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Our Radio Systems Speak for Themselves.

Sumter County, Florida
Public Safety Radio Consulting Services
Conceptual Solutions Report

May 26, 2011

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1.0 Abstract

Tusa Consulting Services (TCS) II, LLC, a radio consulting firm experienced in the field of public safety radio communications, was retained by Sumter County, Florida, to provide consulting services associated with the development, design, procurement and award of a county-wide 800 MHz Project 25 (P25) radio communications system. TCS' contracted scope of services included an assessment of user agency needs and development of conceptual solutions and recommendations for a new interoperable radio communications configuration.

As is often the case with older public safety communication infrastructures, radio coverage and reliability needs within an agency's operational borders tend to expand in step with ongoing population and business growth. Some rural areas of the county have seen modest growth in both population and business over the past twenty years. Thus, it is not uncommon to find public safety agencies now searching for new ways to improve their radio coverage, reliability and capacity.

Additionally, federally sponsored interoperability initiatives and recent grant opportunities have been structured to favor the deployment of standards-based, spectrum efficient digital radio technologies. Thus, conceptual solutions to enhance the County's radio performance must be geared to support existing and future federal goals for interoperable public safety digital radio networks, while achieving user agency performance expectations.

The first significant step taken by TCS in the course of this enhancement project was its completion of user interview sessions with the County's key public safety user agencies. The purpose of conducted interview sessions was for TCS to gain a general understanding of agency mission roles as well as those operational and functional characteristics desired to support existing field and departmental operations. Interview questions and discussion topics focused on identification of coverage, capacity and reliability shortfalls within the existing infrastructure configuration. In addition, discussions focused on user equipment and vendor support. Finally, we investigated interoperability needs and potential agency expansions/changes whose scope could potentially impact coverage and capacity needs.

Second, our work's attention turns toward those specific technologies and configuration schemes that could offer potential improvements to current as well as future public safety operations. The subject matter contained in subsequent portions of this Report provides a general overview of technologies currently available as well as conceptual short and long term solutions. In those cases where an immediate low-cost and easily implemented corrective action was apparent to TCS personnel, such information is likewise included.

Additionally, within this Report we have included radio coverage predictions for the various conceptual solution alternatives, where appropriate, as well as rough order of magnitude costs estimates for each solution's implementation. By so doing, Sumter County can make informed decisions on how to best develop the County's current communication capabilities into a seamless, high-performance network.

Based on the information gathered during the needs assessment, the firm will develop design standards to be used during the procurement of a community-wide 800 MHz Digital Trunked (P25) radio system. These design standards cover the voice system requirements, mobile data sub-system

feasibility/requirements, coverage analysis, microwave path analysis, antenna configurations, site configurations and equipment specifications. The County's intent is to leverage existing and planned communication assets in a manner that facilitates a seamless, regional communications network supporting public safety professionals at all levels.

Whereas enhanced operability is a key component of this network's functional vision, the long term goal envisioned by this Report entails the integration of separate system components that facilitate seamless user roaming throughout the neighboring counties. That is, while the radio network would function and provide the user equivalency as a single communications "cloud", it in fact could be constructed of infrastructures and user equipment procured from multiple vendor sources. Each of these radio components would fully comply with APCO (The Association of Public-Safety Communications Officials) Project-25 standards. Compliance with Project-25 interoperability standards, both existing and as they continue to evolve, is key to preserving a competitive procurement environment and ensuring the network's ability to support large numbers of outside user radios in the event of a catastrophic natural or terrorist related incident.

While interoperability is an obvious goal of this investigative action, an often overlooked and underappreciated aspect of interoperable radio communications is the reliability, capacity and security of facilities used to integrate separate radio systems into one cohesive network. In commercial radio networks, infrastructure interconnectivity is usually accomplished through leased telephone T-1 or fiber circuits. Yet, these commercially available sources, while relatively low in both initial and operational costs, are often unreliable or disrupted in the immediate aftermath of weather related incidents such as, thunderstorms, tornadoes or hurricanes.

Fortunately, the decision makers for Sumter County recognized the critical importance of secure, reliable backhaul communications and embraced licensed microwave technology for the 800 MHz digital trunked (P25) simulcast radio communication system. This investigation continues that approach and suggests the potential of data networking between county facilities through the concept of enhanced, high-capacity microwave SONET ring connectivity.

In this Report, we discuss a scheme to provide for an enhanced, interoperable microwave transport subsystem vital to ensuring necessary connectivity between the County's various public safety radio systems. We also describe potential ways in which these capabilities can be leveraged and enhanced to support more users and can be structured into a single, comprehensive shared communications resource.

2.0 Existing Network Configuration

During the month of March, 2011, TCS performed an inspection of the sites containing critical infrastructure components. These inspections involved Sumter County's E911 Dispatch Center, six tower sites and the water tower in The Villages.

Sumter County operates an E911 system and a conventional UHF/VHF radio system. This system consists of a multiple towers and shelters, containing base stations and repeaters, throughout the County. Sumter County's public safety agencies currently operate on a mixture of VHF, UHF and 800 MHz frequencies which cause difficulty when communicating via radio across various jurisdictions. Paging is provided by wideband simplex VHF. Dispatch for the majority of agencies is handled by the Sheriff's Office with dispatch services for EMS being provided by Lake-Sumter EMS.

Within the County, 26 buildings have been identified as important for public safety communications, shown below:

Agency	Address	City	Zip	TYPE
The Villages Hospital	1451 El Camino Real	The Villages	32159	Hospital
Sumter County Courthouse	215 E. McCollum Avenue	Bushnell	33513	County
Service Center	7375 Powell Road	Wildwood	34785	County/Fire
Transit	229 E. Anderson Avenue	Bushnell	33513	County
Public Works Division	319 E. Anderson Avenue	Bushnell	33513	County
Animal Control	819 CR-529	Lake Panasoffkee	33538	County
Waste Management	835 CR-529	Lake Panasoffkee	33538	County
Station 11	324 E. Seminole Avenue	Bushnell	33513	Fire
Station 12/Webster PD	71 SE 1st Street	Webster	33597	Fire/PD
Station 14	87 West King's Hwy	Center Hill	33514	Fire
Station 15	1405 CR-526A	Sumterville	33585	Fire
Station 21	1488 CR-459	Lake Panasoffkee	33538	Fire
Station 28	12042 CR-684	Webster	33597	Fire
Station 29	7725 W. CR-476	Bushnell	33513	Fire
Station 31	227 Hall Street	Wildwood	34785	Fire
Station 32	4147 CR-466	Oxford	34484	Fire
Station 33	3290 CR-521	Wildwood	34785	Fire
Station 34	9641 CR-235	Royal	34785	Fire
Sumter County Sheriff's Office	1010 N. Main Street	Bushnell	33513	Sheriff
Lake Panasoffkee Annex (SO)	2027 North C-470	Lake Panasoffkee	33538	Sheriff
The Villages Annex (SO)	8033 East C-466	Lady Lake	32159	Sheriff
Wildwood Annex (SO)	362 Shopping Drive	Wildwood	34785	Sheriff
Wildwood PD	100 Huey Street	Wildwood	34785	PD
Bushnell PD	501 North Market Street	Bushnell	33513	PD
Center Hill PD	94 South Virginia Avenue	Center Hill	33514	PD
Coleman				PD

These agencies utilize two local communications shops to provide support for public safety and local government communications needs. Electronics & Communications Co. maintains the majority of Sumter County's agencies' VHF and UHF radio equipment. Tri-Co Communications maintains the VHF and 800 MHz radio equipment used in The Villages by Sumter County Fire Rescue.

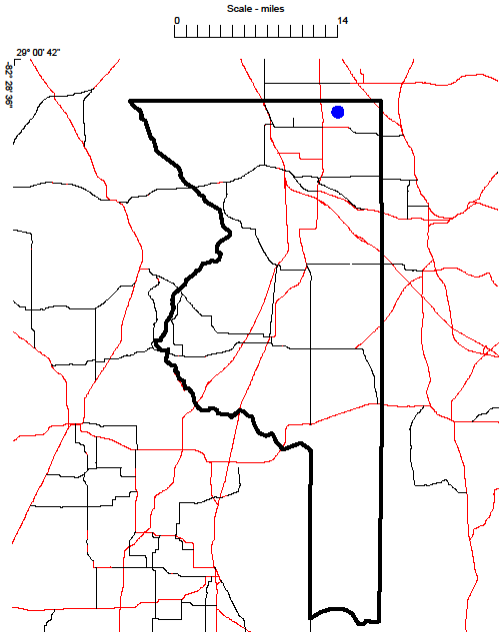
Electronics & Communication Co.
10800 US HWY 301, Dade City, Florida 33525
(352) 567-6146

Tri-Co Communications
5326 South Florida Avenue, Inverness, Florida 34450
(888) 726-7234

All Sumter County agencies, both public safety and non-public safety, acknowledge issues with radio propagation coverage. Of particular concern is the coverage problem in the north end of the county in the Villages area and along the Withlacoochee River. On the south end of the County, propagation is an issue in the Green Swamp, but traffic in this area is limited to a few instances a year per agency at the most. The lack of sufficient radio coverage in these areas could potentially inhibit disaster response with emphasis placed on the north end of the county because of higher population densities.

The Villages Tower

Lat: 28°56'45.42"N
Long: 82° 0'57.50"W
ASR #: N/A
AGL: ~200'
Site Elevation: 82'
Type: SST
Build Date: 10/2000
Owner: Private



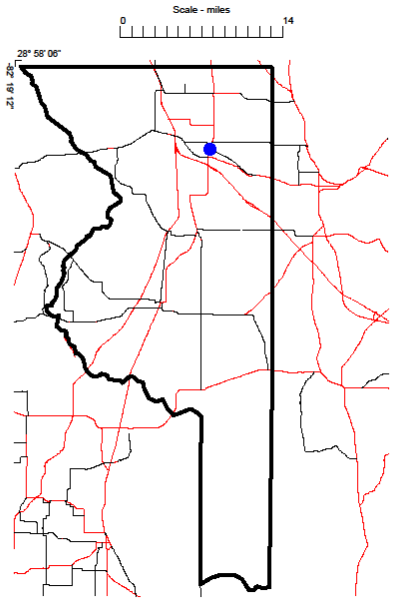
Resistance Measurements:

Tower leg	0.13 Ω
Ground bus	0.04 Ω
Generator	0.16 Ω

Antennas:
- M/W to Wildwood
- UHF/VHF
- Unused Yagi
- Cellular Sectors

Wildwood PD Tower

Lat: 28°51'23.13"N
Long: 82° 2'32.25"W
ASR #: 1030876
AGL: 197'
Site Elevation: 59'
Type: SST
Build Date: 08/1996
Owner: City of Wildwood



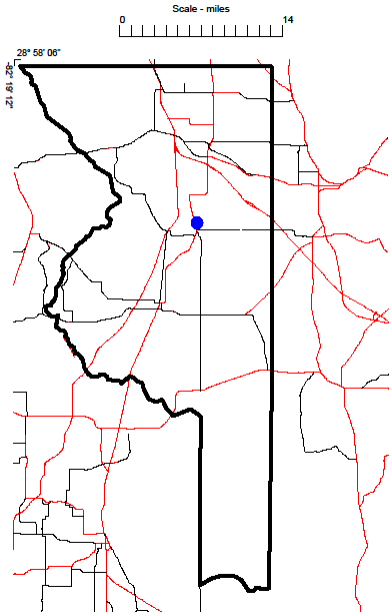
Resistance Measurements:

Tower leg	0.30 Ω
Shelter	0.20 Ω

Antennas:
- UHF/VHF
- Yagi
- M/W to Rutland
- M/W to Villages
- M/W to Sumterville
- M/W to Unk

Sumterville Tower

Lat: 28°45'50.84"N
Long: 82°03'36.26"W
ASR #: 1029186
AGL: 400'
Site Elevation: 58'
Type: Guyed
Build Date: 01/1982
Owner: Sumter Communications, Inc.



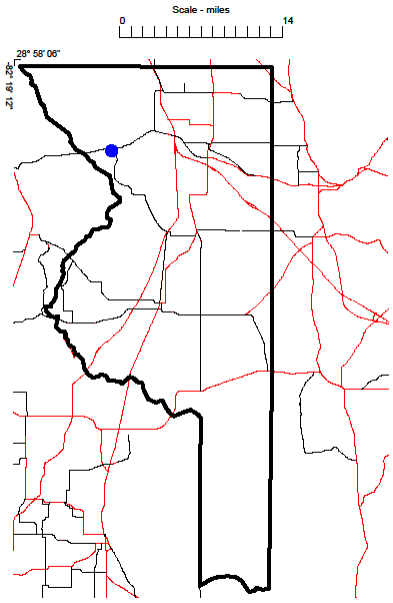
Resistance Measurements:

Tower base	0.30 Ω
Shelter	0.07 Ω

Antennas:
- UHF/VHF
- Yagi
- M/W to Rutland
- M/W to Villages
- M/W to Sumterville
- M/W to Unk

Rutland Tower

Lat: 28°51'17.06"N
Long: 82°10'52.87"W
ASR #: 1210877
AGL: 328'
Site Elevation: 49'
Type: Guyed
Build Date: 01/2000
Owner: Sumter Communications, Inc.



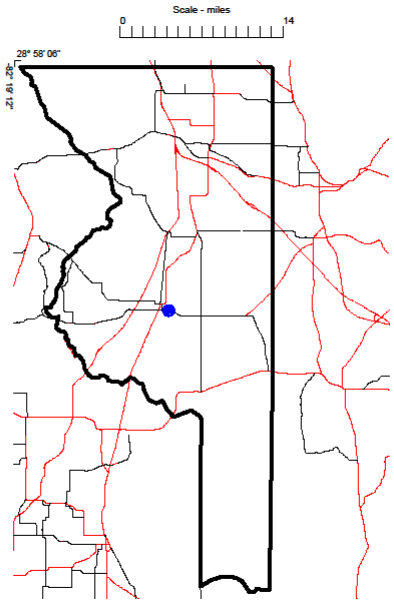
Resistance Measurements:

Tower leg	0.05 Ω
Radio Cabinet	0.07 Ω

Antennas:
- VHF
- Yagi
- M/W to Wildwood
- Cellular Sectors

Bushnell Tower

Lat: 28°39'21.72"N
Long: 82°06'03.33"W
ASR #: 1063264
AGL: 300'
Site Elevation: 78'
Type: Guyed
Build Date: 05/1995
Owner: City of Bushnell



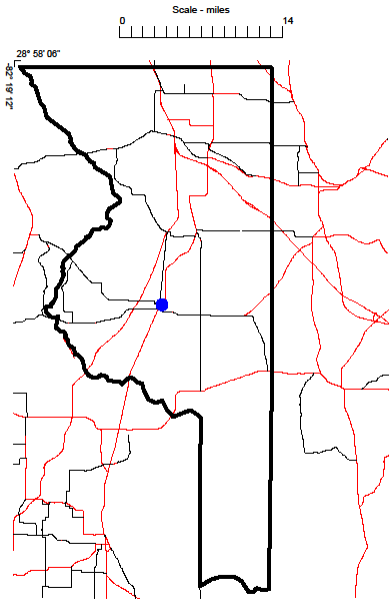
Resistance Measurements:

Tower leg	0.07 Ω
Shelter (Outside)	0.09 Ω
Shelter (Inside)	0.07 Ω

Antennas:
- UHF/VHF
- Yagi
- M/W to Unk
- Cellular Sectors

Bushnell Monopole

Lat: 28°39'46.43"N
Long: 82°06'35.24"W
ASR #: N/A
AGL: <200'
Site Elevation: 77'
Type: Monopole
Build Date: Unk
Owner: City of Bushnell

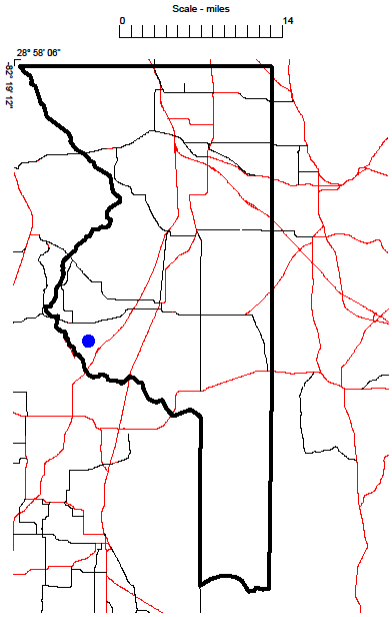


Resistance Measurements:
Monopole 0.36 Ω

Antennas:
- UHF/VHF
- M/W to Sumterville
- M/W to Main Office
- M/W to Wilson's Corner
- M/W to Sumter Correctional

Sumter Correctional Institute Tower

Lat: 28°37'00.02"N
Long: 82°12'50.23"W
ASR #: 1003461
AGL: 449'
Site Elevation: 69'
Type: Guyed
Build Date: 12/1996
Owner: State of Florida



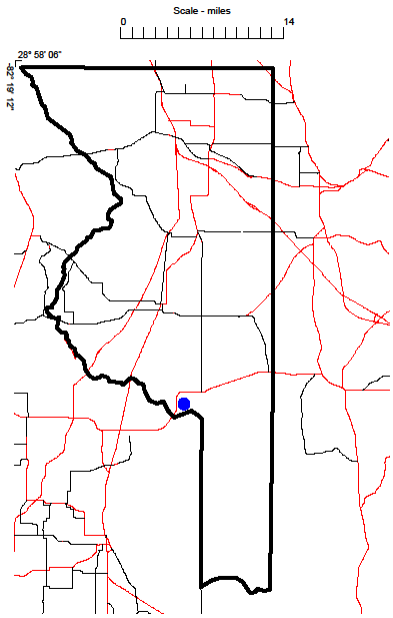
Resistance Measurements:

Tower base	0.04 Ω
Shelter 1	0.04 Ω
Shelter 2	0.07 Ω

Antennas:
- UHF/VHF
- M/W to Sumter Monopole

Wilson's Corner Tower

Lat: 28°32'23.55"N
Long: 82°04'47.92"W
ASR #: 1210879
AGL: 328'
Site Elevation: 08/2000
Type: Guyed
Build Date: 10/2000
Owner: Sumter Communications, Inc.



Resistance Measurements:

Tower base	0.10 Ω
Radio cabinet	0.07 Ω

Antennas:
- UHF/VHF
- M/W to Sumter Monopole

3.0 Technology Options Available to Sumter County

In order to fully understand the pros and cons of the various options available to Sumter County, it is important to recognize the benefits and limitations presented by the technologies used in these conceptual system designs. Following is a brief overview of these technologies. This overview in no way attempts to touch on all of the aspects of any of these technologies, but instead focuses on the features and limitations of each that directly relate to Sumter's situation. The discussion touches on the differences between analog and digital systems as well as aspects of proprietary systems versus systems based on open standards. In addition, included is an overview of system configuration alternatives available to support the wide-area coverage desired by Sumter County, for example multisite, simulcast and hybrid systems.

Analog vs. Digital Systems

Since the late 1930's, public safety radio communication has used analog Frequency Modulation (FM) almost exclusively as its wireless communications technology. This is the technology currently being used primarily by Sumter County and the cities within the county. Analog FM is inexpensive, robust, and provides good voice quality given reasonable signal levels. In terms of disadvantages, while FM's strong signal voice quality is good, the quality begins to degrade rather quickly as communication distance increases. As users move farther and farther from the main transmitter site, and signal levels drop, static and other noise factors steadily increase until finally the received signal is rendered unintelligible.

In many cases users operating within the outer reaches of coverage are able to communicate only with difficulty. This usually requires message repeats and results in misunderstood message intention. Furthermore, analog systems provide little security from eavesdroppers. Anyone with an inexpensive scanner can easily intercept and monitor the traffic on an analog system. Analog voice scramblers are available, however they are expensive, offer poor voice quality and are cumbersome to implement.

Digital communications systems first arrived on the public safety communications scene in the late 1980's. These initial systems were characterized by poor range and highly distorted voice audio, but they were highly secure. In the past two and a half decades digital radio technology has advanced to the point that voice clarity in digital systems rivals the best analog audio. Radio coverage of a digital system is equivalent to or exceeds that of a similarly designed analog system. Furthermore, the static and noise that is typical in analog systems is dramatically reduced.
Digital systems provide significantly more voice security than analog systems. Voice encryption on a digital system is easy to implement, provides excellent voice quality, and is virtually impossible to crack. Digital systems represent the future of public safety communications. As an example, the

FCC has allocated a new section of spectrum in the 700 MHz band exclusively for public safety use, designed for digital systems only. Analog systems will not be permitted to utilize this new spectrum.

The County's current VHF systems are analog, and are not capable of digital operation without a major overhaul. Most P25 systems are digital only although some vendors offer combinations of digital P25 and analog technologies.

Proprietary vs. Open Standard Systems

To provide needed call capacity, the agencies in Sumter County use multiple VHF channels. The operation of these conventional repeaters are not proprietary and a considered an open standard.

Older trunked systems, as well as some currently available ones, utilize proprietary signaling protocols in their design. Examples of such systems are Motorola SmartNet, Motorola SmartZone, Harris EDACS, and Harris OpenSky. While these proprietary protocols significantly increase the system's functional capabilities, they do so at the expense of intersystem interoperability and competition. In general, users with equipment from different vendors cannot directly communicate on the same system and interoperability between them depends upon dispatcher relaying, console patches, or inter-system bridges. In terms of competition, if a system owner needs to expand or replace equipment in a proprietary system, the owner's procurement options are limited to one, or at most, a very limited number of vendors. Historically, this has resulted in a significant increase in the cost of a system over its lifetime.

Initially all trunking systems developed for the public safety market, were proprietary. An agency that purchased a trunking system from one vendor would be stuck with that vendor for the life of the system. If a neighboring agency purchased a system from a different vendor, direct interoperability between the two was impossible. To address these and other issues, APCO, in concert with representatives of the Federal government and radio equipment manufacturers, have been working for more than a decade to develop a suite of open standards defining technical specifications needed to build systems that can meet the functional requirements of public safety communications yet not limit interoperability or competition. This suite of open standards is known collectively as Project 25 (P25).

While still not complete, sufficient progress has been made such that P25 compliant systems and user equipment are available today from multiple vendors. If adjacent agencies purchase P25 compliant systems from different vendors, users from both systems will be able to communicate directly with each other and on each others' system infrastructure. In addition, each agency would be free to purchase from any vendor providing P25 compliant equipment, based on required features and budget.

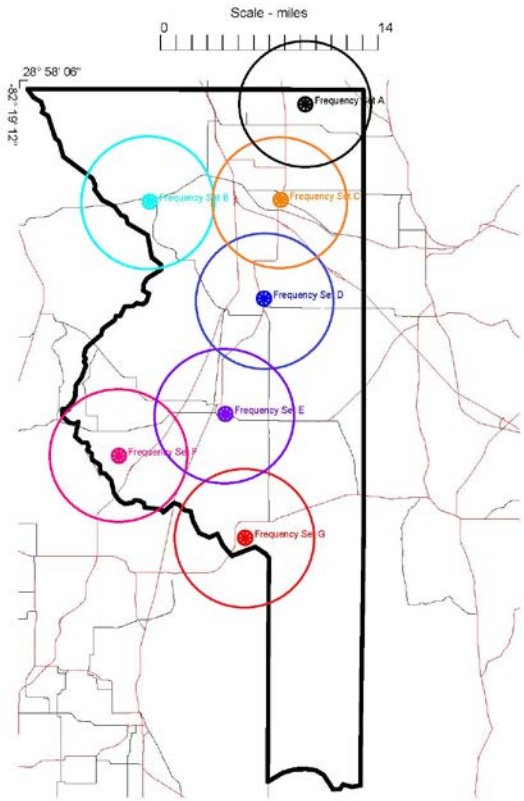
It should be noted that many of the Federal public safety communications grants available now, or in the near future, either explicitly define P25 systems and equipment as a requirement, or heavily favor applications from agencies defining P25 in their requests. An agency applying for such a grant based on proprietary, non-P25 technology will be at a significant disadvantage in the competition for the available funds and would potentially need to seek waivers for grant funding.

Options for Covering Large Geographic Areas (Wide Area Systems)

Wide area systems fill the need when an agency's radio coverage requirement exceeds that which is capable of being met by a single site, as is the case in Sumter County. Simply adding sites will increase radio coverage, but adding sites alone will not result in a cohesive public safety communications system. Without a means of connecting these additional sites together, the result would be an uncoordinated collection of multiple independent coverage zones where users within the coverage area of one site are isolated from users covered by another.

What is needed is the capability for users operating on one site to communicate with the users operating on the others along with seamless switching between zones when traveling in the county. That capability is provided by wide-area technology. The industry has developed several approaches to accomplishing this task, three of which are available to Sumter County. Those three available options are Multisite Networks, Simulcast Systems, and Hybrid Simulcast/Multisite Networks. For those unfamiliar with wide area voice system technology, the following provides a general overview and describes the pros and cons of each approach. Specific conceptual designs using each system type, as appropriate to the agencies in Sumter County, are presented in a subsequent section of this Report.

Multisite Networks



Each site has its own set of frequencies

In order to allow communication between users operating in different coverage areas, a means must be provided for calls within the coverage area of one tower site to be retransmitted on another tower site or combination of sites. Within a multisite network, each tower site in the system encompasses its own unique set of frequencies. Communication between users operating on different sites is accomplished through an intelligent central "switch" that monitors the site activity of every operational unit in the system and connects users together as needed. A call using a frequency on one site is connected to the appropriate, but different frequency on another. When a call is placed, the switch determines which sites and frequencies are to be assigned for that call and connects them all together via leased lines or microwave circuits.

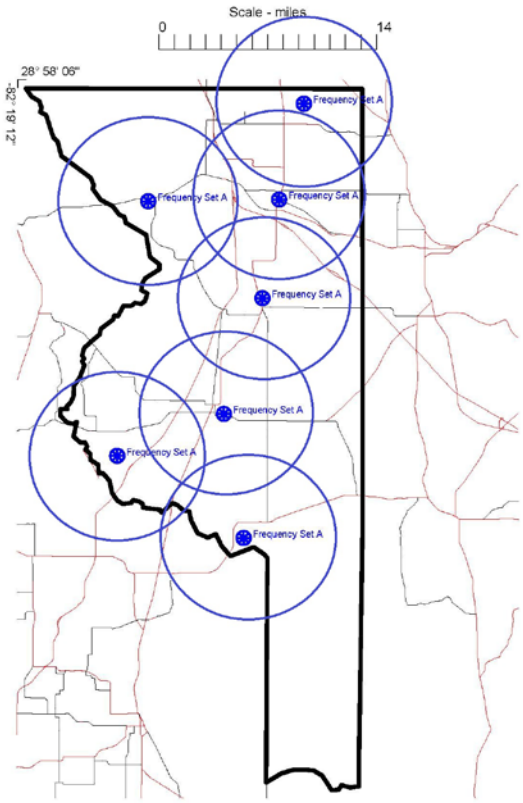
The key characteristic of this type network is that a completely *separate set of frequencies* is needed at each site. Because inter-site interference is not an issue, site placement is much less critical for a multisite network, compared to other system types. In addition, a multisite network is extremely robust from the standpoint of reliability. In the event of a failure of one or more of the inter-site links, a simulcast site must operate with reduced capacity, or shut down completely. A multisite network can continue to operate at full capacity in the event of such a failure, although with reduced wide are capability. The technical requirements for the communication links connecting the sites are also less critical than for simulcast systems, which can result in lower system implementation and operating cost.

While a primary strength in one regard, the requirement for separate frequency sets for each site is also a multisite network's primary weakness. The frequencies available for public safety use are extremely limited. Of concern to Sumter County specifically, many of the available 800 MHz public safety frequencies in Florida are already in use. The limited availability of frequencies effectively blocks a multisite system's capability for expansion, in terms of either coverage or capacity. If additional frequencies cannot be made available, additional sites cannot be added to an existing multisite network to increase future coverage.

Capacity expansion is further constrained by frequency availability as capacity expansion usually requires adding channels to multiple sites in the network. In order to prevent dropped or missed calls, the quantity of channels at each site must be high enough to handle all of the calls that the central switch may route to that site at any instant. The limited number of frequencies available to Sumter County is a critical system design constraint blocking a simple solution to the coverage and capacity problems that Sumter County could face in the future.

Another issue to consider is the effect of transitioning from one site to another when traveling throughout the county. Site transitioning has an effect on the apparent coverage performance of a multisite network. In order to ensure that coverage within the required service area is contiguous, the coverage from adjacent sites must overlap each other. As users travel in these overlapping coverage areas, the radio must determine which site provides the strongest signal at that specific location and transition to the stronger site's operating frequencies. This transition is not instantaneous. To prevent missed calls due to excessive transitioning between sites, the transition to the stronger site is delayed until the signal difference between the current site and the new site exceeds a specific signal difference threshold. The net result is that a user may not be always operating on the optimum site. From the user's perspective, system coverage is less than expected.

Simulcast Systems



Each site shares the same set of frequencies

Like multisite, simulcast is a technology that increases coverage beyond that available from a single site by implementing multiple sites throughout the desired coverage area. Simulcast differs from a multisite network in that the same frequencies are used throughout the system. With a simulcast system, the transmitter at each site broadcasts the same information simultaneously on the same RF channel as the other sites, hence the name.

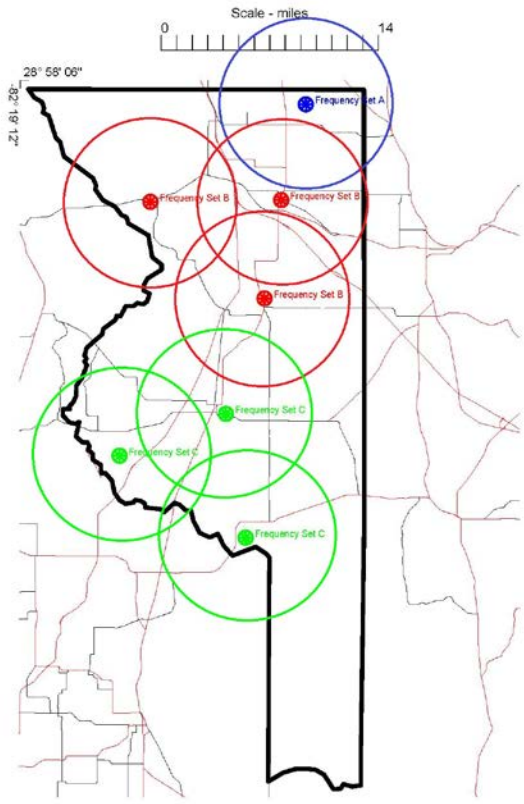
The primary advantage of a simulcast system over a multisite network is that simulcast increases coverage without increasing the number of channels necessary to support the system. Also, given the same site configuration, inbound coverage from subscriber units to the base stations is improved over multisite because of the diversity effect of multiple receiver sites monitoring the same inbound frequency, and outbound coverage is improved because there is no site transitioning effect to contend with. From the user's point of view a simulcast system operates exactly like a single site system. There are no zones or site transitions for the user to contend with.

However as a result of multiple sites transmitting on the same frequency, each site's transmit frequency, phase and timing must be precisely controlled to prevent destructive interference where signals from multiple sites overlap. This requirement to precisely control the output signals from each site in order to prevent destructive interference makes the implementation and long term

support of a simulcast system more complex and costly than for a multisite network. This disadvantage also places constraints on a simulcast system's site placement.

A simulcast radio system also requires highly stable and reliable inter-site connectivity. If inter-site connectivity is lost in a simulcast system, the affected sites will either shut down completely, or operate as stand-alone sites with severely limited capacity. This requirement for reliability and stability can usually only be met by a dedicated microwave or fiber optic sub-system. Currently leased circuits, even leased fiber, are not recommended for simulcast, and some vendors will not support simulcast systems utilizing them. From the standpoint of reliability, microwave has proved to be far more reliable and robust in the face of severe storms than leased circuits.

Hybrid Simulcast/Multisite Systems



Hybrid combination of Multisite and Simulcast

The final wide area system configuration is a hybrid design using a combination of multisite and simulcast technologies. This system configuration consists of several simulcast sub-systems, or "cells" connected together in a larger multisite network. From the standpoint of the multisite network, each simulcast cell looks like a single site, but each of these cells has significantly greater coverage than is possible from a single site. This design can provide a system solution when the

geographic area is too large to be accommodated by a single simulcast system, and frequency constraints preclude a purely multisite network approach.

Available Wireless Data System Configurations

The following section provides an overview of the various wireless data options currently available to Sumter County.

Commercial Wireless Data

Sumter County's current public safety wireless data requirements are being met almost entirely by commercial air-cards. The initial deployments of commercial wireless data provided only moderate data rates and spotty coverage. Within the past several years, however, commercial system data rates have dramatically improved. Commercial wireless carriers are currently implementing improvements to their systems to provide significantly increased data speeds compared to services available only a few years ago.

As an example Cingular and T-Mobile have committed to high-speed downlink packet access (HSDPA) sometimes known as 3.5G, with initial deployments providing peak rates in excess of 1 Mb/s and theoretical peak rates of 14 Mb/s. While performance is good and getting better, it is important to remember that these systems are still commercial networks. They are not hardened to withstand severe storms and long periods without commercial power. In addition, public safety users do not receive priority over private subscribers. Experience proves that these systems quickly overload and are rendered essentially useless during and immediately after a natural disaster such as a hurricane. The bottom line is that a commercial wireless data solution cannot be counted on to provide reliable service in an emergency situation. While commercial systems can provide economical high capacity mobile data connectivity on a routine basis, public safety agencies should have plans in place to deal with inevitable service outages.

Private Narrowband Wireless Data

A private narrowband data system provides data connectivity over narrow bandwidth RF channels that are primarily meant for voice service. These systems can provide good geographic coverage, but the narrow bandwidth limits data throughput. Such systems normally provide data throughput rates measured in thousands of bits per second instead of the hundreds of thousands of bits per second or more that a commercial data network can provide. The primary advantage of such a system is that it can be designed to public safety reliability standards. In addition, user access can be strictly controlled, reducing the possibility of system overload during emergency situations. In short, while the data throughput of a narrowband data system cannot match that of a commercial system, it is far more likely to be available when needed most.

Private Broadband Wireless Data

Private broadband data systems operate on frequencies that have channel bandwidths measured in MHz. As such they are capable of very high data throughput, but only over a very small area. Typically they operate in the 900 MHz, 2.4, 4.9, and 5GHz bands and utilize an access point model

similar to Wi-Fi networks in their design. Because each access point only provides coverage over a small area, it would be extremely costly to attempt to cover an area the size of Sumter County with broadband wireless. Instead a more practical approach would be to provide access points at strategic locations throughout the county to form high speed wireless "hotspots". This high speed connectivity would then be available to users when they come within range of a hot spot, allowing them to access the central network and perform functions that require very high speed, such as updating local databases or uploading reports. Outside of the range of hotspots, users would have to rely on other means of data connectivity, either commercial or private narrowband. A limiting factor in the deployment of a network of hotspots is the cost and availability of the high speed data connections necessary to connect each hotspot to the primary network.

Data on the Trunked Voice Network

Many trunked voice systems, including EDACS, OpenSky, and P25 have the capability of providing data communication using the voice network. This approach is called trunked data. It has the dual advantages of not requiring the implementation of a separate data infrastructure, and the data network inherits the same reliability as the voice network. The disadvantages are that a certain amount of voice capacity must be sacrificed in order to support trunked data, and that the maximum data rate that this technology can support is quite low. Typically, trunked data rates are measured in hundreds of bits per second, instead of the kilobits or megabits per second offered by other options. This slow throughput of trunked data cannot support the requirements of modern public safety applications and most users that relied on this approach in the past have abandoned it for other options that provide the required higher data rates. The technology is still applicable in certain niche applications such as status reporting and short text message delivery.

Hybrid Wireless Data

Each of the previous data options has advantages and disadvantages. Commercial data options have high throughput, good coverage, but poor reliability. Narrowband data has good coverage and reliability, but only moderate throughput. Trunked data has high reliability and low cost, but miserably low throughput, where as broadband data has excellent throughput, reasonable reliability, but poor coverage. A hybrid data solution is a mixture of the available options configured to provide an acceptable system solution when a single technology cannot. This hybrid approach does significantly increase cost and complexity. Unlike with a voice multisite/simulcast hybrid approach where the subscriber equipment is essentially unaffected and the additional complexity is in the infrastructure, a data hybrid solution pushes the complexity out to the subscribers. In addition to multiple infrastructure subsystems, the mobile subscriber equipment must also now be equipped with multiple radio platforms as well as additional software applications to permit selection of the appropriate data provider, depending upon the immediate circumstances.

Digital Vehicular Repeaters

A cost-effective solution to extending RF coverage is accomplished through the use of a digital vehicular repeater. A digital repeater provides repeater capability between portable radios (portable radios being the most susceptible to coverage problems) and the RF infrastructure system (tower sites). This dramatically improves coverage by leveraging the large mobile coverage of a radio system and extending it to portable radios which would otherwise have little or no coverage in buildings and remote areas.

A digital vehicle repeater accomplishes this "repeating" function by using two radios tied together with a hardware controlling device. One of the radios would be programmed into the trunked radio system with the appropriate talk groups. The second radio (usually supplied with the repeater) operates outside of the frequency range of the trunked radio system. Because of this, a digital repeater for vehicles would require approval and licensing from the FCC via the state frequency coordinator.

In addition, system design and engineering is more difficult with these types of systems. Anytime there is more than one repeater at the same location, a protocol must be established so a portable radio doesn't activate two or more repeaters and cause both to repeat at the same time.

Outdoor Bi-Directional Amplifier (BDA)

The Outdoor Bi-Directional Amplifier (BDA) amplifies and repeats the 800 MHz trunked signal from a donor antenna located in an area where coverage is available. The amplified signal is then repeated toward an area where there is little or no coverage. Likewise, the signal from a subscriber radio is repeated back to the donor antenna which directs it back to the infrastructure sites.

An important difference between BDAs and Digital Vehicular Repeater System (DVRS) is that BDAs do not change the frequency of the signal. This simplifies the operation of the BDA however it has a major drawback in this design. Both antennas operate on the same frequencies and must be separated by distance and building structure. Therefore, the greater the separation between the antennas, the better the BDA will perform in your system.

Water towers/water tanks offer the best type of structure for installing outdoor BDAs. Because of the metal used in these structures, these antennas can be separated in such a way as to offer the most gain. Other types of structures that will also work are buildings with antennas installed on opposite sides.

Another difference between a BDA and a DVRS is that the BDA is not mobile and requires a permanent installation with a power source, either commercial AC power or a type of solar power/battery setup for remote installations.

NPSPAC Mutual Aid System

Most Public Safety agencies in the State of Florida who operate 800 MHz systems or own subscriber units that operate on a participating Public Safety system have access to the nationwide mutual aid channels generally referred to as the TAC (Tactical Communications) channels. These are 5 distinct channel assignments that are designated for conventional analog communications in support of mutual aid operations and interoperable communications. These channels are generally set aside for 3 main categories:

- Day to Day Interoperability – Generally used during routine Public Safety operations such as accident scene response or other first response activity. Several area jurisdictions may respond to these type calls. TAC channels are generally used so that Public Safety agencies may all use a designated common channel for communications during these routine events.

- Mutual Aid Disaster Response – Planned use of specified channels during joint response to major disasters that may exceed the resources of one specific agency. These events include possible terrorist activity, airplane crashes, bombings, large forest fires and other major events and acts of nature when the situation overwhelms local responses and outside support is requested.

- Task Force Interoperability involving state, local and/or federal agencies coming together for a period of time in response to major events such as sporting events, political rallies, or for investigations related to prolonged criminal activity.

The Association of Public-Safety Communication Officials (APCO) and the National Public Safety Telecommunication Council (NPSTC) have submitted a proposal for a new ANSI (American National Standards Institute) Standard for Channel Naming for Public Safety Interoperability Channels to APCO's ANSI Standard Development Committee (SDC). This standard is expected to be approved as an ANSI standard sometime during the 1st quarter of 2010 and FCC approval would follow soon afterwards.

The following table is the 8TAC naming conventions recommended by the APCO and NPSTC.

Description	NPSTC ID	Mobile TX (MHz)	Mobile RX (MHz)
Calling	8CALL90	821.0125(806.0125*)	866.0125(851.0125*)
Calling - Direct	8CALL90D	866.0125(851.0125*)	866.0125(851.0125*)
Tactical	8TAC91	821.5125(806.5125*)	866.5125(851.5125*)
Tactical - Direct	8TAC91D	866.5125(851.5125*)	866.5125(851.5125*)
Tactical	8TAC92	822.0125(807.0125*)	867.0125(852.0125*)
Tactical - Direct	8TAC92D	867.0125(852.0125*)	867.0125(852.0125*)
Tactical	8TAC93	822.5125(807.5125*)	867.5125(852.5125*)
Tactical - Direct	8TAC93D	867.5125(852.5125*)	867.5125(852.5125*)
Tactical	8TAC94	823.0125(808.0125*)	868.0125(853.0125*)
Tactical - Direct	8TAC94D	868.0125(853.0125*)	868.0125(853.0125*)
Default operation should be carrier squelch receive, CTCSS 156.7(5A) transmit. If the user can enable/disable CTCSS without reprogramming the radio, the indicated CTCSS tone should also be programmed for receive, and the user instructed how and when to enable/disable. *The frequency in parenthesis, which is 15 MHZ lower, will be the frequency used after rebanding.			

APCO/NPSTC Proposed TAC Naming Convention

Some agencies have already adopted and implemented these new standards in order to avoid any additional subscriber reprogramming. It has also been reported that some agencies have already rebanded with improper naming convention such as "new ITAC". From this point forward, all agencies which have yet to reband should use the new naming convention. It is the State's goal to have all 800 MHz TAC/8TAC channels changed to the new naming convention as soon as possible. This will require agencies to work closely with their radio shop technicians as well as mutual aid partners to insure interoperability is maintained during this time.

Most agencies have an approved a second touch to all subscribers to remove old channels from their radios once infrastructure has been cutover. Agencies who have completed their first reprogramming and have used improper naming conventions should correct this during their subscriber second touch. The original ITAC naming convention should be replaced by the new channel names beginning with the number "8".

Because alternate funding sources are being used for the rebanding effort, the State will not establish a compliance date. However, the State recommends that each agency weigh the impact on interoperability if both programming conventions are not utilized for an indefinite term.

4.0 Project-25 ISSI – Key to User Roaming

As Florida's cities and counties move forward with their deployments of APCO Project-25 radio systems, the groundwork is being set for user radio roaming. First, of course, all radios in the Region must be capable of operation on P25 equipped infrastructures. This means that owners of proprietary Project 16 radio systems (Hernando, Citrus, etc.) using either Motorola Smartnet II or Harris EDACS technologies should be planning to purchase radios that are capable of dual mode operations (proprietary and P25).

Additionally, all new public safety trunked radio purchases should consider radios that are operable on both 800 MHz and the new 700 MHz voice channels. These new radios must be fully compatible with Project-25's Phase-I (12.5 KHz FDMA) and the recently accepted Phase-II (12.5 KHz, two-slot TDMA) functional and operable requirements. By so doing, user radios purchased in the near future will be fully capable of future expansion and will experience significantly longer service lives than those having only Phase-I capabilities.

While equipping users with P25 compliant equipment will potentially allow a user to communicate while traveling outside of their home area, this step alone will not allow radio users to communicate directly with radio users located in another. Such interoperability and seamless roaming requires instantaneous and continuous connectivity of the various radio system controllers (called switches) throughout the State and the various Regions.

Prior to P25 connectivity standards between compliant radio systems did not exist. These standards exist today, but at a base level where user IDs, talk group and transaction audio can be instantaneously routed between radio systems. These new switch interoperability standards are termed: ***ISSI*** – Inter RF Subsystem Interface.

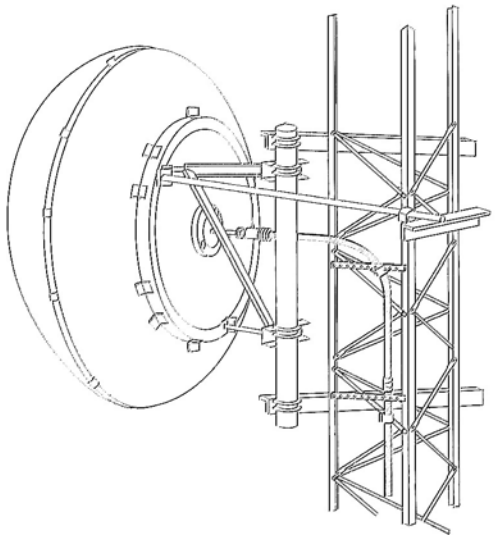
Project-25 ISSI defines the types of functionality that can be supported between radio network/system switches. The ISSI Standard is vendor neutral such that radio systems designed and deployed by competing radio vendors will support call interoperability and user roaming. This is an extremely important point as Project-25 would have otherwise failed its primary goal: *open-architecture and elimination of proprietary solutions*.

It is important to understand that ISSI is a functionality of the controllers/switches in the various deployed radio systems. All switches in a network must support ISSI or interoperability cannot occur. Yet, nothing happens without a secure, reliable means for interconnecting the various radio system switches together…. and this is why an expanded microwave solution is so vitally important and should be considered.

5.0 Enhanced Microwave Subsystem

Immediate attention has been given by the federal government in driving the convergence of new public safety and federally operated radio systems toward the APCO Project-25 digital voice standards. It is important that newly deployed digital radio networks depart from older radio configurations where each manufacturer had developed highly efficient, but proprietary and, thus, incompatible technology solutions.

As radio networks expand in step with coverage needs, the role of remote antenna site connectivity takes center stage. Connectivity is essential as this allows independent antenna sites, each singularly exhibiting natural coverage and performance limitations, to be combined into a cohesive wide-area network. The critical importance of reliable connectivity between sites can overshadow other radio network design consideration as the loss of even a single linkage could lead to devastating consequences.



The fragility of some wide-area trunked radio and commercial cellular networks was vividly laid bare through the devastating effects of Hurricane Katrina. Here, low-cost fiber and copper T-1 connections were either directly damaged by storm winds and flood waters or power-starved by the depletion of run-time limited battery backup systems and the lack of reliable on-site power generation equipment. By far, the biggest contributor to the collapse of radio communications throughout areas damaged by Hurricanes Rita and Katrina was the combined result of failed site interconnectivity and loss of electrical power support. Those few radio systems that remained operational did so due to their use of private point-to-point microwave facilities and well planned standby electrical power systems sized for days…not hours…of operational capacity.

Using the lessons learned from these recent events, our investigation considered the development of a highly robust, protected public safety digital microwave network supportive of the County's range of needs. In this envisioned configuration, broadband microwave technology would provide resilient, seamless interconnectivity with the principal radio dispatch E911 center as well as linkages to the County's 800 MHz trunked radio system sites. This microwave system could be easily scaled to include linkages to other standards-based radio systems as desired (i.e. the Statewide Law Enforcement Radio System).

Consideration should also be given to deployment of a high performance OC-3 loop-protected microwave network (equivalent to 84 T-1 circuits). By so doing, the County could easily accommodate video conferencing and data sharing (CAD, GIS, HAZMAT, supportive building drawings, etc.) between regional dispatch centers as well as secure high-speed broadband access

points supportive of public safety field operations. Such a microwave system could be easily scaled to include linkages to outside standards-based radio systems as desired.

General Configuration

It is recommended that Sumter County operate a microwave system to interconnect its 800 MHz trunked simulcast towers to the radio network's Control Point located near the E911 Center. The control point maintains the precise frequency, phase and amplitude stability necessary to preserve simulcast transmitter functionality. The control point additionally houses the radio network's dispatch console switch, receiver voting equipment, voice encryption and related radio subsystems. Additionally this site supports the various radio gateways to outside radio systems such as neighboring counties (Marion, Lake, Polk, Pasco, Hernando and Citrus) and the Florida Highway Patrol, The Florida Department of Law Enforcement and others.

The microwave subsystem should be configured in a monitored hot-standby mode. Each transmitter, receiver and power supply used in the total microwave network has a fully redundant and operational spare component. The microwave system continuously monitors the condition of all of these various elements and automatically deactivates failed equipment and switching to spare equipment in a manner fully transparent to users.

Reliability Attributes

The Sumter County area is susceptible to many natural weather events that play havoc with commercial telecommunication services. These events include tornados, thunderstorms and of course, hurricanes. Microwave radio antennas are relatively large and unless proper precautions are taken, are vulnerable to wind-related events. Therefore, each antenna system in the network should be equipped with a radome cover and antenna brackets designed to manage high winds and violent physical vibratory effects. Transmission lines, the single-most critical network component, are most vulnerable where they are routed away from the tower to the antenna.

Many public safety radio installations use a common battery backup system that supplies power to both high current devices such as 700/800MHz base stations and microwave subsystems. We feel this practice should be discouraged. The loss of normal electrical power (main and standby) will result in a rapid depletion of a site's common battery supply, due to the comparatively large electrical current demands of the 700/ 800 MHz base stations. Once the battery plant's capacity is exhausted, an agency loses not only the effectiveness of that one radio site, but the critical microwave interconnectivity piece as well. Our recommendation is to incorporate separate and properly sized battery backup systems at all infrastructure facilities.

During emergencies, it is important to keep the microwave backhaul functional even though site-specific mobile radio services may be curtailed. Thus, it is good practice to design microwave backhaul elements to survive extended periods of electrical outage (at least 24 hours but in some cases as long as 72 hours depending upon local circumstances).

Interoperability and Security Attributes

It is likely, as more suppliers enter the marketplace that future radio networks could be furnished by more than a few equipment vendors. Therefore strict functional compliance with APCO standards

for interoperability between system controllers will become critically important. An expansive Sumter County microwave network concept, if adopted, would allow the seamless sharing of radio unit IDs, talk groups and other necessary call attributes required to allow users to roam between radio systems. This would support full unit-to-unit interoperability between agencies. *Long-term electrical outages and multiple tower failures would have little consequence to core operations due to the self-healing aspects of the envisioned loop microwave approach.*

One of the more exciting features of this enhanced microwave solution is its inherently private broadband capacity. The microwave network's excess capacity could be used to support the County's (or Region's) data needs by providing multiple points of entry for outside federal, state, regional or local criminal history databases. Thus, loss of connectivity to such databases within one municipal area would not preclude backhaul of such data from other points in the microwave network.

By comparison, the use of commercial broadband services, while having economic benefits, is inherently susceptible to service interruption. The hundreds of miles of copper and fiber cabling necessary to interconnect these various radio communication systems and dispatch facilities would pass through unprotected spaces and right of ways. As such, they would be vulnerable to unintentional damage caused by forces of nature or construction crews. Worse, the expansive design of wired facilities opens the possibility of unauthorized activity that could compromise the security of critical communications resources.

By direct contrast, this microwave network is completely private. Access points are limited to the network's antenna sites and the interception of microwave communications would require the ability to intersect the actual elevated and narrowly-focused radiated signal. Furthermore, the information contained within the microwave network, particularly voice and mobile data communications, would be encrypted using nationally recognized (standards based AES or DES) security systems having codes that would take impossibly long periods of time (hundreds of thousands of years) to decipher.

Finally, there is the issue of telephony and video conferencing connectivity. The excess bandwidth provided in a microwave network approach can be efficiently and securely used to support emergency telephone or video conference communications between dispatch centers and/or Emergency Operation Centers (EOC's) in support of response coordination. Thus, the loss of commercial telecommunication services could no longer potentially disrupt the operations of radio communication centers at the time when communications and coordination was most needed.

6.0 Interoperability/Roaming Considerations

Lake, Marion and Polk Counties have already constructed Project-25 public safety trunked radio systems that are each managed independently of each other, but are connected together to provide seamless roaming between each county. In addition, Hernando and Citrus Counties have plans to implement 700/800 MHz P25 systems in the near future. Thus, several regional radio users have already moved in the direction of standards-based communication networks and more will follow in the future.

Interoperability between some Sumter County agencies such as the Villages Public Safety and Lake County already exist. This same level of interoperability with the surrounding counties and agencies would be possible for all of Sumter's public safety agencies through inter-system connections as described previously in Section 4.0. These radios would be directly interfaced to Sumter County's radio system's network controller and would appear on radio dispatcher console screens as talk groups/ channels. This is done by interfacing these dedicated radios (one for each channel) directly to the console switch which enables trunked system users to incorporate conventional repeater channels into their dispatch operations without the need for a separate hardware network and channel banks.

All of the counties surrounding Sumter County have expressed an interest in coordinating public safety communications with Sumter County's Law Enforcement and Fire Rescue agencies.

7.0 Regulatory Considerations

Users of radio systems operable below 512 MHz are required to make substantive changes to their radio configurations by the year 2013. This FCC ordered reconfiguration is termed "narrowbanding" and is intended to ultimately expand the number of channels available to public safety four-fold.

By Year 2013, existing licensees must have converted their current 25 KHz bandwidth radio systems to 12.5 KHz. Some time beyond 2013 (to be formally announced by 2011) the FCC intends to force a second narrow-banding of channels to 6.25 KHz bandwidths. This objective can be met using analog technologies, although with some degradation in coverage that could result in the need for additional antenna systems or tower sites. This final migration to 6.25 KHz bandwidths will cause all FCC Part 90 analog systems, as now operated by Sumter County, to become obsolete and will require a conversion to digital technology or a complete overhaul and expansion of the current analog system.

The coverage performance drop-off as a result of 6.25 KHz versus 25 KHz bandwidth operations may require twice the number of infrastructure antenna sites to achieve coverage equivalency. So, the conversion to 6.25 KHz operations would involve both equipment and engineering challenges to maintain analog equivalent grade of service objectives.

This FCC Narrowband Order has far reaching effects to users of radio systems below 512 MHz. The cost to conform to these changes, particularly those related to 6.25 KHz operations, will be very high. A difficulty we foresee is that many of Florida's more rural fire districts rely on volunteer personnel. As volunteers, these individuals often purchase their own radio equipment. Analog VHF radio gear is relatively inexpensive (often for less than $400) and available from many sources. By contrast, digital radio equipment operable in these narrowband channels will be significantly more expensive, perhaps in the order of three times that for a comparable analog radio, which could present a financial hardship for these essential volunteer service providers. Correspondingly, it is reasonable to expect that such conversion costs will become the responsibility of some source other than volunteer individuals.

Occupied bandwidth reductions are not limited to spectrum below 512 MHz. In fact, a major bandwidth reduction is required for radio systems operable on 700 MHz. By Year 2017, the FCC requires all public safety 700 MHz radio systems to be converted to 6.25 KHz operations. Currently, 700 MHz public safety radio systems are operable using Project-25 Phase I standards (12.5 KHz channels). The Year 2017 bandwidth rules will require, at a minimum, software changes to existing Phase I infrastructures.

700MHz portable and mobile radio operable only on Phase I bandwidths will require replacement in order to operate on 6.25 KHz bandwidth systems. Early users of 700 MHz may have purchased user radio equipment that is not adaptable to Project-25 Phase II bandwidths/ technology. Thus, many agencies now considering the purchase of user radios operable on 700 MHz systems are encouraged to secure written assurance from potential radio vendors that any proposed/ supplied equipment is capable of a software upgrade to support APCO Project-25 Phase II operations.

There are no plans or FCC Orders to change the bandwidth characteristics of 800 MHz public safety radio operations. However, as recently as November 2009, the FCC announced that they were requesting public comment on the petition for rulemaking asking the FCC to revise the channel plan for the 800 MHz band for 12.5 KHz bandwidth channels.

8.0 Conceptual Solutions

As described in the overview, prior to entering the conceptual design phase, TCS performed a thorough evaluation of previous radio communications within Sumter County. This included evaluating the required coverage and conducting user interviews to determine operational requirements to support Sumter County's communications needs. The results of that work are presented in this report to the County. To summarize, two key deficiencies exist today, coverage and interoperability. Any potential solution must address deficiencies immediately and in the long term. Another major concern is the long term viability of any potential solution.

While there are no universally accepted minimum standards for either coverage or capacity for a Public Safety radio system, the objectives defined by Tusa for coverage and capacity follow those generally employed in the industry. Specifically, any potential solution should provide no less than 95% countywide portable on street coverage with a Delivered Audio Quality (DAQ) level of at least 3.4, and no less than 95% coverage in 12 dB of loss in buildings in critical coverage areas, also at DAQ level of at least 3.4. The table below provides a definition of DAQ levels. Critical coverage areas are areas other than wetlands, forests, and agricultural areas.

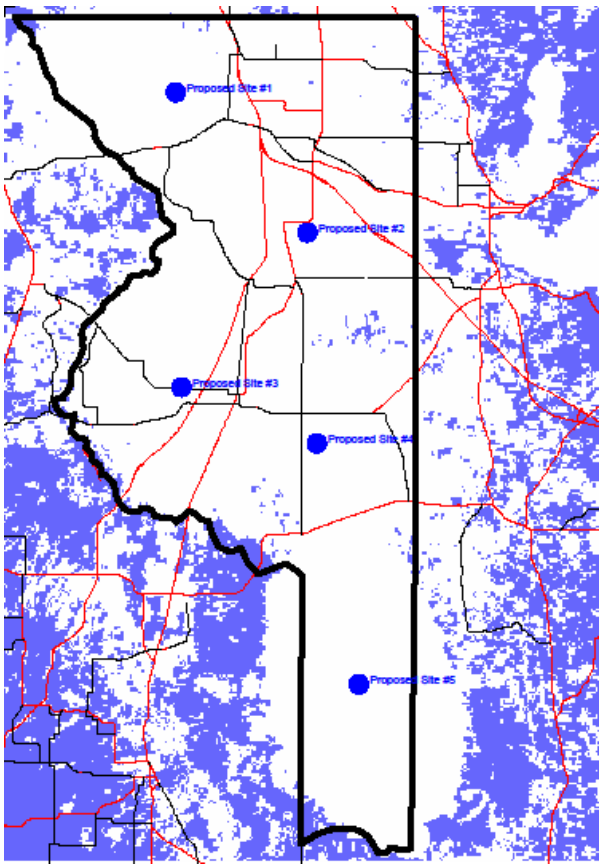
DAQ	DESCRIPTION
5	Reception is very clear and message is perfectly readable. No background noise is present and every word is understood.
4	Reception is clear, but with slight background noise. Message is readable and every word is understood.
3.4	Reception is clear, but with slight background noise. Message is readable and understood with few/occasional missing syllables.
3	Background noise is evident. Message is readable and understood even with missing syllables.
2	Background noise is prevalent. Message is readable with difficulty and requires repetition.
1	Evidence that transmission being made. Voice message is barely discernible and no words are understood. Unusable.
0	No transmission is heard. No activity on the channel is evident.

Minimum capacity requirements are defined as a Grade of Service (GOS) better than .01, which is statistically defined as less than 10 in 1,000 calls could be delayed as a result of system loading and the delay, itself, should not exceed 0.5 seconds.

Today, coverage deficiencies in certain areas of the county are particularly acute, primarily in the northwest part of the County along the Withlacoochee River, in the northeast part of the County in The Villages and in the southern part of the County in Green Swamp. Capacity problems are also sensitive, primarily due to the growth of agencies using a limited number of repeaters.
TCS evaluated multiple conceptual design solutions that have the potential to address these key issues. All of these potential solutions include a new 800 MHz network incorporating a new multisite design, a new simulcast design or hybrid multisite/simulcast options.

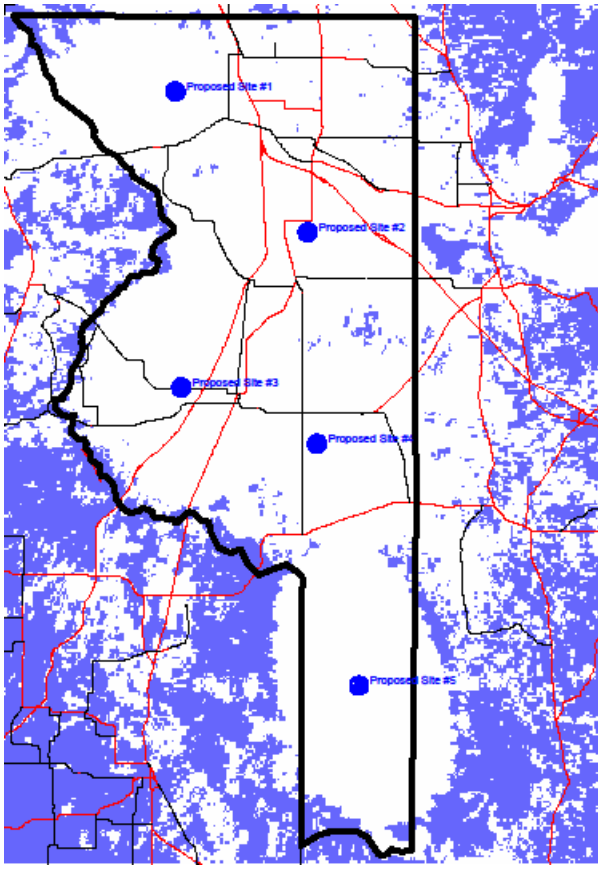
Multisite Only

Computer based coverage models show that in order to increase coverage to meet objectives, a new multisite configuration will require no less than five sites for a P25 solution. Being a multisite design, each of these sites would require their own set of frequencies. Unfortunately, even though Sumter County has 800 MHz frequencies available, the County does not have enough frequencies for a system of this design without the use of 700 MHz channels. In addition, the use of these frequencies requires that the system use no more than 12.5 KHz of bandwidth for each voice channel.



Portable Outdoors Talk-Out, 97.9% Coverage

The first step in determining the feasibility of this approach was to perform a coverage analysis to determine the number of sites needed to meet portable radio coverage objectives. The results of that analysis show that a minimum of five sites will be needed to reach the minimum coverage of 95.0% (portable outdoor talkback). Additional coverage can be obtained through the use of outdoor BDAs placed in various positions throughout the County and the use of vehicular repeaters (DVRS) installed on the County's fire trucks.



Portable Outdoor Talk-Back, 95.4% Coverage

The real benefit of a multisite system is that they are much less complex and are correspondingly less costly. These types of systems do not require critical frequency synchronization between the tower sites. This simplification of the infrastructure sites drives down the cost. However, this cost saving approach does put an additional burden on the users of the system as the radios roaming through the system must transition from one site to the other, often with a delay and occasionally not to the best site for coverage.

Sumter County currently has nine 800 MHz frequencies available. This is far short of what would be needed for a purely multisite design. Implementing a system that meets coverage objectives as well as providing for capacity enhancement would require many more frequencies and it is unrealistic to believe that the County could ever acquire that many channels.

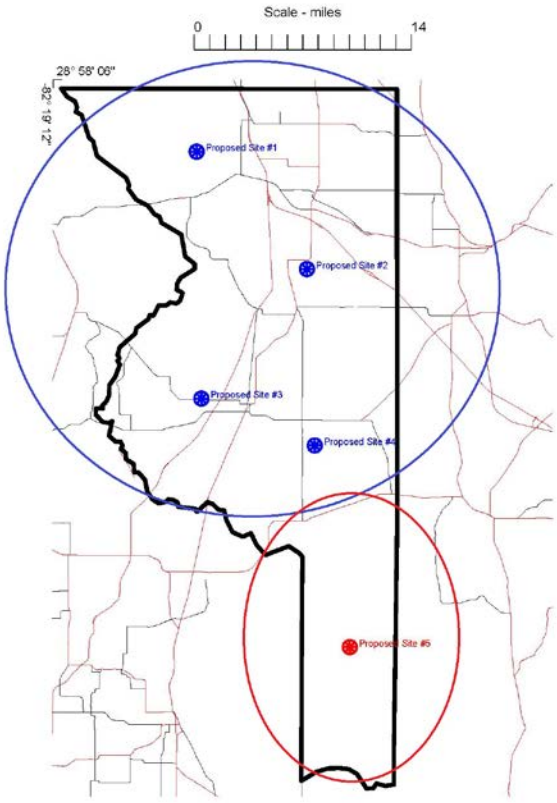
In addition, there are other drawbacks to a multisite-only solution that are worth reviewing, primarily the lack of receiver voting. A receiver voting system allows improved talk-back capability among radios in the field, particularly with portable radios. The voter will determine the "best" received signal from all receiving tower sites and use that signal throughout the system. Since multisite systems have unique frequencies at each tower site, the receive signal will originate at only one tower site, eliminating the option of receiver voting.

In-building coverage will also suffer performance degradation with a multisite design, relative to a simulcast system. Because each site has its own set of frequencies, the tower sites do not "work together" by providing signal penetration from multiple directions into a building.

Simulcast/Multisite Hybrid Solutions

A hybrid simulcast/ multisite design is, as the name implies, a combination of the two technologies. The system is composed of the number of sites necessary to meet coverage objectives. Subsets of these sites are combined into smaller simulcast "cells". These cells are then linked together with multisite technology, resulting in a cohesive wide area coverage solution. Many large systems, including several counties in Florida and the Florida State Law Enforcement Radio System (SLERS) use this design. The primary advantage of this approach is that coverage and capacity objectives can be met with moderate frequency resource requirements compared to a multisite only solution. The primary disadvantage is that the system is more complex due to the integration of both technologies into a single system.

Tusa Consulting Services evaluated several possible design solutions for a Hybrid Multisite/ Simulcast network with the primary goal of meeting coverage and capacity objectives. Maximizing the use of the County's existing infrastructure resources was also a design consideration. The best of these conceptual solutions is a five site design, with those five sites configured into two separate simulcast cells. The cells provide coverage for regions in north and south Sumter County, in a configuration similar to today's multisite network. These two simulcast cells are interconnected via multisite technology into a countywide network. A diagram of this design is provided below. Note that the circles on this diagram represent simulcast system affiliation, and not coverage. Coverage maps are provided in following sections of the report.



Conceptual Hybrid Solution

Simulcast Only

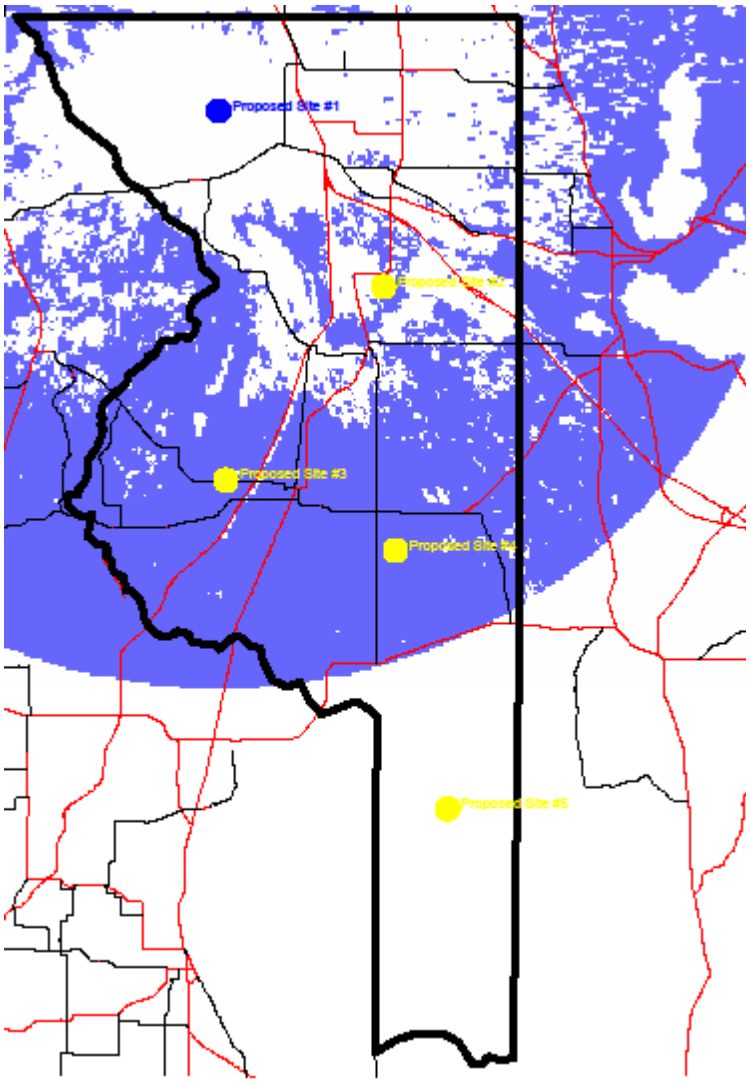
A countywide simulcast system design was the next potential solution investigated. Like multisite systems, computer based coverage models show that five simulcast sites would be required to meet the County's objectives.

The simulcast only solution has many advantages and is the best approach to a P25 800 MHz radio system modernization that TCS is recommending to Sumter County. The first advantage, as explained in Section 3.0 of this Report is that the same set of frequencies can be used throughout the County. This is a good fit for the County's limited number of available frequencies. In addition, because of this, the subscriber radios only need to synchronize on power up. There is no need for the user to consider their location relative to tower/sites. The second benefit is improved in-building coverage due to greater 'same frequency' signal propagation as a result of transmission from multiple towers. This approach will also give the impression of better coverage to the users of the system due to the receiver voter function improving the talkback capability.

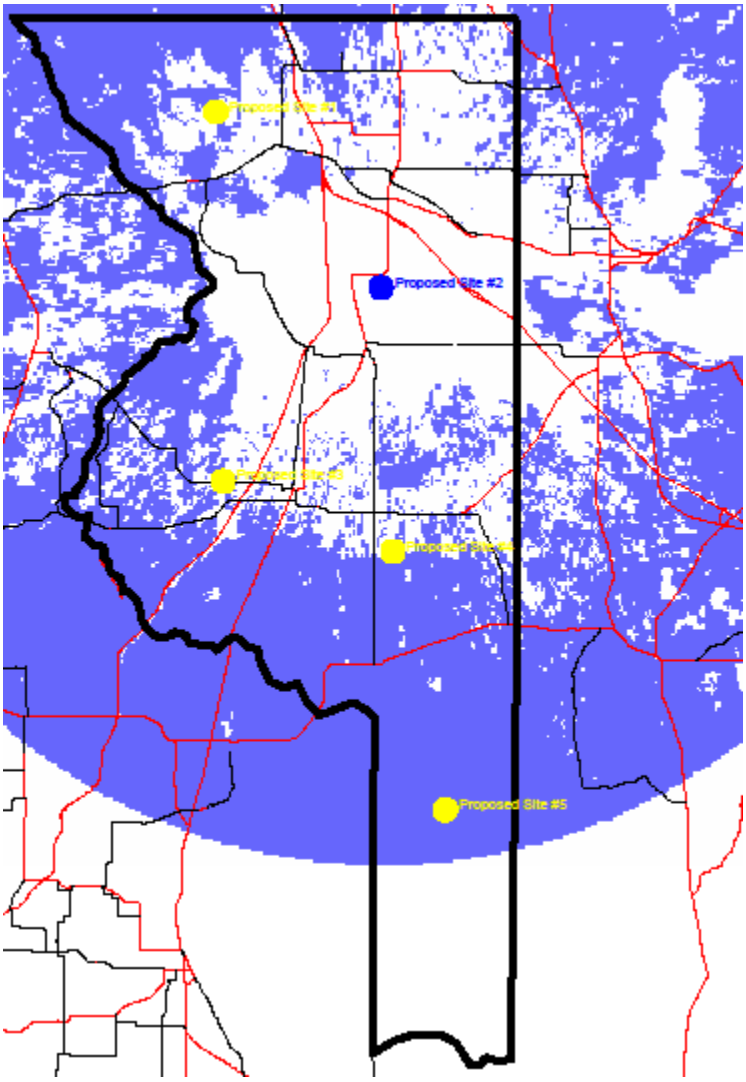
The example simulcast system provided below offers a hypothetical design that would support the County's coverage and interoperability needs. In this design, coverage for the majority of the County could be provided by a five site simulcast cell. These sites do not currently exist as their locations were chosen for optimal coverage.

Name	Location	Height
Proposed Site #1	28°54'03.351"N 82°10'02.544"	TX - 400', RX - 380'
Proposed Site #2	28°47'27.476"N 82°02'27.476"	TX - 400', RX - 380'
Proposed Site #3	28°40'10.824"N 82°09'43.401"	TX - 400', RX - 380'
Proposed Site #4	28°37'32.406"N 82°02'30.064"	TX - 400', RX - 380'
Proposed Site #5	28°26'12.080"N 82°00'16.340"	TX - 400', RX - 380'

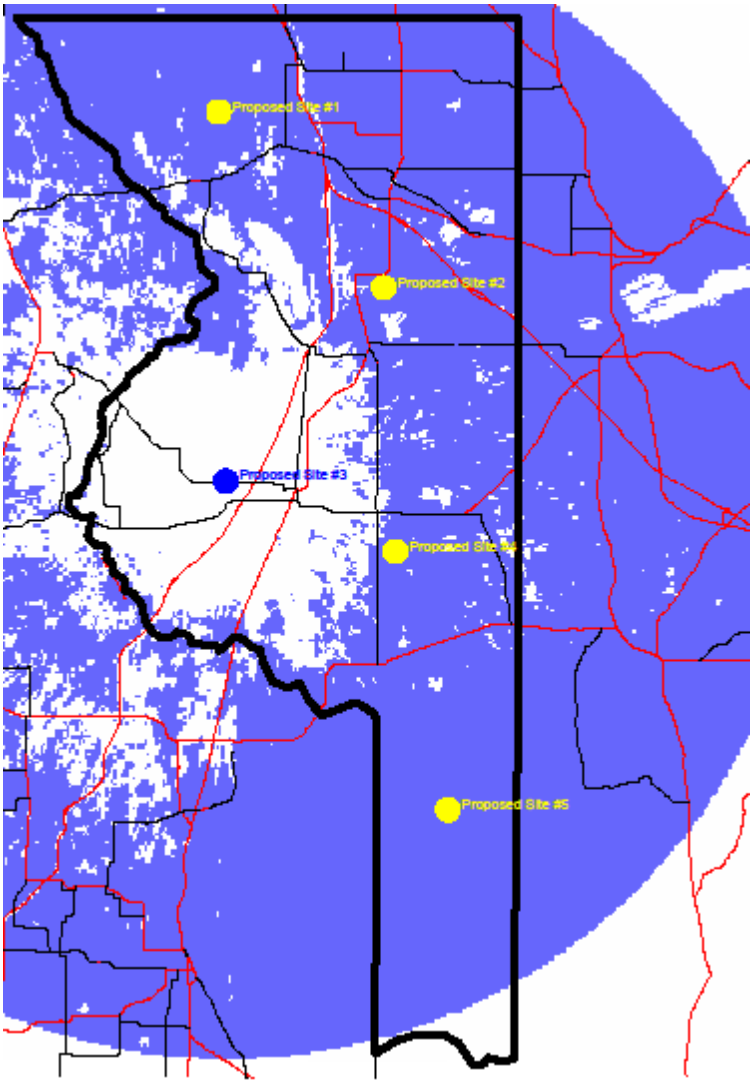
Proposed Site #5 in Green Swamp would serve as the primary control point. Tower heights of 400' AGL will provide the needed coverage.



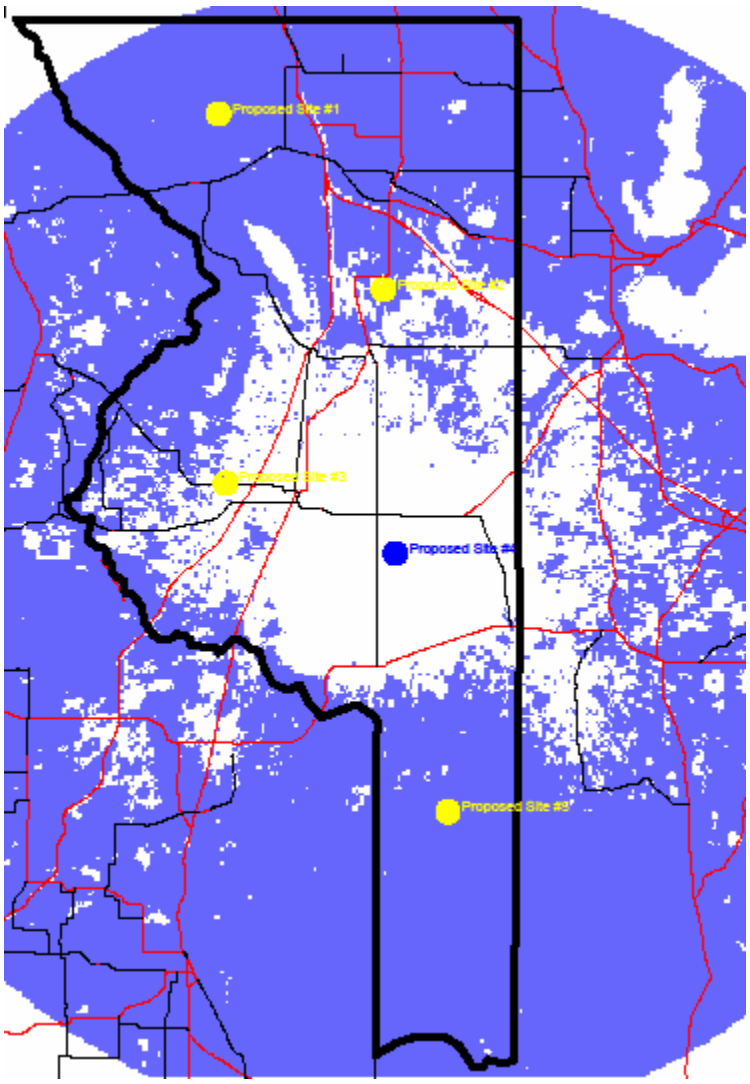
Proposed Site #1 – Rutland Area



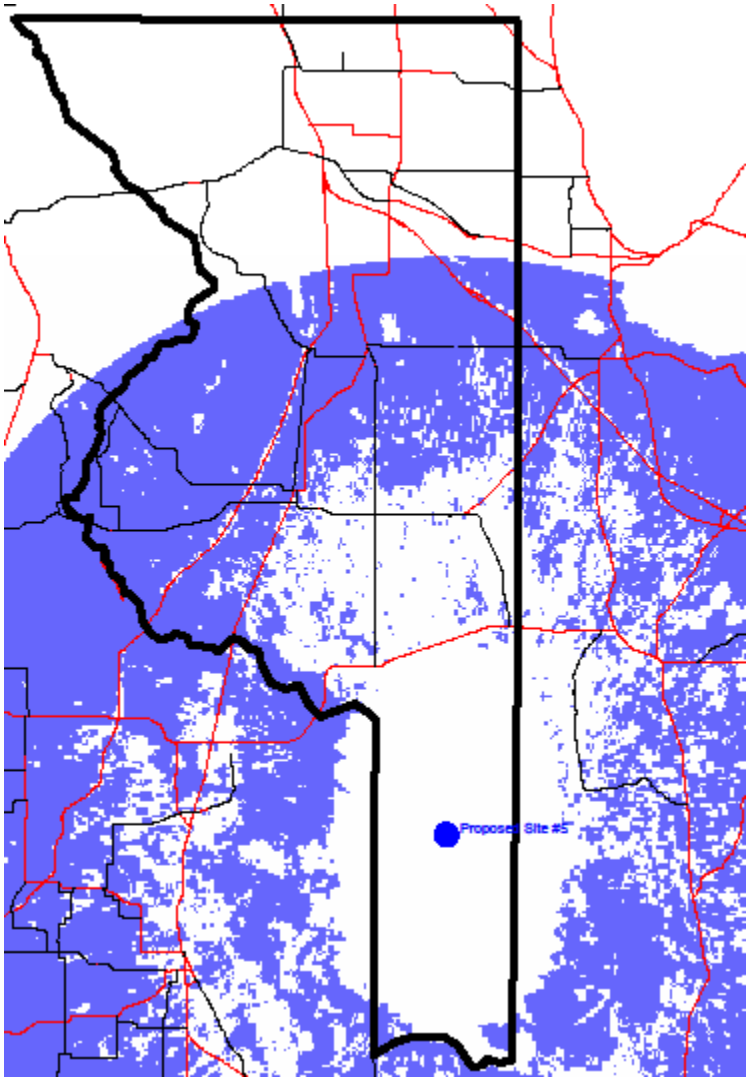
Proposed Site #2 – Coleman Area



Proposed Site #3 – Bushnell Area



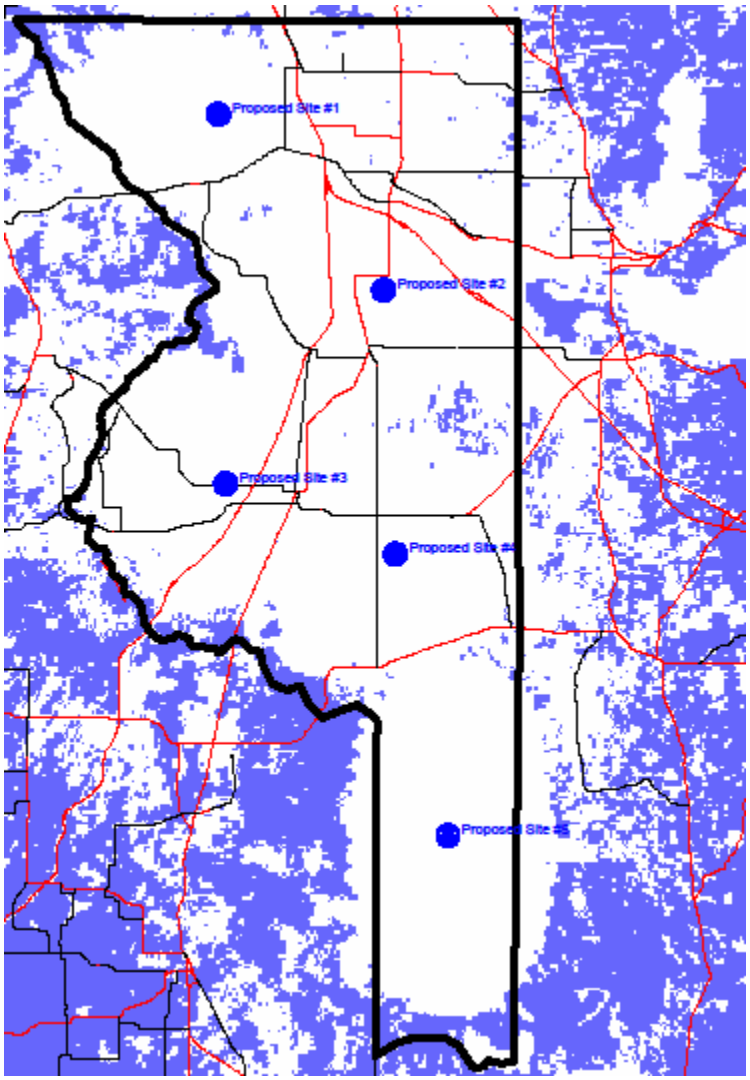
Proposed Site #4 – Webster Area



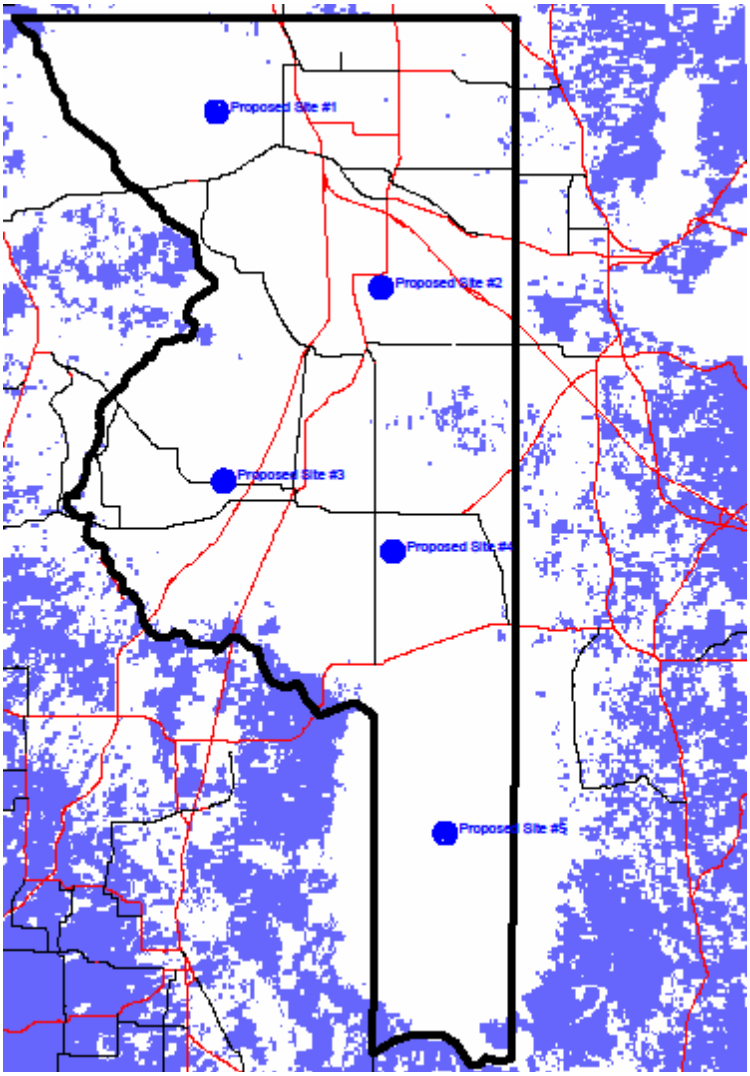
Proposed Site #5 – Green Swamp Area

Composite Coverage

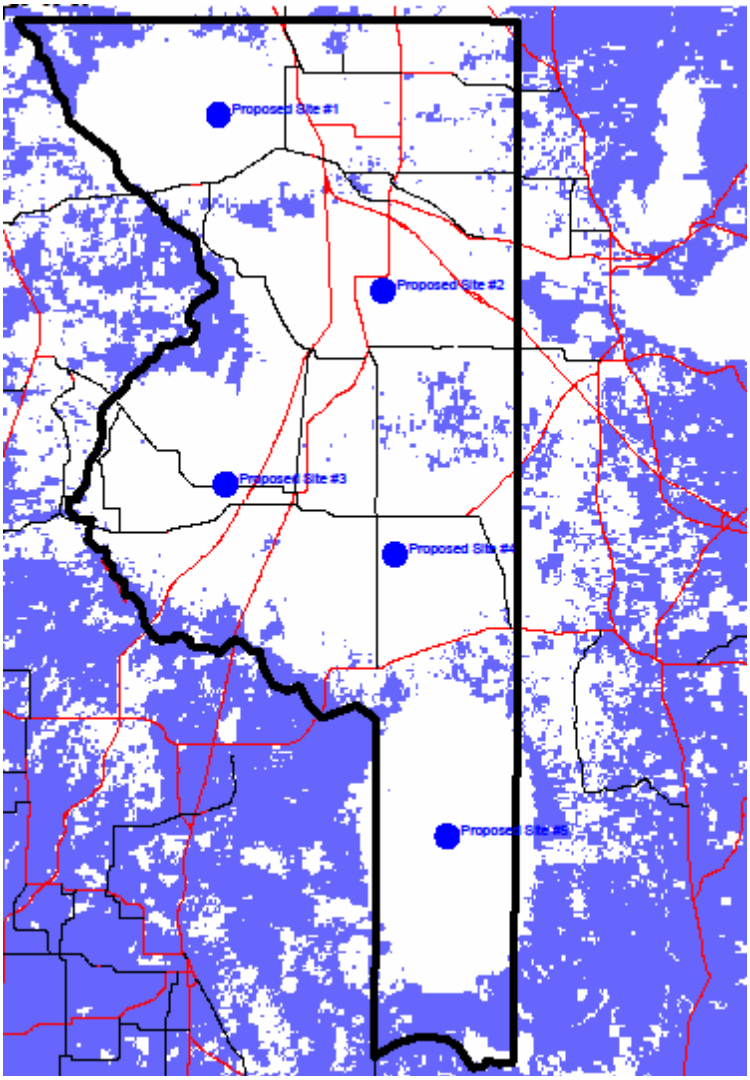
The coverage maps below show the predicted overall coverage from the five towers/sites combined.



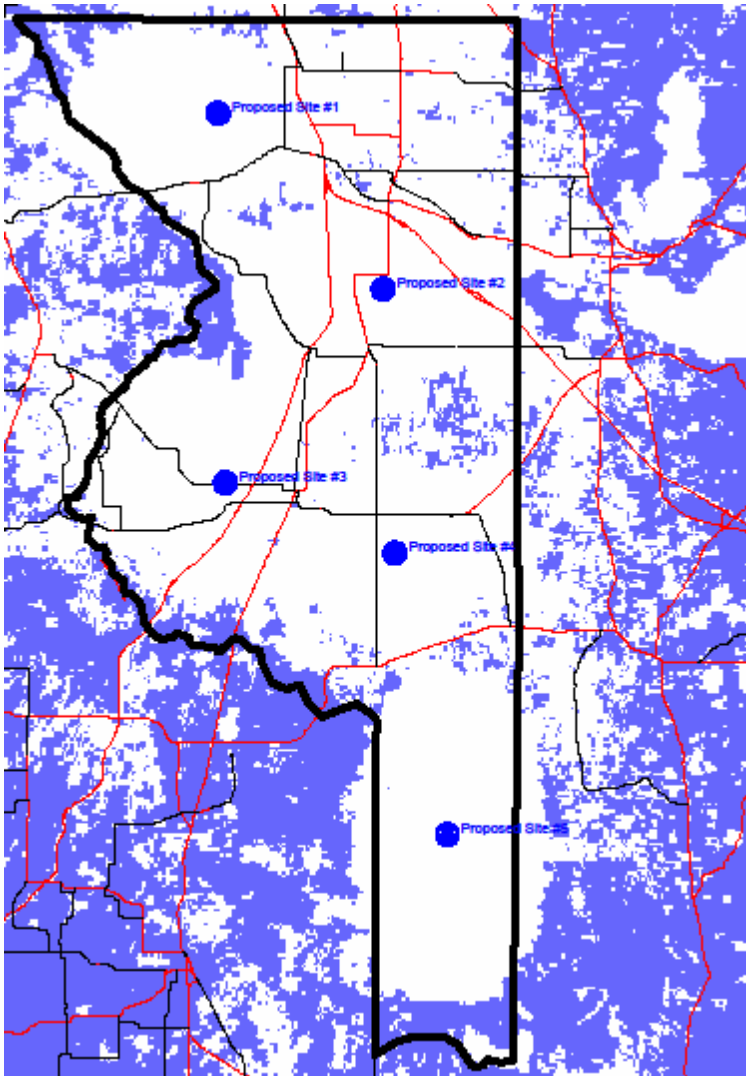
Composite Portable Outdoor Talk-Back (POTB)



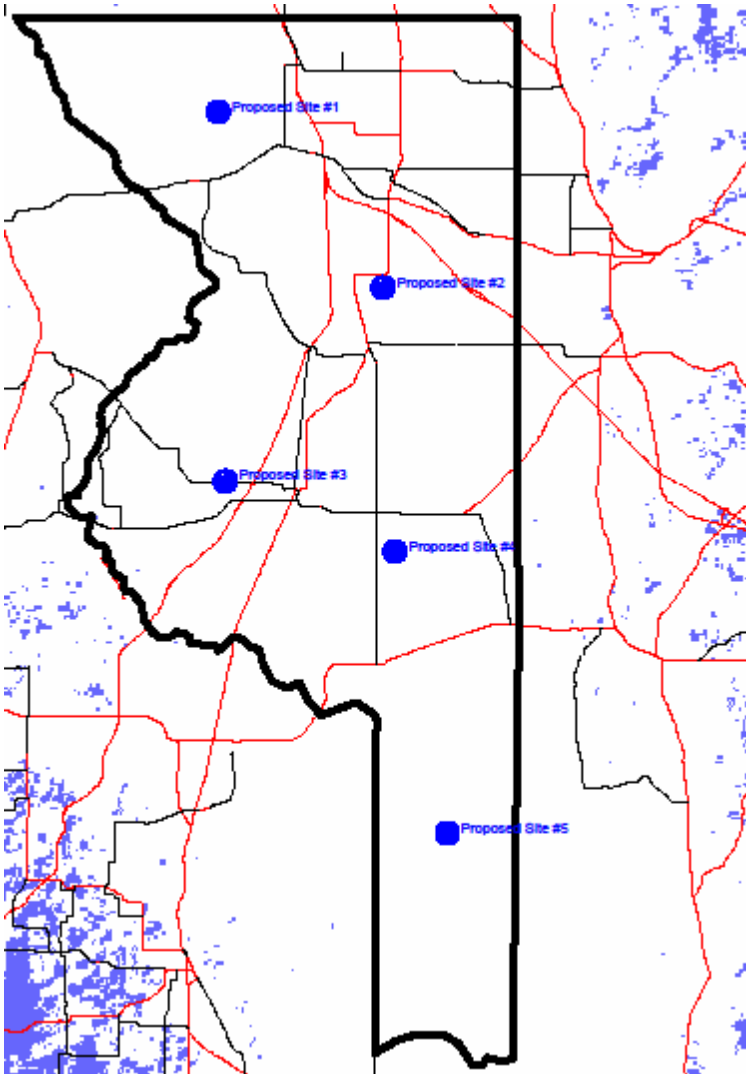
Composite Portable Outdoor Talk-Out (POTO)



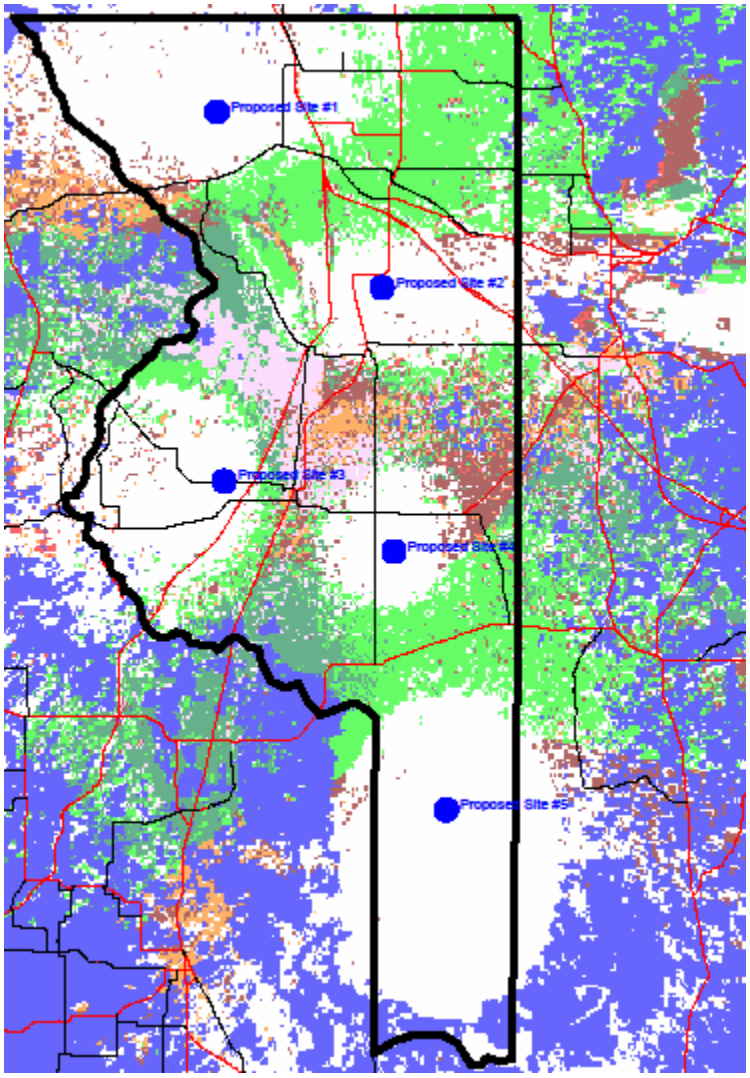
Composite Portable Indoor Talk-Back (PITB)



Composite Portable Indoor Talk-Out (PITO)



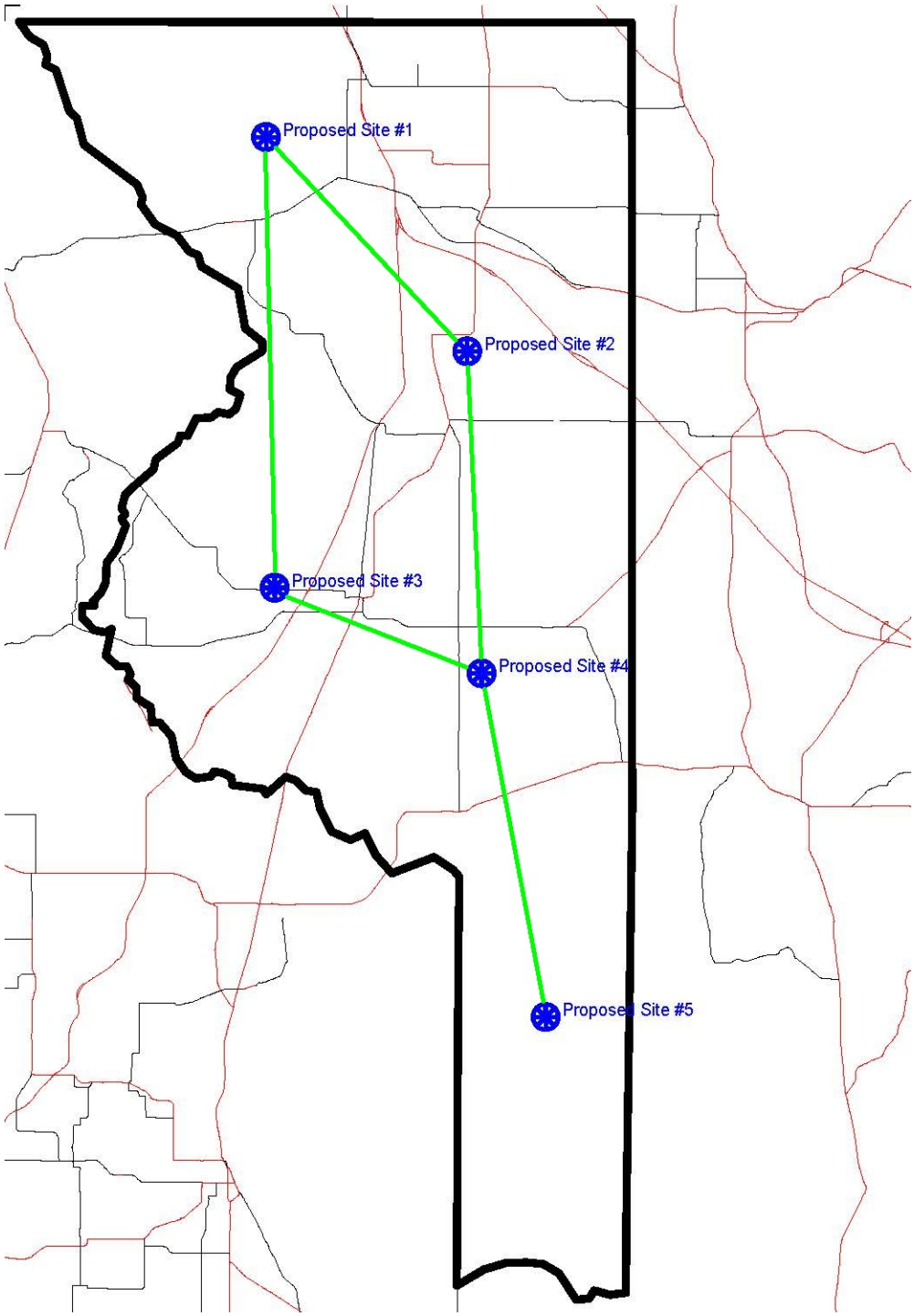
Composite Mobile Talk-Back (MOTB)



Composite Simulcast Propagation Timing

System Connectivity and General Implementation Issues

To support a simulcast design, a new microwave subsystem would be required. For the purposes of this conceptual design, Tusa envisions a combination loop protected and monitored hot standby network. The county simulcast cell would be connected by loop protected links, shown in green below. The remaining site would be a spur and will connect the "Green Swamp" area site to the "Bushnell" area site.



Microwave Paths – 5 Site Design

Simulcast 5-Site System Cost Estimate

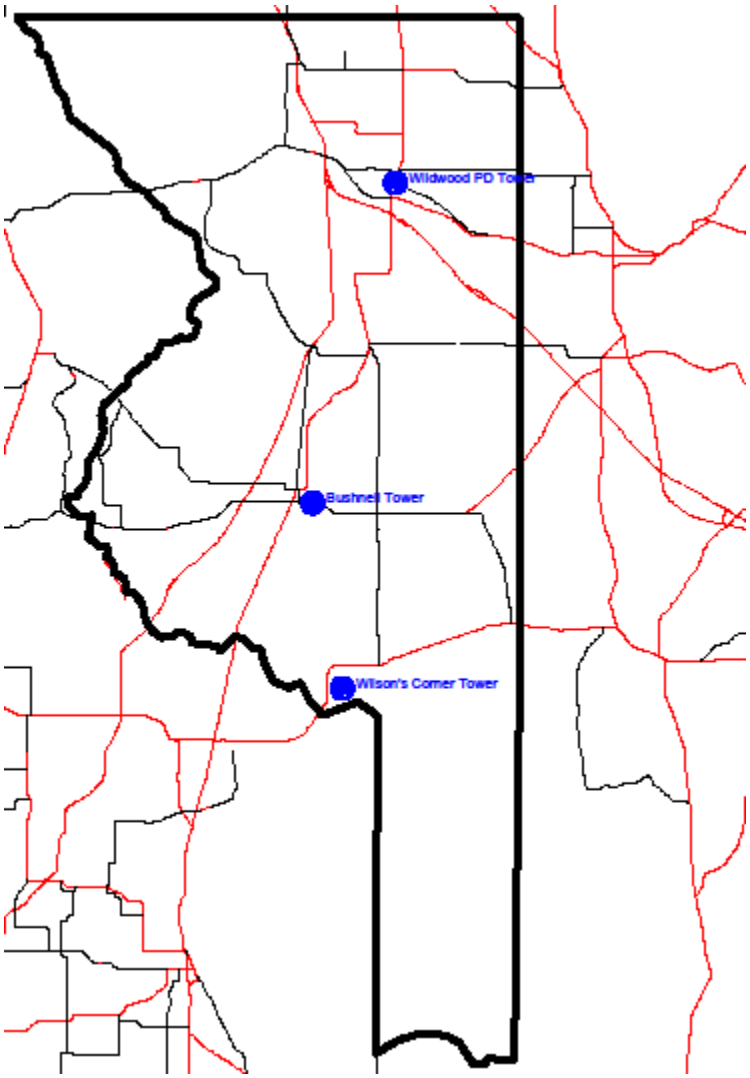
Presented below is TCS' cost estimate for a P25 simulcast conceptual design. The cost of the actual system is dependent upon the system requirements and features included in the final specification, but these estimates can be considered reasonably accurate for budgetary purposes. They are based upon TCS' understanding of Sumter County's requirements, resources and upon recent competitive pricing for similar equipment and systems. Additionally, this solution is contingent upon the availability of licensable frequencies.

Sumter County Pricing Summary - 5 Site Design	
Description	**Total**
Voice Infrastructure	$4,024,000.00
Systems Integration	$650,000.00
Voice Infrastructure Total	**$4,674,000.00**
Site Construction	$4,387,000.00
Site Construction Contingency	$877,000.00
Site Construction Total	**$5,264,000.00**
Microwave	$970,000.00
Microwave System Integration	$200,000.00
Microwave Contingency	$194,000.00
Microwave Total	**$1,364,000.00**
Sumter County Dispatch Center	**$1,031,000.00**
Sumter County Subscribers	**$3,478,000.00**
Sumter County Grand Total	**$15,811,000.00**
Competitive Procurement Process	
Infrastructure w/shared switch	$7,519,000.00
Dispatch	$552,000.00
Subscribers	$2,608,500.00
Competitive Process Grand Total	**$10,679,500.00**

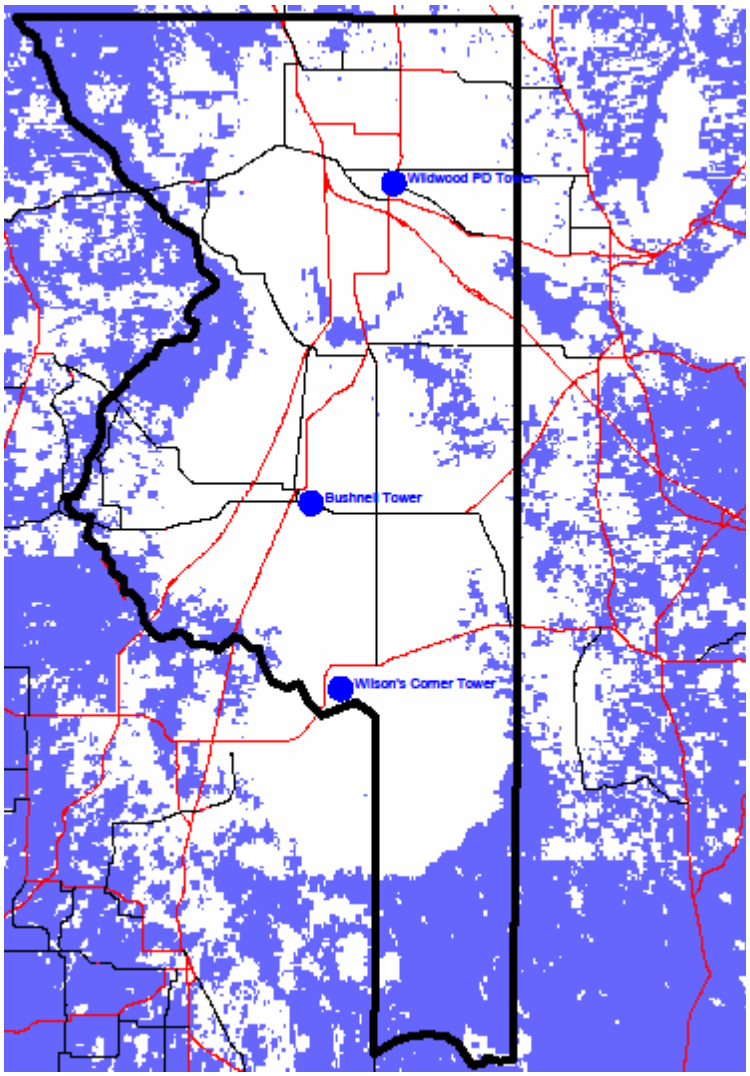
Maintenance Services (Yearly)	
Software Services	$87,500.00
Infrastructure Equipment	$141,000.00
Simulcast Control Point	$27,000.00
Primary Network Switching Center	$15,000.00
Microwave	$16,000.00
Dispatch Equipment	$19,000.00
Subscribers	$97,000.00
HVAC	$18,000.00
Generators	$8,000.00
UPS	$12,000.00
Logging Recorder	$10,000.00
Network Preventative Maintenance (twice annually)	$40,000.00
Maintenance Services Plan Total	**$490,500.00**

Optional Simulcast Design

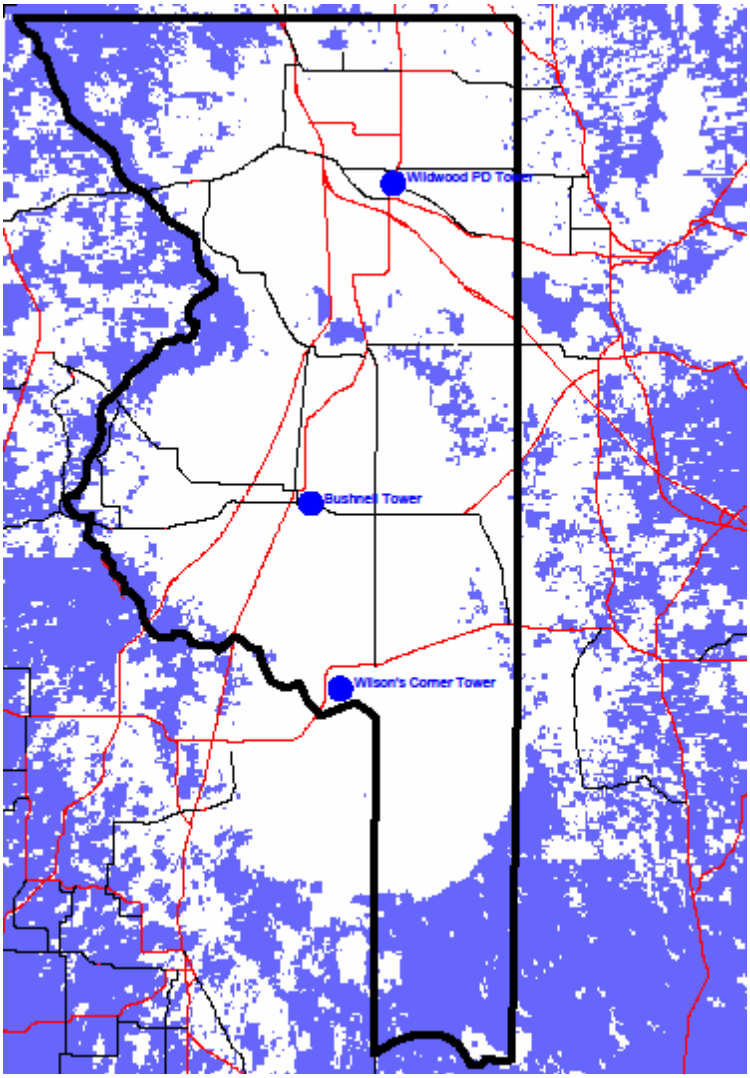
As an option, TCS has included a lower cost 3 site option. This option provides the required level of mobile talk-out and talk-back coverage, but at the price of reduced portable coverage within the County in heavily forested areas. The Wildwood PD site, Bushnell site and Wilson's Corner site could potentially be reused, but would require replacement of the towers and site upgrades.



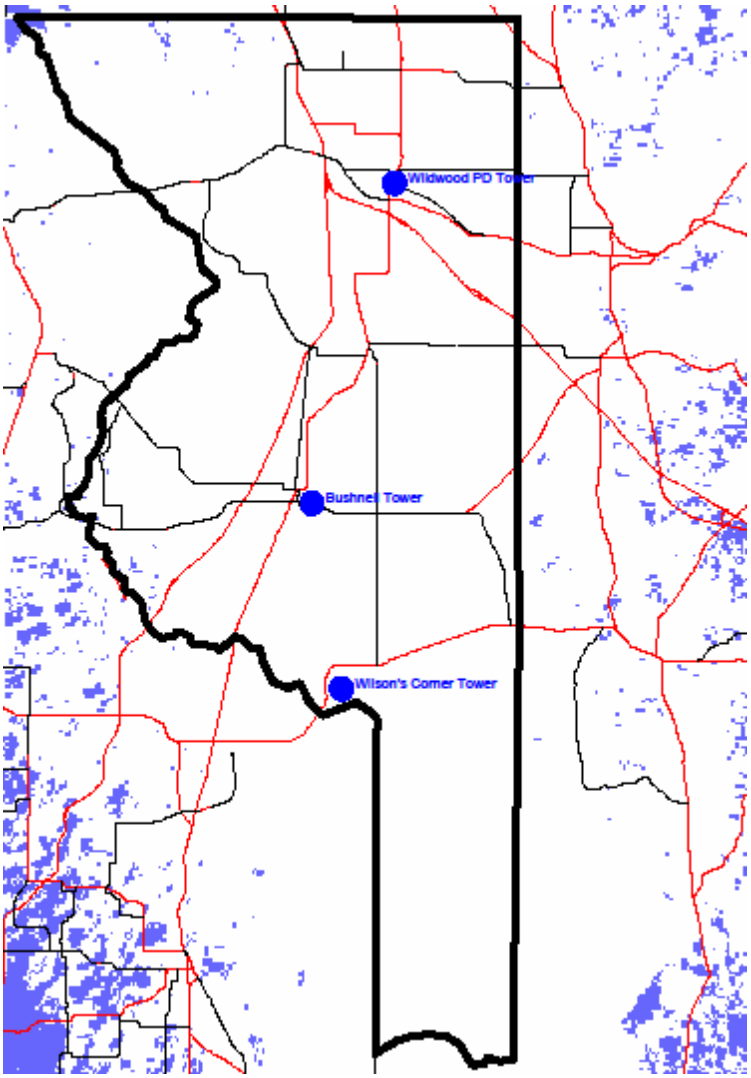
Simulcast 3-Site Design



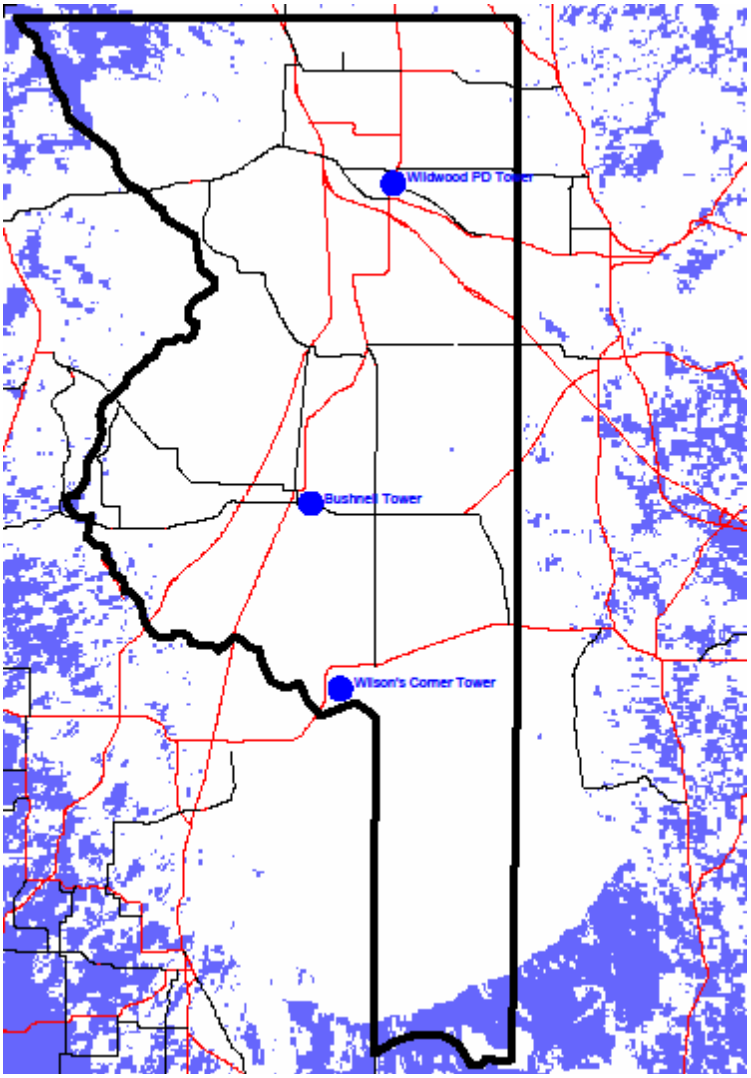
3-Site Portable Outdoor Talk-Back



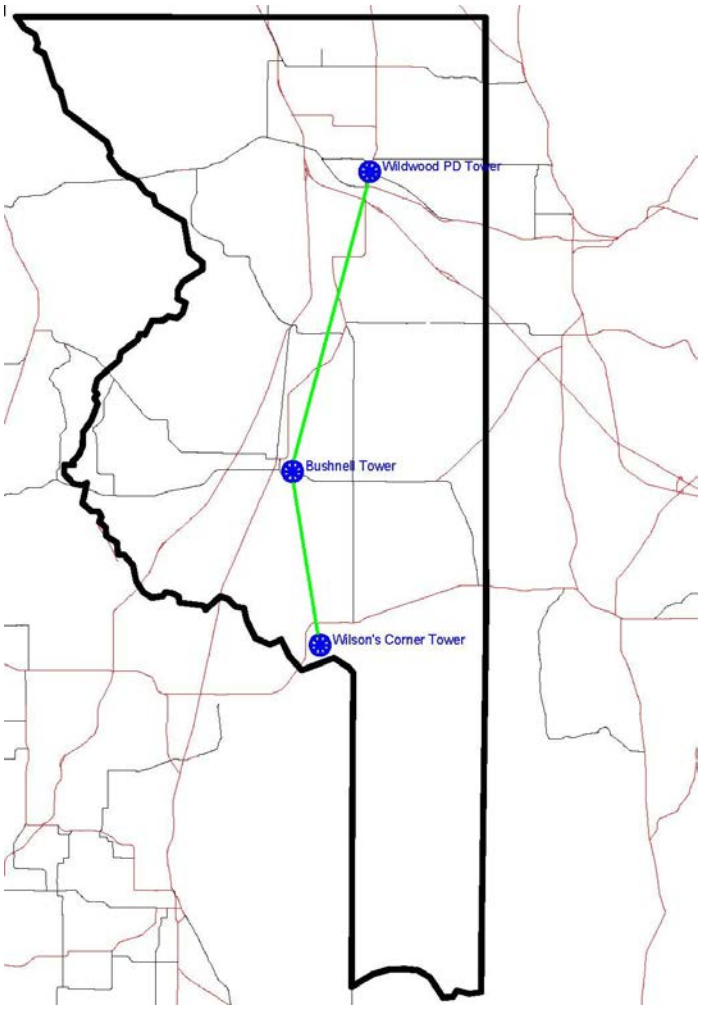
3-Site Portable Outdoor Talk-Out



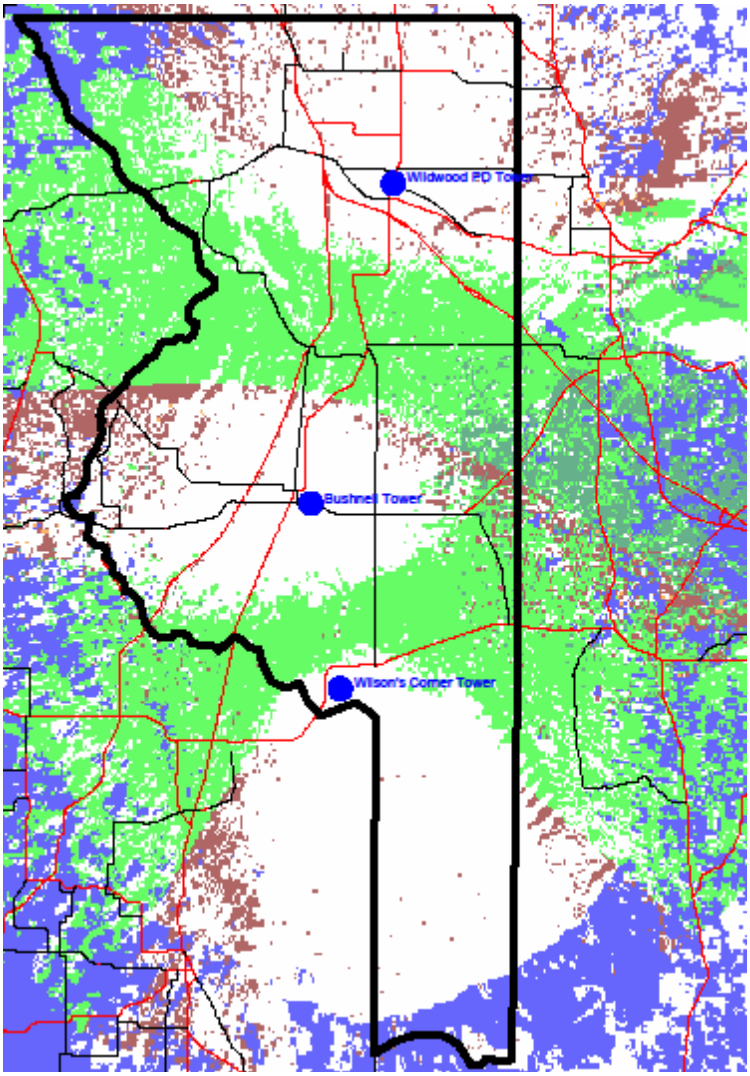
3-Site Mobile Talk-Back



3-Site Mobile Talk-Out



3-Site Microwave Path



3-Site Simulcast Timing

Simulcast 3-Site System Cost Estimate

Presented below is TCS' cost estimate for a P25 simulcast conceptual design. The cost of the actual system is dependent upon the system requirements and features included in the final specification, but these estimates can be considered reasonably accurate for budgetary purposes. They are based upon TCS' understanding of Sumter County's requirements, resources and upon recent competitive pricing for similar equipment and systems. Additionally, this solution is contingent upon the availability of licensable frequencies.

Sumter County Pricing Summary - 3 Site Design	
Description	**Total**
Voice Infrastructure	$3,252,000.00
Systems Integration	$390,000.00
Voice Infrastructure Total	**$3,642,000.00**
Site Construction	$2,827,000.00
Site Construction Contingency	$565,000.00
Site Construction Total	**$3,392,000.00**
Microwave	$585,000.00
Microwave System Integration	$200,000.00
Microwave Contingency	$117,000.00
Microwave Total	**$902,000.00**
Sumter County Dispatch Centers	**$1,031,000.00**
Sumter County Subscribers	**$3,478,000.00**
Sumter County Grand Total	**$12,445,000.00**
Competitive Procurement Process	
Infrastructure w/shared switch	$4,920,000.00
Dispatch	$589,000.00
Subscribers	$2,608,000.00
Competitive Process Grand Total	**$8,117,000.00**

Maintenance Services (Yearly)	
Software Services	$52,500.00
Infrastructure Equipment	$84,600.00
Simulcast Control Point	$27,000.00
Primary Network Switching Center	$15,000.00
Microwave	$9,600.00
Subscribers	$97,000.00
HVAC	$10,800.00
Generators	$4,800.00
UPS	$7,200.00
Logging Recorder	$6,000.00
Network Preventative Maintenance (twice annually)	$24,000.00
Maintenance Services Plan Total	**$338,500.00**

Wireless Data Conceptual Solutions

Some of Sumter County's public safety agencies currently use mobile wireless data. Those agencies that do not yet use mobile data, consider it a future requirement. Given today's available technology, there are three practical county-wide wireless data options available. 1) High speed data via a County implemented public safety wireless data network using narrowband channels. 2) 700 MHz LTE. 3) Wireless data service provided by commercial carriers. These three options provide the greatest potential of meeting the County's wireless data needs. An overview on the relative merits of these three technologies was provided in the technology overview section of this report.

Two other wireless data options are available, the first low speed data using the voice system's infrastructure, and the second, a wireless broadband system based on WI-FI hotspots. Neither was considered as candidates for the County's primary data network. These last two options are not considered viable because the performance of the first option is to poor to meet the needs of the majority of the County's users, and the cost of the second is exorbitantly high. Both could be useful to the County in support of certain niche applications or as a supplement to the County's primary wireless data system.

Many County agencies currently use commercial providers to meet their wireless data requirements. There is no reason why this option cannot continue to be viable as long as the agencies using these services understand that the service is not designed to meet public safety standards for reliability and accessibility. If agencies use these services, they should also implement contingency plans to cover the inevitable system outages. Commercial wireless data service should not be relied upon to serve any critical role in storm plans.

Implementing a County-wide, public safety hardened high speed data network using 800 MHz channels is also possible. Equipment appropriate to implementing this data network is available

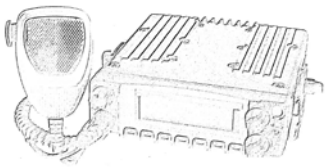
from multiple vendors and could be obtained competitively. This system could share the voice system's site resources and microwave backhaul, but because the wireless data system is essentially standalone, the choice of the system type or vendor for the voice system would have little effect on this portion of the project. For budgetary purposes the RF infrastructure portion of such a system would cost between $600,000 and $1M dollars. The bulk of the cost is in terminal equipment, with $2,500 to $3,500 per mobile radio typical. Assuming 800 MHz data equipped mobiles, the total estimated cost for RF data would be between $2.6M and $3.8M, exclusive of mobile data computers and software.

The final option is for the County to implement a wireless data solution using the 700 MHz LTE (3GPP Long Term Evolution) platform. The main advantages with LTE are high throughput, low latency and *plug and play* technology. LTE technology also offers the ability to roam onto commercial systems if needed.

While LTE does offer many advantages, there are some disadvantages that are significant. The cost of the infrastructure sites is still unknown at this time since the technology is still evolving. This unknown factor is important because the LTE coverage footprint is smaller than an 800MHz P25 coverage footprint. Because of this additional infrastructure sites will be need to deploy a LTE network. In addition, in order to deploy a LTE network, the County would need to apply for a waiver from the FCC rather than a license.

LTE also requires a much larger backhaul component in order to deliver the high bandwidth. Because of this, the cost of the backhaul will be much more expensive than what would be used on an 800 MHz P25 network.

9.0 Subscriber Radios



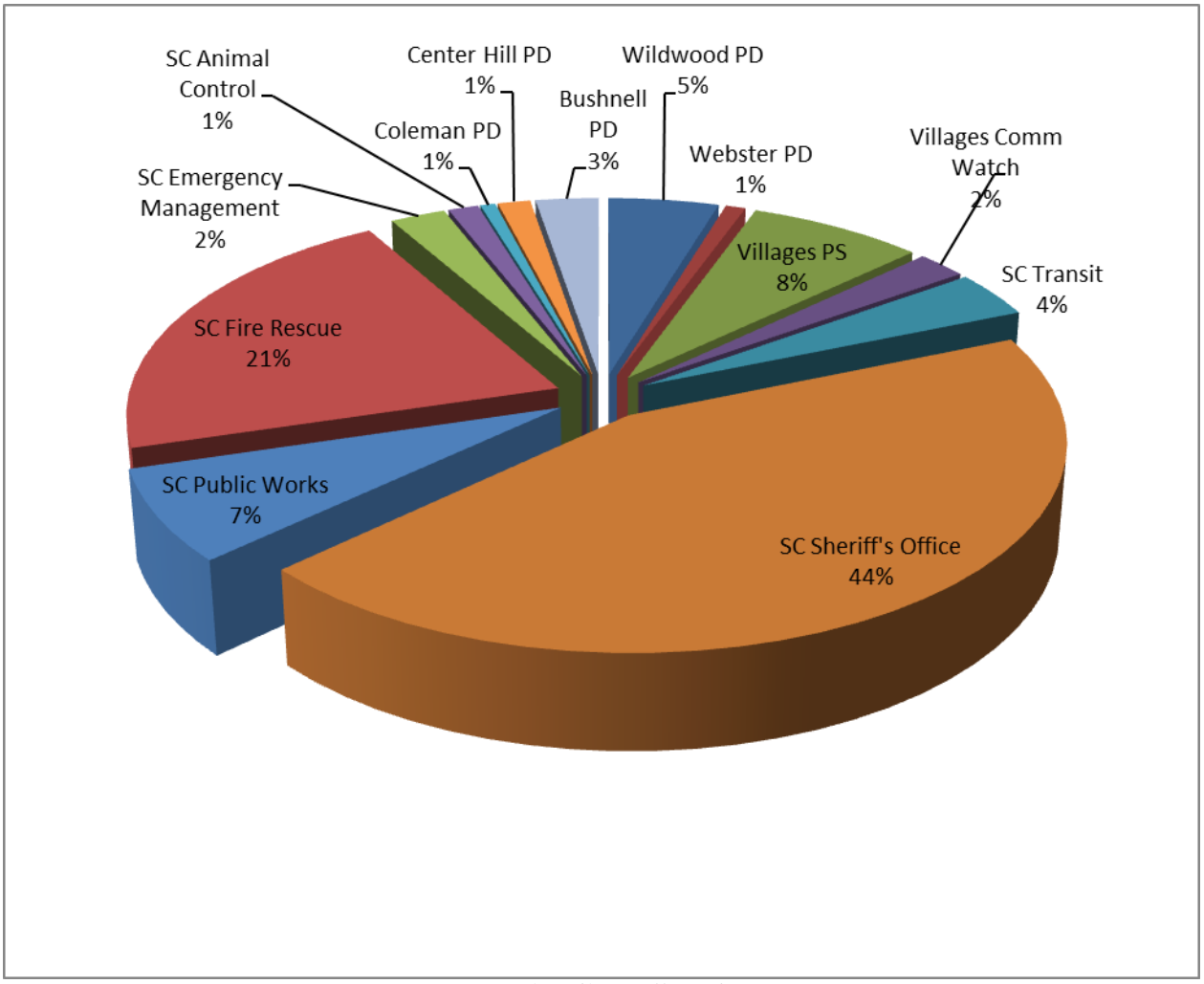
Public Safety users have stringent expectations for system reliability, radio coverage and audio quality. Interruptions in radio service availability and access are, in most cases, unacceptable. High-quality portable unit coverage is desired and necessary throughout the user-agency's geographic service area, both on-street and within buildings and automobiles. Delivered audio must be of the highest order of clarity with little background noise or radio static.

Public safety grade radio requirements greatly exceed the needs of non-public safety agencies, commercial and radio-dispatched delivery services, but are essential to the mission of Public Safety departments. Unfortunately, increased performance leads to more complex and costly radio communication infrastructures. On the other hand, non-public safety agencies' mobile and portable radios do not need to meet the stringent engineering specifications as required by the State of Florida and are therefore much less expensive.

Coverage reliability is enhanced through proper consideration of environmental losses, building losses and other user configuration factors. For example, at 800 MHz, it has been found that in-vehicle propagation losses may be 6 to 10 times higher than those encountered on-street. Portable radios operated at hip-level (by speaker/ microphone) are subjected to additional body losses which may be 8 to 10 times higher when compared to utilizing the same radio at head level. Building propagation losses vary widely due to location (densely-packed structures are affected by shading losses) and construction materials further aggravating portable radio operations.

How users intend to operate radio communications systems and equipment has a profound impact on infrastructure design configurations. Generally speaking, Public Safety systems are optimized for the user group having the most stringent operational requirements, which automatically provides an enhanced performance margin to those groups having lesser needs.

The dispatch and coordination of Sumter County emergency communications resources occur principally through either Sumter County Sheriff's Office or Lake-Sumter EMS. Officers and paramedics are directed to specific incidents and locations in response to citizen calls placed via the County's 911 Emergency Telephone Network. The County intends to purchase hundreds of radios and intends to have a multiple agencies utilizing the new 800 MHz P25 system.



Sumter County Subscriber Allocations per Agency

10.0 Conclusion and Recommendation

Voice System

Investigated options

Tusa has determined that a comprehensive long term 800 MHz trunking solution would require the following. To review, the approaches considered are listed below, along with brief comments for each.

- Implementation of a multisite network
  This approach was rejected due to limitations of the County's frequencies and poor long-term expansion capability

- Implementation of a hybrid simulcast/multisite network
  This approach was rejected due to the increased and unnecessary complexity, and the low traffic levels in remote parts of the County

- Implementation of a county-wide simulcast system
  This is a viable system configuration that can be implemented with the 5 (or 3) infrastructure sites identified in the County

Recommended Solution and Plan

Tusa Consulting recommends that the County move toward a competitive bid procurement of a P25 based simulcast radio network. This implementation should be comprehensive and include all aspects of the desired voice network, including the RF infrastructure, inter-site connectivity, dispatch subsystem, and user equipment. The intent should be that at the end of the project that the entire County's fixed equipment has been replaced and is fully compatible with the vendor's latest available 800 MHz P25 infrastructure. Similarly all user equipment would be upgraded to 800 MHz P25 compatibility.

At the conclusion of this project, the County would have a fully modernized public safety wireless communications system that:

- Meets or exceeds industry standards;
- Meets current communications requirements;
- Meets future (10-15 year) requirements for capacity and expansion;
- Meets communication interoperability needs with neighboring agencies And;
- Is capable of being maintained and supported for the life of the system.

Data System

Recommended Solution and Plan

The County's options regarding public safety mobile data are somewhat limited. Tusa recommends that County agencies continue to use commercial carriers for service in the near term. The trunked voice system should include provisions for trunked data capability to provide that capability to support those applications that can tolerate the slow data throughput provided by that feature. The effect on cost of including this capability on the voice system would be insignificant.

A longer term solution should address the reliability issues inherent in a commercial service. At present, the only sure option is to implement a County owned public safety wireless data network using the County's existing and soon to be available 700 and 800 MHz channels. Due to the current uncertainty regarding the future of 700 MHz wideband/ broadband data, Tusa Consulting Services recommends any decision regarding this option be delayed at least a year, by which time the current open questions regarding the future of 700 MHz data should be answered.

tusa | consulting services

Our Radio Systems Speak for Themselves.

Sumter County, Florida
Public Safety Radio Consulting Services
Conceptual Solutions Report

Addendum 1.0

June 06, 2011

Table of Contents

1.0 Abstract

On May 26, 2011, Tusa Consulting Services (TCS) presented a Conceptual Solutions Report to Sumter County. Based on research of County assets and communications needs, this report offered two examples of how county-wide radio coverage could be implemented within Sumter County. The first design provided the industry standard of 95% coverage for portables and 100% coverage for mobile radios. A second solution was offered that would provide less than 95% (~80%) coverage for portables and 100% coverage for mobiles, but at a much reduced cost for implementation.

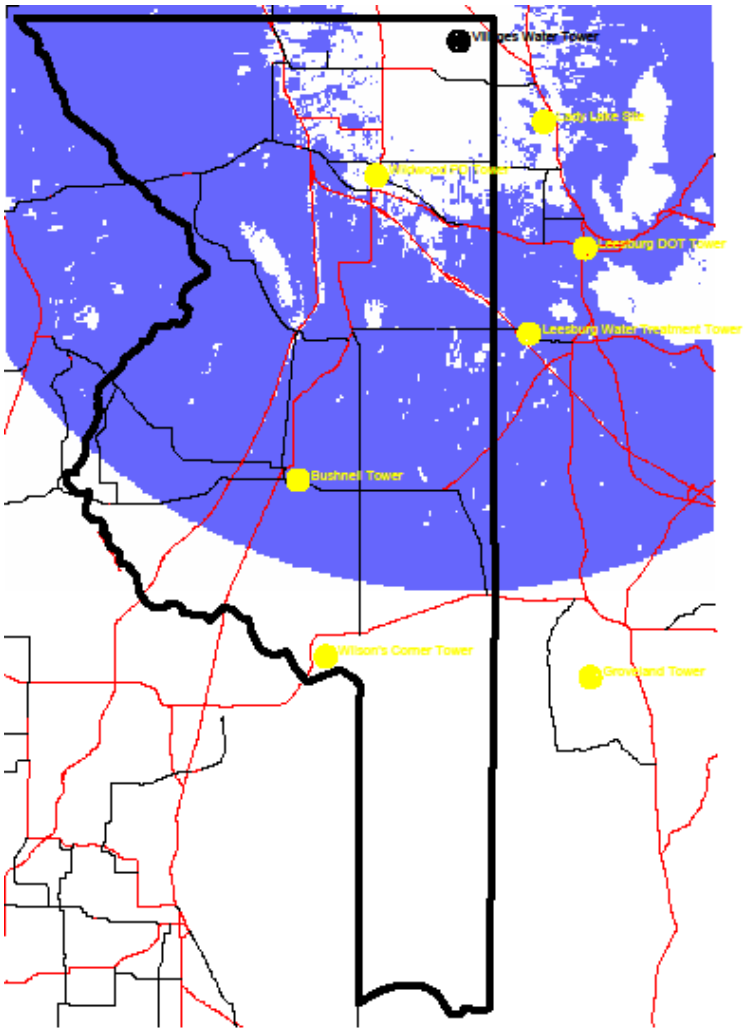
During the presentation, TCS was asked to provide an analysis of potential benefit that could be gained by sharing resources with a neighboring county. By leveraging existing radio resources, Sumter County could potentially build a modern 800MHz radio system for less cost than building a standalone system. Reductions in cost can be obtained by either using a neighboring county's Master Site Switch or by using a neighboring County's existing towers/sites to provide coverage in Sumter County. TCS did not include an analysis of Hernando County or Citrus County due to the age of their existing systems and the lack of a clear schedule for modernization. It was also determined that Polk County and Pasco County could not offer any feasible benefit due to the distance of their towers/sites and radio resources. Instead, this addendum focused on the existing radio resources in both Lake County and Marion County to determine the extent, if any, to which Sumter County would benefit.

It is important to note that the Conceptual Report only presents estimates of expected coverage and cost. The final designs and system implementation costs presented by vendors will potentially vary, but will be held to strict standards as outlined in the RFP and negotiated in the contract between the vendor/consultant and Sumter County.

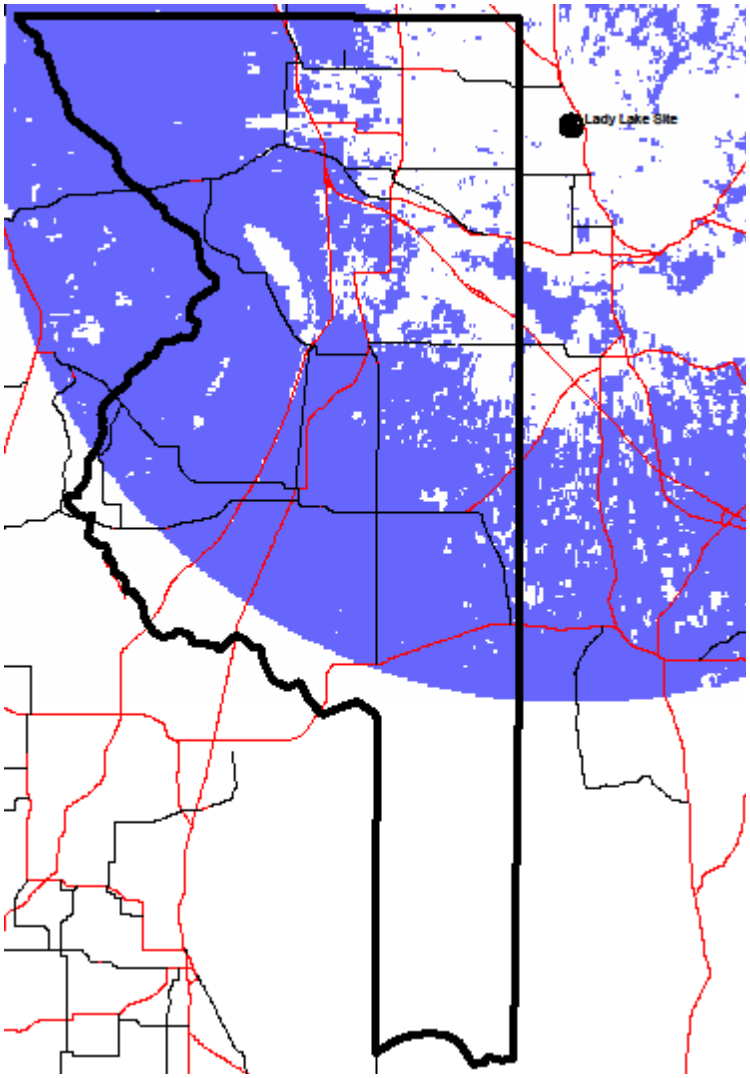
2.0 Lake County Sites/ Coverage

Greg Holcomb, Division Director/E911 Coordinator, Lake County Department of Public Safety, provided site locations in support of Sumter's efforts to modernize its Public Safety radio system. While all sites show some coverage within Sumter County's borders, none of the sites are close enough to change the conceptual tower locations as recommended in the Conceptual Design Report. This is expected as 800MHz systems in Florida must meet the Region 9 Plan for Public Safety Radio Communications. This plan seeks to limit radio transmissions from traveling into and interfering with those of adjoining counties. Lake County is interested in sharing their Master Site Switch.

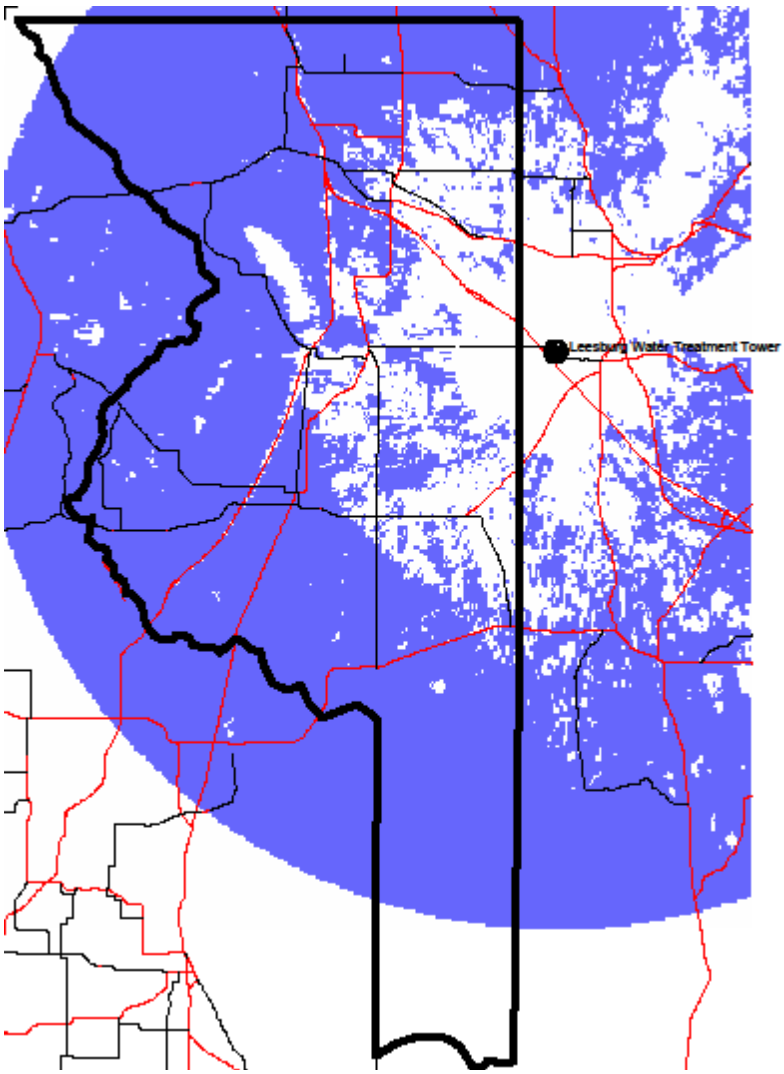
*According to Mr. Holcomb, the Leesburg DOT Tower and Groveland Park Tower as not suitable for co-location of antennas. There are offered here to show beneficial coverage for Sumter personnel traveling into Lake County.



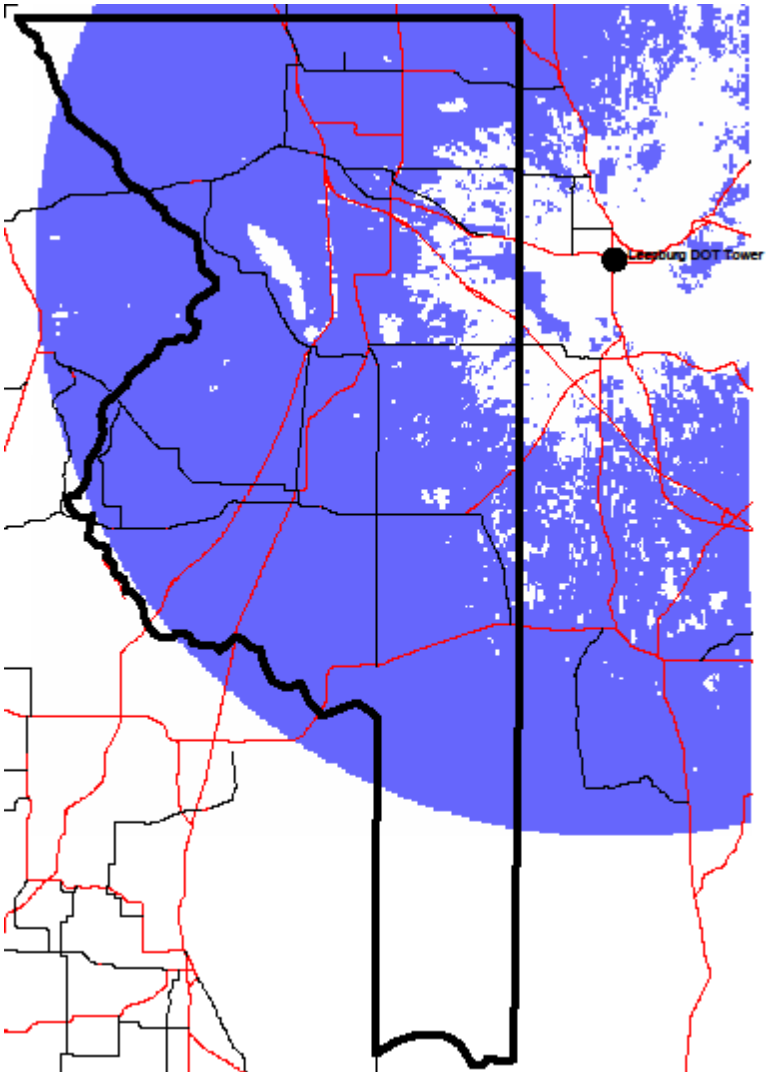
Lake County – Villages Water Tower Site – Portable Talk-Back



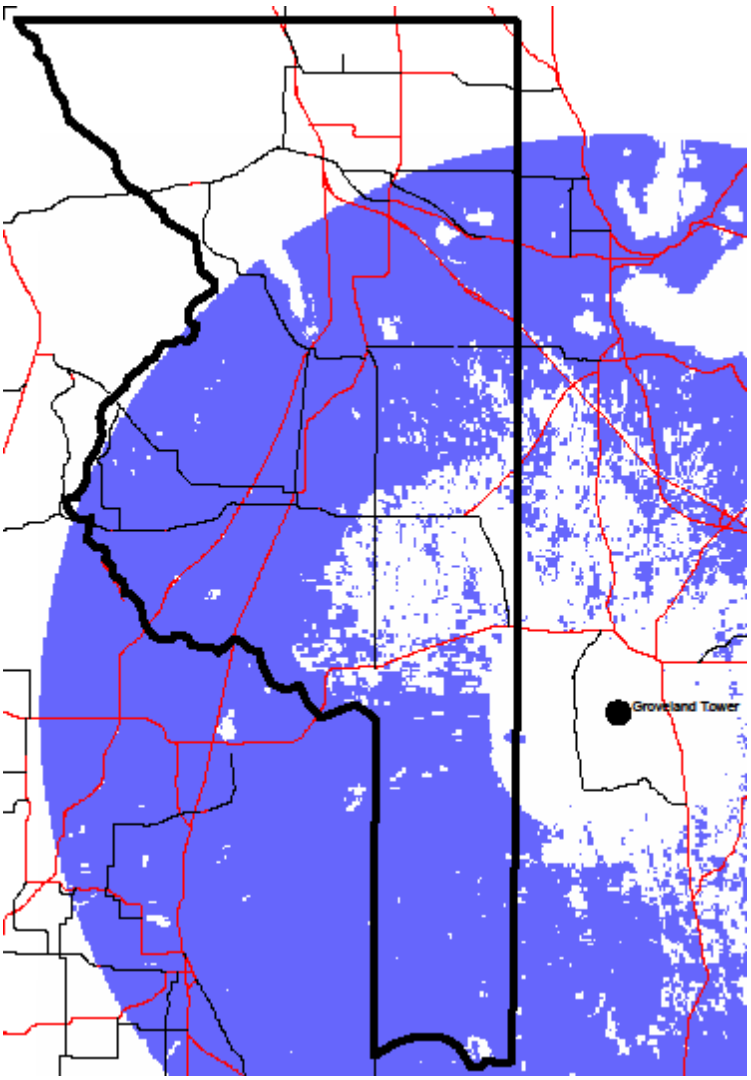
Lake County – Lady Lake Site Coverage – Portable Talk-Back



Lake County – Leesburg Water Treatment Tower – Portable Talk-Back



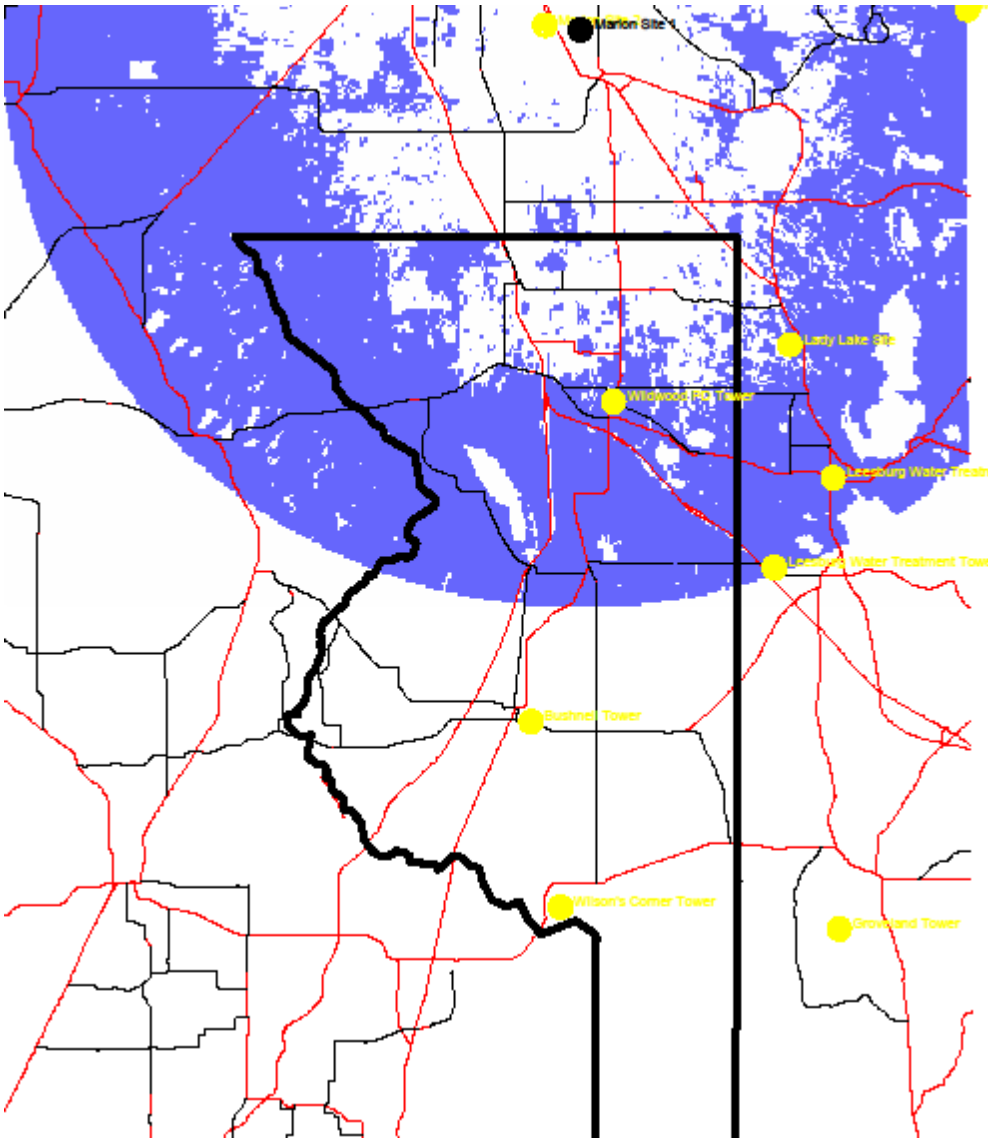
Lake County – Leesburg DOT Tower* – Portable Talk-Back



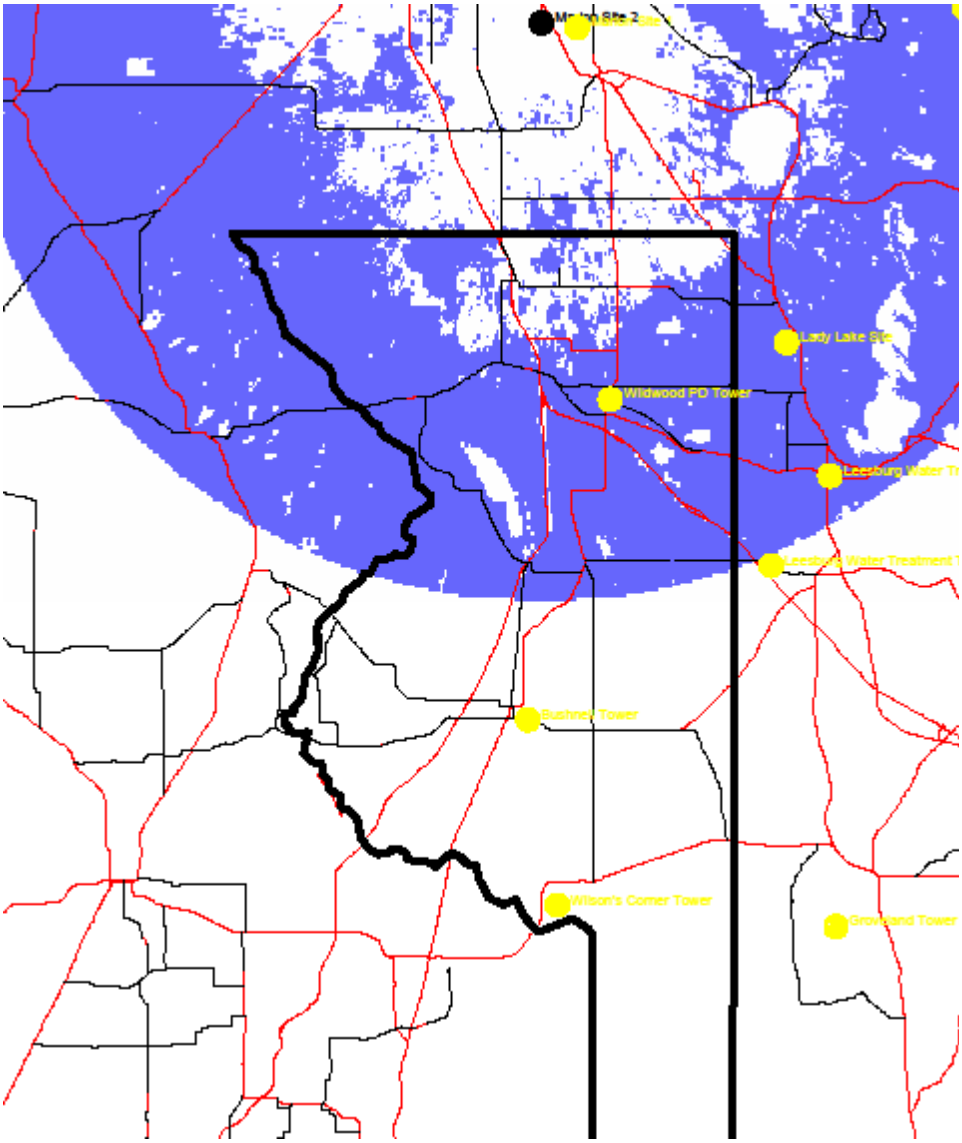
Lake County – Groveland Park Tower* – Portable Talk-Back

3.0 Marion County Sites/ Coverage

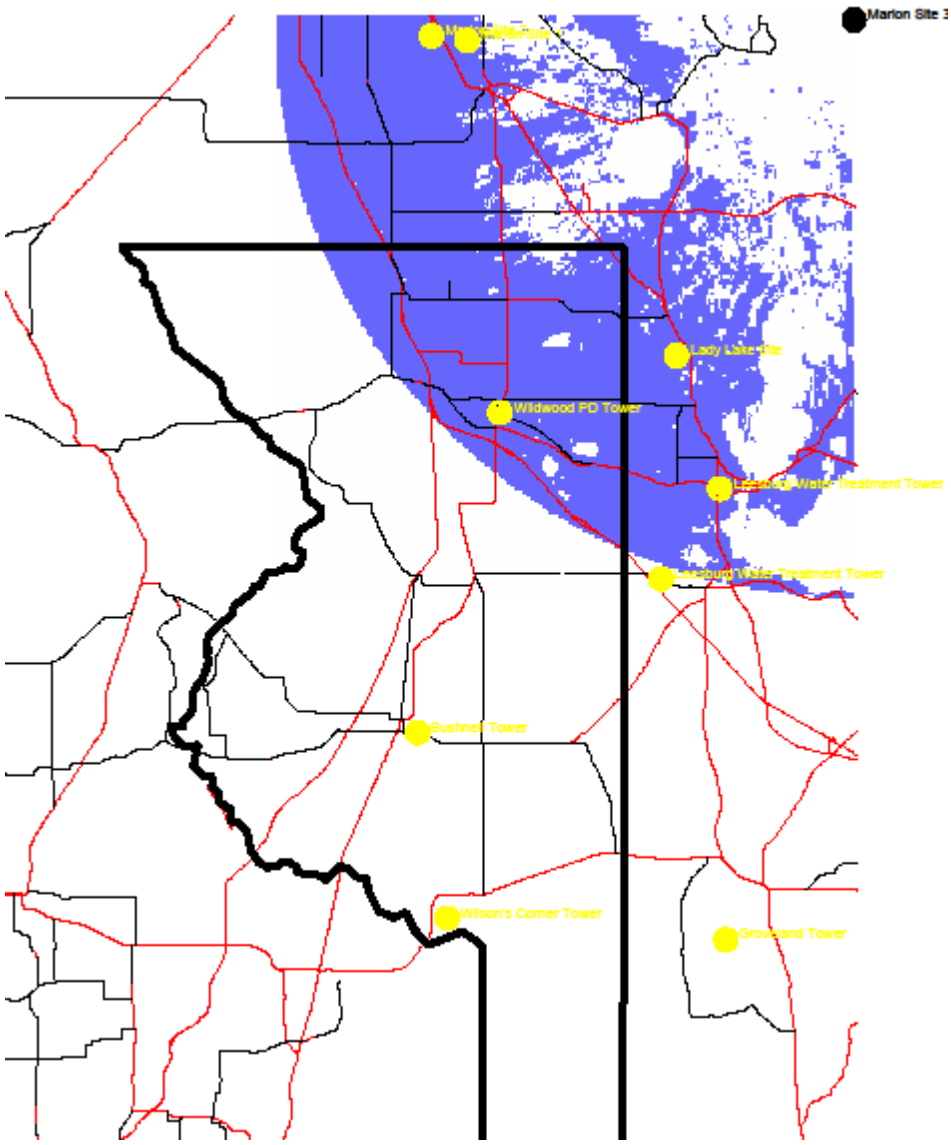
Gordon Alphonso, the Radio Systems Manager for the Marion County Department of Public Safety provided site locations for Marion's three closest towers/ sites. Like the Lake County sites, none of these sites are close enough to Sumter to alleviate the need for the sites recommended in the Conceptual Report.



Marion County – Site 1 Coverage – Portable Talk-Back



Marion County – Site 2 Coverage – Portable Talk-Back

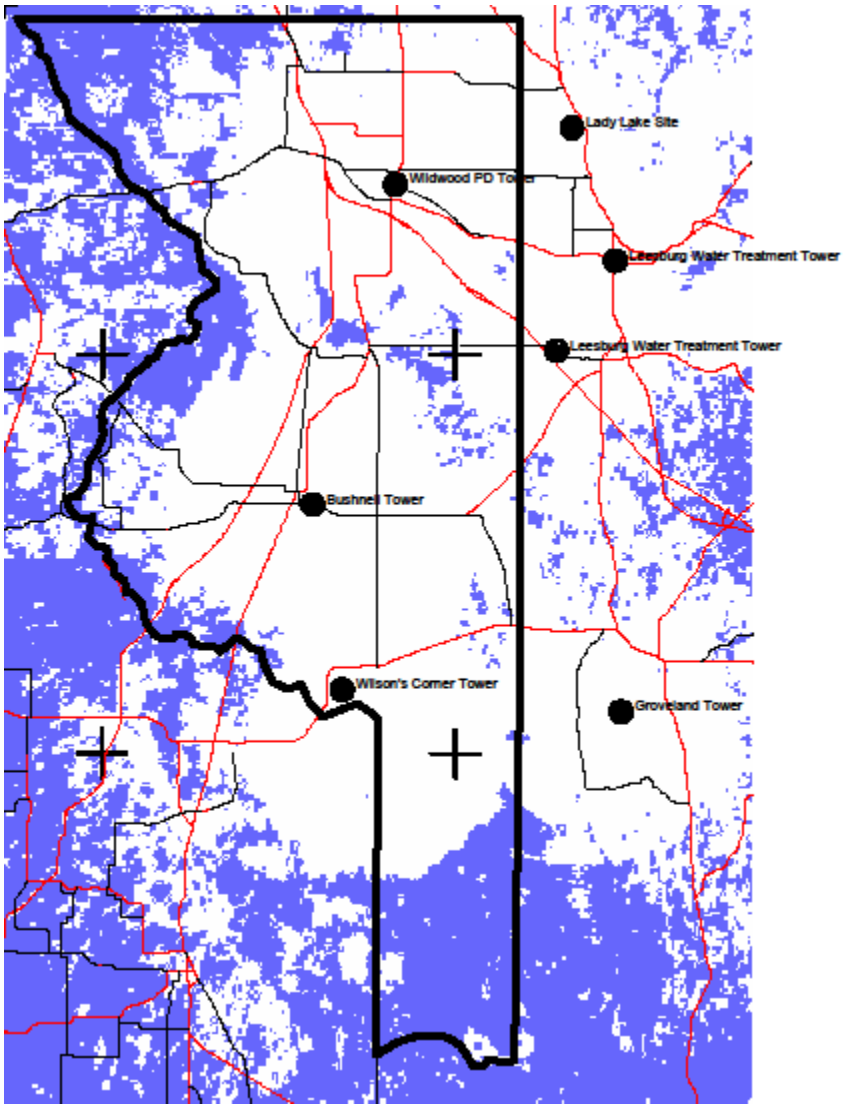


Marion County – Site 3 Coverage – Portable Talk-Back

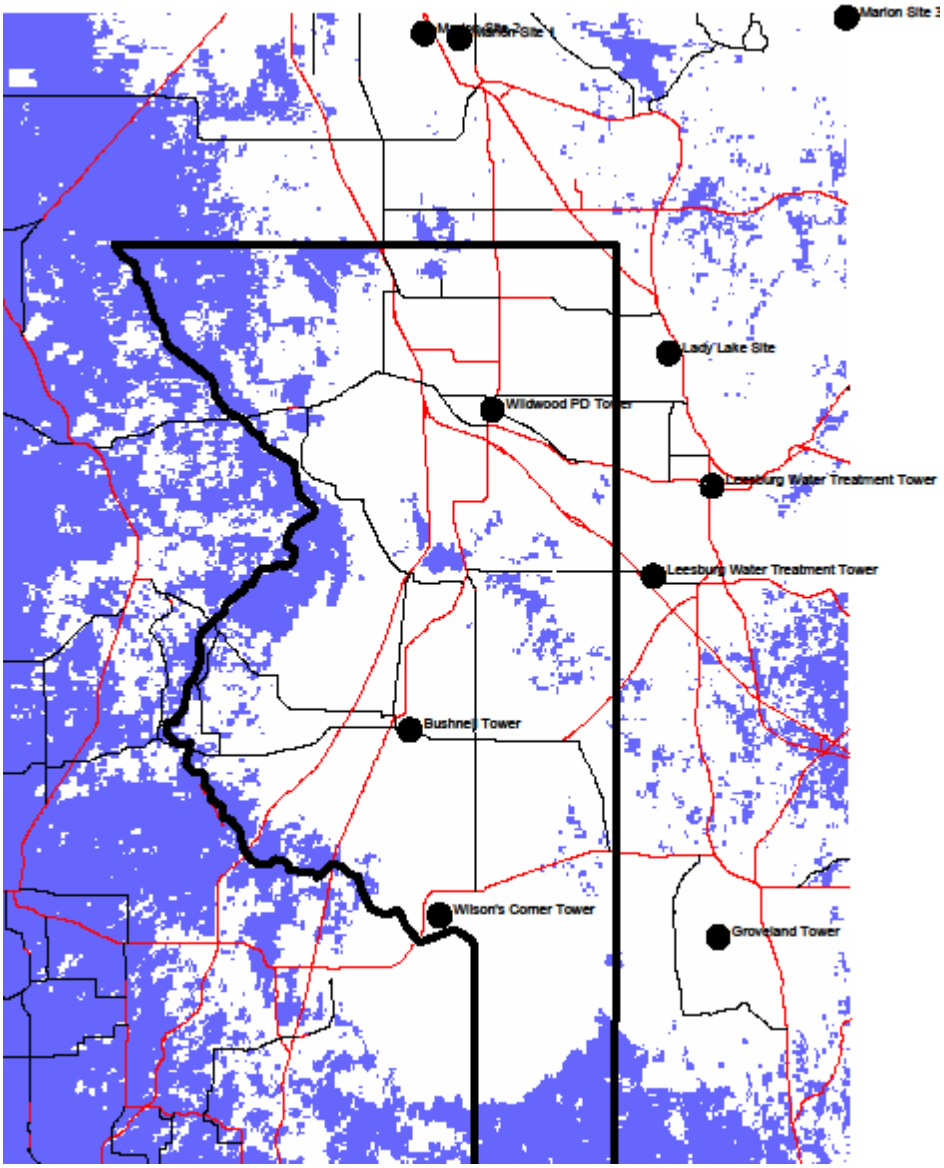
4.0 Interoperability and Roaming

Although interoperable communications can be achieved with all adjacent counties, true "seamless" roaming can only occur between counties that share a Master Site Switch. Roaming between Sumter non-switch sharing counties and the State could be configured to occur by turning the knob on the radio. This requires additional ISSI (Inter Sub-System Interface) equipment and proper programming.

*Interoperability between EDACS based systems, such as SLERS, and older non-P25 Motorola based systems are limited to a mobile or portable radio's ability to talk-back to its own towers/ sites. The Harris M7300/P7300 radios can operate on EDACS and P25 systems only.



Sumter and Lake Counties - Combined Coverage – Portable Talk-Back



Sumter, Lake and Marion Counties – Combined Coverage – Portable Talk-Back

5.0 Estimated Cost Reduction with Shared Resources

By sharing the existing resources of a neighboring county, Sumter County can expect to partially reduce the implementation costs associated with the Voice Infrastructure as follows:

Voice Infrastructure Total	$3,642,000	
Cost Reduction for use of existing Master Site Switch	(**$1,876,000**)	(decrease)
Site Construction Total	$3,392,000	(unchanged)
Microwave Total	$900,000	
Additional cost for microwave link to Master Site	+$300.000	(increase)
Dispatch Center Total	$1,031,000.	(unchanged)
Subscriber Units Total	$3,478,000	(unchanged)
Total w/Shared Resources (pre-RFP)	$10,867,000	(decrease)
Total Savings	**$1,578,000**	

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Competitive RFP Bid Process Estimates

Infrastructure w/shared switch	$1,766,000
Dispatch	$589,000
Subscribers	$2,608,000
Competitive Process Grand Total	**$4,963,000**

This estimate is similar to an unsolicited proposal cost that Sumter County had previously received from one of the vendors and could potentially be improved upon through contract negotiations after the bid process.

*Note – There may be additional equipment costs for connections to radio systems outside of a shared resource scenario (i.e. Hernando, Citrus or the State).
**Note – Sumter County may be expected to share the burden of maintenance costs for the Master Site Switch if resources are shared, but this is typically negotiated through the MOU and are not expected to effect the estimates for yearly maintenance.

6.0 Recommendations

After analysis of the P25 radio system assets of Marion County and Lake County, TCS maintains its recommendation that Sumter County pursue modernization of their system through a competitive RFP bid process. This process benefits Sumter two ways: 1) it forces the vendor to provide their best pricing possible and increases the number of services offered and 2) an RFP outlines every standard, detail and expectation that the vendors will be scored against during evaluation of proposals. This leaves the vendor with very little room for cutting corners. A well written RFP ensures that vendor offered proposals meet all of the County's and TCS' expectations for coverage, audio quality, features, interoperability, redundancy and pricing.

Although it appears as though the most beneficial approach will be for Sumter to share radio resources with Lake County, it is recommended by TCS that this information is not shared with any vendors until proposals have been received and a vendor has been chosen. If a particular vendor feels they have an edge, they may not provide the best pricing possible. Likewise, it other vendors think any of their competitors have an edge they may not offer serious proposals or any proposal at all.

Likewise, an MOU between Sumter and another county should take place after proposals have been received. This allows both counties to ensure that the expected resource sharing and mutual benefit is acceptable before a vendor's proposal has been formally chosen.