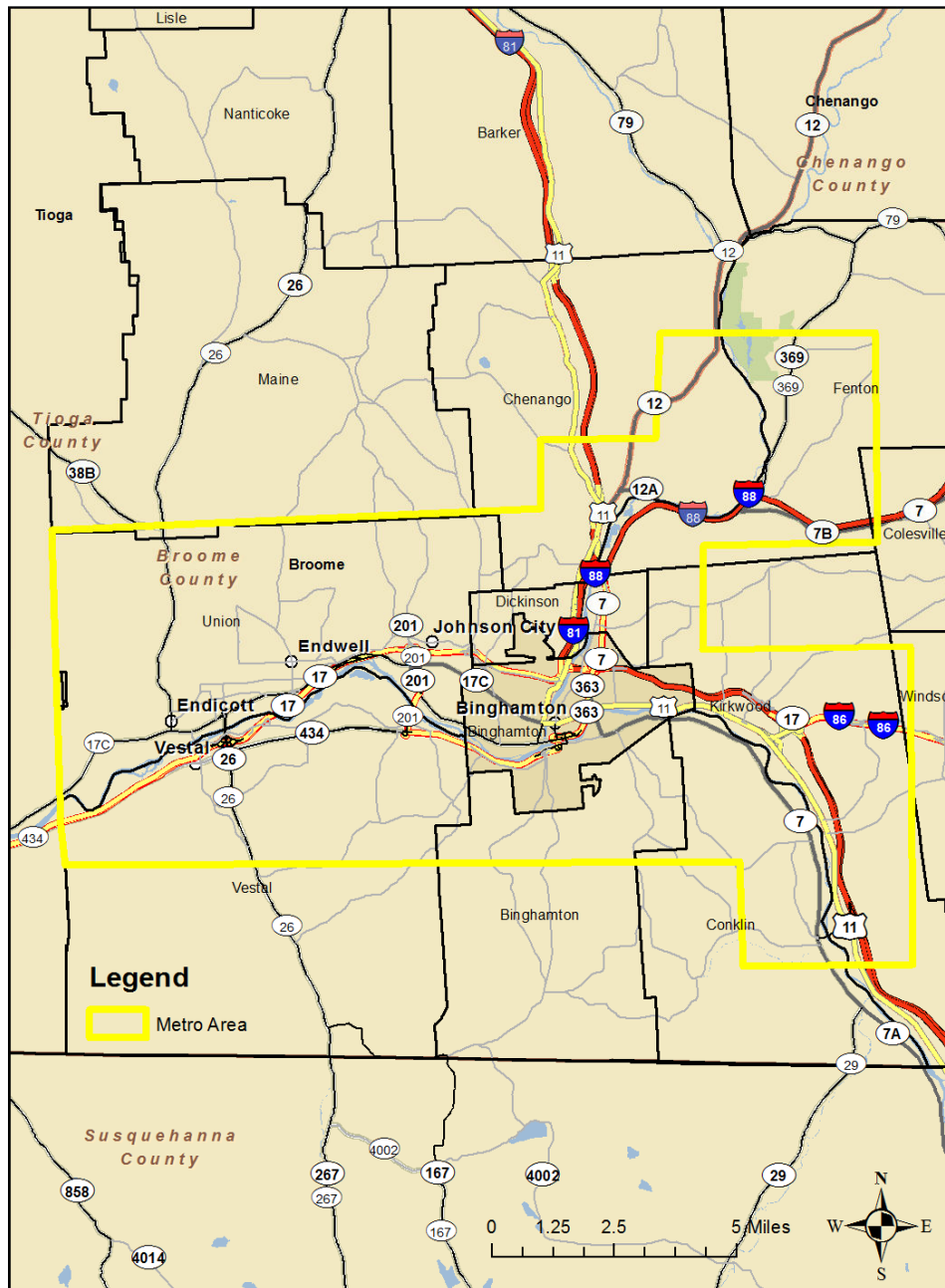


Figure 5-5: Broome Metro Area

The propagation plots for portable talk in (weakest communication path) are shown in the Figures that follow. Sites that are transmitting are shown in yellow. Coverage percentages for the Metro Area are given in Table 5-5.

Operation	Area Coverage (%)
Talk In Without Optional Sites	94.1
Talk In With Optional Sites	96.4

Table 5-5: Portable Metro Area Coverage Percentage

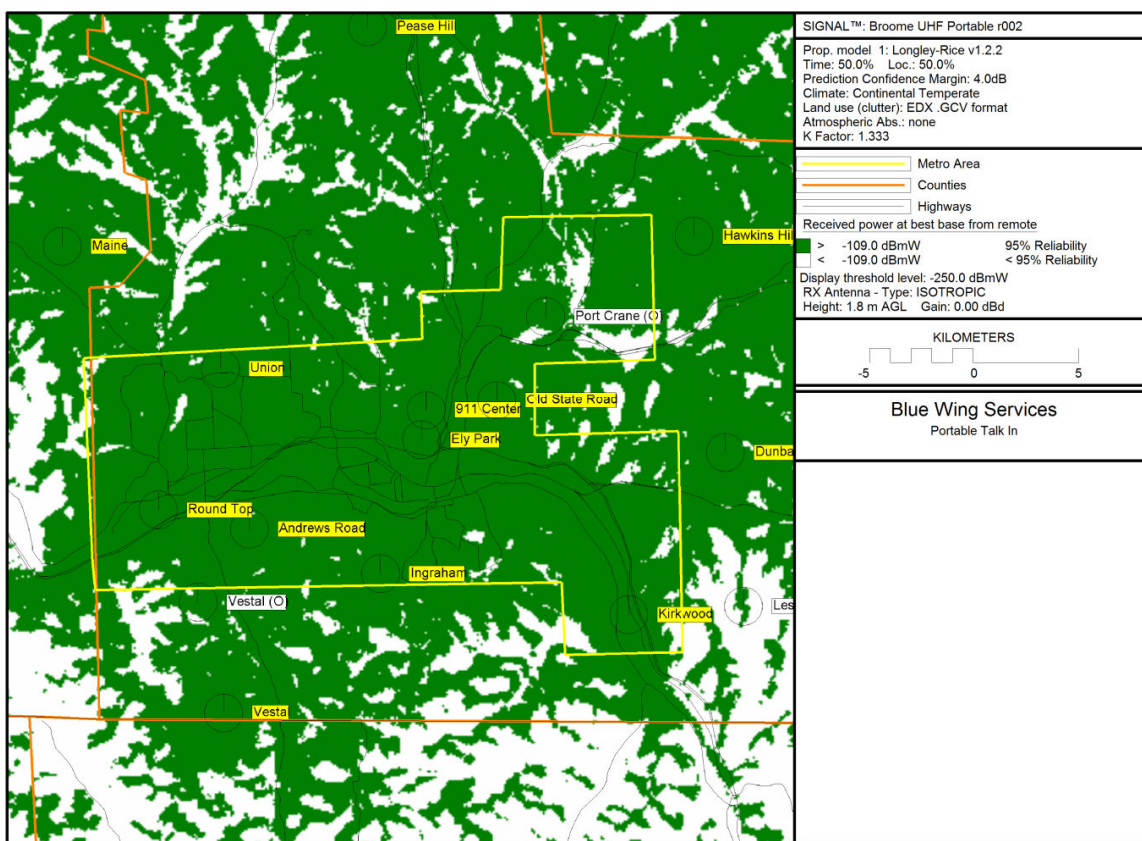


Figure 5-6: Portable Talk In Coverage Metro Area Without Optional Sites



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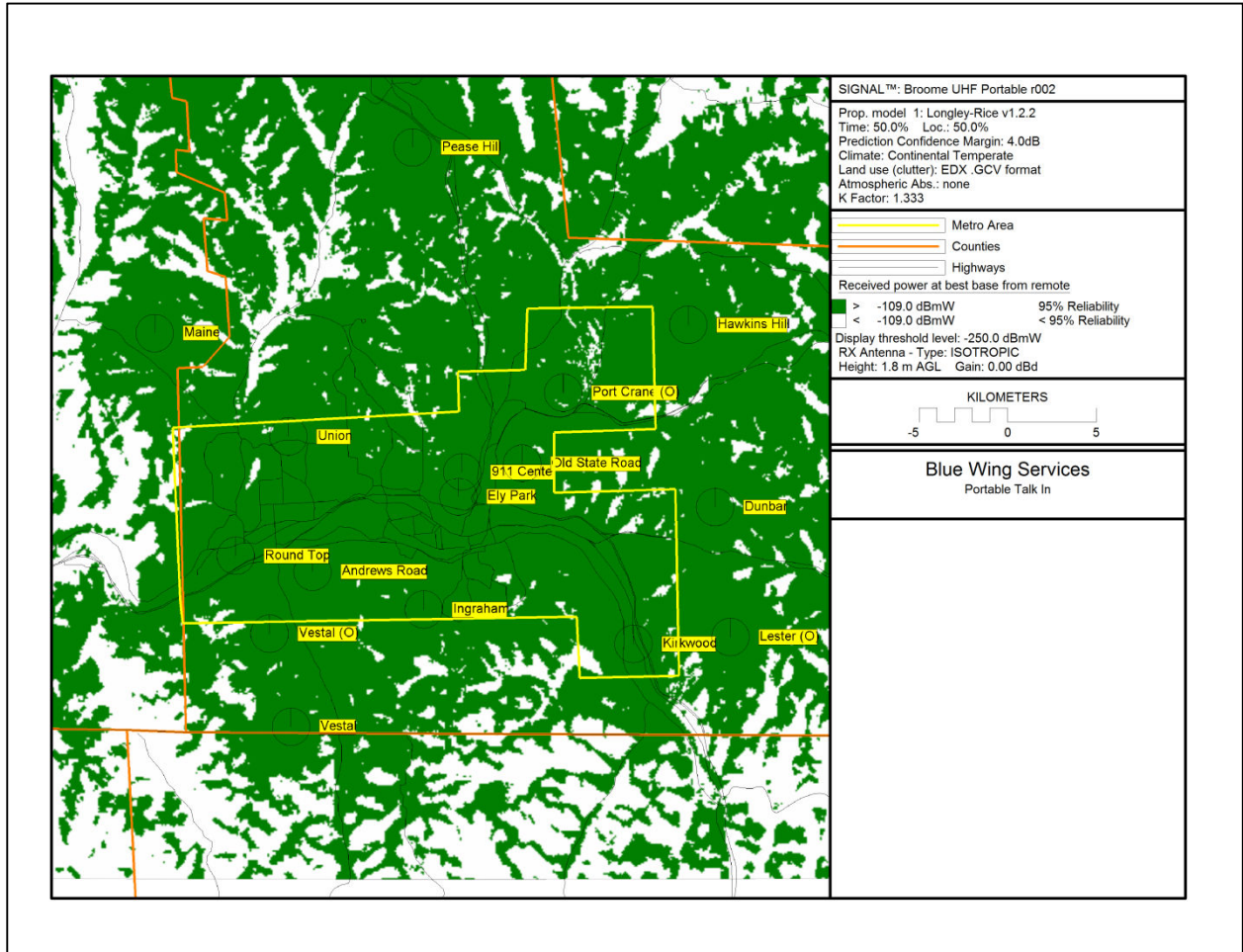


Figure 5-7: Portable Talk In Coverage Metro Area With Optional Sites



## **6 Interconnects**

### **6.1 Interconnect Opportunities**

Blue Wing reviewed the current County microwave system and potential County owned interconnects. Through this process, it was discovered that the current County microwave system although very useful for the current application would not be useable for the future radio system because of bandwidth and topology/design. In addition, no additional fiber and/or microwave were discovered that could be used for the future radio system. Therefore, a new MW system would need to be constructed to support the future radio system.

### **6.2 Interconnect Capabilities**

Blue Wing will determine capacity that would be required to connect the various sites. Blue Wing will work with Broome County to understand any additional needs that might be required, as well the possibilities of integrating into other initiatives or partnering with other governmental or commercial agencies. Blue Wing will provide the recommended system to be implemented and detail the bandwidth required, path analysis and equipment required. Blue Wing will work with Broome County to ensure all connection alternatives are reviewed including microwave and fiber.

Because the interconnect opportunities in the County were very limited, Blue Wing began by using the sites needed for radio coverage as a baseline for the required microwave sites. The methodology used to determine the microwave system design was to first investigate the individual paths between radio sites. The current band of choice to be used for the microwave is licensed 6 GHz which provides up to 150 Mb of data bandwidth and allows for distances from 20-25 miles between sites. Approximately, 1.44 kbps of bandwidth would be required between each site and the central site on the system. Blue Wing investigated all the potential paths between sites. Once it was determined what was the potential for each path, the microwave system plan was then developed. The preferred topology for the microwave system is a ring topology which eliminates the need for redundant radios and provides redundancy through a ring design that is able to operate in either direction allowing one path to be compromised and still maintaining connectivity to all the sites. To have all the sites on the ring was not possible, therefore, a number of sites will be required to be spurs to emanate from the ring. The microwave path plan and topology are shown in the figure below and the details of the MW paths are shown in Appendix C.





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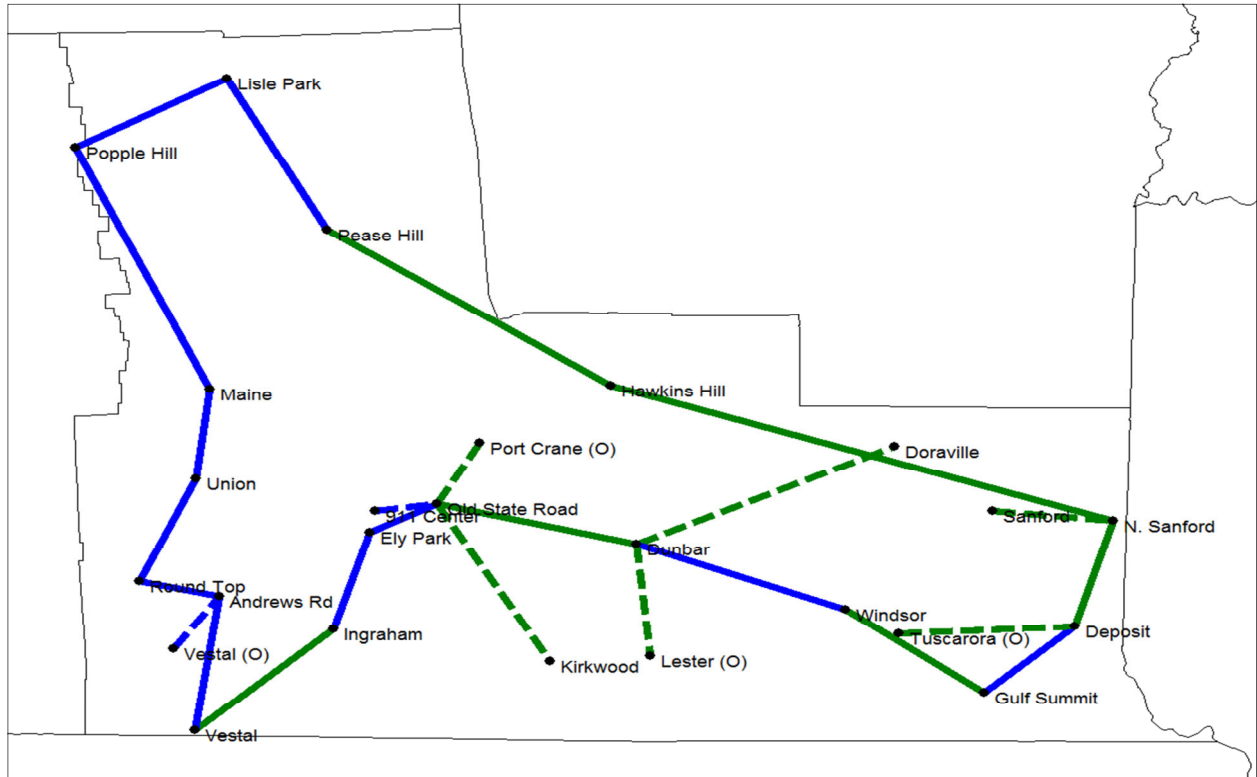


Figure 6-1: Broome County - MW Interconnect Plan



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## 7 Cost Estimates

There are many variables in system cost. The calculated costs for the systems were derived from the system designs based on the coverage predictions and potential sites. These costs could change based on numerous factors, including but not limited to, greater economic conditions, site locations, channel number, interconnect configuration and subscriber numbers.

Blue Wing prepared two costs estimates based on the implementation of optional sites. The cost could be further reduced by decreasing the coverage requirement within the County. This would reduce the number of sites and provide a saving of approximately \$1.1 million per site reduced. Other factors associated with the dispatch center or subscriber units would change very little with the reduction of sites. The reduction of sites provides the greatest reduction in cost.

The other cost that will provide a significant on-going cost is the increase in maintenance costs associated with the interconnect and radio system. This cost is a significant increase over the current maintenance cost associated the current system.

Items	Unit Cost	Units	Cost	Units	Cost
<b>Site</b>					
Building	\$ 100,000	21	\$ 2,100,000	25	\$ 2,500,000
Generator	\$ 30,000	21	\$ 630,000	25	\$ 750,000
Tower	\$ 150,000	21	\$ 3,150,000	25	\$ 3,750,000
Site	\$ 75,000	21	\$ 1,575,000	25	\$ 1,875,000
Total Site Cost			\$ 7,455,000		\$ 8,875,000
<b>Interconnects</b>					
6 GHz	\$ 200,000	23	\$ 4,600,000	27	\$ 5,400,000
Total Interconnect Cost			\$ 4,600,000		\$ 5,400,000
<b>Radio System</b>					
<b>Analog System</b>					
Non-simulcast Channel	\$ 25,000	20	\$ 500,000	20	\$ 500,000
Paging - Simulcast Channel	\$ 40,000	21	\$ 840,000	24	\$ 960,000
<b>Digital System</b>					
<b>Project 25 Trunked Simulcast</b>					
Console - Main	\$ 75,000	15	\$ 1,125,000	15	\$ 1,125,000
Console - Backup	\$ 75,000	15	\$ 1,125,000	15	\$ 1,125,000
Main Site - 10 Channels	\$ 2,000,000	1	\$ 2,000,000	1	\$ 2,000,000
Remote Site - 10 Channel	\$ 600,000	20	\$ 12,000,000	24	\$ 14,400,000



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Items	Unit Cost	Units	Cost	Units	Cost
<b>Interop System</b>					
National Interop	\$ 25,000	15	\$ 375,000	15	\$ 375,000
Total Radio System Cost			\$ 17,965,000		\$ 20,485,000
<b>End User Equipment Cost</b>					
Tone/Voice Pager	\$ 400	2500	\$ 1,000,000	2500	\$ 1,000,000
Alphanumeric Pager	\$ 175	0	\$ -	0	\$ -
Analog Conventional Radio	\$ 800	0	\$ -	0	\$ -
P25 Conventional Radio	\$ 2,000		\$ -	0	\$ -
P25 Trunked Radio	\$ 3,000	3000	\$ 9,000,000	3000	\$ 9,000,000
Total End User Equipment Cost			\$ 10,000,000		\$ 10,000,000
<b>Total System Cost</b>			<b>\$ 30,020,000</b>		<b>\$ 34,760,000</b>
<b>Total Cost</b>			<b>\$ 40,020,000</b>		<b>\$ 44,760,000</b>
<b>Yearly System Maintenance</b>			<b>\$ 1,796,500</b>		<b>\$ 2,048,500</b>

Table 7-1: Cost Estimates



## 8 Implementation Plan

The timeline for implementation of the upgrade of the County’s project is very dependent on the acquisition of the required spectrum and the acquisition and construction of sites. Therefore, the schedule below provides a high-level view of the rollout of the system. Blue Wing highly recommends that the County develop a clear spectrum strategy and have significant progress and clarity to the procurement and approval of sites before moving forward with interconnect and radio system RFP development and procurement.

In addition, Blue Wing recommends that the County procure the site equipment, interconnect equipment and radio system as three distinct processes to achieve the lowest cost and the least amount of design risk.

Activity	2012	2013	2014	2015
<b>Resource Allocation</b>				
Determine Frequency Plan	Fall			
Determine Final Site Plan	Fall			
<b>Final Design</b>				
Design Recommendations	Fall			
Implementation Schedule	Fall			
<b>Pre-Bid Specification Preparation</b>				
Site Approval	Fall	Wntr/Smr		
Spectrum Approval	Fall	Wntr/Sprg		
<b>Bid Specification Development</b>				
Site Development Bid Specification		Sprg/Smr		
Interconnect Bid Specification		Sprg/Smr		
Radio System Bid Specification		Sprg/Smr		
<b>System Procurement</b>				
Site Procurement		Smr/Fall		
Interconnect Procurement		Smr/Fall		
Radio System Procurement			Fall/Wntr	
<b>System Installation, Testing and Cutover</b>				
Site Implementation		Sprg/Fall	Wntr/Smr	
Interconnect Implementation		Fall	Wntr/Smr	
Radio System Implementation			Fall	Wntr/Sprg
Training				Summer
System Cutover				Summer

Table 8-1: Implimentation Timeline



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## **9 Conclusion**

In conclusion, Broome County currently has a significantly fragmented operations and system. To update and streamline the operations into on common system, there will be significant capital and on-going costs. Because of the talk path requirements, the County has very few options for a significant upgrade that would resolve the radio system issues with one centralized system. The buildout of this system will require 3 plus years. Fortunately, the County currently has spectrum possibilities with the UHF band. However, these spectrum opportunities have a limited window. The next potential spectrum choice will be the 800 MHz band which will require more sites and additional costs. Therefore, the County has limited to time to act on the spectrum available and develop its next generation system. Delays in action cause a significant increase in cost for the same performance in the future.



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Public Safety Communications System Assessment and Design

**Broome County, New York**

Resource Review and Design Recommendations

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## **Appendix A - Broome County VHF High-Band Frequency Search**



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## **Appendix B - Broome County UHF Frequency Search**



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## **Appendix C - Microwave Connectivity**