RICHLAND COUNTY, WISCONSIN

Public Safety Radio System Assessment

Project 21-0318

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1 OBJECTIVE STATEMENT

Richland County Wisconsin has retained the professional services of True North Consulting Group (TNCG) to develop an assessment study of their current public safety radio systems. The goal of this project is to complete a review of existing system infrastructure, perform an analysis, and develop recommendations for the possible design and implementation of a replacement system. The intent is to ultimately provide reliable radio coverage throughout Richland County and adjoining areas where emergency response agencies need to rely on these systems to perform their duties.

This study provides a technical review and evaluation of the emergency communications equipment, facilities, system management, and overall design. Existing system documentation was collected and provided to TNCG then reviewed against equipment layouts. Work was done to develop an understanding of the current interoperability capabilities and needs with adjacent county agencies, the State of Wisconsin, and other mutual aid requirements. Details of all existing practices were identified and evaluated with comparison to system best practices known to be implemented today with modern public safety systems. Finally, coverage modeling was performed to provide a visual understanding of the challenges various equipment/systems perform at in operation today.

This report provides the County with multiple practical recommendations of possible upgrade and/or replacement system options offering the baselines needed to understand solutions to address user needs. Each offered option provides a budgetary estimate of what implementation costs could be in a practical design of the system presented. Using these options as a guide for further discussions and practical analysis, the County will drive the development of a plan and identify needs vs. wants to address the key concerns. Some recommendations and challenges to this process have been detailed to provide guidance from experiences learned on previous projects by TNCG.

2 EXECUTIVE SUMMARY

Richland County operates at multiple sites with VHF analog repeaters throughout the County to provide local coverage of an area for public safety radio communications. These repeaters are dedicated to an identified service such as Law and Fire to support those agencies. Each agency repeater shares common frequency operation at the various sites and uses a different squelch code to operate that station. The system is then supplemented with additional mutual aid and simplex (ground) channels for operations as well. Equipment is constructed at seven (7) various locations throughout the County, however not all locations operate the same configurations.

Within the County the Richland Sheriff's Department operates the only public safety answering point (PSAP) that provides 911 call receiving and dispatch services for coordinating emergency responders. The center provides for two (2) dispatch furniture positions but staffing often is provided by a single dispatcher on duty throughout a dedicated shift. Also supporting jail operations from this location, additional personnel and duties are engaged at the center.

Emergency service agencies responding to calls are divided up in the three standard groups of Law, Fire, and EMS providing coverage to county areas. Many of the various agencies provide services outside the county borders as well as into neighboring counties such as Fire and EMS services and tend to rely on other radio channels or ground channels when operating far beyond county borders.

2.1 OBSERVATION POINTS

- The current County system implementation has come about as a product of identifying needs and obtaining solutions without a common overall goal in consideration. Reversing this process will be challenging without a complete forklift replacement of the system or a final plan to work backwards from.
- The 911 center's radio communications capabilities systems were provided from a neighboring County (used) and have served a number of years in Richland and are no longer supported by the manufacturer.
- With the operation of multiple repeater systems on common frequencies no system limitations are available for devices interfering with each other and possibly causing lost communications. It is difficult to understand and define the possible ramifications of operating this type of system.
- Countywide planning and governance functions of emergency communications equipment and operations needs to be improved to ensure any migration.
- 911 radio dispatch consoles provide key Jail access/control and intercom operations. These system need to be separated to ensure better reliability and vendor support.

- Richland County subscriber equipment needs to be brought up to a more robust public safety level of standards assuring reliability and timely performance testing.
- With any upgrade, every effort should be made to reduce the complexity for public safety officers and dispatchers to allow the communications to quickly, effectively and efficiently be delivered.
- With the County's terrain, design challenges to minimize tower sites and maximize coverage will be difficult. Reaching public safety standards may be difficult without major civil investments.

2.2 TNCG'S RECOMMENDATION

TBD at final version

2.3 BUDGETARY COST – RADIO SYSTEM OPTION 1

Option	Description of Improvement	Estimated Cost	Outcome
1	✓ VHF Analog Repeater Stations (X2 per site) ✓ Dedicated Paging operation is part of the design ✓ Coverage levels are improved Countywide ✓ Greenfield site likely needed ✓ Voting/Simulcast Controller Systems ✓ Transmit/Receive Antenna Systems ✓ Transmit/Receive Antenna Combining System ✓ Site shelter, grounding and structure enhancements ✓ Battery back -48-volt power systems ✓ Backup AC generator at all sites ✓ Minimal microwave network connection to all sites ✓ Site and system alarm capabilities ✓ Console X2 and associated radio equipment upgrades	**$3,280,500**	This lowest cost option provides for improving operational coverage of the existing design. Using this option would have the County seeking a migration strategy to the extent possible of the existing system. 95% countywide coverage levels would not be achieved with this option without design changes and additional cost. Sites are designed with dedicated shelter space and backup power capabilities (Hardened). Subscriber equipment has not been estimated as part of this possible phased approach with reuse being probable. Likely cost savings of at least $1M. Would provide a completed design that may not be able to easily expand coverage levels down the road.

2.4 BUDGETARY COST – RADIO SYSTEM OPTION 2

Option	Description of Improvement	Estimated Cost	Outcome
2	✓ VHF Digital P25 repeater stations (X3 per site) ✓ Standalone analog paging base station system ✓ Coverage levels improved to 90% on the street portable on the hip. ✓ Console X2 and associated radio equipment upgrades ✓ Public Safety grade P25 capable subscriber radios ✓ Voting/Simulcast Controller Systems ✓ Transmit/Receive Antenna Systems ✓ Transmit/Receive Antenna Combining System ✓ Site shelter, grounding and structure enhancements ✓ Battery back -48-volt power systems ✓ Backup AC generator at all sites ✓ Microwave ring network connection to all sites ✓ Site and system alarm capabilities ✓ P25 digital operation with noise-cancelling capabilities, Encryption, etc.	**$5,792,000**	This option seeks to improve the Option #1 design coverage using a digital operation. A migration to P25 operation would provide the County improvements and capabilities of designed system coverage. Improvements include new system support of improved P25 capabilities. Subscriber radio equipment has been estimated for replacement to provide P25 operations. Subscriber equipment would support County and WISCOM operations. Would provide a completed design that may not be able to easily expand coverage levels down the road.

2.5 BUDGETARY COST – RADIO SYSTEM OPTION 3A

Option	Description of Improvement	Estimated Cost	Outcome
3	✓ VHF Digital P25 repeater stations (X5 per site) ✓ P25 paging operation and subscriber equipment ✓ Console X2 and associated radio equipment upgrades ✓ Public Safety grade P25 capable subscriber radios ✓ Voting/Simulcast Controller Systems ✓ Transmit/Receive Antenna Systems ✓ Transmit/Receive Antenna Combining System ✓ Site shelter, grounding and structure enhancements ✓ Battery back -48-volt power systems ✓ Backup AC generator at all sites ✓ Ring topology microwave network connection to all sites ✓ Site and system alarm capabilities ✓ P25 digital operation with noise-cancelling capabilities, Encryption, etc.	**$7,710,000**	Seeking to meeting in building public safety coverage levels with design. This option seeks to improve the Option #2 design by adding coverage with additional sites. A migration to P25 operation would provide the County improvements and capabilities of designed system coverage. Improvements include new system support of improved P25 capabilities. Subscriber radio equipment has been estimated for replacement to provide P25 operations. Paging operations is moved to P25 systems and pager equipment replacement is anticipated.

3 OVERVIEW

3.1 RADIO SYSTEMS

Richland County public safety two-way radio users rely on various capabilities of a multiple site narrowband VHF analog architecture. The core components supporting the main law and fire agency channels are standalone repeaters operating on common reused frequencies. These repeaters are dedicated to their identified service and provide localized coverage of the area they are in based on the implementation characteristics. Each repeater shares a common transmit and receive frequency operating at the various sites and uses a different receive squelch code to enable only that station. All repeaters share a common transmit squelch code allowing the field units an ability to receive from any of the various agency channels. Law and Fire repeaters are constructed at five (5) various locations throughout the County.

Agency voice paging operations is supported in the County as well using analog VHF operations and two-tone encode format. Encode activation using a two-tone format is sent via the County dispatch console system dedicated to the agency for decode by each agency's pager devices. Paging operations are supported mainly using a wireline controlled base station unit operating on the Tower Hill – USCC Site. A secondary repeater system is located on the Lone Rock Site and uses a unique frequency and code to repeat the operations locally on the Paging channel.

Finally, the system is then supplemented with additional mutual aid and simplex (ground) channels for operations as well. Local, State of Wisconsin, and national channels were identified supporting field users and the dispatch center.

Sites include a mix of tower structures and water tanks providing antenna height for mounting antenna systems using omni-directional gain antennas and 3/4" coaxial cable runs. Locations seem to be chosen based on need and availability of structures in the area using favorable siting practices. No sites were found to be owned by Richland County and many shared equipment spaces were found supporting the system.

Repeater and base station equipment from various vendors and with varying models indicate system expansion and replacement on an as needed basis.

3.2 PSAP

Within Richland County, the Maquoketa police department operates the county's only public safety answering point (PSAP) that provides 911 call receiving and dispatch services for coordinating emergency responders. The center provides for two (2) dispatch furniture positions but staffing often is provided by a single dispatcher on duty throughout a dedicated shift.

3.2.1 RICHLAND COUNTY SHERIFF DEPARTMENT

The only Richland County 911 Public Safety Answer Point (PSAP) is located at 181 West Seminary Street within the City of Richland Center. The PSAP is located at the County courthouse building on the 2nd floor inside jail area and serves to provide both 911 dispatching and jail control operations. The dedicated area provides space for two dispatch furniture positions along with some equipment support space in a lower area. The room is access via the jail entrance but also stands behind the Sheriff department hallway glass entrance. This allows the dispatchers to also perform receptionist duties to the public as needed.

For radio communication capabilities the PSAP is equipped with two (2) each dispatch consoles that are computer-based systems. These provide operations using a dedicated software program operating on the computer screen and are supported by an audio control device for microphone and speaker operation. These client computers are interfaced to a dedicated electronics rack providing equipment interfacing that resides in the basement equipment closet.

This computer-based console system interfaces to various radio station equipment via wireline control using analog tone control operation. Station equipment is located at the site in the penthouse equipment room and supported by rooftop antenna systems. These provide the operation pathways to accessing all remote repeater devices located throughout the County. Other local equipment located at the Tower Hill – USCC Site is controlled using a wireline (Telco) connectivity between the console systems and the site.

3.2.2 BACKUP SERVICES

TBD

3.2.3 EMERGENCY OPERATION CENTER (EOC)

TBD

4 SYSTEM USERS

4.1 SERVICE BOUNDARIES

Richland County divides its emergency service agencies up in the three standard groups of Law, Fire, and EMS providing coverage to county areas. Many of the various agencies provide services outside the county borders as well as into neighboring counties. Those in Richland County are the Fire and EMS services and tend to rely on other radio channels or ground channels when operating too far beyond county borders.

Service zone maps have been included in Appendix 6.

4.2 LAW ENFORCEMENT

4.2.1 RICHLAND COUNTY SHERIFF'S DEPARTMENT

The Richland County Sheriff's department provides law enforcement services to all unincorporated areas of the county. The department is dispatched by the county PSAP and operates mainly on the Law repeater channel. The officers develop an understanding of when to switch between the various sites. The department has vehicle repeaters available that interface to Kenwood radio equipment for mobile operation. Motorola XTS2500 & 5000 models make up most of the portable radio equipment models.

4.2.2 RICHLAND CENTER POLICE DEPARTMENT

The City of Richland Center Police Department provides law enforcement services to the community. The department is dispatched for 911 calls by the County PSAP as well as taking calls for service during business hours from the department's office. The department has a dedicated radio repeater system available for operations that is located at the department building using a rooftop antenna. This repeater is capable of operating on Motorola DMR architecture, but currently the department has a variety of Kenwood and Motorola subscriber equipment. Mobile APX and XTL models do not support DMR schemes and as well the portable XPR models are supplemented with some Kenwood models.

4.2.3 CITY OF VIOLA POLICE DEPARTMENT

The Viola Police Department provides law enforcement services to the Village of Viola incorporated areas. The department is dispatched by the County PSAP and operates on the Law repeater channel from the Sylvan Site for communications. The department uses Motorola radio equipment for mobile and portable operations that are considered mostly previous platform models. The Department identified a vehicular repeater system in operation as well.

4.3 FIRE AND RESCUE

4.3.1 BLUE RIVER FIRE & RESCUE

Blue River Fire & Rescue is a department located outside the boundaries of Richland County just across southwest border in Grant County. The Department provides fire, and rescue services to the Richwood township area and points east. The department is dispatched by the County PSAP and operates on the Fire repeater channel with coverage coming likely from the USCC Site. With mostly Motorola listed equipment the department operates XTS & XTL model units considered previous lines. Some Kenwood mobiles were identified as well. Paging equipment was identified as Motorola Minitor VI model units.

4.3.2 CAZENOVIA FIRE DEPARTMENT

Cazenovia Fire Department is in the Village of Cazenovia in the northeast corner of Richland County and across into Sauk County. The Department provides services in the northeast region of Richland County.

4.3.3 LA FARGE FIRE DEPARTMENT

The La Farge Fire Department is located in Vernon County with agency service boundaries into the northwest Richland County boundary. It operates voice communications to the PSAP from the Sylvan site Fire channel repeater. The department identified the use of mostly Kenwood radio equipment and some Icom portables. Paging subscriber units were listed as Motorola Minitor V & VI models with stored voice.

4.3.4 LONE ROCK FIRE DEPARTMENT

Lone Rock Fire Department is in the Village of Lone Rock in the southeast corner of Richland County and across into Sauk County. The Department provides services in the southeast region of Richland County.

4.3.5 MUSCODA FIRE DEPARTMENT

Muscoda Fire Department is in the Village of Muscoda located across in Sauk and Grant Counties. The Department provides services in the south central region of Richland County.

4.3.6 RICHLAND CENTER FIRE DEPARTMENT

Richland Center Fire Department provided Richland County a major amount of district coverage stretching across the middle of the County, border to border. The Department is dispatched by the County PSAP on calls for service and would operates from the USCC site on the Fire repeater channel. Listing all Motorola vendor equipment, the department has a combination of older and current model units. Having some Motorola APX versions that a current production and would support P25 features. Paging subscribers were identified as Motorola Minitor V & VI model equipment.

4.3.7 VIOLA FIRE DEPARTMENT

The Village of Viola Fire Department provides fire district coverage in the northwest corner of the County. Dispatched by the County PSAP it would rely on coverage from the Sylvan Fire repeater channel. The community straddles the county border with neighboring Vernon County. The department has a combination of portable and model radios from vendors Motorola, Kenwood, and Icom. The department uses Motorola (Minitor V) and Unication (G1) model paging subscribers.

4.3.8 YUBA FIRE DEPARTMENT

Yuba Fire Department provides fire district services to the community and the northern central part of Richland County. Dispatched by the County PSAP and using the Fire repeater, coverage would likely come from the Bunker Hill Site. The department listed operating Motorola mobile radio equipment and Minitor V model paging devices.

4.4 AMBULANCE SERVICES

4.4.1 BLUE RIVER EMS

Listed as a service provider covering the southwest corner of the County this group is combined with the Fire Department.

4.4.2 BOAZ FIRE RESPONDERS

TBD

4.4.3 CAZENOVIA EMS

Listed as a service provider covering the northeast corner of the County this group is combined with the Fire Department.

4.4.4 ITHACA MEDICAL FIRST RESPONDERS

The department operates a single mobile and Icom portable radios and listed Motorola Minitor VI pager models.

4.4.5 LA FARGE EMS

Listed as a service provider covering some small areas in the northwest corner of the County this group is combined with the Fire Department.

4.4.6 LONE ROCK EMS

Listed as a service provider covering the southeast corner of the County this group is combined with the Fire Department.

4.4.7 MUSCODA EMS

Listed as a service provider covering the south central part of the County this group is combined with the Fire Department.

4.4.8 RICHLAND COUNTY EMS

The Community Ambulance Services is dispatched by the County PSAP and operates on the Preston Fire repeater channel. The department operates Kenwood mobile radio equipment with Kenwood portable radios as well. Paging equipment was identified as Motorola Minitor V model units.

4.4.9 VIOLA EMS

The department operates previous model Motorola mobile and Icom portable radios and listed no pager models.

4.4.10 YUBA FIRST RESPONDERS

Listed as a service provider with no distinguished coverage area this group is combined with the Fire Department.

4.5 EMERGENCY MANAGEMENT AGENCY (EMA)

Richland County operates an independent Emergency Management Agency (EMA) providing services to the County. The agency identified approximately eight spare radio units in reserve within the county. However, the agency does not have a cache of spare radios that could be provided for use during a major incident.

4.6 HIGHWAY DEPARTMENT

Richland County operates the Highway Department on an independent radio system providing services to the agency with a single site repeater unit. Operated in the VHF frequency band the unit is located on the WRCO tower site. Similar to many public works agencies the department relies heavily on Kenwood model TK-7360 mobile radio units. Kenwood model TK-2160 portable radios were also listed.

4.7 OTHER

4.7.1 RICHLAND COUNTY JAIL

A separate radio system was identified for use in Richland County jail operations operated in the UHF frequency band.

4.7.2 AIR AMBULANCE

TBD

4.7.3 HAZMAT

TBD

4.7.4 RACES/ARES

Richland County has recently identified support from an amateur radio group and the implementation of equipment at the Courthouse building.

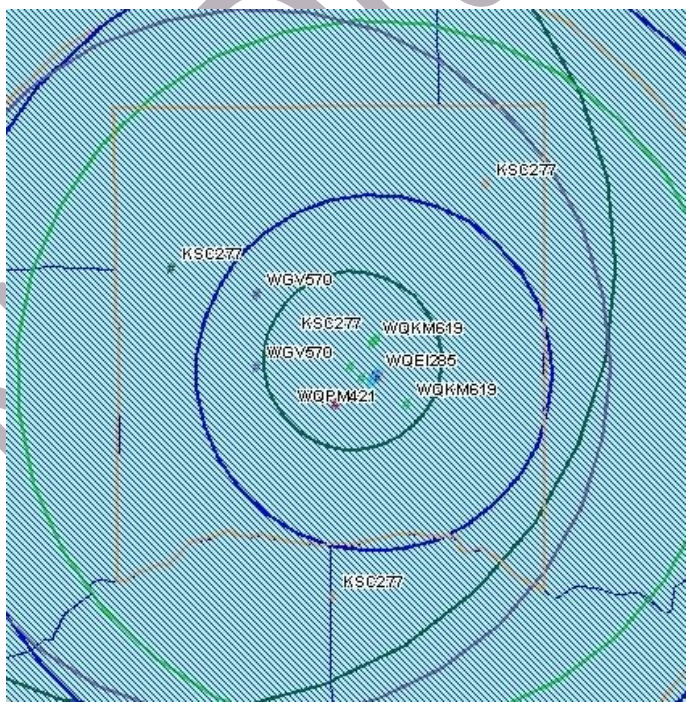
5 FCC LICENSING

5.1 OVERVIEW

FCC licensing for the operational frequencies needed to construct a radio system are the key ingredient of any design. TNCG identified multiple public safety agency FCC licenses in the County belonging to various agencies and performed a complete review of the detail.

FCC licensing on the key system channels are well grouped on two key licenses (WQPM421 & KSC277), and both share the same FRN ownership. Renewal timelines are fast approaching on most of the licensing, starting as early as the fall of 2021 and going through 2023. Updates of these licenses likely took place last around narrowbanding mandate processes.

Some licensing was found with simple construction deadlines needing to be updated. These simple housekeeping issues could be addressed with online modifications done by the County.



Data Table

	Drill To	Type	Call Sign	Status	Radio Service	License Name	Market Code	Sub Market	Channel Block
	Detail	G	WPJS680	A	PW	RICHLAND CENTER, CITY OF			
	Detail	G	WNYU878	A	PW	RICHLAND, COUNTY OF			
	Detail	G	WNPS436	A	PW	RICHLAND CENTER, CITY OF			
	Detail	G	KB83045	A	PW	RICHLAND CENTER, CITY OF			
	Detail	G	KSC277	A	PW	RICHLAND, COUNTY OF			
	Detail	C	KRY532	A	IG	RICHLAND GRANT TELEPHONE COOPERATIVE INC			
	Detail	C	WGV570	A	IG	RICHLAND ELECTRIC COOPERATIVE			
	Detail	C	WNAE298	A	IG	RICHLAND CENTER REDI MIX			
	Detail	C	WQDF508	A	PW	RICHLAND HOSPITAL INC			
	Detail	C	WQEI285	A	IG	RICHLAND HOSPITAL INC			
	Detail	G	WQKM619	A	PW	RICHLAND CENTER, CITY OF			
	Detail	G	WQKM620	A	PW	RICHLAND CENTER, CITY OF			
	Detail	G	WQPM421	A	PW	RICHLAND, COUNTY OF			
	Detail	G	WRCJ251	A	IG	RICHLAND SCHOOL DISTRICT			

5.2 FREQUENCY CHART

The following chart identifies the licensed frequencies being operated in Richland County and appearing on the FCC licenses.

FREQUENCY	CHAN NAME	CALL SIGN	FRN #	LOC #	ANT #	STATION	EMISSION	SITE NAME	NOTES
151.2275		KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
151.2275		KSC277	,0002682763	6	1	MO3	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
154.7400	Sheriff TX	KSC277	,0002682763	1	1	FB2	11K2F3E - 8K10F1D - 8K10F1E	Tower Hill USCC	
154.7400	Sheriff TX	KSC277	,0002682763	2	1	FB2	11K2F3E - 8K10F1D - 8K10F1E	Sylvan Site	
154.7400	Sheriff TX	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
154.7400	Sheriff TX	KSC277	,0002682763	7	1	FB2	11K2F3E - 8K10F1D - 8K10F1E	Eagle Tower Site	
155.0550	Fire TX	KSC277	,0002682763	1	1	FB2	11K2F3E - 8K10F1D - 8K10F1E	Tower Hill USCC	
155.0550	Fire TX	KSC277	,0002682763	3	1	FB2	11K2F3E - 8K10F1D - 8K10F1E	Bunker Hill Site	
155.0550	Fire TX	KSC277	,0002682763	4	1	FBC	11K2F3E - 8K10F1D - 8K10F1E	Cazenovia Fire	
155.0550	Fire TX	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
155.3700	Point to Point TX/RX	KSC277	,0002682763	1	1	FB	11K2F3E - 8K10F1D - 8K10F1E	Tower Hill USCC	
155.3700	Point to Point TX/RX	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
155.4750	VLAW31	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
155.9700	Richland PD RX	KSC277	,0002682763	5	1	FX1	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 6.1 Meter Rule	
155.9700	Richland PD RX	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
158.7525		KSC277	,0002682763	9	1	MO	11K2F3E	Area of Operation - Richland County	
158.8950	Fire RX	KSC277	,0002682763	5	1	FX1	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 6.1 Meter Rule	
158.8950	Fire RX	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km	
158.9250	Sheriff RX	KSC277	,0002682763	5	1	FX1	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 6.1 Meter Rule	
158.9250	Sheriff RX	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km around #1	
173.2625	VRS	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1E	Area of Operation 40.0 km around #1	
173.2625	VRS	KSC277	,0002682763	6	1	MO3	11K2F3E - 8K10F1E	Area of Operation 40.0 km around #1	
453.9625	UHF	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km around #1	
453.9625	UHF	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km around #1	
460.2000	Jail	KSC277	,0002682763	6	1	MO	11K2F3E - 8K10F1D - 8K10F1E	Area of Operation 40.0 km around #1	
460.2000	UHF	KSC277	,0002682763	8	1	FB	11K2F3E - 8K10F1D - 8K10F1E	Dispatch Center Site	
151.1300	Highway TX	WNYU878	,0006632244	1	1	FB2	11K2F3E	Tower Hill USCC	
151.1300	Highway TX	WNYU878	,0006632244	3	1	MO	11K2F3E	Area of Operation 6.1 Meter Rule	
159.0150	Highway RX	WNYU878	,0006632244	2	1	FX1	11K2F3E	Area of Operation 40.0 km around #1	
159.0150	Highway RX	WNYU878	,0006632244	3	1	MO	11K2F3E	Area of Operation 40.0 km around #1	
154.2950		WPJS680	,0002684496	1	1	FB	11K0F3E	Richland Center Fire Station	
154.2950		WPJS680	,0002684496	2	1	MO	11K0F3E	Area of Operation 32.0 km around #1	
154.4300	RC Fire Ground	WPJS680	,0002684496	1	1	FB	11K0F3E	RC Fire Station	
154.4300	RC Fire Ground	WPJS680	,0002684496	2	1	MO	11K0F3E	Area of Operation 32.0 km	
154.3550	Paging	WQPM421	,0002682763	1	1	FB2	11K2F3E	WRCO Site	
151.2800	Marc TX	WQPM421	,0002682763	1	1	FB2	11K2F3E	WRCO Site	
156.1575	Paging RX	WQPM421	,0002682763	2	1	MO	11K2F3E	Area of Operation 40.0 km around #1	
154.3550	Paging TX	WQPM421	,0002682763	2	1	MO	11K2F3E	Area of Operation 40.0 km around #1	
156.1575	Paging RX	WQPM421	,0002682763	3	1	FX1	11K2F3E	Area of Operation 6.1 Meter Rule	
153.8450	Marc RX	WQPM421	,0002682763	3	1	FX1	11K2F3E	Area of Operation 6.1 Meter Rule	
154.3550	Paging	WQPM421	,0002682763	4	1	FB	11K2F3E	Dispatch Center Site	
151.2800	Marc TX	WQPM421	,0002682763	4	1	FB	11K2F3E	Dispatch Center Site	
154.7400	Sheriff TX	KB83045	,0004796306	1	1	MO	11K2F3E	Area of Operation 16.0 KM around #2	
154.8450	RCPD TX	KB83045	,0004796306	1	1	MO	11K2F3E	Area of Operation 16.0 KM around #2	
155.3700	Point to Point TX/RX	KB83045	,0004796306	1	1	MO	11K2F3E	Area of Operation 16.0 KM around #2	
155.4750	VLAW31	KB83045	,0004796306	1	1	MO	11K2F3E	Area of Operation 16.0 KM around #2	
155.9700	RCPD RX	KB83045	,0004796306	1	1	MO	11K2F3E	Area of Operation 16.0 KM around #2	
154.8450	RCPD TX	KB83045	,0004796306	2	1	FB	11K2F3E	Dispatch Center Site	
154.8450	RCPD TX	KB83045	,0004796306	3	1	FB	11K2F3E	Richland Center Police Station	
155.4750	VLAW31	KB83045	,0004796306	3	1	FB	11K2F3E	Richland Center Police Station	
154.8450	RCPD TX	KB83045	,0004796306	3	1	FB2	11K2F3E	Richland Center Police Station	
155.9700	RCPD RX	KB83045	,0004796306	3	1	FX1	11K2F3E	Richland Center Police Station	
155.3400	VMED28	WQDF508	,0013675228	1	1	FB	11K2F3E	WRCO Site	

5.3 SITE CHART

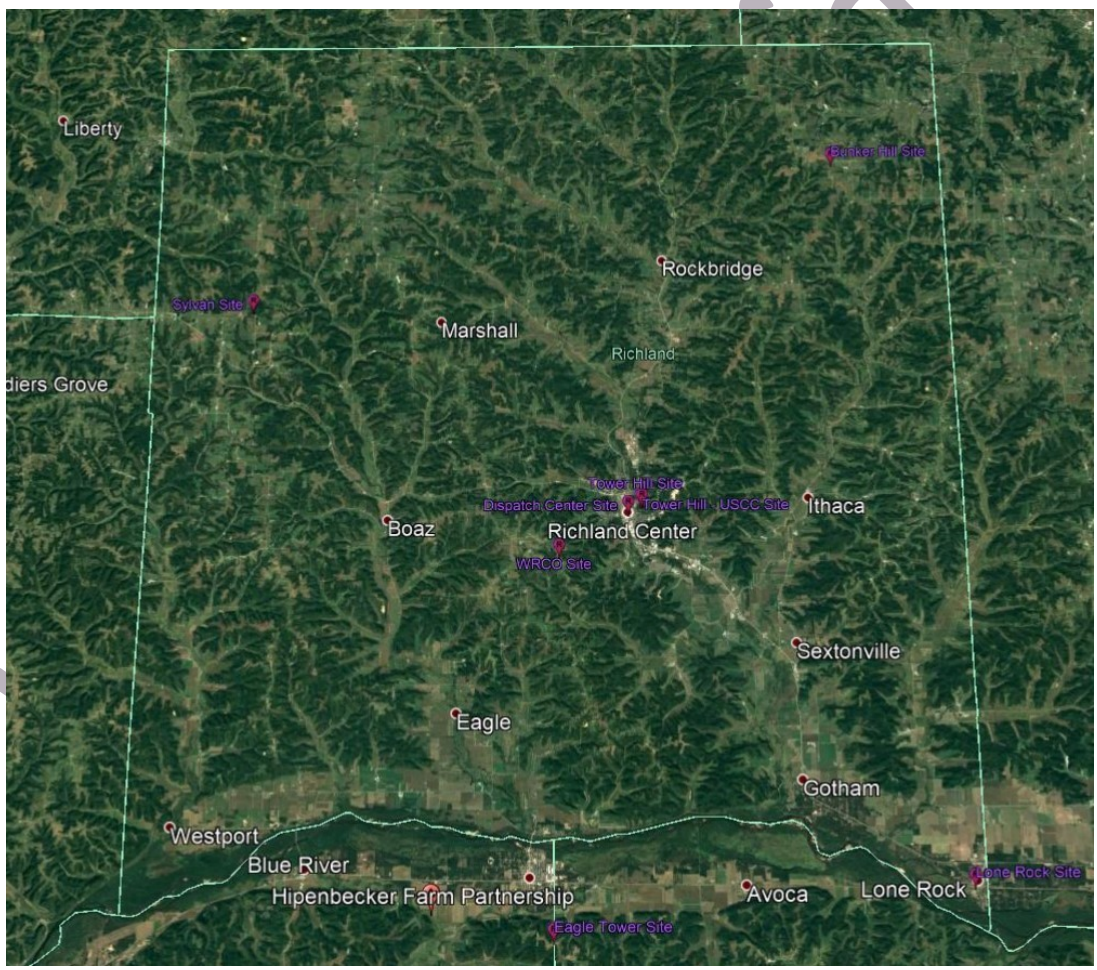
The following chart identifies the licensed locations for operating various frequencies listed on FCC licenses in Richland County.

	Call Sign	SITE NAME	Location	Transmitter Address /Area of Operation	City	NOTES	
	KSC277	**Tower Hill - USCC Site**	1	200 Tower Hill Road	Richland Center		
	KSC277	**Sylvan Site**	2	HWY E 1.6KME	Sylvan		
	KSC277	**Bunker Hill Site**	3	30638 HWY I Bunker Hill	Cazenovia		
	KSC277	**Cazenovia Site**	4	N Main Street	Cazenovia		
	KSC277	**6.1 Meter Rule WI**	5	Area of Operation			
	KSC277	**40.0 KM radius around location #1**	6	Area of Operation			
	KSC277	**Eagle Tower Site**	7	36 Hipenbecker Road	Muscoda	Grant County	
	KSC277	**Dispatch Center Site**	8	181 W. Seminary Street	Richland Center		
	KSC277	**Countywide Richland WI**	9	Area of Operation			
	KB83045	**16.0 KM radius around location #2**	1	Area of Operation			
	KB83045	**Dispatch Center Site**	2	181 W. Seminary Street	Richland Center		
	KB83045	**Richland Center Police Station**	3	470 S. Main Street	Richland Center		
	WNYU878	**Tower Hill Site**	1	Roosevelt Drive on Adj Hill	Richland Center		
	WNYU878	**6.1 Meter Rule WI**	2	Area of Operation			
	WNYU878	**40.0 KM radius around location #1**	3	Area of Operation			
	WPJS680	**Richland Center Fire Station**	1	205 East Mill Street	Richland Center		
	WPJS680	**32.0 KM radius around location #1**	2	Area of Operation			
	WPQM421	**WRCO Site**	1	Hillview Drive between Premo Rd & County, 2.4 MI SW of	Richland Center		
	WPQM421	**40.0 KM radius around location #1**	2	Area of Operation			
	WPQM421	**6.1 Meter Rule WI**	3	Area of Operation			
	WPQM421	**Dispatch Center Site**	4	181 W. Seminary Street	Richland Center		
	WQDF508	**WRCO Site**	1	Hillview Drive between Premo Rd & County, 2.4 MI SW of	Richland Center		

6 EXISTING SYSTEM INFRASTRUCTURE DESIGNS

6.1 VOICE SYSTEMS

Voice radio channels in Richland County operate as standalone site repeaters or base stations providing a level of coverage based on their individual antenna designs. As standalone systems they also heavily rely on the subscriber terminal equipment to create the coverage footprint. Operating from five (5) identified tower (site) locations these repeaters provide coverage based on the re-used frequencies they operate, and the unique squelch code used to activate each specific repeater station. This is true for the Law and Fire system channels.



Based on the County's FCC licensing and station equipment models, the operational power of most stations is likely 50-100 watts output. Each coverage pattern provided by the various sites is likely greatly support by the station antenna height, terrain, and location. For the base stations in the system design every communication is a radio-to-radio call to each unit.

Repeater operation by design performs the improvement of expanding a radio-to-radio conversation using the power and antenna system to increase the coverage footprint of the subscriber terminal. Repeater design systems place the limiting factor in communicating on the subscriber's device transmit signal reaching the repeater clearly. Repeating a clearly received signal from a tower site then enhances other subscriber terminals ability to receive.

However, when reusing frequencies on multiple sites without a simulcast implementation the system greatly increases the possibility of creating interference. As radio communications is PTT (one way at a time, talk or listen) the subscriber user does not know the level of clarity in their communications without feedback from the other system users or dispatch. The design allows for system users of different locations to create simultaneous calls. As dispatch can hear multiple repeaters operating on the same channel two or more of these repeaters active at the same time can prevent dispatch from effectively monitoring field unit traffic.

Where the real complexity occurs is when there are numerous incidents occurring simultaneously - dispatch also needs to be become a communications traffic cop. Dispatchers must switch between multiple repeaters as they communicate with each public safety officer.

This multiple repeater design also shifts the responsibility of understanding coverage capabilities and best performance to the subscriber user who must know where they are and which repeater to connect with.

CHAN NAME	SITE	Equipment	TX	RX	ERP	Ant/TP
SHERIFF - SYLVAN	Sylvan Site	Harris - Master III	154.740 (118.8)	158.925 (169.9)	220	131
SHERIFF - RICHLAND	Tower Hill - USCC Site	Harris - Master III	154.740 (118.8)	158.925 (146.2)	180	282
SHERIFF - EAGLE	Eagle Tower Site	Motorola - MTR2000	154.740 (118.8)	158.925 (110.9)	350	157
SHERIFF - LONE ROCK	Lone Rock Site	Motorola - Quantar	154.740 (118.8)	158.925 (91.5)	None	None
SHERIFF - BUNKER	Bunker Hill Site	Motorola - Quantar	154.740 (118.8)	158.925 (311)	None	None
SHERIFF - ITHACA	Not Constructed					
POINT TO POINT	Tower Hill - USCC Site	Harris - Master III	155.370 (146.2)	155.370 (CSQ)	180	282
RICHLAND PAGE	Tower Hill - USCC Site	Harris - Master III	154.355 (131)	154.355 (131)	224	292
LONE ROCK PAGE	Lone Rock Site	Motorola - Quantar	154.355 (131)	158.925 (411)	None	None
RICHLAND FIRE						
FIRE - RICHLAND	Tower Hill - USCC Site	Harris - Master III	155.055 (118.8)	158.895 (118.8)	180	282
FIRE - BUNKER	Bunker Hill Site	Motorola - MTR2000	155.055 (118.8)	158.895 (?)	180	148
FIRE - SYLVAN	Sylvan Site	Motorola - MTR2000	155.055 (118.8)	158.895 (151.4)	None	None
FIRE - LONE ROCK	Lone Rock Site	Kenwood - TKR-750	155.055	158.895	None	None
FIRE - ITHACA	Not Constructed					
HIGHWAY	WRCO Site	Motorola - MTR2000	151.130 (162.2)	159.015 (127.3)	119	282
RCPD	Richland Police Station	Motorola - MTR3000	154.845	155.97	45	27
IFERN	Tower Hill - USCC Site	Harris - Master III	154.265 (210.7)	154.265 (210.7)	None	None
MARC	WRCO Site	Harris - Master III	151.280 (136.5)	153.845 (136.5)	114.3	292
VMED28	WRCO Site	Harris - Master III	155.340 (118.8)	155.340 (118.8)	89	296

6.2 SYSTEM OVERSIGHT

Most current oversight duties of the radio system belong to the Richland County Sheriff and support and funding come from the Public Safety committee. Issues experienced while using the systems would normally be passed onto the dispatch services or department administration to be addressed.

7 EXISTING RADIO SYSTEM INFRASTRUCTURE EQUIPMENT

7.1 REPEATER AND BASE STATION EQUIPMENT

The County operates most of the radio repeater and base station equipment in the current design using numerous vendor's model equipment. Site equipment was found as a mix of Motorola and Harris device, while control station equipment tended to be Kenwood. All models reviewed would be considered not to be currently available in vendor product lines and likely end of life supported by the manufacturers.

Equipment implementation was not found to follow any defined design and no configurations seem to be similar. Equipment configurations and installation characteristics take on the project scope, site availability, and technicians support at the time of construction.

Both Motorola Quantar and MTR2000 stations were found in operation at various sites. Both station equipment are a solid-state design PC programmable platform capable of multiple frequency operation. The main difference between the Quantar series and MTR series other than age of product is a more robust platform was supported in the Quantar series. The Harris Master III model stations were also found used in many of the sites and would match the era and characteristics of the Motorola equipment.

All models are modular designed for rack mount configuration implementation and are capable of analog only operation as they do not support P25 formats. These stations support automatic battery backup and cutover systems to ensure operation during AC power failure.

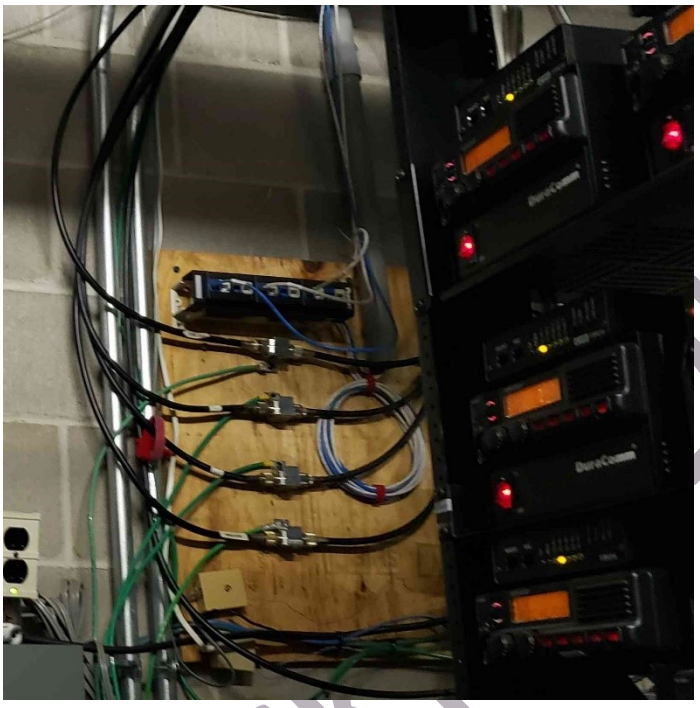
Equipment to rack grounding support was support and outlet and some isolation bar AC power implementations.

7.2 CONTROL STATIONS

Control station operation is key in Richland for supporting the PSAP dispatch radio consoles and independent Kenwood mobile radios provide the bulk of support for operating on the various channels. These radio models were supported with an independent 12-volt DC power supply, dedicated antenna, and a CPI remote adapter device for console interfacing. The TIP216 model CPI remote adapter gives multi-channel control of the radio unit to the console system.

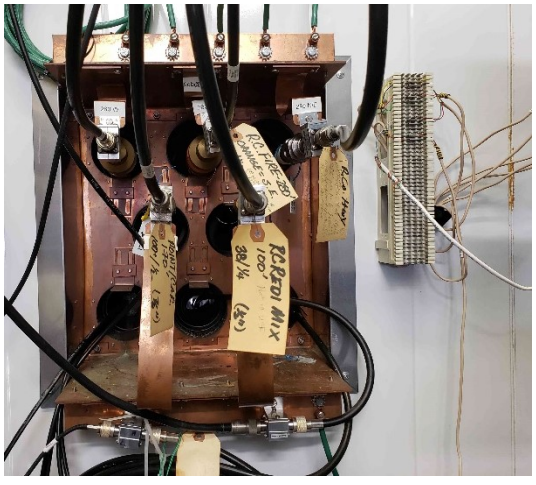
7.3 BACKHAUL

Given the standalone repeater system design used in Richland County the need for backhaul system support is limited to the PSAP console connections needed. The Motorola Centracom consoles support only older wireline control operation and not a digital solution. Wireline needs breakup into the control of radio equipment at the PSAP building and station equipment located in Richland Center at the Tower Hill sites.



The support of the radio stations at the PSAP building is done using premise telco cables from the basement equipment room where the console system backroom electronics are located to the penthouse location of radio equipment. Cabling needs for most radio equipment will be either a single or double pair of standard twisted wire telco cabling. Control functions are likely sent to the radio equipment using tone signals and voice audio also resides on the lines.

This same functionality occurs on telco cabling leaving the Centracom console backroom electronics that is routed to the station equipment off site. Done using 2 or 4 wire circuits leases from telephone vendors these control backhauls are not done over standard telephone lines. Circuits referred to as dry pairs are provided that remove normal telephone line parameters and give a clean pair of cabling to be used, which sometimes does need to be amplified based on distances to any tower location.

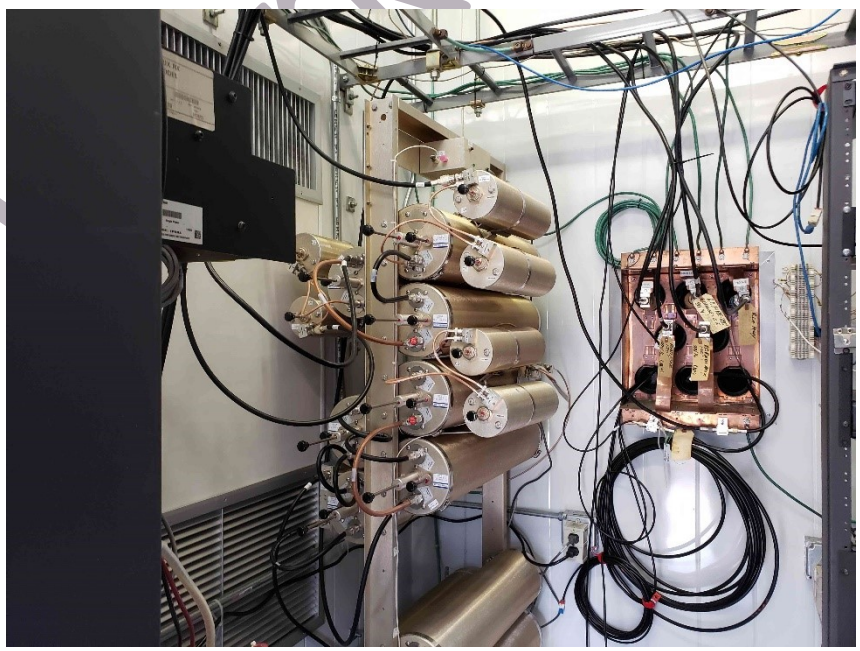


7.4 COMBINING/MULTICOUPLING

Combining both transmit and receive station operation on a single antenna system plays an intricate role in system design in Richland County as repeaters are the main communication devices. Transmit and receive frequency separation can dictate the level of support the antenna duplexer must provide to assure that the simultaneous transmission is not desensitizing the receiver's ability to clearly hear the conversation. The VHF frequency band carries the challenge of obtaining quality operating frequencies as it was not designed to provide for this requirement.

Most site repeater duplexers identified provided a simple rejection only support of the opposite operating frequencies found in the repeater. Various products were used and likely provide a varying degree of performance to each system.

As well some separation cavity support was found to help isolate antenna broadcast interference when frequencies were operating that had limited physical separation. Given the physic characteristics of the VHF frequency range these larger cavity devices are the typical needed size at most sites not having proper frequency separation.



7.5 SITES

Current public safety radio systems operate in Richland County with repeater and base station equipment at eight (8) various antenna site locations dispersed throughout the county to support radio coverage needs. Three (3) other sites are designated on FCC licensing and provide additional equipment location support. Primarily the County's public safety system is supported from leased tower structures and a local water tank.

Site Name	Type	Height	ASR #	Address	Latitude	Longitude
Bunker Hill Site	Guyed Tower	150"		30638 HWY I Bunker Hill	43-29-33.9 N	90-15-34.5 W
Cazenovia Site	Rooftop	10'		N Main Street	43-31-21.9 N	91-11-31.5 W
Dispatch Center Site	Rooftop	50"		181 W Seminary Street	43-20-2.63 N	90-23-10.78 W
Eagle Tower Site	Self Support Tower	245"	1241130	36 Hipenbecker Road	43-09-36.9 N	90-25-47.6 W
Lone Rock Site	Water Tower	110"			43-10-50-41 N	90-11-58.23 W
Richland Center Fire Station	Rooftop	25'		205 East Mill Street	43-20-09.9 N	90-23-01.5 W
Richland Center Police Station	Rooftop	25'		470 S. Main Street	43-19-56.0 N	90-23-13.0 W
Sylvan Site	Guyed Tower	180'		HWY E 1.6 KM E	43-25-27.9 N	90-36-30.5 W
Tower Hill - USCC Site	Self Support Tower	320"	1000186	200 Tower Hill Road	43-20-14.9 N	90-22-42.5 W
Tower Hill Site	Guyed Tower	50"		Roosevelt Drive on Adj Hill	43-20-14.9 N	90-22-41.5 W
WRCO Site	Guyed Tower	350"	1257097	Hillview Drive between Premo Rd & County, 2.4 MI SW of	43-18-55.4 N	90-25-35.0 W

Equipment shelters also mostly consisted of shared equipment space with security to the level of the site owner's needs. Antenna heights and locations appear to have been designed around the structure opportunities and capabilities vs. any coverage capability considerations. These sites rely heavily on the owner's maintenance and upkeep support with items such as AC power and surge protection not well monitored.

7.5.1 BUNKER HILL SITE

The Bunker Hill tower site is located at 30638 Highway I just southwest of the town of Cazenovia. This site is found in the Northeast corner of Richland County and the site belongs to Lavalle Telephone Coop . The site consists of a 150' guyed tower structure with a brick shelter building at the base of the tower. This building is owned by the Coop and provides space to the County's radio equipment. A backup generator unit with LP tank support was in place but no security fencing was providing protection the tower or shelter areas.

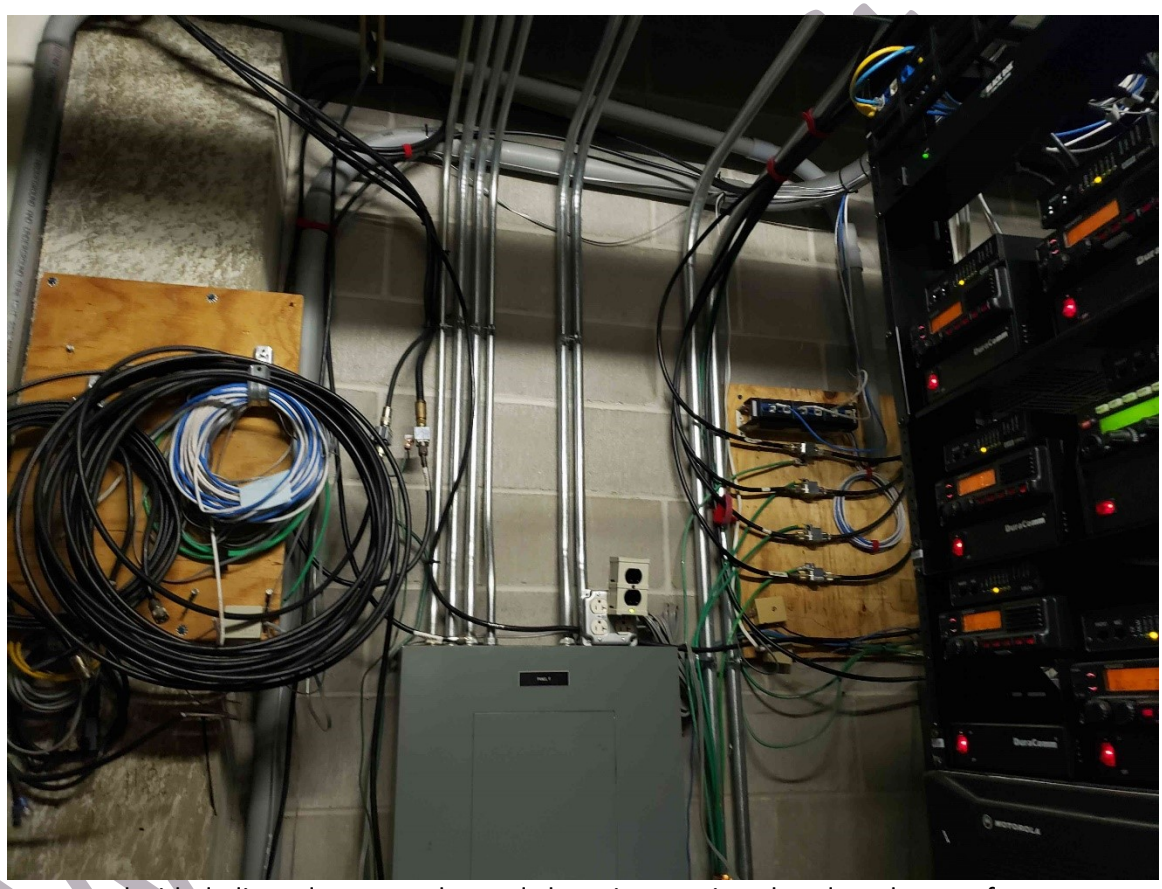
The site supports the County's Law and Fire channels with two (2) omni-directional dipole antennas mounted near the top of the tower and just below. Each antenna is dedicated to the repeater equipment located in the brick building structure. Cabling is routed directly from the tower leg into the shelter likely on the ice bridge structure, but underground conduits also exist. Antenna ¾" coaxial cable route from the tower and into a dedicated arrestor device, where it changes over to an LMR-400 jumper. That jumper then routes to the repeater duplexer equipment.

Motorola Quantar and MTR2000 equipment were installed into a 7' open equipment rack belonging to the County. Installed next to each of the repeaters was a dedicated antenna duplexer device allowing transmit and receive combining. A smaller Motorola equipment cabinet was located next to the rack and found empty. Minimal simple cabinet grounding was identified as tied into the shelter's main ground bus.

7.5.2 DISPATCH CENTER SITE

Richland County radio equipment operating locally at the PSAP site is supported by antenna systems on various rooftop locations of the courthouse building. The courthouse is located at 181 West Seminary Street in Richland Center and although the structure is a combination of multiple buildings it can be considered as a three-story structure. Radio equipment antennas are mounted using various wall and non-penetrating roof top mounts.

Most console radio equipment is installed in a suspended open equipment rack above and next to the building air handling vent systems. These control station configurations are



supported with dedicated antennas located above in a semi-enclosed outdoor roof space. Antennas are connected using the smaller LMR400 coaxial cables due to the proximity of the radio equipment and the control station operation. Cables are routed through dedicated lightning arrestor devices.

7.5.3 EAGLE TOWER SITE

Eagle tower is Richland County's only supported radio system site that is not located within the County boundaries. This site reside just south of the community of Muscoda in neighboring Grant County up on the foothills of the Wisconsin river. Its location serves the southern areas of the County being equally centered to support Richland. As a United States Cellular owned site, the antenna coverage is provided by a 245' self-supporting tower structure and is registered with the FCC using ASR # 1241130.

The site consists of multiple shelter buildings in a fenced compound at the base of the tower. Richland County owns the smaller approximate 8'X10' steel building shelter built by Trachte for locating site equipment.

Eagle tower supports only the County's Law channel from this site with a directional dipole antenna mounted at the approximate 150' tower height. A ¾" antenna coaxial cable provides connectivity from the antenna to the shelter via a dedicated ice bridge. Once inside the shelter the coax is run through a lightning arrestor and jumped into the

enclosed Motorola equipment cabinet. A Motorola MTR2000 repeater unit with a dedicated duplexer device and battery backup was found providing operation. Some empty cabinets were also found within the shelter as well as a small generator device.

The site showed signs of a past electrical surge failure having a failed breaker and the radio equipment installed using an extension cord from a distant outlet.

7.5.4 LONE ROCK SITE

The Lone Rock tower site provides radio system coverage from the antenna location on top of the community's water tank. The Lone Rock community is in the very southeastern corner of Richland County where it meets Sauk County. Located on Exchange Street the tank serves to provide other vendor or community antenna support as well, and is

approximately 110' in height.

County radio system equipment at the site is in a single outdoor rated cabinet unit found within the base of the water tank. The cabinet house both the Law and Fire repeater devices serving this area, but also houses a unique Paging channel repeat device. Appearing to be the only one of this kind in the County's system the Paging channel repeat device reuses the Law receive frequency with a unique squelch code and rebroadcasts on the Paging Channel. This is accomplished still using two site antennas and a shared transmit operation with the Fire channel.

Motorola Quantar repeater stations were identified that support the Law

and Fire channels at the site. Both were equipped with a standard cavity duplexer unit to combine transmit and receive operations. A third Kenwood model station was used to perform the additional page repeat operation. Configuration documents indicated the device gained it's receive antenna by sharing connectivity to the Law repeaters antenna and then through an antenna relay shared it's transmit function with the Fire repeater. This shared antenna arrangement creates an interruption of service for the Fire repeater during paging operation.

Dipole gain antennas on top of the water tank provide the site coverage and are cabled to the back of the equipment cabinet using a 7/8" hard line. At that point they are passed through dedicated arrestor devices and jumpered to the cabinet with ½" coaxial cables.

Cabinet grounding was completed to the tanks main ground bus installed by site users.

7.5.5 SYLVAN SITE

Providing coverage capabilities in the Northwest part of the County is the Sylvan site located just east of the town of Sylvan. The site is listed at Highway E approximately 1.6 KM east on FCC licensing. The site location supports a 180' guyed tower with a small metal shelter at the base of the tower and enclosed by a barbed wire fence compound. This site is a lease/share space from the tower owner Richland-Grant Telephone Cooperative.

Supporting both the Law and Fire repeater coverage are two dipole omni-directional antennas located at the top and near the top of the tower. Connectivity to the antennas are supported by dedicated 7/8" coaxial cable runs via the ice bridge and into the shelter. Coax lightning arrestors were grounded to the building systems directly inside the entry port window, and jumpered to equipment cabinets.

Both Motorola and Harris repeater equipment was found located in dedicated equipment cabinets along with duplexer combining devices. Cabinets were powered from wall outlets and grounding connections supported bonding to the building system. The site had numerous signs of rodent damage with nesting signs within the County cabinets including dead carcasses.

7.5.6 TOWER HILL – USCC SITE

Providing Richland County its main coverage and central location site is a United States Cellular tower located in Richland Center on Tower Hill. Space is provided for County equipment with a shared lease arrangement via the site agreement. The self-supporting 320' structure is an FCC registered (ASR #1000186) location and is located on the high bluff at the east side of town. A fenced compound encircles the single shared equipment shelter at the base of the tower and generator backup equipment.

The County shares the common steel building space with a dedicated access and separated room space. Located at the site are the Law and Fire repeater units as well radio equipment for Page, IFERN, and Point to Point equipment. Harris Master III equipment provides the operation for all stations at the site.

7.5.7 TOWER HILL SITE

Tower Hill as always provided County support as a radio equipment antenna site and some support is still used from the previous location on Tower Hill. Located with walking distance of the USCC site is the approximately 75' guyed tower that supports two brick shelters at the base of the tower. The county relies on the tower to complete a small microwave hop from the Dispatch center site as well as a receive location for paging/cellular conversion equipment.

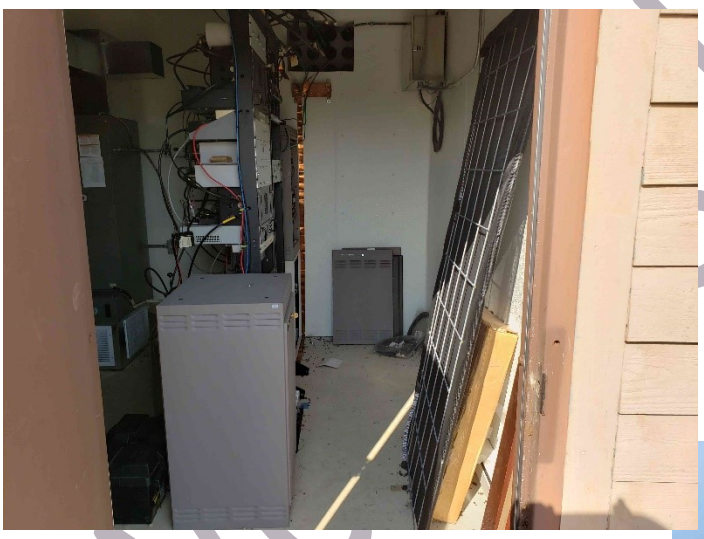
This site does not serve to locate radio communications equipment.

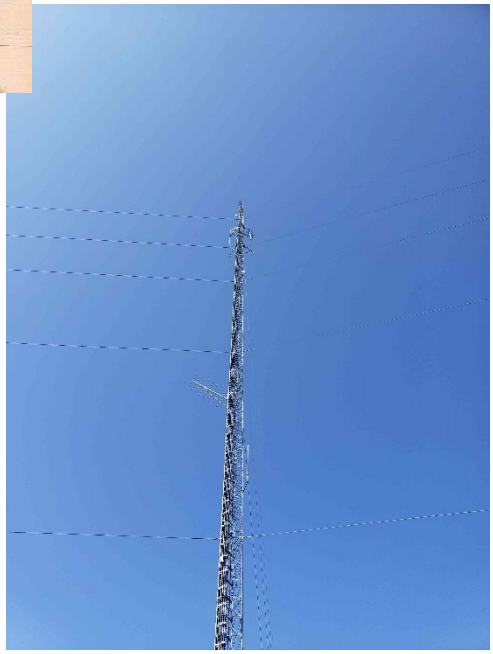
7.5.8 WRCO SITE

Also centrally located in the County and supporting radio coverage near Richland Center is the WRCO Site. Local radio station owns the 350' guyed tower located at Hillview Drive between Premo Road and County. This site is register with the FCC under ASR #1257097.

The site supports a few of Richland County's mutual aid stations and the Highway Department channel from equipment located in the shared shelter space. This 10'X20' wood building shelter is located at the base of the tower and secured with a chain link fence compound. The shelter is also supported with backup power generation using the LP fuel storage tank on-site.

Antennas located near the top of the tower provide dedicated support to the Motorola (Highway) repeater and Harris (Marc 1) station. Dedicated cabinets are used to house the County's radio equipment and any needed combiner systems. Antenna connectivity if via 7/8" coaxial hardline run to each dipole antenna.





8 EXISTING DISPATCH SYSTEMS EQUIPMENT

8.1 LOCATION

Richland County emergency services are dispatched from the counties only 911 PSAP operating at the Sheriff's office in Richland Center. The center is operated in a designed space within the jail on the 2nd floor of the building. Serving as both the 911 PSAP and Jail Operations this approximate 15' X 15' room is located off the main lobby area and accessed through the secured jail entrance. The current space provides for two dispatch console furniture positions facing the walls in a back-to-back configuration. Design of the room provides full view windows on all sides except for one wall having a lower-level hallway equipment space in the room. Windows expose the center to the jail and lobby area which allows access control.

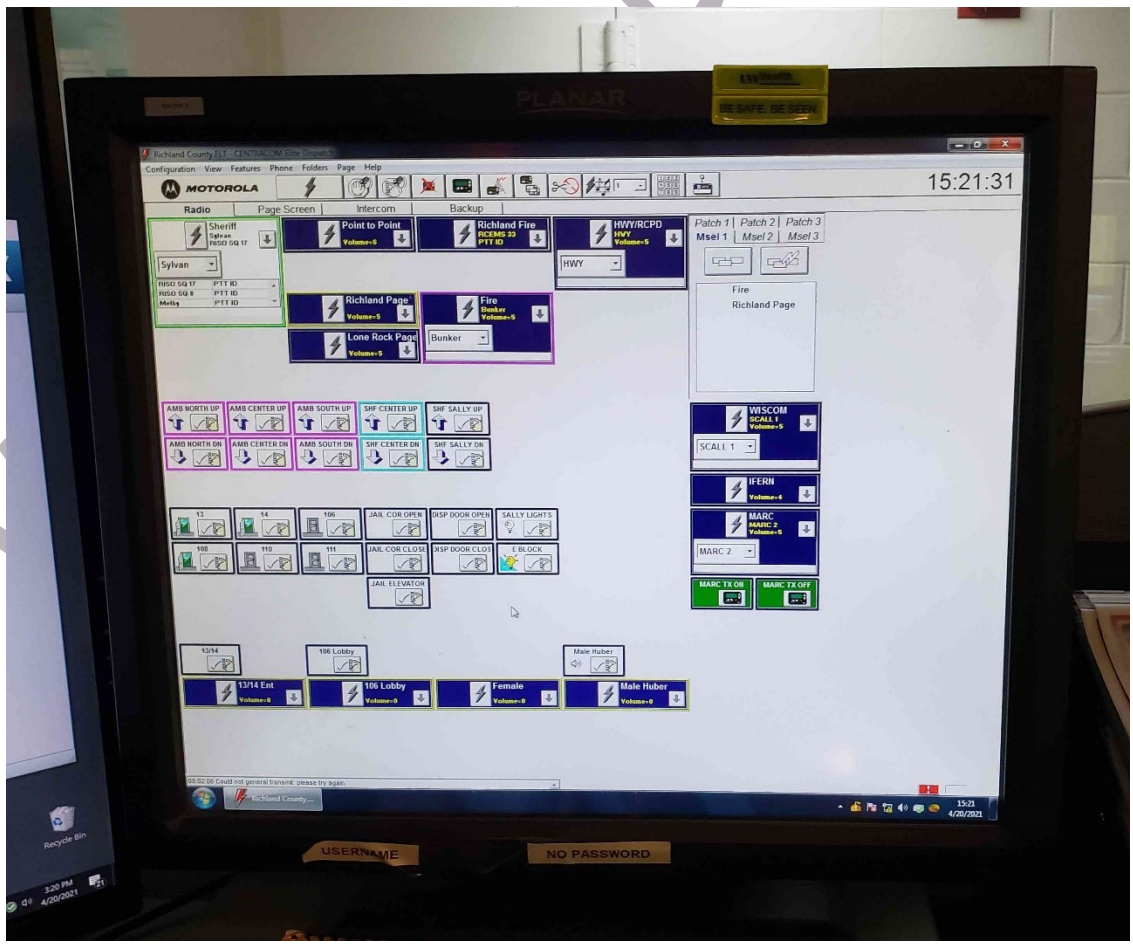
Uniquely, the center configuration allows jail and dispatch operations to mix and match during a personnel shift. This also applies to staffing of console positions always keeping at least one position in operation.

8.2 DISPATCH CONSOLES

The center operates a two-position computer-based radio dispatch console system made by Motorola Solutions. This Centracom Gold Elite model system is design with three main system components needed to have a functional console system. Each position operates a dedicated computer client machine that is connected to the position audio interface panel providing receive speakers and a gooseneck microphone device. This unit also serves to interface footswitch, headset, and performs other position functions as needed.

The console system backroom electronics consist of a server computer communicating with the console PC for configuration and setup. These networks were designed and supported through various Windows generations, but final variations ended with the Windows 7 platform. The IP system operation provides for command-and-control functions while audio routing is via a dedicated proprietary cable between the electronics rack and audio panel.

The electronics rack provides the radio equipment interface capabilities with dedicated rack cards to perform individual functions in the system such as console interface, radio control, aux I/O and others.



8.3 CONSOLE RADIO EQUIPMENT

The Richland County dispatch console systems are supported with radio base and control station equipment located on-site and radio equipment located at the Tower Hill - USCC site. Equipment on-site is housed on a rack system in the building penthouse and provides operation through standard mobile radio units interface with wireline controller modules.

Console connectivity is supported by the dedicated premises cable between the equipment room on the lower floor and the penthouse equipment location. Standard two and four wire telephone pairs are required for operation.

8.4 LOGGING

TBD

8.5 FIRE STATION ALERTING

No Fire Station alerting systems were identified in use by Richland County agencies at the time of this report.

8.6 SIREN ACTIVATION

No standalone Civil Defense Siren (CDS) systems were identified for control operations. County siren activation systems were found to use the radio dispatch console systems to encode a two-tone or DTMF signaling on the main paging channel for activation.

8.7 POWER

8.7.1 PRIMARY

Main electrical power for the dispatch center and radio equipment room is provided via common building power load centers.

8.7.2 GENERATOR

Backup power is provided to the dispatch center via a common generator system which supports the building location. It does not appear to be exercised under load on a regular basis.

8.7.3 UPS

Dedicated uninterrupted power sources (UPS) units were identified providing backup power to critical console system and dispatch equipment support. Power systems seemed adequately sized to provide backup power momentarily until the generator can come online.

8.8 HVAC

All air handling needs for the dispatch center and associated radio equipment room are primarily provided by the building main HVAC systems. No supplemental systems or plug-in fan units were identified in the radio equipment room. Heat generation or temperature change was not identified as extreme in either the dispatch or equipment room.

8.9 GROUNDING

Grounding systems in the dispatch center and associated radio equipment room were found to be in place to the level expected when current systems were installed. These systems were identified as minimal grounding systems by today's standards usually connecting a ground bar to a cabinet or equipment chassis. Systems were not identified to be complete and covering all equipment and systems installed on site.

Verification of a single point ground network could not be done, and no perimeter ground systems were identified as to what would be considered common designs used today.

9 FIELD TERMINAL SUMMARY

Surveys performed by TNCG identified the County stakeholders operating various manufacturers' brands, design tiers, and age of radio equipment throughout the County. A representation of single band VHF operational models with analog and P25 digital capabilities was provided.

The purchase, maintenance, and operational responsibility of field terminals go directly to the department using the equipment in Richland County. With multiple vendors comes the challenges of programming and setup configuration of radio units to a common standard as defined by the National Interoperability Field Operational Guide (NIFOG).

Paging equipment (pagers) identified in use by Fire and EMS agencies were found to be mostly Motorola style tone and voice units either Minitor V or VI models.

Much of the equipment identified could be categorized as low tier public safety or business tier products, and age varies. Replacement and expansion are being done by departments on an as-needed basis and without specified goals, done possibly based on pricing-only considerations.

9.1 KEY POINTS OF CONSIDERATION

- Equipment used mostly does not meet current public safety standards.
- Lack of standardization for purchases of new units misses opportunities to maximize investments toward improved standards.
- Lack of configurations and programming reliance creates potential issues and obstacles.
- Equipment accountability and tracking helps during high demand for resources.
- Equipment maintenance standards promotes confidence in operational success.
- Common County frequency chart to guide users is helpful.
- Backup or emergency resource equipment helps to fill in gaps and ensure reliability in times of need.

9.2 SUBSCRIBER INVENTORY SUMMARY

Richland County public safety agencies operating on the dedicated County radio systems use approximately 550 various devices. Devices are categorized into three main descriptions for inventory purposes. Portable units represent handheld radios that are operated on rechargeable battery power and provide a small whip antenna system. Mobile units represent vehicle-mounted radios that provide the user with greater transmit power capabilities and an improved vehicle antenna. Finally, control station units represent radios (usually mobile radios) that are in buildings and have outdoor antennas providing even stronger antenna systems.

Subscriber Agency	Agency Type	Portable Unit	Mobile Unit	Control Station	Pager	Radio Type	County	Dispatch Via
Richland Police Department	Law	17	3	1	0	VHF	Richland County	Richland County
Richland County Sheriff's Department	Law	21	19	0	0	VHF/P25	Richland County	Richland County
Viola Police Department	Law	4	1	1	1	VHF/P25	Richland County	Richland County
Blue River Fire & Rescue	Fire/EMS	12	6	1	36	VHF	Richland County	Richland County
La Farge Fire Department	Fire	25	10	1	40	VHF/P25	Richland County	Richland County
Richland Center Fire Department	Fire	39	31	1	88	VHF/P25	Richland County	Richland County
Viola Fire Department	Fire	20	9	1	42	VHF/P25	Richland County	Richland County
Yuba Fire Department	Fire	0	12	0	17	VHF	Richland County	Richland County
Ithaca Medical First Responders	EMS	9	1	0	9	VHF	Richland County	Richland County
Richland County Ambulance Service	EMS	31	7	0	24	VHF/P25	Richland County	Richland County
Viola EMS	EMS	2	2	0	0	VHF	Richland County	Richland County
Lone Rock Rescue	EMS	3	2	0	14	VHF/P25	Richland County	Richland County
Richland County EMA	EMA	5	2	1	1	VHF/P25	Richland County	Richland County
							Richland County	Richland County
Richland County Highway	DPW	15	48	4	0	VHF	Richland County	Richland County
	TOTALS	203	153	11			Total Radios	367
							Total Pagers	272

10 USAGE / CAPACITY

Public safety radio communications in Richland County rely on the main system channels of Law and Fire on calls for service. Channel activity on these two dedicated channels was found to be minimal and provided the users a location for operations along with dispatching services. Relief of paging dispatch on the Fire channel with the additional dedicated Page channel assisted as well. Minimal simplex (radio to radio) channels were also defined and provided support of operations but lacked any heavy reliance of use or common setup.

The County's system repeater design provides confusion with multiple radio channels to communicate on by the subscriber user, but with the shared frequency resource. Without this complete understanding of the shared design possible system created challenges could disrupt conversations. These repeaters should not be operated at the same time and must be considered localized identical devices and not independent.

Currently the County is missing additional system resources for peak calls for service that allow Dispatch and users capacity to operate effectively and ensure clear communications.

10.1 UTILIZATION OF CHANNELS TODAY

TBD

10.2 NEIGHBORING COUNTIES

Richland County shares borders with five neighbor Wisconsin counties and service boundary areas from County agencies stretch to these neighbors. As well some agencies outside of the County are found providing services within the County borders. Outside the county borders can also be found local hospitals serving the needs of supporting emergency services and requiring agency transport to those locations.

A goal of providing seamless interoperability communications of emergency response agencies when working with other agencies is stressed more and more each day. These capabilities need to provide the end user the greatest level of simplicity and capabilities.

Creating interoperability between neighboring counties will require an understanding of the coverage areas needed and identifying how incident operations might unfold.

Organization	Neighbor	Agency	Radio Band	Frequency Information
Richland County	Sauk County WI	Sheriff	VHF	155.700 (82.5)
		Fire	VHF	151.250 (97.4)
		Paging	VHF	155.775 (82.5)
Richland County	Vernon County WI	Sheriff	VHF	154.995 (167.9)
		Fire	VHF	154.860 (136.5)
		Paging	VHF	154.175 (167.9)
Richland County	Crawford County WI	Sheriff	VHF	155.685 (152)
		Fire	VHF	154.310 (151.4)
		EMS	VHF	155.655 (151.4)
Richland County	Grant County WI	Sheriff	VHF	155.865 (123.0)
		Fire	VHF	155.745 (91.5)
		Paging	VHF	155.925 (CSQ)
Richland County	Iowa County WI	Sheriff	VHF	155.7225 (BOC NAC)
		Fire/Paging	VHF	154.385 (77.0)
Richland County	State of Wisconsin	State Patrol	WISCOM	VHF Trunked

10.3 STATE OF WISCONSIN (WISCOM)

The Wisconsin Interoperable System for Communications (WISCOM) is a shared radio system first responders in communities across the state of Wisconsin can use to communicate during a major disaster or large-scale incident. WISCOM is designed as a VHF trunked P25 Phase 1 radio network supporting up to four (4) simultaneous conversation paths during an incident. The system is built using EF Johnson radio infrastructure and is designed to provide 95/95 mobile radio coverage on the State's backbone network but has been enhanced by a few counties to meet portable radio coverage needs in their communities.

The WISCOM system is open for use to any agency for use by County subscribers having a VHF P25 capable trunked radio. Its design dedicates talkgroups for communications with state agencies and regional talkgroups dedicated to mutual aid operations Richland County falls into the classification of the southwest region of interoperability on the WISCOM system. As well the system provides a dedicated travel talkgroup for users to keep in contact with their PSAP throughout the state. The finally the design provides dedicated Richland County talkgroups to the County for SCAN and COMMON operations.

The County is supported for coverage on the WISCOM system by tower sites in the neighboring counties as data lists no repeater sites in Richland County.

The WISCOM system and anticipated system changes needs to be a part of planning processes in any Richland County replacement systems. The key decision of frequency band operation would be the most impactful to interoperability with State agencies. With any change to the system there are work arounds that can be used to provide communication solutions that can be implemented.

11 FINDINGS

11.1 INTERVIEWS

In the process to develop a thorough understanding of the Richland County public safety radio system and subscriber operations TNCG visited the county, conducted telephone discussion, and sent out survey requests. Additional investigation helped piece together unknown details and information not readily available. Discussions with representatives from various agencies, radio maintenance personnel, and support staff identified the following findings to be understood with the current systems in place:

GENERAL

- Oversight and funding of the Richland County radio systems is provided by the Sherriff's Department and overseen by the Board of Supervisors Public Safety Committee.
- The current system is a collection of solving identified needs using radio vendor input and site opportunities. The system has expanded over time to provide greater capabilities and increased coverage support. Equipment replacement and design modifications would be considered done on an as needed basis.

E-911 DISPATCH

- PSAP is located at 181 West Seminary, Richland Center WI 53581 inside courthouse building.
- Building constructed as a combination of buildings. New addition in 1985
- Dispatch located beyond public entry area on 2nd floor to Sheriff's department with reception window.
- Room size approximately 15' X 15'
- Two (2) dispatch furniture positions
- Hot seat – Dispatch position #1
- Headsets for 911 phones, but not integrated into radio
- Deputy contacts dispatch on channel they feel works best in area they are working
- CAD system is Zuecher model.
- Paging test performed twice a day. Evening – Fire, Morning - EMS
- Dispatcher and jailer duties intermix.

- Door controls for building and jail operations are integrated into the radio console system.
- Some PTT id alias functions work.
- No emergency button operation.
- Console system is a Motorola Centracom Gold Elite donated from City of La Crosse back in 2013.
- Intercom operations integrated into radio console system.
- Lobby speaker not working.
- CD sirens tested first Wednesday of the month.
- Building generator not exercised under load.

LAW ENFORCEMENT

- Gencomm & Belco provides Sheriff Department upfitter support.
- Baycomm provides system maintenance contract support.
- VRS operation in Sheriff's department.
- Law enforcement – Richland Center/Viola/Lone Rock PD.
- Bear Valley area is a dead zone.
- Lone Rock tower does not perform well on Law Repeater.
- Computer messaging used to avoid scanner land.
- At one time, encryption capabilities.
- Kenwood products

FIRE

- 800 North – dead spot
- Highway 130 by Bear Valley – dead spot
- Highway 113 – dead spot
- Casenovia EMS – poor paging coverage
- Use of cellphone communications in case of HIPA requirements.
- Fire ground channels are available.
- Stored voice paging is used.
- Iam Responding is available
- IFERN operation from WRCO – poor.
- Viola coverage area on Fire - poor

EMS

- No dedicated radio channel available for use.
-

SERVICE FIRMS

Various service firms have played a part in providing Richland County agencies radio communication equipment and system support. Brought on using multi-vendor equipment in the purchasing processes which can create operational challenges. Given the analog design parameters used today these challenges are minimal and easily overcome with some good documentation.

Richland County's system equipment also relies on various vendor and model equipment. Primarily supported today by Baycom Communications (Motorola) the challenge are found when various vendor equipment come together at the interface points. This again is not to a great degree with the design model in place on the current system.

12 INTEROPERABILITY FINDINGS

Interoperability in radio communications is a key focus in providing effective public safety radio system operations and becomes an important part of any system replacement process. Although many possible options can provide interoperability avenues it is key that solutions always be focused on simplicity of use and ease of operation to the emergency service user. This effectiveness helps assure that the end user will rely on these services during a time when stressful situations can slow the processes of understanding.

Interoperability communications also becomes more of a concern with the movement of public safety systems to multiple frequency bands, digital operations, and encryption services. Richland County users today rely on simple programming avenues of implementing other neighboring user's information into department radios or relying on mutual aid channels.

12.1 INTEROPERABILITY OBSERVATION POINTS

The following were identified during this study and represent key points of understanding about the existing Richland County interoperability needs and concerns.

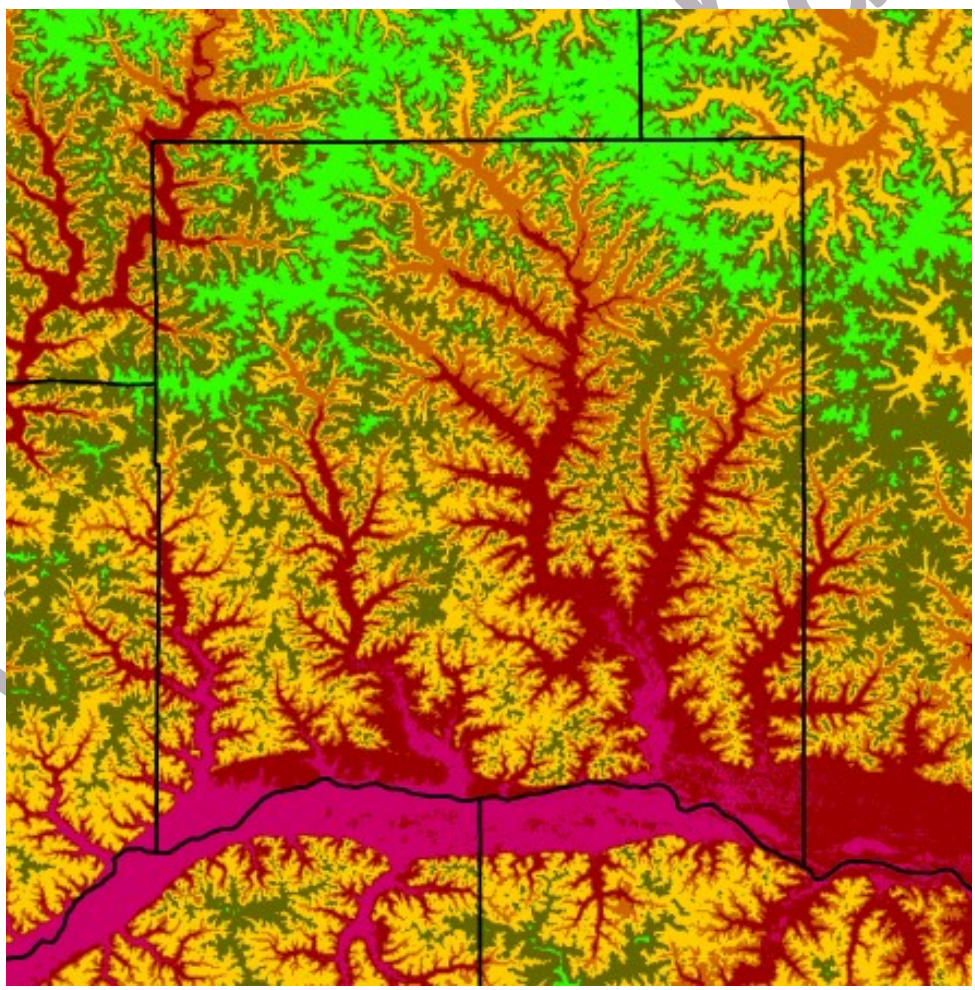
- Subscriber equipment radio channel naming is not identified in a common County document for all agencies to put into practice. Accurate radio frequency and naming of channels is key to assure communication.
- National mutual aid channels do not follow National Interoperability Field Operations (NIFOG) standards on many stakeholder subscriber equipment.
- All neighboring counties appear to operate radio systems on the VHF frequency band, but some have migrated to digital (P25) configurations.
- Interoperability system channels are limited in the dispatch center support.

13 RADIO COVERAGE

13.1 TERRAIN

The terrain of Richland County is heavily weighted by the Wisconsin river valley provideing the southern border of the county. Low areas along the river extend like fingers up into the county that can easily rise over 500 feet to the high points on the northern end of the county. The County is also somewhat impacted by the Kickapoo river valley to the same extent in the northwest corner of the county.

These dramatic change in elevations from the river valleys not only provide challenges to coverage based on elevation changes but also usually means the presence of larger wooded areas with foliage losses to overcome. This is defined as land clutter displayed below and is calculated into prediction models.

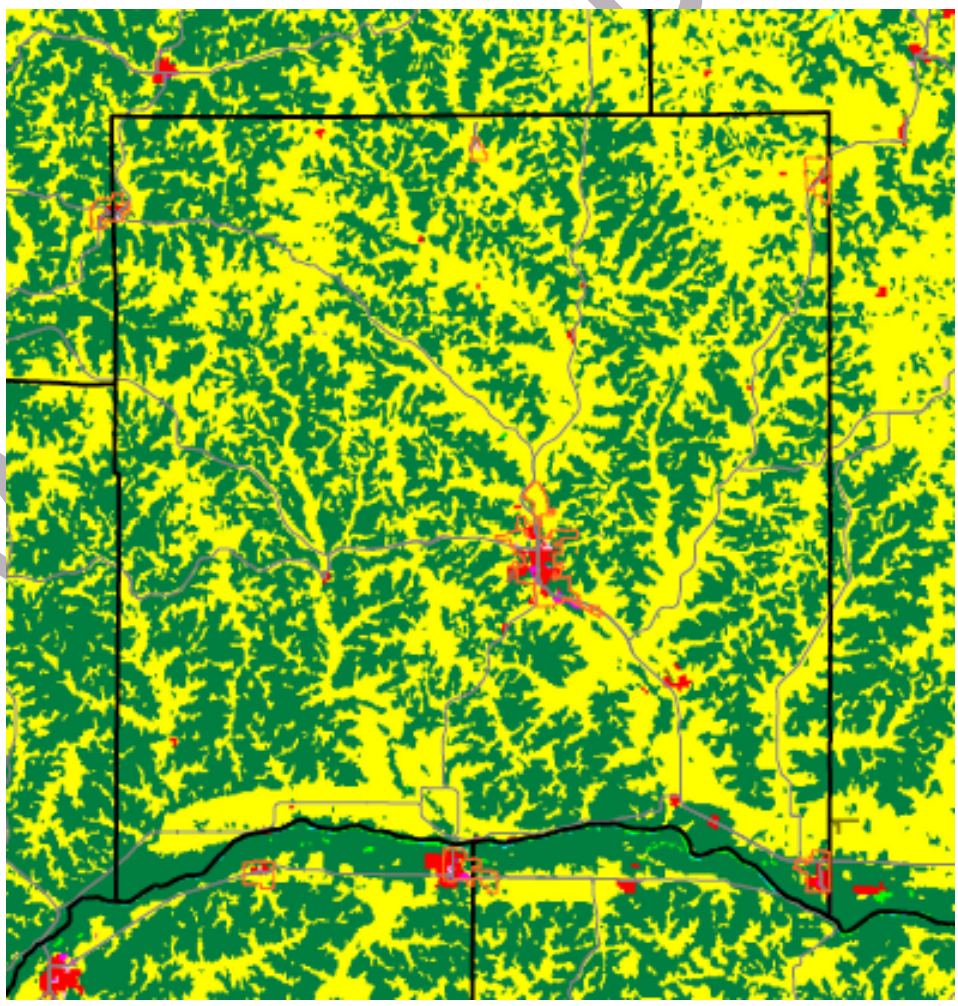


13.2 LAND CLUTTER

Clutter predictions are defined to identify loss factors needed to anticipate signals being reduced by natural and manmade items. As with many Wisconsin counties Richland is defined by the forest and agricultural categories. Agricultural plays a key role impacting radio communications during the summer growing season. Other factors such as the Urban category is minimal in the county with mostly smaller communities.

LULC Color Customization

Color	Description
	Water
	Snow Ice
	Wetland
	Open Land
	Rangeland
	Transportation
	Agricultural
	Residential
	Forest
	Mixed Urban/Buildings
	Commerial/Industrial
	High Density Urban



13.3 COVERAGE PREDICTIONS

Coverage predictions calculate an estimated signal level that would be received by a field unit from a repeater or base station antenna and signal levels received by a base station from a user radio operating mobile or portable. Predictions use the effective radiated power level allowed by the FCC license, terrain, land use, and body losses among other attenuation factors in the calculations. Reliability and fading factors are also used in the calculation to provide a realistic map of system expected performance.

The minimum receive sensitivity level of portable receiver designs today will vary but commonly falls from -120 to -117 dBm (0.22µV to 0.32µV). Any signal level appearing at the receiver antenna less than the minimum would be considered noise and not be decoded.

The larger the signal level, the more attenuation the receiver can overcome. Once the received level exceeds the atmospheric noise, man-made noise, body loss, and path losses, it is possible for the receiver to decode a signal. In predictions, a reliability factor is also added to overcome losses that may be present in any location. In general, for analog systems, this is about 20 dB which increases the required design signal level for public safety portable on the hip performance to -97 dBm. For digital, an equivalent level is about -107 dBm due to processing gain and the quality of the delivered audio. Digital P25 systems will generally recover the system losses introduced by the previously FCC mandated narrowband conversion a few years back.

Due to the curvature of the earth and how this affects VHF – 800 MHz, portable coverage from a 180’ tower is limited to about 6-7 miles; thus, this is also considered.

The provided coverage predictions for operation use a set of levels separated by a predefined range. Every 10 dB in change indicates a 10X change in power level. For the TNCG predictions, the following scheme has been adopted for comparisons:

- Gray color is used to indicate a signal level that falls under a receiver’s ability to decode.
- Red areas are outdoors and found to be unreliable.
- Yellow range is considered operational for on-the-street operations.
- Green range indicates good portable (small building) indoor coverage.

Note: Some common structures (i.e., metal clad exterior without windows, stone exterior courthouse, LEC, hospital, etc.) may be even more difficult to penetrate due to their construction.

Out of Range	Unreliable	Street Level	Building Level

The computer-generated predicted coverage may show an area is not covered, while experience says this is not the case. Also, other areas showing coverage may in fact not have coverage due to factors not considered in the model. Predictions use the losses noted above to provide a coverage estimate. Overall, they are found to provide good indications of the coverage to expect. Thus, most designs factor in some headroom to ensure they are conservatively ensuring acceptable coverage.

Keep in mind that these areas are a range of signal levels, and the level tends to get stronger closer to a tower and weaker as one moves away from the tower location. A yellow level closer to the tower can be quite a bit stronger and more reliable than the yellow level five miles further away from the site. It would be possible to provide an increased breakdown of these levels, but that would require a greater level of understanding and has shown to be more confusing. Viewing the model from a high level of seeing where signal flows evenly away from a site, or where unreliable areas come into play gives the general understanding needed for County decision making.

13.4 COVERAGE PREDICTIONS FOR CURRENT SYSTEMS

Coverage predictions for the current analog system are found on the following pages. Predictions include Mobile Talk Out (MTO), Mobile Talk Back (MTB), Portable Talk Out (PTO), and Portable Talk Back (PTB).

13.5 BUNKER HILL SITE

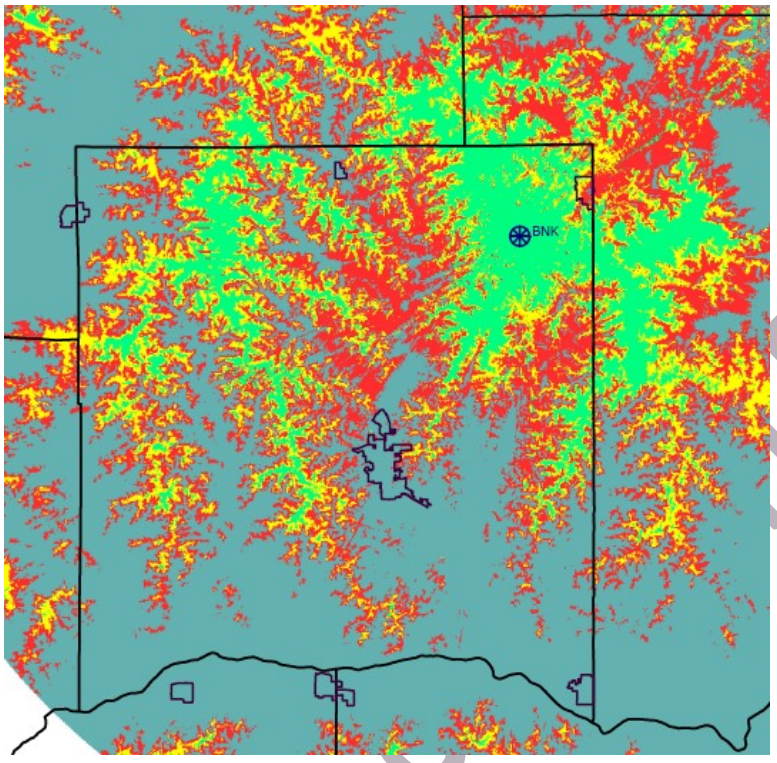


Figure 1- Portable Talk Back

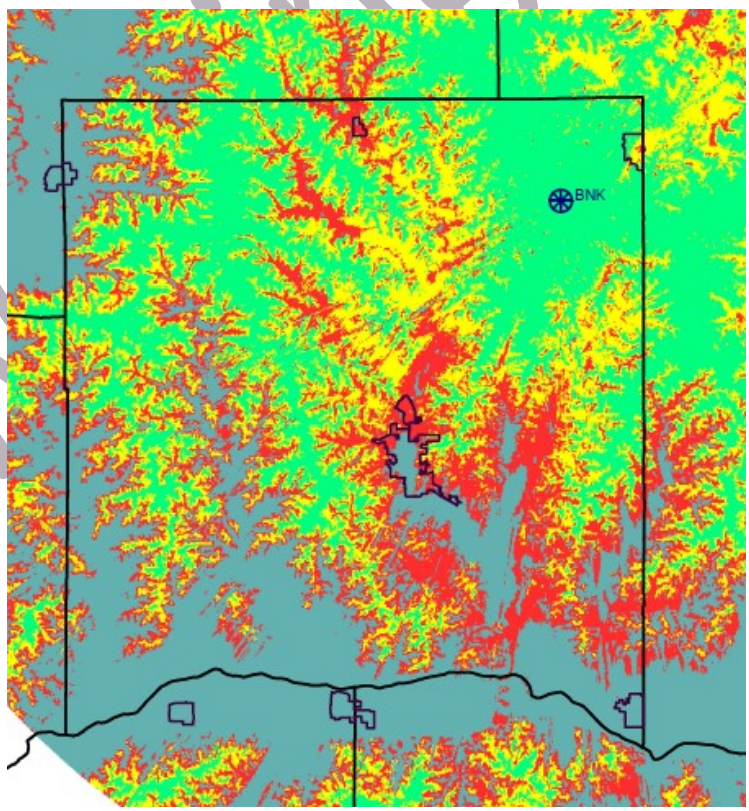


Figure 2- Portable Talk Out

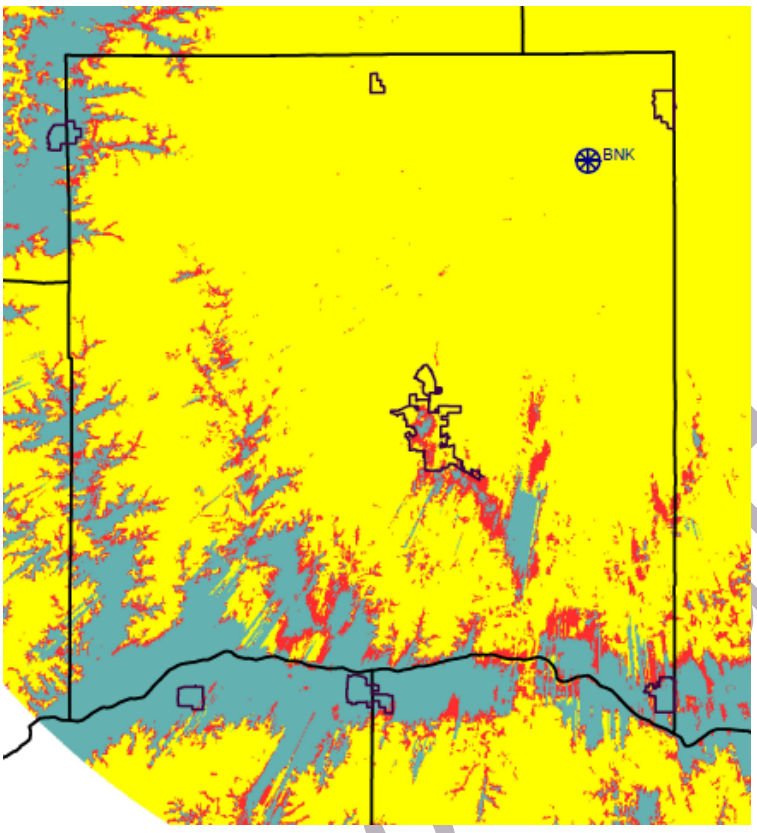


Figure 3- Mobile Talk Back

13.6 EAGLE TOWER SITE

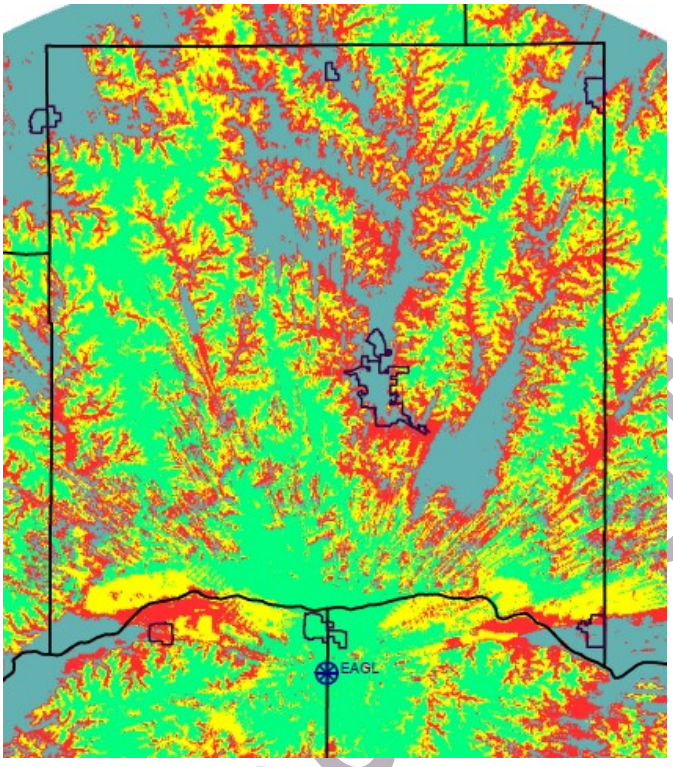


Figure 4 – Portable Talk Back

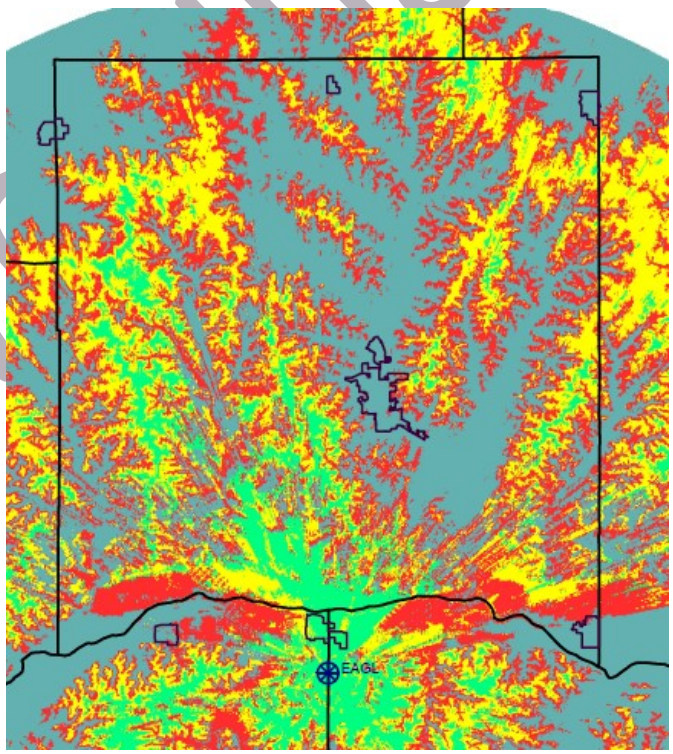


Figure 5 – Portable Talk Out

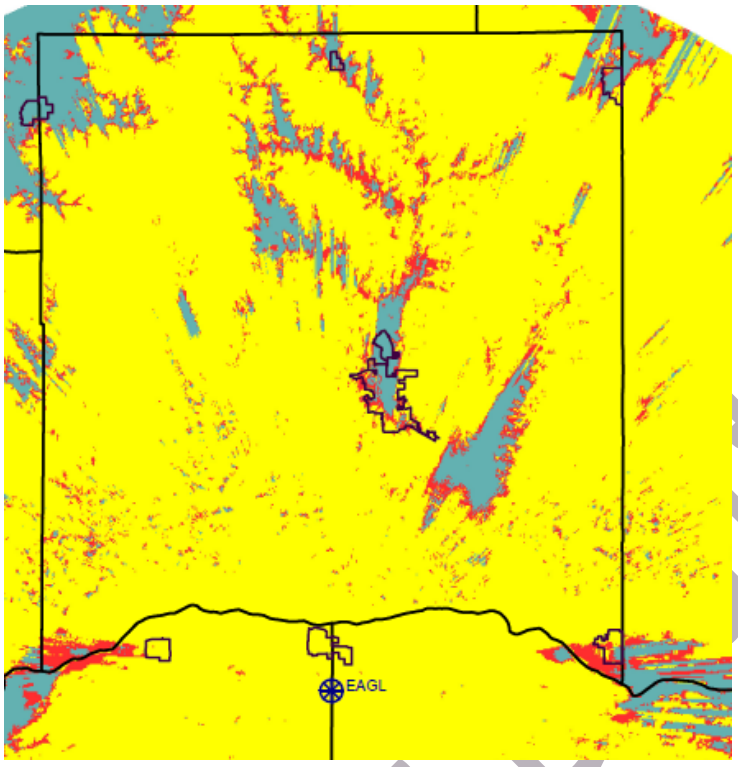


Figure 6 – Mobile Talk Back

13.7 LONE ROCK SITE

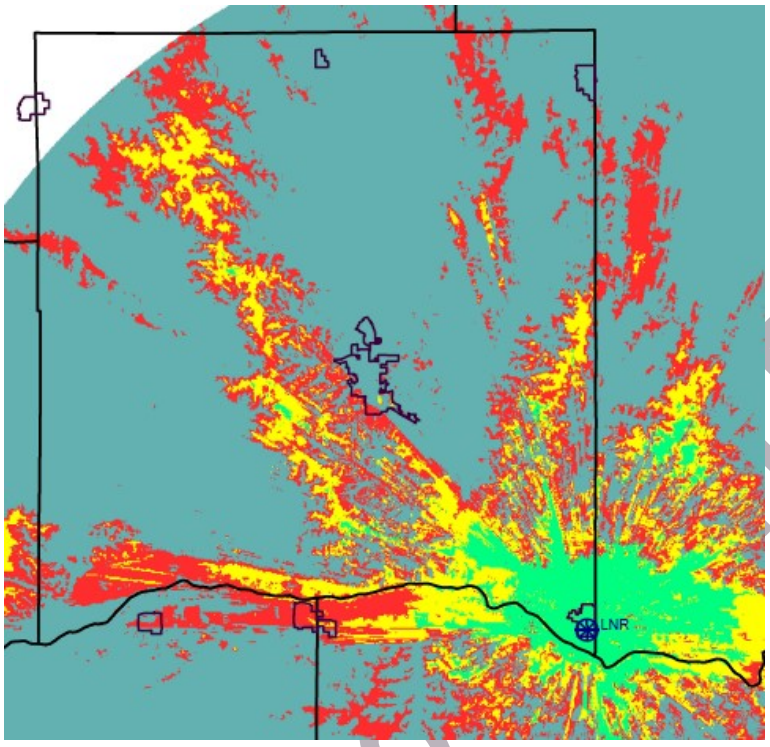


Figure 7 – Portable Talk Back

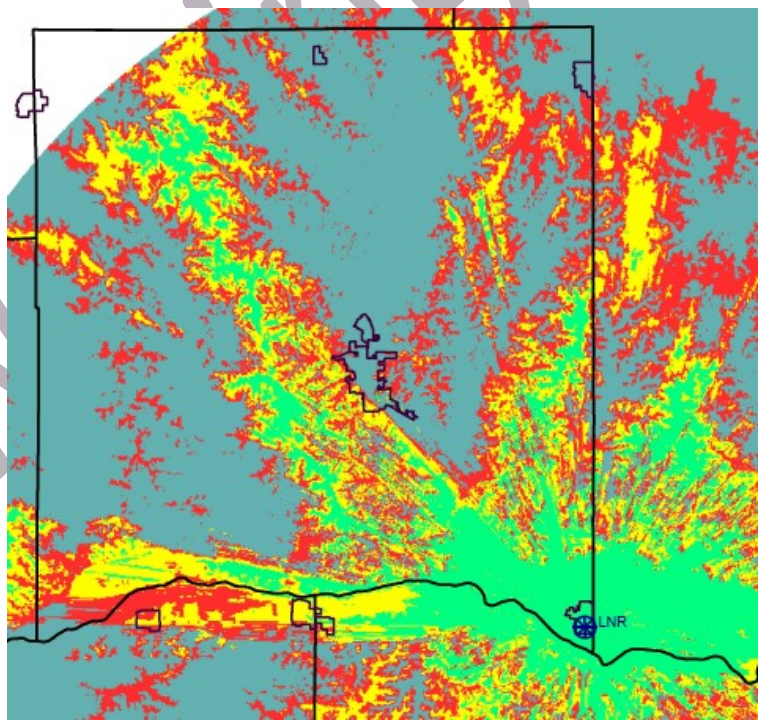


Figure 8 – Portable Talk Out

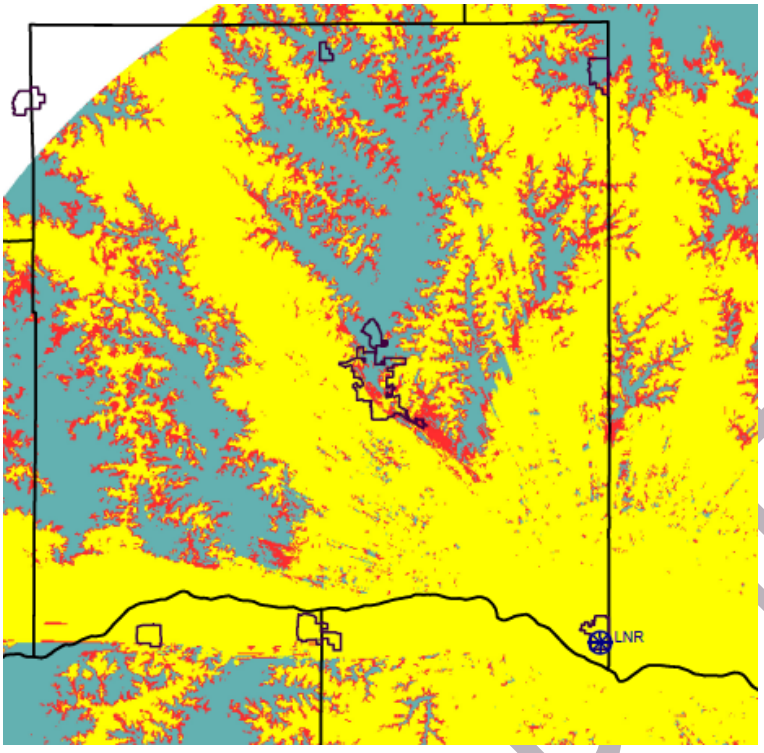


Figure 9 - Mobile Talk Back

13.8 SYLVAN SITE

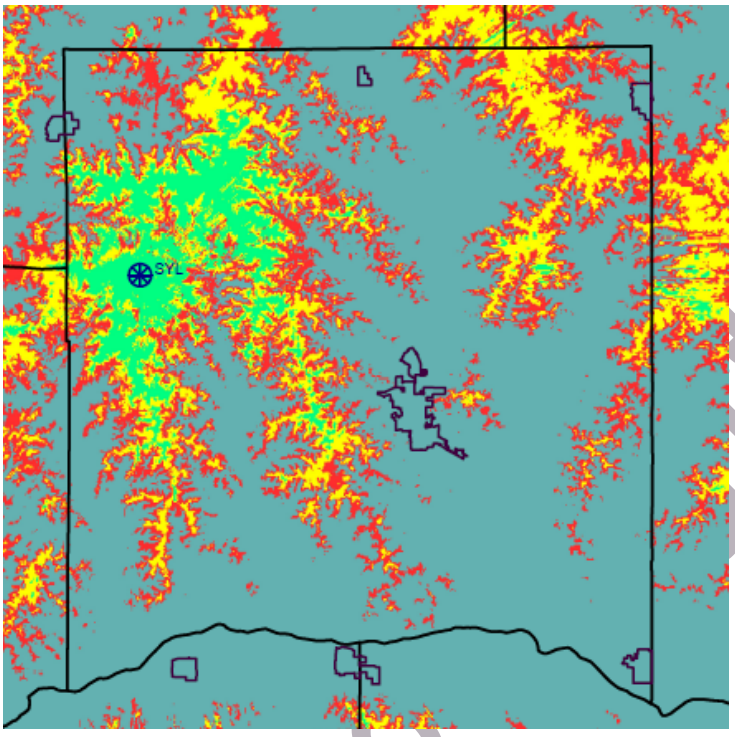


Figure 10 - Portable Talk Back

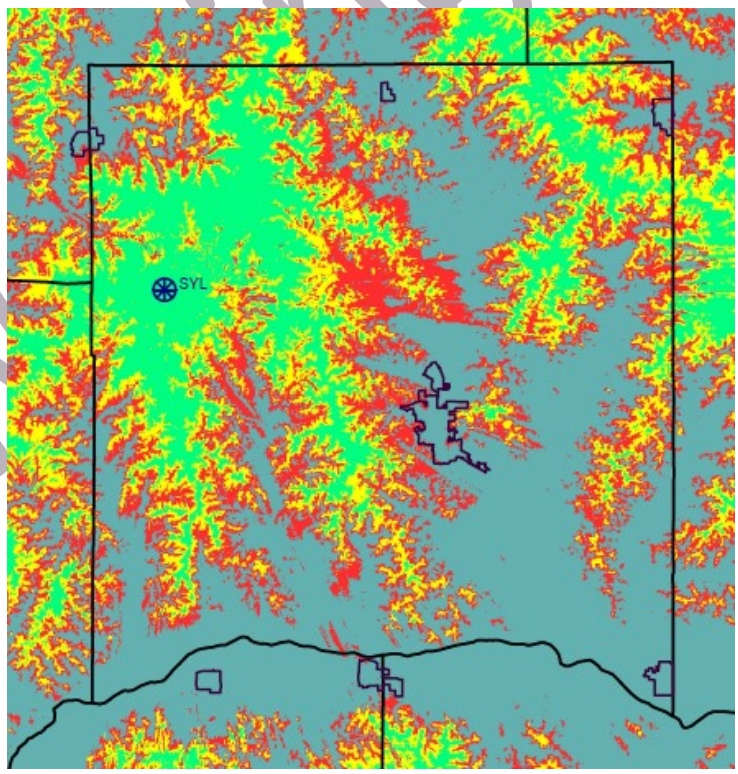


Figure 11 - Portable Talk Out

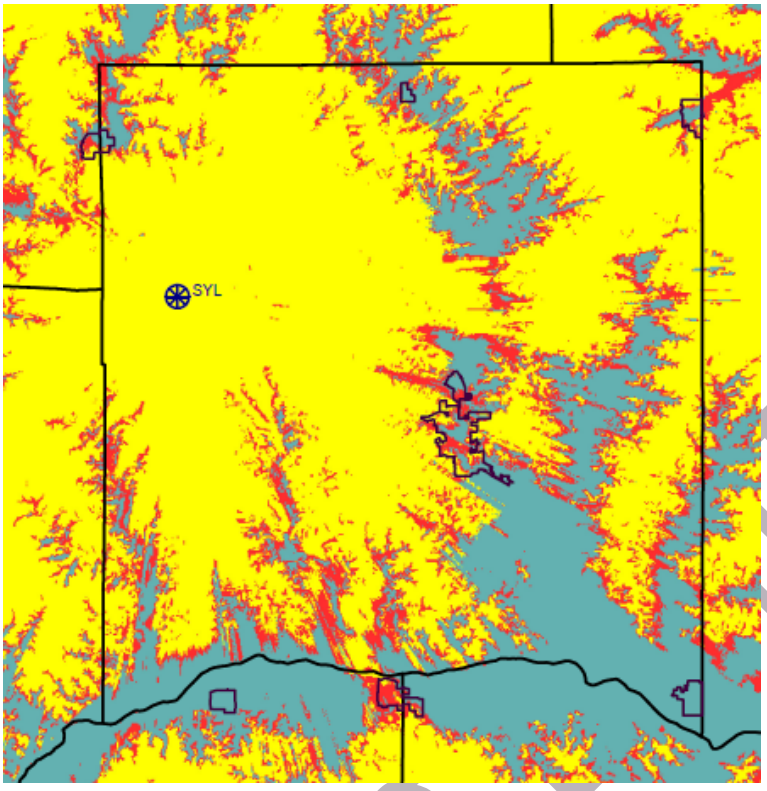


Figure 12 - Mobile Talk Back

13.9 TOWER HILL - USCC SITE

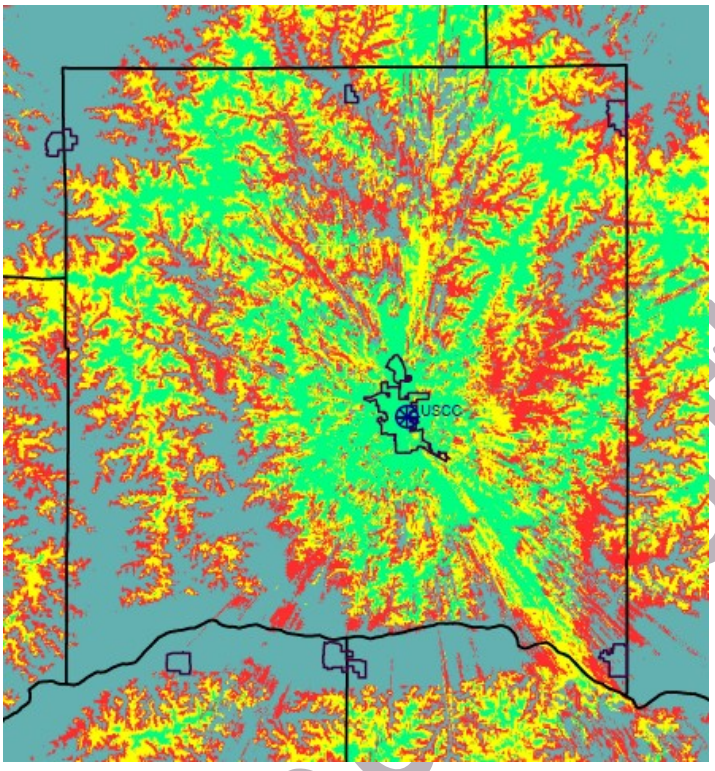


Figure 13 - Portable Talk Back

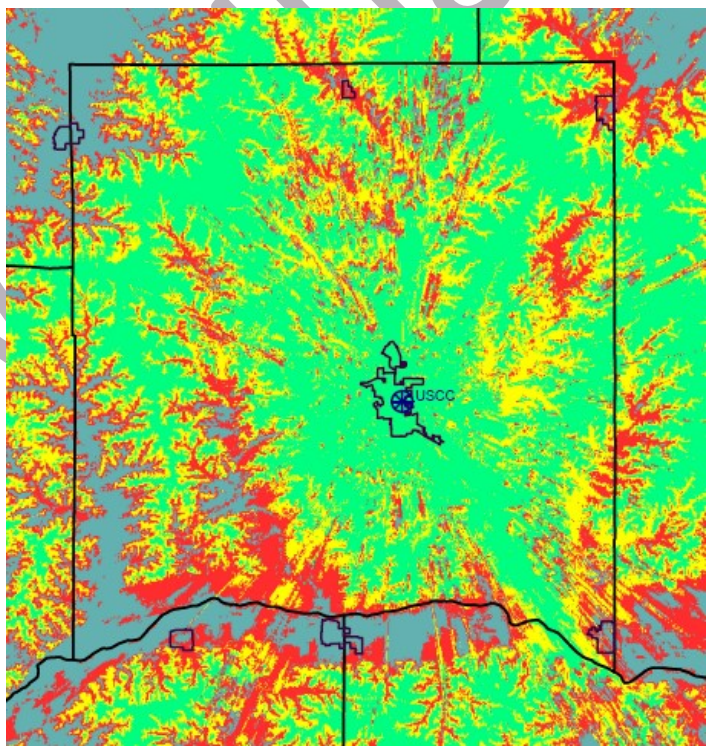


Figure 14 - Portable Talk Out

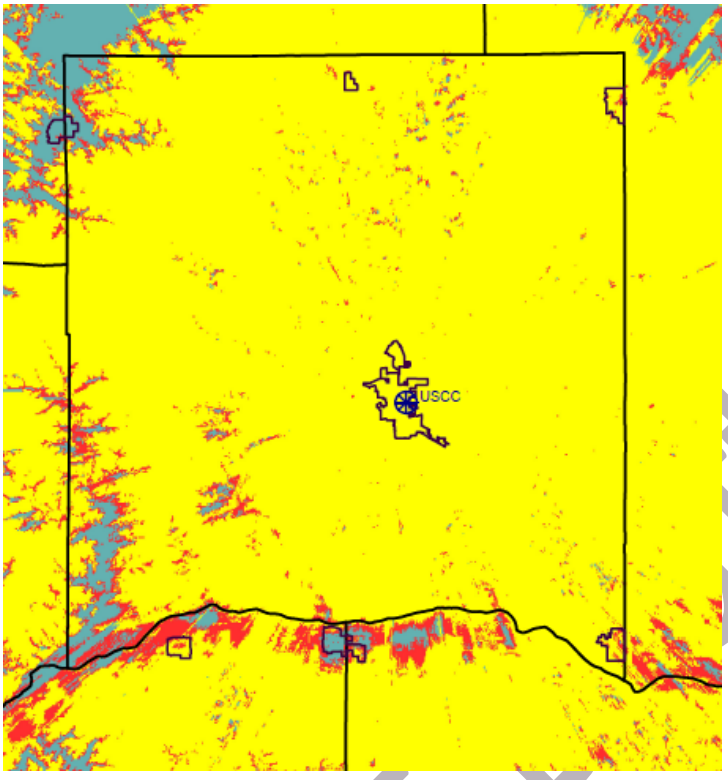


Figure 15 - Mobile Talk Back

13.10 WRCO SITE

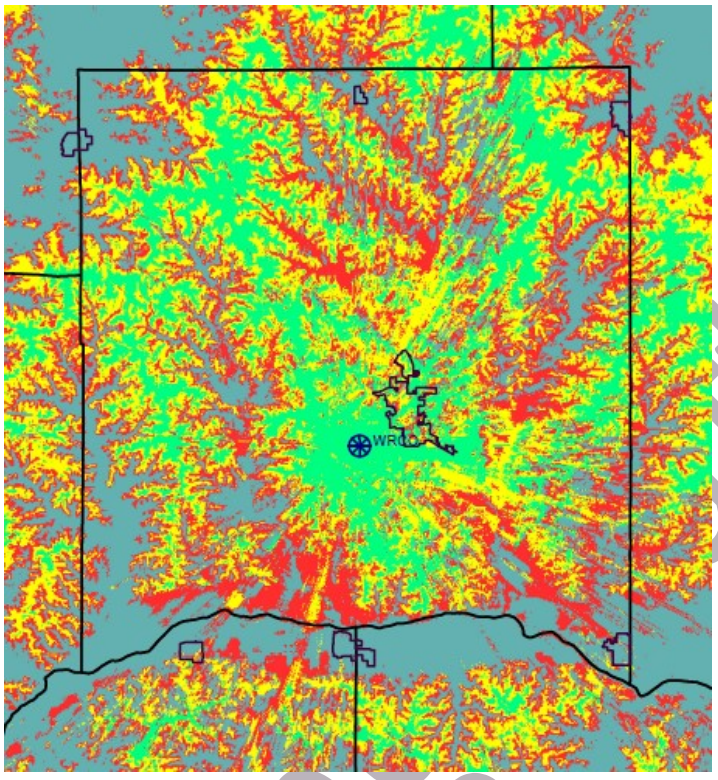


Figure 16 - Portable Talk Back

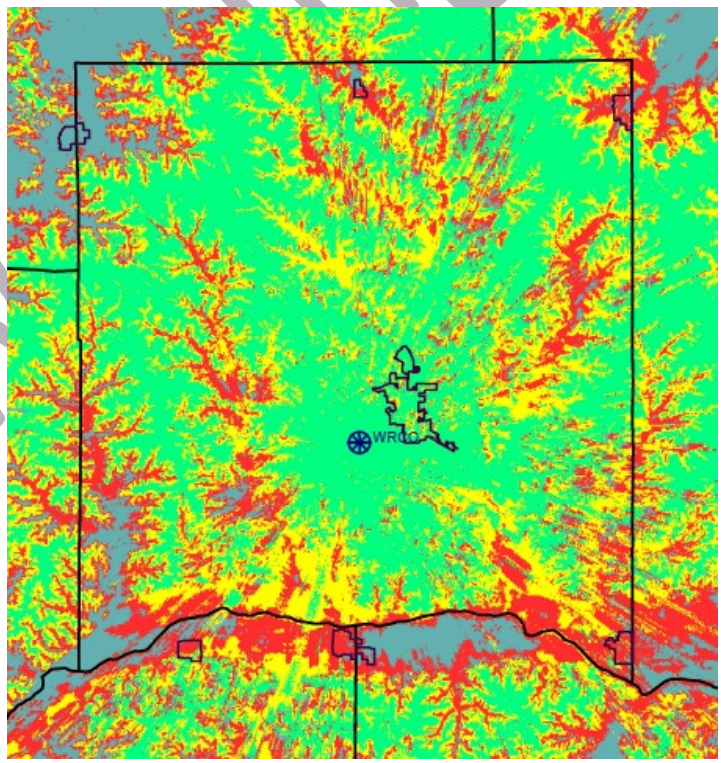


Figure 17 - Portable Talk Out

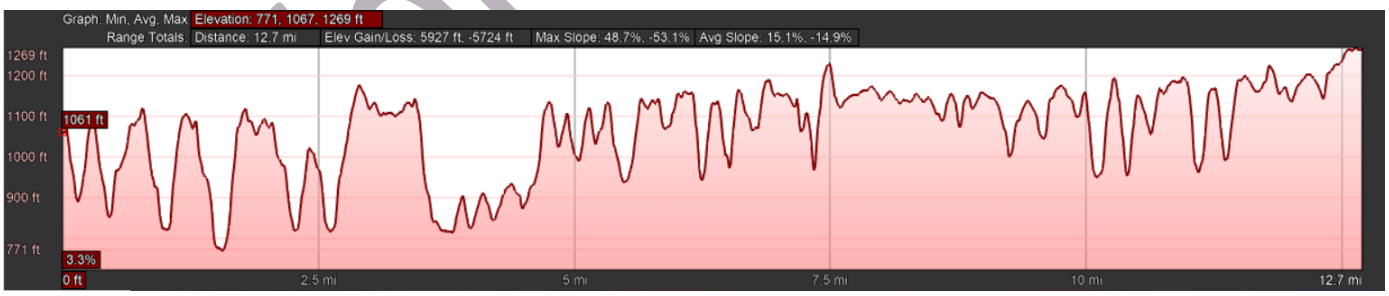
13.11 LIKELY SERVER

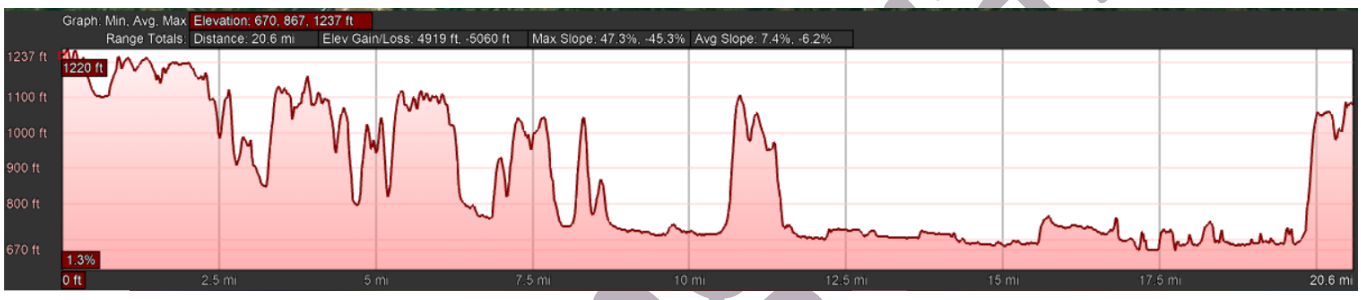
TBD

Figure 18- Likely Server Map

Figure 31 helps provide context of site performance when comparing all available locations to Richland County. This map distinguishes where sites provide a coverage threshold (-100 dBm) giving an indication of which might better serve the subscriber radio.

13.12 MICROWAVE PATHS





14 TECHNOLOGY OVERVIEW

14.1 FREQUENCY BAND

Which frequency band should be selected for operation and why does it matter? At one time, it was extremely important to know the exact frequency. Crystals were ordered for the radio, and they took time to obtain. That has long disappeared, and today a radio capable of covering almost every frequency is available. Convenience comes with a price tag and physics has not changed.

It is also important to understand how the frequency bands are configured and used. For a discussion of public safety radio bands, the terms VHF, UHF, 700 MHz and 800 MHz are used to define the bands for discussion. The physics of radio signal propagation gets involved as 700 and 800 are essentially one band to the radio manufacturers, and in-building coverage is better than VHF. Thus, 700/800 band operation is more common in metropolitan areas, though it is growing in its use in rural areas also for other reasons. There is little "skip" in this band to deal with, and antennas are smaller thus offering greater flexibility. Tests have been conducted by others comparing VHF, UHF and 700/800 MHz. There were only negligible differences outdoors for portable operation, but VHF underperformed the other bands indoors.

14.1.1 TABLE OF FREQUENCY BAND TECH SUMMARIES

Band	History	Spectrum	FCC Plan	Advantages	Disadvantages
VHF	Came along after low band.	150 – 174 MHz	Scattering of frequencies thus no plan for trunked operation.	Travels long distance well as follows earth's curvature	Does not penetrate structures well due to the length of the wavelet length. Skip due to atmospheric conditions.
UHF	New radio development allowed this new band to be created.	450 – 470 MHz	Planned for repeaters 5 MHz splits.	More line of sight than VHF and shorter wavelet offers better in-building penetration.	Most of the band was given over to business operations thus sometime public safety must purchase the frequencies from a broker.
700	Created from the upper UHF television service which was not being used.	700 MHz	Planned for repeaters 45 MHz splits. Narrowband operation only for voice.	Line of sight operation thus requiring higher repeater antennas but excellent in-building penetration Penetrates structures well, sometimes called the sweet band. Still wideband capable operation and supports both metro and rural operations.	Must operate narrowband and there is some adjacency to the planned use of FirstNet which has the potential for interference.
800	Created from assigned channels and expanded when Nextel frequencies were released.	806 – 866 MHz	Well planned with 45 MHz splits and wideband operation.		Sometimes difficult to obtain spectrum in some areas of the country.

14.2 OPERATIONAL TYPES

Voice radio system operations fall into two main configurations: conventional and trunked. Both conventional and trunked operation can support digital services. Voice operation, however, uses narrow bands, 12.5 kHz or less per channel on 700 MHz, VHF, and UHF bands. With digital, however, it is possible to combine two voice channels into one RF channel typically using time division multiplexing (TDMA) for public safety which is how P25 Phase 2 operation occurs.

The conventional radio system configuration can be described as conversations taking place on one piece of radio equipment in a manner that lacks much intelligent control. Conventional operation can normally be thought of as a one-channel function in a system configuration. In turn, the subscriber equipment trying to communicate with this configuration need only know the frequency and the access code needed to open the audio path. Conventional operation can be set up in the various categories (simplex, half duplexer, or repeater) based on the actual equipment being used.

The second system type is trunked radio which comes from the telco industry and describes a group of radio equipment shared by several user groups. This type of configuration takes the various pieces of radio equipment and interconnects them via an intelligent controller thus distributing them as needed. Trunked systems are always multiple repeater systems. To use these systems and open a path for the voice conversation, the control equipment must approve a request by a user and inform the users who wish to communicate. When this wish is granted, a two-way conversation can take place on a computer-assigned channel. This constant need for communication between the system and the subscriber dictates the need for constant data exchange and more intelligent subscriber radio equipment. Trunked radio can support hundreds of short communications sharing a few channels, though it can be much more expensive than a conventional operation. The real power of trunked radio is the fact that all users of the system can become part of a talkgroup if needed and that priority messages can be sent to all system users quickly and easily. APCO Project 25 is one specialized use of trunking technology that goes to a higher level of interoperability than with the old Project 16 capability of the 1979 vintage of trunking (Smartnet and EDACS).

In less dense rural areas, conventional is generally used due to the limited number of user groups and number of communications to be supported. In larger areas, trunked radio systems allow many users/groups to share a smaller number of radio channels using the spectrum more efficiently. Interoperability can also be vastly improved, and special services incorporated.

14.3 ANALOG OR DIGITAL MODULATION FORMATS

Voice radio communications, like many of the modern technology systems, is migrating towards digital operation. It has been experienced in many of the areas we are all familiar with such as movies, music, television, cell phones, and computers.

All transmissions modulate the carrier frequency in some way directly by using the analog waveform received from the microphone. With digital, the voice is converted to bits and this digital signal created from the analog voice signal is compressed and then transmitted. Digital technology allows the audio to be nearly free of the noise heard when receiving a weak analog signal through a process defined as vocoding. It is also helpful in eliminating background noise and allows for overhead messages to be sent with the encoded voice data to provide user identification, priority, and other data used for system operation.

However, digital operation has the potential of not providing a user with an indication when the user is at the end of usable system coverage. Before the coverage cutoff, the received signal is near perfect and then can drop. The range of a properly designed digital system will extend beyond that of the comparable analog system, though the important phrase here is “properly designed.” If trunked, then an alert tone can tell the user when the radio is out of range.

14.4 DIGITAL PLATFORMS

There are multiple digital formats in use today. Public safety has adopted the APCO P25 standard for digital communications. TETRA is an ETSI standard that has been adopted by countries in other parts of the world. Only P25 and TETRA are intended for use by public safety as they have incorporated features needed by public safety; the other forms described in the next paragraph do not have these features.

Other common digital formats are DMR (digital mobile radio), NXDN (Next Generation Digital Narrowband), and TETRA (Terrestrial Trunked Radio). These other formats are not compatible with P25 or with each other. NXDN was designed for commercial Private Land Mobile Radio and low-end public safety communications systems. NXDN is offered by ICOM (IDAS) and Kenwood (NEXEDGE), but each company has implemented unique versions and are not 100% compatible. Except for NXDN, multiple vendors manufacture field radios that operate in these formats. Only ICOM and Kenwood make field units for their unique versions of NXDN.

14.5 APCO P25 STANDARD

APCO P25 digital is the technology adopted by the United States as the standard digital protocol for public safety radio systems. Systems can operate in a conventional mode where each user group communicates on a single channel, or in a trunked configuration where user groups share a set of channels. The overall goal of having a common digital standard is interoperability in the digital mode of operation for the end user. Without a common standard, radio users would be forced to a manufacturer and the equipment they produce and unable to talk to another manufacturers' equipment.

P25 Phase 1 operation has been proven to have better coverage than analog using the same tower locations. When the FCC announced narrowbanding, it was recommended users consider P25 to recover the lost coverage resulting from this action.

It should be noted, however, P25 defines the air interface signal between the radio user and the system of repeaters. Once the signal from the repeaters moves into the system infrastructure, there is no standard, and each manufacturer has created its subsystem. Thus, in most cases, everything from the repeater to the console and everything in between is proprietary. Standards are under development to allow these systems to be interfaced using a gateway product. Non-OEM equipment is possible to use, but some of the features of the trunking system will be lost or modified.

The P25 standards are not a finished product. Like all standards, they are continually being refined and thus do not mandate all functions of a P25 system. Some functions are defined by the vendor and used to create differences in product capabilities giving vendors an advantage. Great care must be taken in the selection of features being used to ensure these unique features do not get in the way of interoperability with neighboring P25 trunked systems.

Today, P25 is divided into what has been defined as Phase 1 and Phase 2, with Phase 1 being the most common. Within Phase 1, the standard was each RF channel would support one voice channel, while with Phase 2 each RF channel supports two voice channels. A slightly different form of modulation (full rate or half rate vocoding) is used for each thus requiring transcoding if interoperability is needed. All newer P25 radios can support both Phase 1 and Phase 2, while some older radios only support Phase 1 channelization.

For trunking to work, there is a requirement for a control channel which means this channel does not support any voice traffic but rather controls all the subscriber radios in the background. This channel is the same for either Phase 1 or Phase 2 operation and operates at 9.6 KB/s. It is monitored by all radios on a system and must have continuous communications always established to all radios on the system. This channel is also used to authenticate a radio attempting to be added to a trunked system by exchanging unit ID information and doing a lookup on the associated database.

14.6 ENCRYPTION

Encryption operation on voice radio channels adds a layer of protection to the users to assure information is not easily obtained by the wrong individuals. Most encryption operation is standards-based in the modern public safety radio system with AES-256 the most commonly accepted for public safety.

Encryption in an analog mode of operation impacts the quality of the voice signal causing it to sound different than the normal voice. It does not happen in a digital system configuration as the scrambling operation is put back into its normal digital state before being outputted. It is highly recommended encryption occurs in the mapping of talk groups as a defined group and not turned on/off as needed by the user.

Generally, with trunked radio systems, encryption is applied by talkgroup; whereas, in a conventional system, encryption would be by channel. Thus, with a County wishing to encrypt, a channel or channels would be set up for this application. There is a cost to encryption both in licensing per device and in maintaining the capability in an up-to-date fashion with routine changes to the encryption key. Re-keying requires touching every encryption capable device or using over the air encryption on a trunked system.

14.7 VOTING SYSTEMS

Radio communications in its purest form is a transmitting device emitting a signal that is heard by a receiving device. The quality of this operation is dependent on many variables such as power level, antenna, height, and others. The main improvement for expanding a systems coverage area is accomplished by increasing the antenna height of the base or repeater being operated. Once this is done, the ultimate weak link to any communications system is the field (subscriber) unit due to its lower power. Thus, the signal being sent out to the field unit will be stronger than the signal back from the field unit.

Voting systems are designed using receivers placed at multiple sites to collect the weaker signals and return them (via a backhaul system) to aggregate these signals at a common location where they are compared, and the best signals are used for dispatch audio and retransmission. Voters can select the best signal multiple times per second. This operation can be used to match the talk out and talk-back capabilities of a voice system which is referred to a balanced system. Which is the design goal in engineering a quality system.

Voting and remote receive sites are common with VHF conventional systems allowing for the lower power portables to be received, while a higher power repeater transmitter can make up for the losses between the repeater sites and the subscriber radios.

With UHF and 700/800 MHz operation, a tower top preamplifier at the repeater can overcome these same losses thus pretty much eliminating the need for voting. Tower top preamplifiers cannot be used in the VHF band due to excessive atmospheric noise. Analog voting and digital voting is done differently. With analog, signal to noise is used while with digital, received Bit Error Rate is used for the selection.

14.8 SIMULCAST SYSTEMS

Systems needing to move beyond the reach of a single transmitter site with or without voting operation must look to multiple transmitters. Simulcast operation is the process of transmitting identical information from multiple transmitters all using the same frequency that may or may not overlap each other in their coverage areas. This process expands the transmit capabilities of a network to an almost limitless coverage.

Simulcast requires repeater equipment that is designed to produce virtually identical modulation characteristics. A backhaul system (usually microwave) distributes copies of the traffic to be transmitted to all sites. Most simulcast systems use a GPS clock to control frequency. All repeaters that transmit on the same frequency must be able to maintain identical transmitter frequency, phase, and modulation such that field units detect little difference in signals transmitted from different locations.

With trunked radio, both simulcast and voting are incorporated, while with conventional systems they may or may not.

14.9 MULTICAST SYSTEMS

Systems needing to move beyond the reach of a single transmitter site with or without voting operation must look to multiple transmitters. The multicast operation is the process of transmitting identical information from multiple transmitters using multiple frequencies that may or may not overlap each other in their coverage areas.

For this multicast operation to be seamless to the end user, a smart radio platform needs to be in place. Radios need to be able to locate systems (sites) on their own using a scanning operation referred to as roaming. Otherwise, users would need to switch channels manually based on location and their knowledge of coverage. As a rule of thumb, multicast is normally used in wide area networks where sites are spread out and simulcast is used where sites are more closely spaced in smaller networks.

14.10 BACKHAUL AND NETWORK SYSTEMS

Most modern multisite radio communication systems can only provide the level of services needed with the assistance of a backhaul system. Backhaul systems transport the information to various locations which allow for wide area operation status and control. Any number of mediums can be used for the backhauling operation to include telco, fiber, and even radio (in some situations though the FCC frowns on radio and may not license). For public safety, licensed microwave radio is generally used to interconnect infrastructure sites as the telco circuits have been found to be very unreliable. Fiber would be the second choice, though it does not meet the reliability of microwave unless there are two completely discrete physical paths.

As with voice radio systems, microwave radio comes in many different varieties and operates on various frequency bands. To ensure reliability, paths must be engineered to provide five nines (99.999%) reliability. To improve reliability, public safety systems generally use a ring topology that allows backhaul traffic to run in either direction away from the site in case a link should be disabled keeping all radio sites operational. If fiber optics is available, it can be used as an alternative to microwave operation, but it should also have multiple routes for reliability.

As most communications systems today utilize IP vs. analog, microwave is no different with most manufacturers supporting digital interfaces and system management. With this move to digital and IP, the network has now become an integral part of the radio system. The network technology defined as Multi-Protocol Label Switching (MPLS) has become the fabric support full integration of microwave and fiber optics plus the entirety of management and alarming.

There are also multiple bands of possible microwave radios with some being dedicated licensed channels and others, like Wi-Fi, unlicensed and shared use with little to no protection. Common licensed bands for public safety are 6 and 11 GHz, while unlicensed are 5.2 to 5.8 GHz. The 4.9 GHz public safety band is another choice though for microwave it is registerable as secondary use and thus in some areas, not a good choice.

14.11 PAGING SYSTEM

Paging operation is used to alert emergency service personnel of the need to aid over a paging device. Traditionally, the paging system was operated on the voice channel, and the paging device allowed the user not to have to monitor or concern themselves with traffic not requiring their assistance. The device is alerted by sending out a specific code and following it up with a voice message. This type of system is commonly referred to as a tone and voice paging system.

Some communities have also implemented alternate systems to enhance the paging system by incorporating systems that rely on cellphone operations. Messages are delivered to the phone devices normally via a Computer Aided Dispatch (CAD) system interface. This interface removes any burden of additional work needing to be done by the dispatcher. Cellphone alerting operation can provide levels of service such as two-way communications that are not available in standard paging systems. Without the guarantee of a timely message receipt, these types of systems must be relied on as secondary to the primary paging system as per the NFPA 1221 standard.

Choices in a modern primary paging system start with types of operation desired in use. What the voice style of system relied on for so many years is still available, but some users are also looking at a messaging type of system that mirrors the cellphone type of alert delivery. The type of method preferred is more of a preferred operational decision than any technical decision and is the starting point of knowing what options are available in a replacement option.

Messaging system choices will require the move to implementing a separate voice and paging radio system. Choosing to stay with a voice paging system may allow you to leverage the voice network to deliver the alerting operation as it did in years past. Voice paging can even be delivered on a P25 radio system with specialized pager devices.

14.12 VEHICULAR REPEATER SYSTEMS (VRS)

In its simplest form, a VRS system is a low powered radio device connected to a mobile vehicle radio (usually existing) that communicates to the standard portable radio on a new (separate) channel. Which allows the low powered portable radio that cannot reach the system to communicate to the VRS which is then sent to the system through the high-powered mobile radio that can reach the system. These devices add a layer of operational understanding which requires specific configuration and protocol implementation.

The use of VRS/extenders by some designers has been to implement this technology in all vehicles in a system with mobile-only coverage to provide portable performance. Assuming all portable base communications will happen within proximity of the associated VRS equipped vehicle. This concept is generally not accepted when all the protocol, operational aspects, and technical inadequacies are reviewed in detail. None of the repeater/extenders manufacturers suggest this concept as the best use of their technology. In fact, some of these manufacturers have gone so far as to describe ways and means where it will not work. Great care must be used to reduce the impact of interference and not following protocol in their use to avoid problems and thus officer communications abilities at critical times. Thus, buyers need to be fully aware of the limitations while understanding their capabilities.

Most system designs never provide 100% coverage for mobile operation much less portable due to the cost of the infrastructure. Modern public safety systems are designed to provide 95% portable coverage and still may have areas where mobiles cannot communicate with the infrastructure. Vehicular repeater technology can improve communications performance in some areas that do not meet the coverage goal in portable based system solutions. The conceptual designs offered and presented all assume the desire for the County to create a solution for the infrastructure to provide portable coverage to a relatively high level throughout.

Vehicular repeaters have been used to improve or provide portable communications for specific locations like schools, hospitals, or industrial parks depending on the need for such service. For locations that require routine or daily service, the infrastructure would be built to provide in building performance or a bi-directional amplifier (BDA) and distributed antenna system (DAS) could be considered for such areas.

Some very rural areas such as the Dakotas, part of Wyoming, and Montana have made use of vehicular repeaters to allow portable operation. A vehicle repeater would be utilized to provide portable coverage in the immediate area of the vehicle by extending the signal from a nearby fixed repeater.

Since they are limited by mobile coverage and the ability of the portable to communicate with the mobile, performance is very difficult to model. Due to its ad hoc usage and protocols required for use, some have dropped this solution from consideration from daily use. To ensure portable operation using a vehicle repeater, the infrastructure of the radio system would be designed to the greatest degree possible for mobile coverage. Any gaps in mobile coverage would prevent use and not be cost-effective to correct.

How would the vehicular system work? If the vehicle repeater is mounted in a vehicle when an officer arrives on scene at an incident, what means is used to turn it on? It could be as simple as removing his/her portable from the vehicle charger, manually switching it, wiring it to the officer's seat switch, or some combination. The selection of which type of repeater/extender to use may involve such needs as encryption, cost, feature extension, or other factors.

Some devices only support analog operation by the portables, while others offer P25 digital. Some disconnect the ability to use their mobile when energized, and some do not. The cost of these extenders can range from $7,500 to $12,000 depending on the desired capabilities.

14.13 SIREN CONTROL SYSTEMS

There are numerous methods of controlling sirens via radio frequency channels including a one-way or a two-way system, analog or digital. P25 is seldom ever used, while Two Tone page tones, DTMF (dual tone multi-frequency) or FSK (frequency shift keying) could be the controlling method. With one-way paging, it is unknown if the siren works; though, with two-way capability, FSK is usually the method. Secondarily, some siren systems allow for voice to be delivered and then again, FSK is the desired control. FSK is the fastest form of setting of the sirens and most secure.

14.14 TOWER STRUCTURAL ANALYSIS

As radio communication towers are like any man-made structure, they are engineered to certain guidelines and making changes to a structure should only be done when assured they don't risk exceeding that engineering. With public safety radio towers, it is even more important that the engineering holds up to strict levels.

The specific services required varies, and the information below identifies possible work to be performed on any given site work:

Field Inspection, Data Collection & Surveying

- Complete property/boundary and lease parcel survey.
- Develop lease survey map of the proposed tower site including access and utility easements with legal descriptions. Map to include easements and other encumbrances identified in the Title Report.
- Stake out lease parcel corners and easements
- Provide 1A certificate for proposed tower center coordinates.
- Complete field topographic survey of proposed project site to document existing conditions and map out existing site features. Survey to be used as the basis for project design and construction.
- Establish a minimum of 2 project benchmarks. Vertical control to be tied to NGVD datum
- Horizontal control to be based upon County coordinates.
- Develop topographic map of project site. Topographic map to include mapped topographic features, utilities, contours and other items necessary for project development.
- Furnish final map(s) in electronic pdf format.

Zoning and Construction Drawings

- Perform site visit to review existing site conditions and project constraints.
- Develop Preliminary Review (PR) / Zoning level drawing set which depicts the general orientation and location of the proposed improvements. PR drawing set to include: ○
- Existing Site Plan
- Site Plan
- Tower Loading/Elevation
- Upon approval of the PR drawings, develop detailed construction drawings (CD) for project sealed by a Wisconsin Registered Professional Engineer. Construction drawing set to include:
  - ✓ Existing Site Plan
  - ✓ Site & Compound Plans
  - ✓ Grading & Erosion Control Plan
  - ✓ Utility Plan
  - ✓ Landscaping Plan
  - ✓ Tower Loading/Elevation
  - ✓ Grounding Plan
  - ✓ Shelter Foundation Plan
  - ✓ Details: ice bridge, fencing, grounding, site construction and feed line routing.
  - ✓ Provide PE Sealed pdf soft copy and up to (10) ten hard copy originals and of the completed drawings.

Water Tower Structural Analysis

- Perform pass/fail structural analysis of existing water tower structure, foundation and top railing system to support the proposed antenna and equipment installations. **In the case of a fail situation, modification design has not been included and if required shall be considered an additional expense.**
- Existing water tower plans including foundation design to be provided at the project outset. Additional fees shall apply for services associated with procuring plans from the water tower manufacturer.
- Provide electronic pdf deliverable of completed structural analysis report.

Tower Foundation Inspection

- Perform **one-day** site inspection at time of tower foundation installation, including the following:
  - ✓ Check soil conditions for general compliance with the geotechnical report. It should be understood that the in-situ soil properties can be difficult to verify conclusively, especially with the reinforcing steel in place. However, at a minimum a check for general conformance with the soil type, depth, depth of water, etc.
  - ✓ Check overall excavation dimensions for general compliance with plans
  - ✓ Check reinforcing steel for property quantity and placement
  - ✓ Check for proper concrete cover on reinforcing steel
  - ✓ Cast concrete cylinders for compression testing
- Upon completion of inspection, collect the concrete cylinders and deliver them to a certified laboratory for compressive strength testing. Testing will be completed until the design strength is met (7, 14 & 21 days) with final break at 28 days.
- Provide construction inspection field report (pdf) documenting the results of the inspection. The report will contain photographs of the foundation installation and pour.
- Provide concrete break results as they become available.

5. Punch List Inspection

- Perform site inspection at time of substantial completion to review installed tower and civil improvements. Inspection to include a tower climb to review tower construction, antenna installations and to develop an As-Built inventory of equipment installed on the tower. At grade inspection to include grounding system resistance test, generator functional test and tower plumb and twist verification.
- Develop Punch List of items requiring additional work by the Contractor. Punch list to include photographs of problem items, descriptions and identification of responsible party.
- Provide field report (pdf) documenting the results of the Punch List inspection. The report will contain photographs of the site, As-Built antenna inventory and test results.

6. Final Inspection

- Perform at grade site inspection (no tower climb) to confirm completion of Punch List items and document As-Built site conditions.
- Update overall project Punch List based on observed conditions.
- Coordinate with Contractor for completion of any remaining Punch List items.

7. As-Built/Record Drawings

- Prepare final Record Drawings (RDs) for site to document As-Built conditions. Drawings to document Change Order items and other project changes implemented during construction.

8. Specs, Bid Documents & Public Bid Process

- Prepare detailed CSI specifications which clarify requirements for major project components and work items.
- Prepare Project Manual which includes project drawings, bidding requirements, contracting requirements, and project specifications suitable for Public Bidding of project.
- Advertise project and facilitate public bidding of project in accordance with local purchasing requirements.
- Conduct on-site Pre-Bid Meeting (if desired) to review project requirements and answer Contractor questions.
- Issue Addendum(s) as necessary throughout bidding process.
- Provide Bid Summary of received bids and provide recommendation for Contract Award.

14.15 GROUNDING AND POWER

Grounding is a term used to describe the function of protecting equipment against damage from electrical surges. Surges can come through the electrical system, but the more common source is lightning created during storms. Radio systems have always been concerned with lightning strikes due to the use of antennas mounted on towers that attract a strike. With modern technology, the issue of the power line and telecom surges has become more of an issue that must be addressed.

Along with those needs, modern electronic equipment must be extensively protected from surges due to the low voltage levels from which they operate. A higher level of concern must be placed on assuring practices are followed and verified to assure equipment longevity of the modern radio system.

Grounding and power practices and standards have been created by the major manufacturers of radio equipment and have been in use for some time such as Motorola's R56. The National Fire Protection Association (NFPA) has produced guidelines for safety for electrical power systems, and there has been a tremendous amount of research thus providing a safer environment for personnel. There are two specific standards: Part 70 (National Electrical Code) and Part 607 (Grounding).

14.16 EXTENDED MOBILE COVERAGE SPEAKER-MICROPHONE

A new option being considered to provide communication range extension to an officer away from the vehicle is that of a wireless speaker-microphone device using the vehicle radio. To the best of TNCG's knowledge, Safemobile is the only company that makes this product today. This subsystem replaces the normal wired microphone on a mobile radio with a wireless microphone utilizing the 2.4 GHz unlicensed frequencies to cover a line of sight range of up to 1600 radius feet around the vehicle. Its battery charge life is more than 12 hours under normal usage.

Additional features include the potential of encryption, emergency button, earphone, talk-around to other like devices, and noise canceling. Each speaker-microphone only pairs with one mobile radio; thus, it is a one-to-one extender and not like the previously-described repeater/extenders. Price is estimated from $550 to $900 with the basic interface.

Users of this option would be those who may leave their mobile but be near enough to take part in effective communications. This device could also be considered for use for communications at a small office or County shed where a control station is used to communicate with mobiles in the field. It could minimize or eliminate the use of remote-control devices. As with all applications, it is completely dependent on its ability to communicate back to the radio. If 2.4 GHz is used for Wi-Fi, then there is also the potential of local interference which should be subject of determination when attempting to use.

14.17 BI-DIRECTIONAL AMPLIFIER (BDA) AND DISTRIBUTED ANTENNA SYSTEM (DAS)

Depending on the desired coverage requirement, the radio system infrastructure is designed to deliver a specific level of the signal to the user service area. In any portable based coverage design, outdoor performance is to be achieved at a minimum but may include in-building performance whether it be residential (8dB), commercial (15dB), or some higher level of desired performance.

To achieve these levels, the outdoor performance must increase by the level needed to penetrate the building and provide the indoor performance. Any level over the commercial level may be attainable close to a tower site, but generally, the cost of the infrastructure escalates and limits the level of indoor coverage attainable.

In most radio systems, there will be buildings that users will desire to have communications within, but the level of attenuation exceeds the delivered level of the design making communications impossible. For those buildings where, communications are necessary on a regular basis, a bi-directional amplifier system can be considered.

These systems have a donor antenna mounted on the outside of the building which brings the desired radio signals (talk-out) into the building. These signals are amplified and distributed throughout the building as required via distributed antenna system (DAS). This same DAS system also collects the indoor signals (talk-in) and sends them back through the amplifier sent back out the donor antenna.

These systems are designed specifically for the radio signals desired for operation. Some communities have adopted ordinances that require new buildings to be equipped with such devices to ensure public safety communications. Others have installed such systems to ensure public safety communications. The improperly designed system can cause self-interference or interference to other radio systems.

To properly design a BDA/DAS system for a building, the radio system should already be in operation or at least optimized for operation as testing should be done to determine the amount of signal is penetrating the building. Once this is known, the areas that require improvement can be determined and a design completed. Unlike legacy DAS designs where the antennas were placed in the interior of a building to send signals outwards, new designs aim signals into the interior. Digital radio, whether it is cellular, P25 or any other digital format, must be able to decode and process the digitally modulated signal. Signals received from more than one source may not be able to be decoded due to a phase difference. Keeping outdoor and indoor signals separated will eliminate self-interference.

15 COMMERCIAL SERVICE OPTIONS (FIRSTNET)

15.1 COMMERCIAL SERVICES

Today, commercial wireless service providers are integrated into public safety systems in many aspects as an adjunct to the private-public safety systems. Those integrations are continuing to evolve with the implementation of more and more networks providing an ever-improving technology solution to the end users and improved coverages. The lack of priority and control is the mechanism for measuring the degree of reliance each agency is comfortable with using these ever-expanding networks.

Historically, organizations began to rely on the use of voice cellular services to supplement radio conversations or enhance communication capabilities where possible. Voice communications along with the use of add-on alerting systems used by fire and ems services over cellular are key examples of that supplement, and support users rely on in their duties. Probably the most key shift to commercial services is in the use of data connectivity services.

Many agencies implemented stand-alone data systems attempting to provide their users' services for messaging, data access, and digital work platforms. Most of these systems have been shelved today and have moved to commercial wireless broadband services providing a higher level of system performance at a reduced operating cost to the public safety agencies. Other limiting factors to a standalone data system also played a role in the shift and must be considered when analyzing this use of commercial data services and why it ultimately worked better for most agencies. However, current cellular commercial service options today see a public safety user no different than any other user of the services, and this can be problematic. FirstNet is intended to fix the priority services that commercial services lack.

15.2 FIRSTNET

To overcome commercial services limitations encountered by public safety users, the federal government introduced a dedicated solution. The First Responder Network Authority (FirstNet) of the United States was created under the Middle Class Tax Relief and Job Creation Act of 2012 (MCTRJCA) as an independent authority within the National Telecommunications and Information Administration (NTIA).[1] The purpose of FirstNet is to establish, operate, and maintain an interoperable public safety broadband network. To fulfill these objectives, Congress allotted 7 billion dollars, and 20 MHz of valuable radio spectrum to build the network.

The FirstNet authority then accepted a proposal from AT&T to be the contracted commercial service provider and build out this network. In turn each state had to decide the option to construct their piece of that network or allow AT&T to perform that service for them. All states ultimately approved the use of AT&T as their designated contractor. This approval process was completed in December of 2017, and AT&T's implementation plans are currently underway.

FirstNet is currently being launched on AT&T existing network as that network is being updated to band 14 operation and expanded to meet coverage requirements. This network will provide mission-critical, high-speed data services to supplement the voice capabilities of today's Land Mobile Radio (LMR) networks. Initially, the FirstNet network will be used for sending data, video, images, and text. The FirstNet network will also carry location information and eventually support streaming video. FirstNet plans to offer cellular voice communications such as Voice Over Long-Term Evolution (VoLTE) or other alternatives initially, but these are not considered public safety level systems. The goal of Mission Critical Voice (MCV) and Mission Critical Push-to-talk (MCPTT) over LTE does not have any identified timelines for these system implementations as the standards needed for operation have not been finalized to date.

The job of creating a nationwide wireless network from scratch to provide the level of services identified and deliver those services with the same robust levels of coverage in all areas would be considered a lengthy task. Possibly keeping the network from being ready for public safety users for years as the implementation of most County radio systems can take up to two years. The relationship between FirstNet and AT&T is more than just hiring of the firm to implement the network. It is the reliance on AT&T's existing network to begin delivering services, begin developing equipment, and being able to migrate user as the dedicated FirstNet frequency band is being installed. To accurately understand FirstNet's capabilities of service, it is important to understand these processes and how they apply in the area in question.

AT&T has already begun the process of FirstNet implementation using the existing AT&T network as a starting point. That network will deliver services to the capabilities in place today, and as AT&T develops the capabilities and features, those will be migrated into the platforms. Alongside this AT&T will be implementing the dedicated spectrum (Band 14) provided by FirstNet to increase coverage areas.

VoLTE is the proposed standard for the interface between a P25 trunked radio system and FirstNet. It should be noted, however, when this voice service becomes available for mass use is not yet on the timetable. FirstNet was developed first for data and video with this then being the priority. Most of the leadership in the development of FirstNet has suggested even after its full deployment, VoLTE should be considered secondary and not expect this service to replace radio to radio voice communications any time soon.

16 IMPROVEMENT OPTIONS FOR RICHLAND COUNTY

16.1 OPTIONS OVERVIEW

The following improvement options are presented to the County for consideration. True North used the information collected throughout this study to develop potential options that would likely serve the County for system improvement. These models are chosen to give the County varying levels of system technologies to consider as well as financial commitments needed to pursue these choices. It is not TNCG's intent to provide these models as an only possible solution but rather a point to begin the discussions of what the County may wish to pursue.

All options include budgetary pricing models with new repeaters, stations for regional interoperability, DC power systems, site equipment shelters, backup generators, alarm systems, a microwave backhaul network, and possible new towers (greenfield) and professional services. Coverage predictions were made using existing FCC database identified tower sites located in the County where possible. Greenfield sites (new towers) were used in models when no suitable sites were identified.

Appendix 4 & 5 shows a database of existing sites in and around Richland County.

Note – (GF) labeled sites depicted on below maps indicate greenfield sites not currently constructed or sites needing towers increased in height or replaced and budgetary estimates have been made to reflect.

16.2 COLORS AND COVERAGE REMINDER

The provided coverage predictions for operation use a set of levels separated by a predefined range.

- Gray color is used to indicate a signal level that falls under a receiver's ability to decode.
- Red areas are outdoor unreliable.
- Yellow is a range that should allow for on-the-street operations.
- The green range indicates good portable (small building) indoor coverage.

Note: Some common structures (i.e., metal clad exterior without windows, stone exterior courthouse, LEC, hospital, etc.) may be even more difficult to penetrate due to their construction.

Out of Range	Unreliable	Street Level	Building Level

16.3 RADIO SYSTEM OPTION 1

16.3.1 VHF ANALOG CONVENTIONAL SIMULCAST SYSTEM

This TNCG conceptual design option assumes Richland County wishes to stay operating in the VHF radio frequency band and attempt to slowly migrate subscriber and system equipment using a defined plan. A probable goal with this option would be improving radio coverage with a minimal investment or a possible migration of the radio system channels or sites and possibly analog to digital.

As a baseline design for providing the County an understanding of what might be a possible scenario, TNCG has chosen to create this option as a five (5) site VHF conventional analog system providing coverage. This option identifies a completed system design and assumes subscriber radios are handled separately.

- Designed using a minimal number of system sites and attempted existing site reuse where possible.
- Coverage holes or gaps will exist if system does not design for minimal public safety levels.
- The design needed a greenfield tower site to provide quality coverage in Lone Rock and ensure a successful microwave path.
- The design showed better results using two new lease sites on the west side of the County.
- The design anticipated two antennas (transmit & receive) per site and combining of all repeater frequencies.
- Simulcast/voted system design provides for expanded channel coverage and common channel footprint on each channel.
- System design parameters were generated using a three (3) channel design, adding one (1) to the current County design.
- A standalone VHF analog paging system was anticipated in the design providing coverage from the voice sites.
- The Highway channel was designed as a two (2) site mobile only channel.
- Microwave connectivity would be needed for simulcast operation and considerations for non-redundancy could be given to decrease the budget.
- The design anticipates the need for public safety grade compounds with backup power capabilities at each site.

- Design would allow County users to operate existing subscriber equipment. Costs not estimated.
- Analog operation fails to improve audio quality and interference noise inherent to the VHF frequency band.
- Dispatch console systems were replaced, and upgrades made to the PSAP in the budget.
- This design shows the main Richland County channels providing 60% portable on the hip indoor (small buildings) coverage.
- This design shows the main Richland County channels providing 90% portable on the hip outdoor coverage.
- This design shows the communities of Richland Center, Muscoda, and Lone Rock reaching the 95% public safety indoor (small buildings) coverage levels.

16.3.2 OPTION #1 BUDGETARY COSTS

System Component	Description	Cost
Vendor Infrastructure & Services	Repeaters, control equipment, antennas, microwave, power, dispatch equipment, alarms, engineering, FCC licensing, installation, testing, commissioning, and training	$1,710,500
Field Terminal Equipment	Mobiles, portables, and control stations including installations and associated accessories	$ 0
Civil Construction Work	Towers, grounding, shelters, generators	$995,000
Contingency	Additional funds set aside for unknown project needs	$275,000
Professional Services	Civil, consulting, and project management	$ 300,000
	Total	**$3,280,500**

16.3.3 OPTION 1 VHF COVERAGE PREDICTIONS

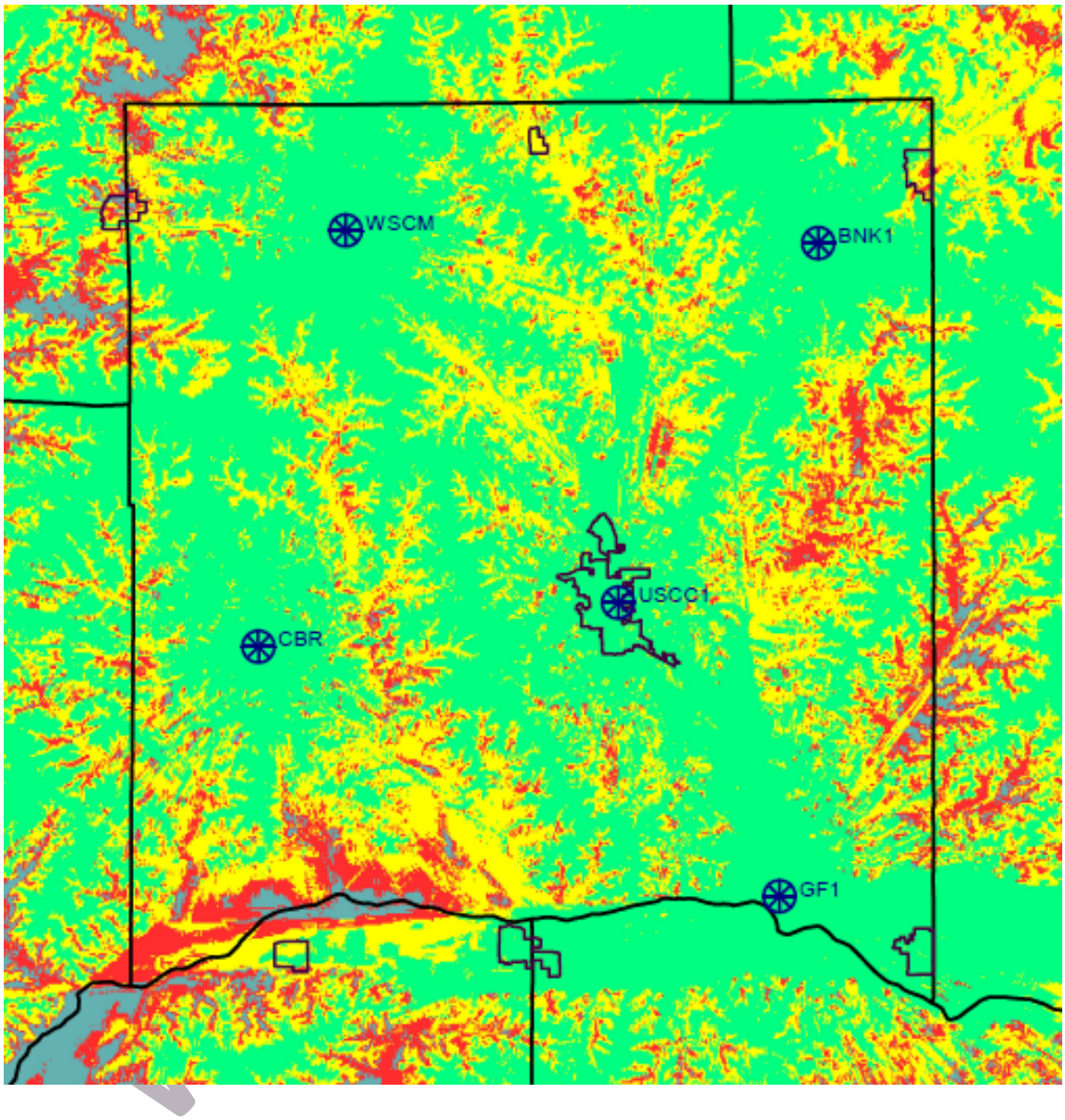


Figure 19 – OPT #1 - ANALOG VHF – Portable Talk Back

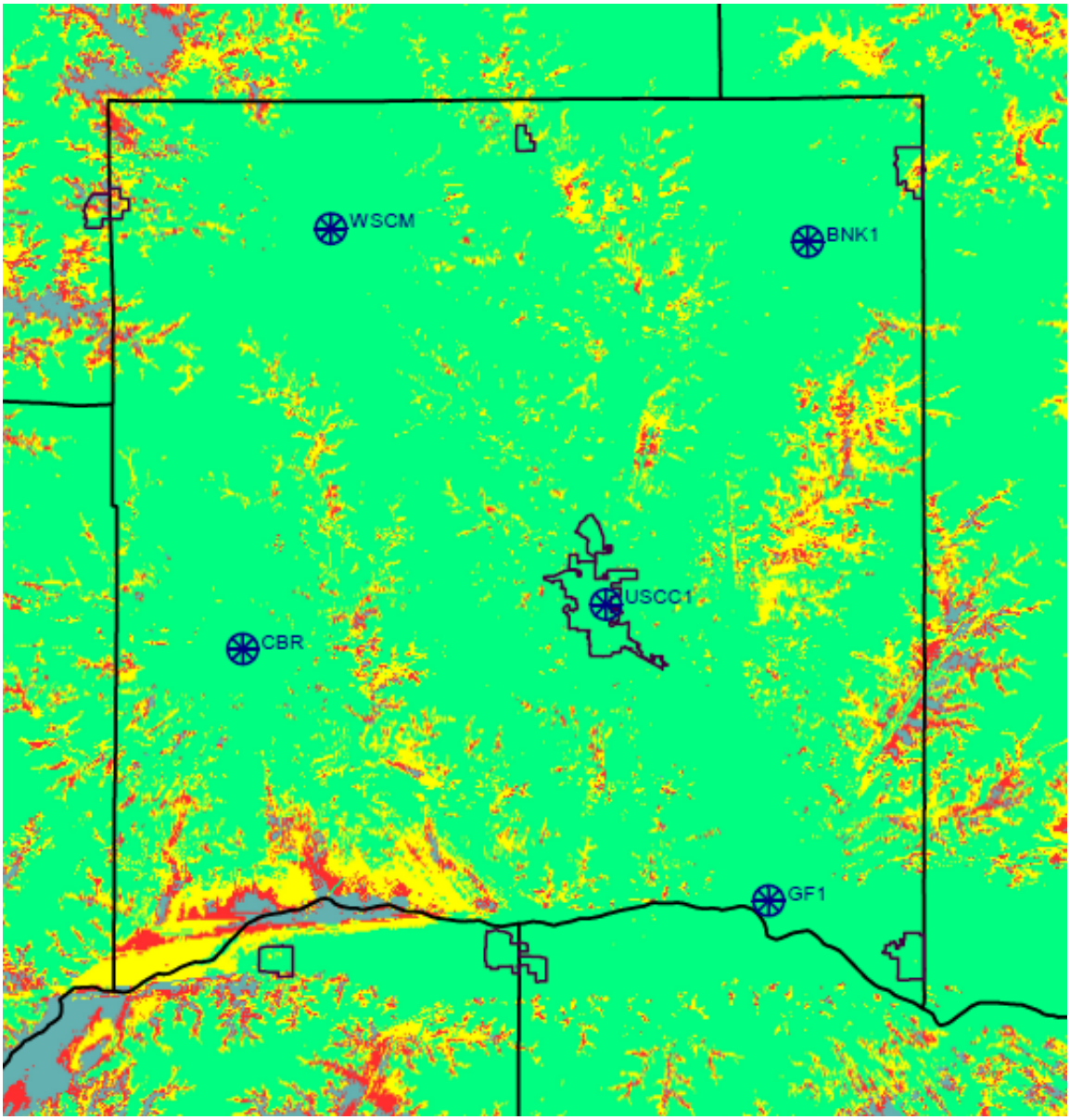


Figure 20 – OPT #1 - ANALOG VHF – Portable Talk Out

16.4 RADIO SYSTEM OPTION 2

16.4.1 VHF P25 DIGITAL CONVENTIONAL SIMULCAST SYSTEM

This TNCG conceptual design option assumes Richland County wishes to move radio communications to P25 digital operations and attempt to keep a minimal design configuration. Choosing to do so would provide the County with improved operating characteristics, system features, and some level of public safety coverage standards.

As a baseline design for providing the County an understanding of what might be a probable scenario, TNCG has chosen to leave this option as a five (5) site voice radio system. Switching the design to digital operation provides a level of coverage improvement. TNCG identified making the switch to P25 would require subscriber radio needs to be addressed.

- All equipment and parameter design configurations were matched to option #1.
- Locating a Greenfield site in this part of the County will be challenging to balance a microwave link and coverage footprint.
- Villages of Cazenovia and Viola still appear to be challenging for in-building coverage levels.
- System design parameters were generated using a four (4) channel design, adding two (2) to the current County design.
- The Highway channel was left as a two (2) site (Analog) mobile only system.
- A standalone VHF analog paging system was anticipated in the design providing coverage from the voice sites, however digital paging could be considered.
- Coverage estimations show portable in-building (small) level operation at 70% of the Richland County boundary.
- Coverage estimations show portable on the street level operation at 85% of the Richland County boundary.
- System design parameters were used to balance the talk-in and talk-out design.
- Microwave connectivity is designed in a ring layout to provide redundancy on the voice network.
- P25 system features such as encryption were anticipated in the budget.

- Digital operations would provide additional P25 feature sets and capabilities such as PTT-ID, Alert, Encryption, Emergency Button, etc.
- This design updates all subscriber radios in the County to public safety digital capable models capable of WISCOM operation.
- Improving coverage in the southeast corner of the County is difficult without pulling a site closer.
- Given the County terrain of ridges and river valleys, designs meeting 95% in building coverage may require a higher number of sites.

16.4.2 OPTION #2 BUDGETARY COSTS

System Component	Description	Cost
Vendor Infrastructure & Services	Repeaters, control equipment, antennas, microwave, power, dispatch equipment, alarms, engineering, FCC licensing, installation, testing, commissioning, and training	$2,572,000
Field Terminal Equipment	Mobiles, portables, and control stations including installations and associated accessories	$1,350,000
Civil Construction Work	Towers, grounding, shelters, generators	$1,100,000
Contingency	Additional funds set aside for unknown project needs	$370,000
Professional Services	Civil, consulting, and project management	$400,000
	Total	**$5,792,000**

16.4.3 OPTION 2 VHF COVERAGE PREDICTIONS

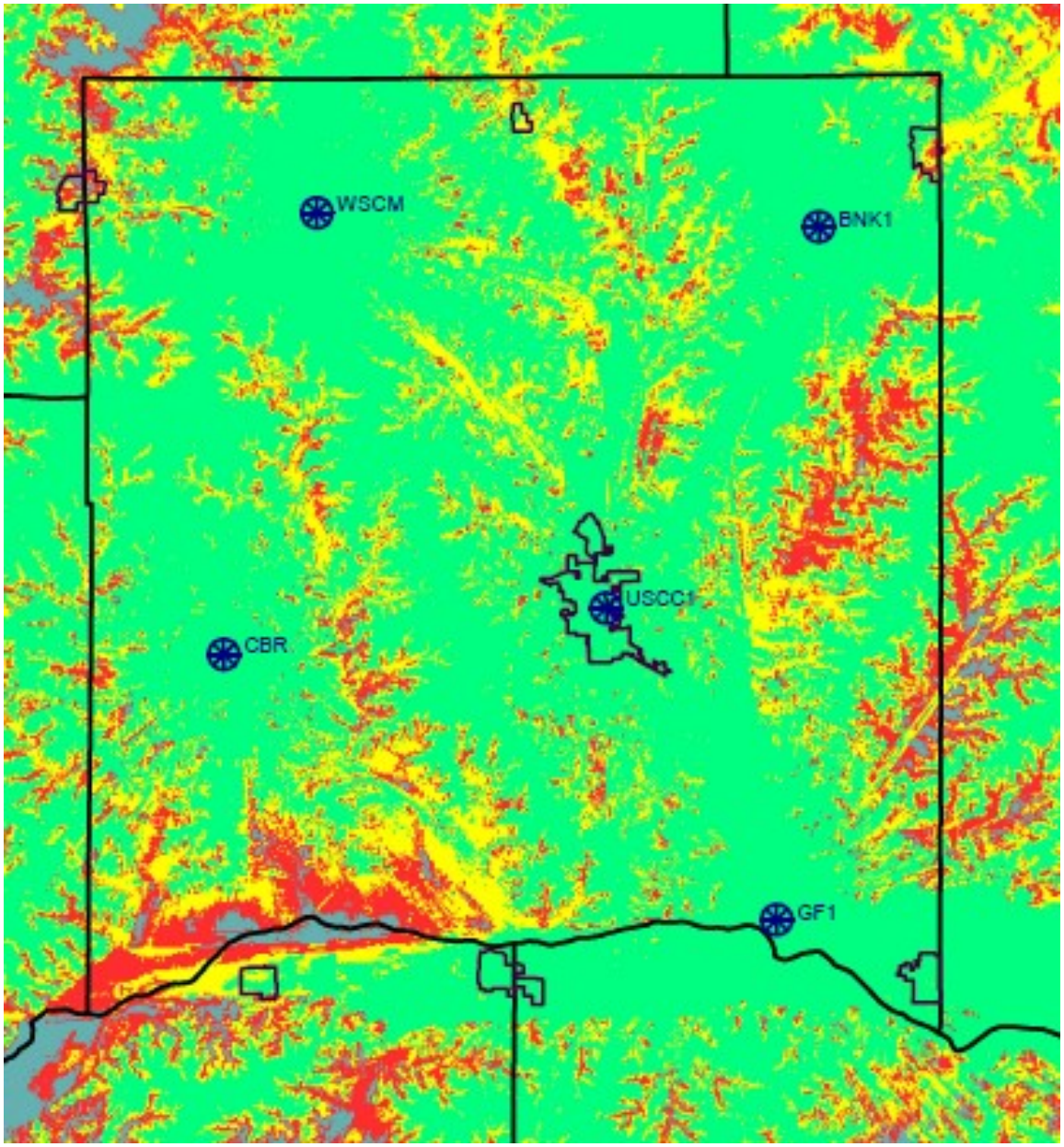


Figure 21 - OPT #2 - DIGITAL VHF – Portable Talk Back

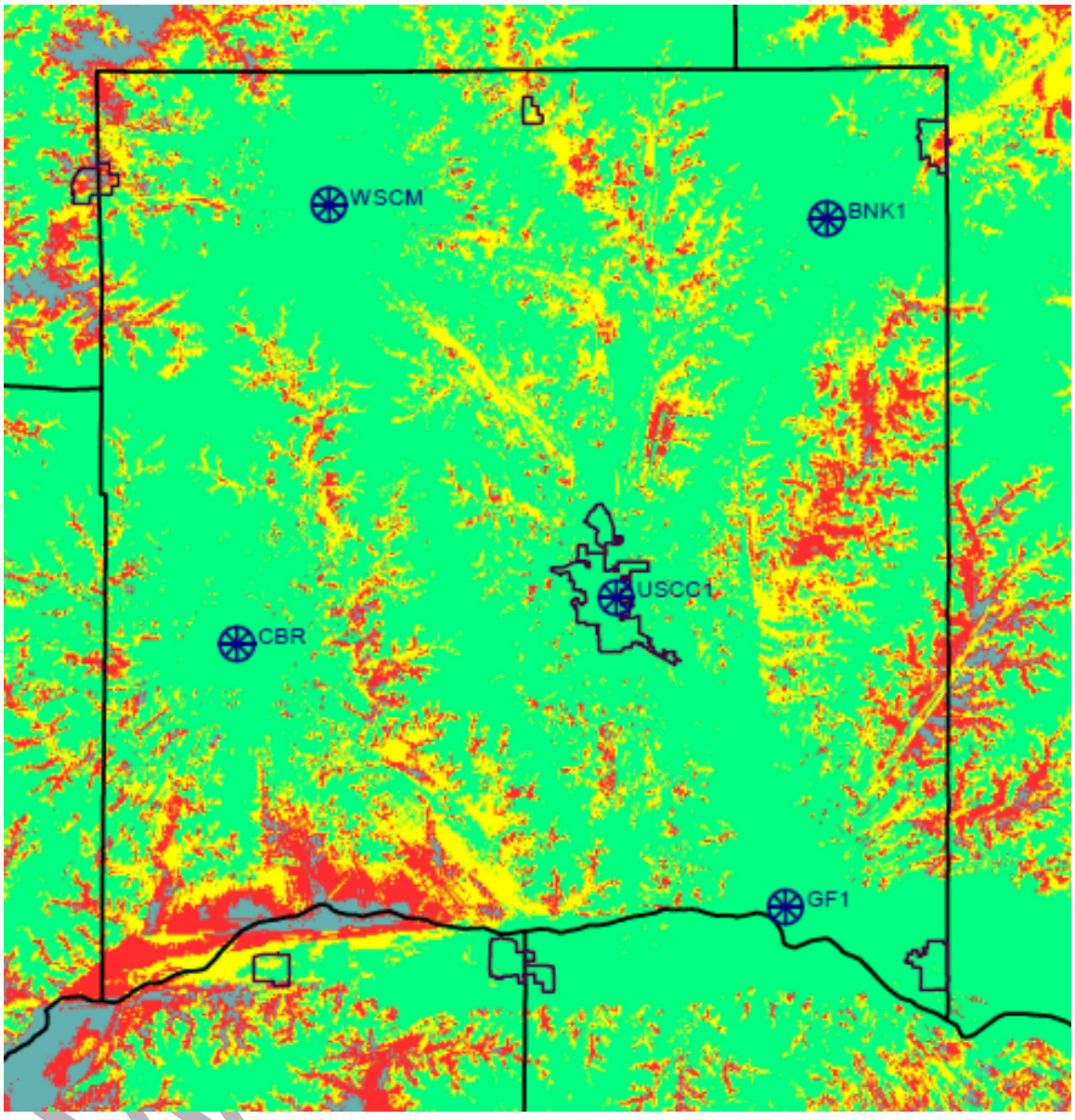


Figure 22 - OPT #2 - DIGITAL VHF – Portable Talk Out

16.5 RADIO SYSTEM OPTION 3

16.5.1 VHF P25 DIGITAL CONVENTIONAL SIMULCAST SYSTEM

This TNCG conceptual design option assumes Richland County wishes to move radio communications to P25 digital operations and develop a system design to meet public safety standards. Choosing to do so would provide the County with improved operating characteristics, system features, and a portable in-building level of public safety coverage standards.

As a baseline design for providing the County an understanding of what might be a probable scenario, TNCG has chosen to migrate the design to a seven (7) site voice radio system. This system would standalone providing the County all necessary services.

- All equipment and parameter design configurations were matched to option #2.
- Locating two (2) Greenfield sites in the southern parts of the County will be challenging to balance a microwave link and coverage footprint needs.
- System design parameters were generated using a five (5) channel design, adding two (2) voice and one (1) dispatch (paging) channel to the current County design.
- The Highway channel was left as a two (2) site (Analog) mobile only system.
- P25 digital paging was added to this system design, replacing all pagers.
- Coverage estimations show portable in-building (small) level operation at 92% of the Richland County boundary.
- Coverage estimations show portable on the street level operation at 97% of the Richland County boundary.
- System design parameters were used to balance the talk-in and talk-out design.
- Microwave connectivity is designed in a ring layout to provide redundancy on the voice network.

OPTION 3 BUDGETARY COSTS

System Component	Description	Cost
Vendor Infrastructure & Services	Repeaters, control equipment, antennas, microwave, power, dispatch equipment, alarms, engineering, FCC licensing, installation, testing, commissioning, and training	$3,260,000
Field Terminal Equipment	Mobiles, portables, and control stations including installations and associated accessories	$1,600,000
Civil Construction Work	Towers, grounding, shelters, generators	$1,850,000
Contingency	Additional funds set aside for unknown project needs	$520,000
Professional Services	Civil, consulting, and project management	$480,000
	Total	**$7,710,000**

16.5.2 OPTION 3 COVERAGE PREDICTIONS

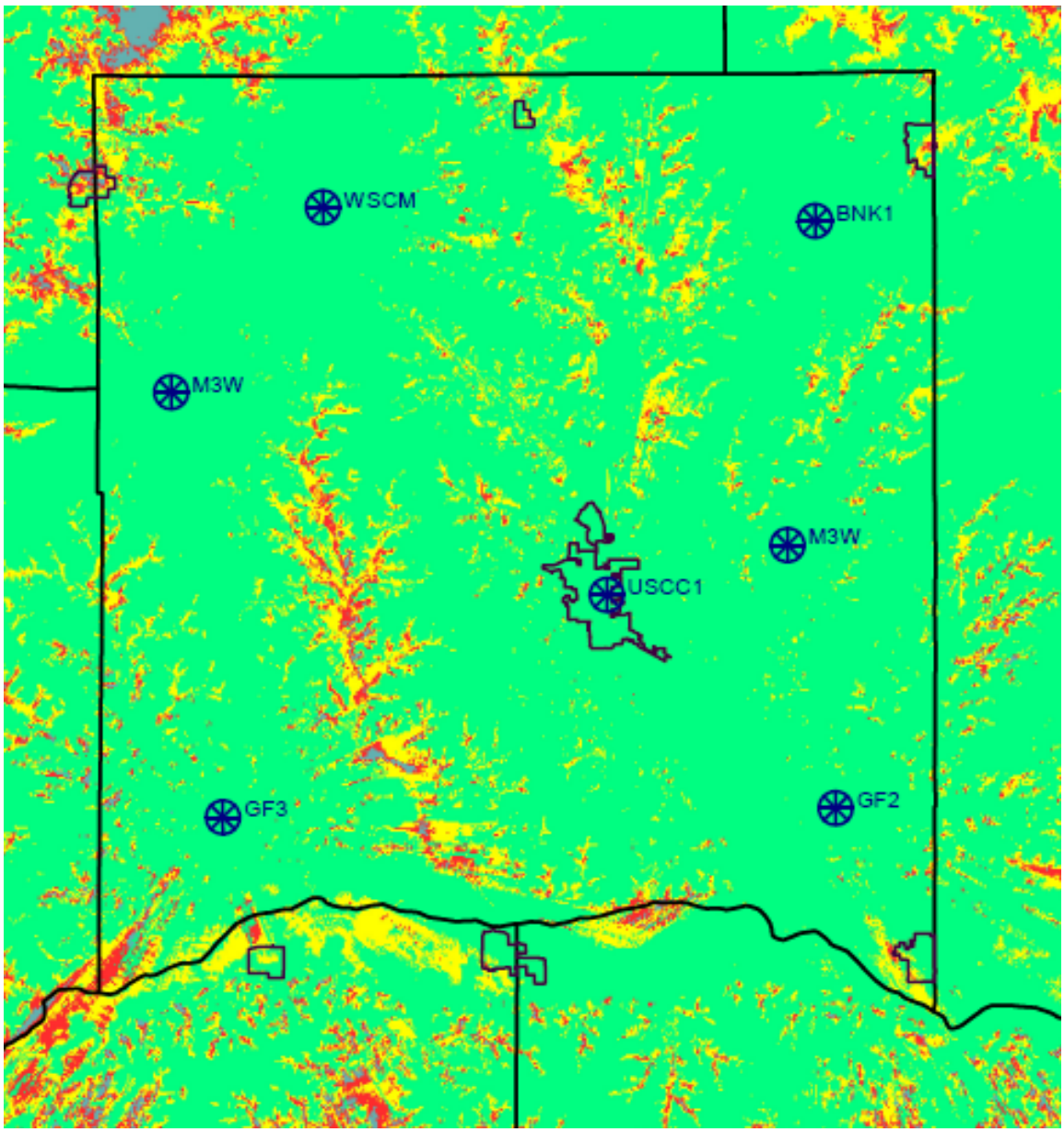


Figure 23 - OPT #3 - DIGITAL VHF – Portable Talk Back

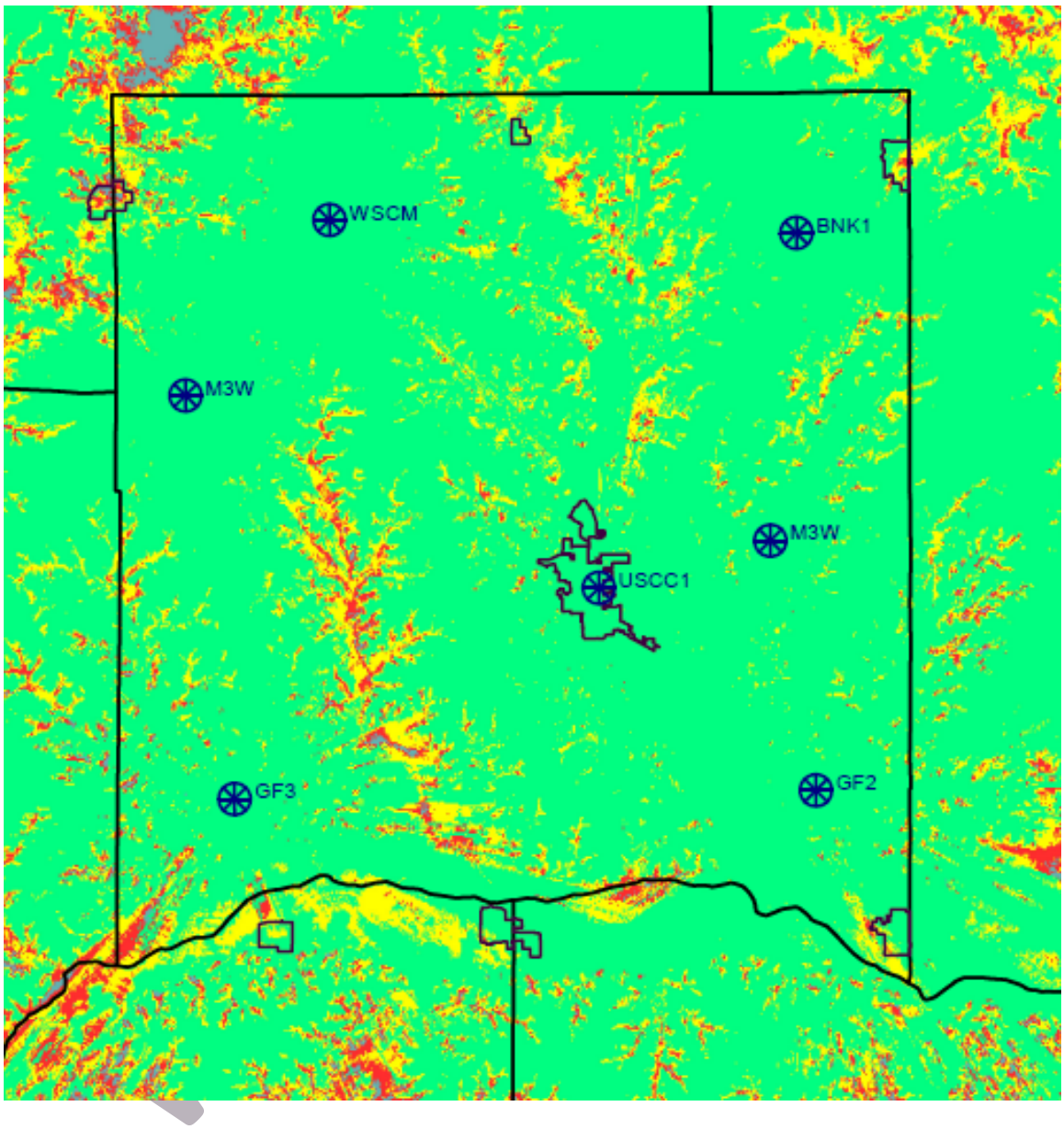


Figure 24 - OPT #3 - DIGITAL VHF – Portable Talk Out

16.6 ADDITIONAL IMPLEMENTATION CONSIDERATIONS

16.6.1 SYSTEM ONGOING COSTS

Modern radio systems require a greater level of facilities support and ongoing maintenance considerations than the previous generations of systems. Rules of consideration normally apply that the greater the size and scope of the system the greater the ongoing costs will be. Richland County is somewhat familiar with a few of these costs with sites in their current system. Other considerations should be understood to assure what level of needs will be added with any system update.

Additional Costs	Description	Cost
Tower / Lease Fees	Lease fees for use of tower space on non-owned properties fluctuate depending on owner of the site. Fees are usually based on height of antenna, number of antennas, and space used. Land lease fees also possible for greenfield sites.	Monthly Fee (Est. $2,000 - $5,000/month)
Electrical Services	Sites having a dedicated County shelter facility would have a dedicated electrical service feed and is common in a modern system. With greater amounts of equipment at a site, they tend to consume more power than older system sites.	Monthly Fee $150 - $300/month per repeater site
Generator Maintenance	Sites using backup electrical generators will require a minimum yearly maintenance of those units and contracts should be put in place.	Yearly Fee
Generator Fuel	Sites using backup electrical generators will require fuel levels to be monitored and maintained.	As Needed
HVAC Servicing	As modern system equipment requires a regulated operating condition, it is critical to maintain air handling systems at sites.	Yearly contract
System Maintenance Fees	Systems maintenance contracts are commonplace with a modern radio network. Fees can include monitoring of alarms and technical support for repairs on a 24 X 7 X 365 need. Contracts are scaled based on the size and complexity of the system.	Yearly contract 4-5% of System Cost with yearly increase
System Updates	As modern systems are very software based, keeping up with changes means anticipating updates. Especially with trunking system as described in Option 3, the County must be aware the manufacturer continues to develop and provide upgrades which will have an ongoing cost. Recommendations are to stay within two versions of the current software offering.	Yearly contract 6-7% of System Cost

16.7 TIMELINE CONSIDERATIONS

As an understanding TNCG provides the following standard processes used by many public safety clients to take the information developed in this report and complete a process to update systems. Some projects move in unique direction, but this can be used to understand the basic time for completing an average project.

Phase II – RFP Development - RFP development as a phase incorporates time spent working with agencies who decide to take the next step in the procurement process and develop a request for vendors to use in the process of quoting them a replacement system. This phase takes some time to get the necessary consensus and a designated group together that works with TNCG & Associates to further identify and drill down on the specific needs of the replacement system. That group then oversees the document assembled by TNCG to its completion. **(3-5 Month process)**

Phase III – System Procurement Process, Contract Negotiations and Award – Having reached a design that best meets all needs and having put in place the funding mechanisms needed to support the purchase, an RFP release is made. The Procurement phase takes in the time need to provide vendors time to build designs based on the RFP and work through negotiations to a solution that will meet all needs. **(4-6 Month process)**

Phase IV – System Implementation – Final project phase of system implementation depends on the level of system needs and many tower siting considerations of design. Most projects will require some level of developmental work. **(18-30 Month process)**

16.8 COUNTY SUPPORT

- Evaluate presented options and identify and develop an optimal path for Richland County.
- Evaluate operational changes needing to be addressed and updated.
- Facilitate the financial process for implementation of new system.
- Create a core group of representatives that have a vested interest in the success of a new system that will serve to provide input through the design/purchasing processes.
- Coordinate the implementation of the new communication system and the transition of County agencies with the successful vendor.
- Implement all necessary new practices, project management, and finalize documentation to complete project and assure future success.

17 PLANNING CONCERNS AND RECOMMENDATION

17.1 PLANNING CONCERNS

TNCG identifies the following concerns and considerations to be focused on by leadership during planning activities:

- The current County system implementation has come about as a product of identifying needs and obtaining solutions without a common overall goal in consideration. Reversing this process will be challenging without a complete forklift replacement of the system or a final plan to work backwards from.
- With the County's terrain, design challenges to minimize tower sites and maximize coverage will be difficult. Reaching public safety standards may be difficult without major civil investments.
- With the operation of multiple repeater systems on common frequencies no system limitations are available for devices interfering with each other and possibly causing lost communications. It is difficult to understand and define the possible ramifications of operating this type of system.
- Countywide planning and governance functions of emergency communications equipment and operations needs to be improved to ensure any migration.
- The 911 center's radio communications capabilities systems were provided from a neighboring County (used) and have served a number of years in Richland and are no longer supported by the manufacturer.
- 911 radio dispatch consoles provide key Jail access/control and intercom operations. These system need to be separated to ensure better reliability and vendor support.
- Richland County subscriber equipment needs to be brought up to a more robust public safety level of standards assuring reliability and timely performance testing.
- With any upgrade, every effort should be made to reduce the complexity for public safety officers and dispatchers to allow the communications to quickly, effectively, and efficiently be delivered.
- Implementation practices of sites not having proper housing, electrical, and grounding infrastructure may be costly in the event of failures.
- Fire ground operational capabilities and reliance should be considered and improved as part of any Countywide design.
- Multi-band radio considerations will add to the purchase price of any new public safety radio approximately $1000 per unit.

- Paging system improvements need to be considered with enhancements to the voice systems that improve in building service levels greatly.
- At most of the locations visited there was a lack of what is proper grounding designs which should be implemented if a system upgrade occurs. With the advent to newer technology operating at much lower voltage levels, they are much more susceptible to surges in power and atmospheric conditions.
- Project budgets should anticipate civil costs slightly higher for Greenfield sites, or carry a higher percentage contingency.

17.2 TNCG'S RECOMMENDATION

TBD with final version

18 APPENDIX 1 – PUBLIC SAFETY FCC LICENSE SEARCH - RICHLANDCOUNTY

	Call Sign	Loc #	Ant #	Frequency	Station Class	Emission	CHAN NAME	
	WQLJ354	3	1	153.8525	MO	11K2F3E	EMA REPEATER RX	
	WQLJ354	4	1	153.8525	FX1	11K2F3E	EMA REPEATER RX	
	WQLJ354	6	1	153.8525	FB2	11K2F3E	EMA REPEATER RX	
	WQLJ354	7	1	153.8525	MO	11K2F3E	EMA REPEATER RX	
	WQLJ354	8	1	153.8525	FX1	11K2F3E	EMA REPEATER RX	
	KNEJ488	5	1	153.8900	MO3	11K2F3E	FUTURE USE	
	WBY232	2	1	153.9350	FX1	11K2F3E	COUNTY ROADS REPEATER RX	
	WBY232	3	1	153.9350	MO	11K2F3E	COUNTY ROADS REPEATER RX	
	WBY232	3	1	153.9350	MO	11K2F3E	COUNTY ROADS REPEATER RX	
	WPGQ342	1	1	154.2050	FB2	11K2F3E/20K0F3E	FIRE REPEATER TX	
	WPGQ342	2	1	154.2050	FB2	11K2F3E/20K0F3E	FIRE REPEATER TX	
	WPGQ342	3	1	154.2050	FB2	11K2F3E/20K0F3E	FIRE REPEATER TX	
	WPGQ342	4	1	154.2050	FB2	11K2F3E/20K0F3E	FIRE REPEATER TX	
	WPGQ342	5	1	154.2050	FB2	11K2F3E/20K0F3E	FIRE REPEATER TX	
	WPGQ342	6	1	154.2050	FB2	11K2F3E/20K0F3E	FIRE REPEATER TX	
	WPGQ342	8	1	154.2050	MO	11K2F3E/20K0F3E	FIRE REPEATER TX	
	KAF497	1	1	154.7700	FX1	11K2F3E/20K0F3E	LEA REPEATER RX	
	KAF497	3	1	154.7700	MO	11K2F3E/20K0F3E	LEA REPEATER RX	
	KAF497	2	1	154.8600	FB	11K2F3E/20K0F3E	OPS REPEATER TX	
	KAF497	3	1	154.8600	MO	11K2F3E/20K0F3E	OPS REPEATER TX	
	KNEJ488	1	1	154.8600	FB2	11K2F3E	OPS REPEATER TX	
	KNEJ488	2	1	154.8600	FB2	11K2F3E	OPS REPEATER TX	
	KNEJ488	3	1	154.8600	FB2	11K2F3E	OPS REPEATER TX	
	KNEJ488	6	1	154.8600	FB2	11K2F3E	OPS REPEATER TX	
	KNEJ488	7	1	154.8600	FB2	11K2F3E	OPS REPEATER TX	
	KNEJ488	8	1	154.8600	MO	11K2F3E	OPS REPEATER TX	
	KNEJ488	8	1	154.8600	MO	11K2F3E	OPS REPEATER TX	
	KAF497	2	1	155.3100	FB	11K2F3E/20K0F3E	INFORMATION BASE	
	KAF497	2	1	155.3700	FB	11K2F3E/20K0F3E	POINT TO POINT	
	KAF497	2	1	155.4750	FB	11K2F3E/20K0F3E	VLAW31	
	KAF497	3	1	155.4750	MO	11K2F3E/20K0F3E	VLAW31	
	KAF497	2	1	155.7600	FB	11K2F3E/20K0F3E	MAQUOKETA DPW	
	KAF497	3	1	155.7600	MO	11K2F3E/20K0F3E	MAQUOKETA DPW	
	KAF497	3	1	155.8500	MO	11K2F3E/20K0F3E	FUTURE USE	
	KAF497	3	1	155.9100	MO	11K2F3E/20K0F3E	INFORMATION MOBILE	
	WQLJ354	1	1	156.1725	FB2	11K2F3E	EMA REPEATER TX	
	WQLJ354	3	1	156.1725	MO	11K2F3E	EMA REPEATER TX	
	WQLJ354	5	1	156.1725	FB2	11K2F3E	EMA REPEATER TX	
	WQLJ354	7	1	156.1725	MO	11K2F3E	EMA REPEATER TX	
	WQLJ354	8	1	156.1725	FB2	11K2F3E	EMA REPEATER TX	
	WQLJ354	2	1	156.1725	FB2	11K2F3E	EMA REPEATER TX	
	WBY232	1	1	158.8350	FB2	11K2F3E	COUNTY ROADS REPEATER TX	
	KNEJ488	4	1	159.0300	FX1	11K2F3E	OPS REPEATER RX	
	KNEJ488	5	1	159.0300	MO	11K2F3E	OPS REPEATER RX	
	KNEJ488	5	1	159.0300	MO	11K2F3E	OPS REPEATER RX	
	KNEJ488	8	1	159.0300	MO	11K2F3E	OPS REPEATER RX	
	KNEJ488	8	1	159.0300	MO	11K2F3E	OPS REPEATER RX	
	WPGQ342	7	1	159.4650	FX1	11K2F3E/20K0F3E	FIRE REPEATER RX	
	WPGQ342	8	1	159.4650	MO	11K2F3E/20K0F3E	FIRE REPEATER RX	
	WQMS296	1	1	154.2050	FB2	11K2F3E	FIRE REPEATER TX	
	WQMS296	2	1	159.4650	MO	11K2F3E	FIRE REPEATER RX	
	WQMS296	3	1	154.2050	FB2	11K2F3E	FIRE REPEATER TX	
	WQMS296	4	1	159.4650	MO	11K2F3E	FIRE REPEATER RX	
	WPEP624	1	1	159.4650	FB2	11K2F3E	FIRE REPEATER RX	
	WPEP624	1	1	159.4650	FB	11K2F3E	FIRE REPEATER RX	
	WPEP624	2	1	159.4650	FB	11K2F3E	FIRE REPEATER RX	
	WPEP624	3	1	159.4650	MO	11K2F3E	FIRE REPEATER RX	

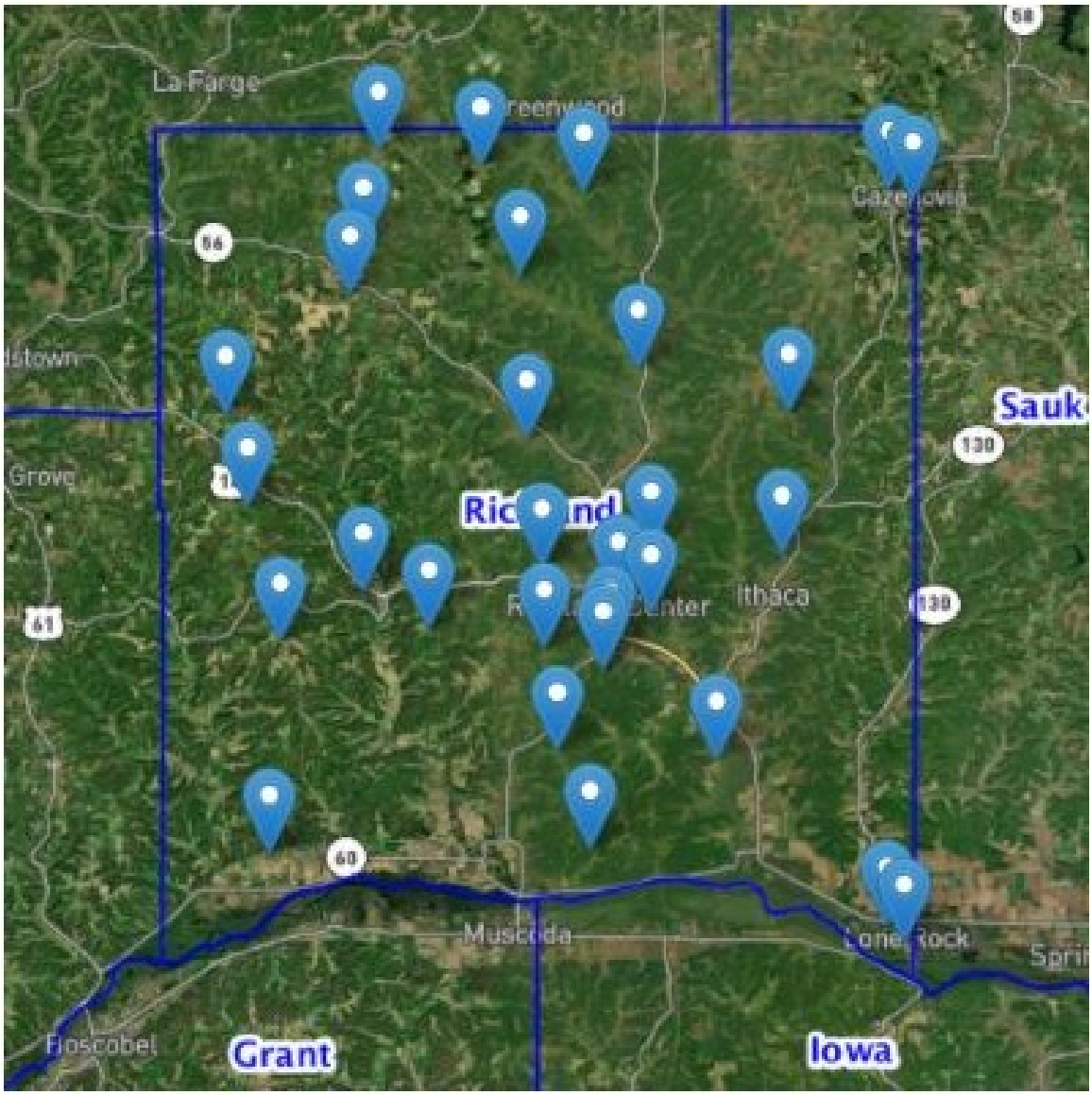
19 APPENDIX 2 – MUTUAL AID CHANNELS

Organization	Neighbor	Agency	Radio Band	Frequency Information	Notes
Jackson County	Dubuque County IA	Sheriff	800	EDACS Trunking (RACOM)	Moving to 800 MHz P25
		Fire	800	EDACS Trunking (RACOM)	Moving to 800 MHz P25
Jackson County	Jones County IA	Sheriff	VHF	151.295 (107.2)	
		Fire	VHF	154.385 (146.2)	
Jackson County	Clinton County IA	Law	VHF	154.965 (146.2)	
		Fire	VHF	154.235	
Jackson County	Carroll County IL	Sheriff	VHF	155.670	
		Fire	VHF	151.3925	
Jackson County	Jo Daviess County IL	Sheriff	VHF	159.210	
		Fire	VHF	155.820	
Jackson County	Grant County WI	Sheriff	VHF	155.865	
		Fire	VHF	155.745	
Jackson County	State of Iowa	State Patrol	ISICS		
Jackson County	State of Illinois	State Patrol	800	Starcom	

20 APPENDIX 3 – DELIVERED AUDIO QUALITY

DAQ Delivered Audio Quality	Subjective Performance Description
1	Unusable; speech present but unreadable.
2	Understandable with considerable effort. Frequent repetition due to noise/distortion.
3	Speech understandable with slight effort. Occasional repetition due to noise/distortion.
3.4	Speech understandable with repetition only rarely required. Some noise/distortion.
4	Speech easily understood. Occasional noise/distortion.
4.5	Speech easily understood. Infrequent noise/distortion.
5	Speech easily understood.

21 APPENDIX 4 – TOWER SITES MAP



22 APPENDIX 5 – TOWER SITES LIST

ASR Registration Search

Registration Search Results

Displayed Results

PA = Pending Application(s)

Specified Search

Structure State = **WISCONSIN**
Structure County = **RICHLAND**

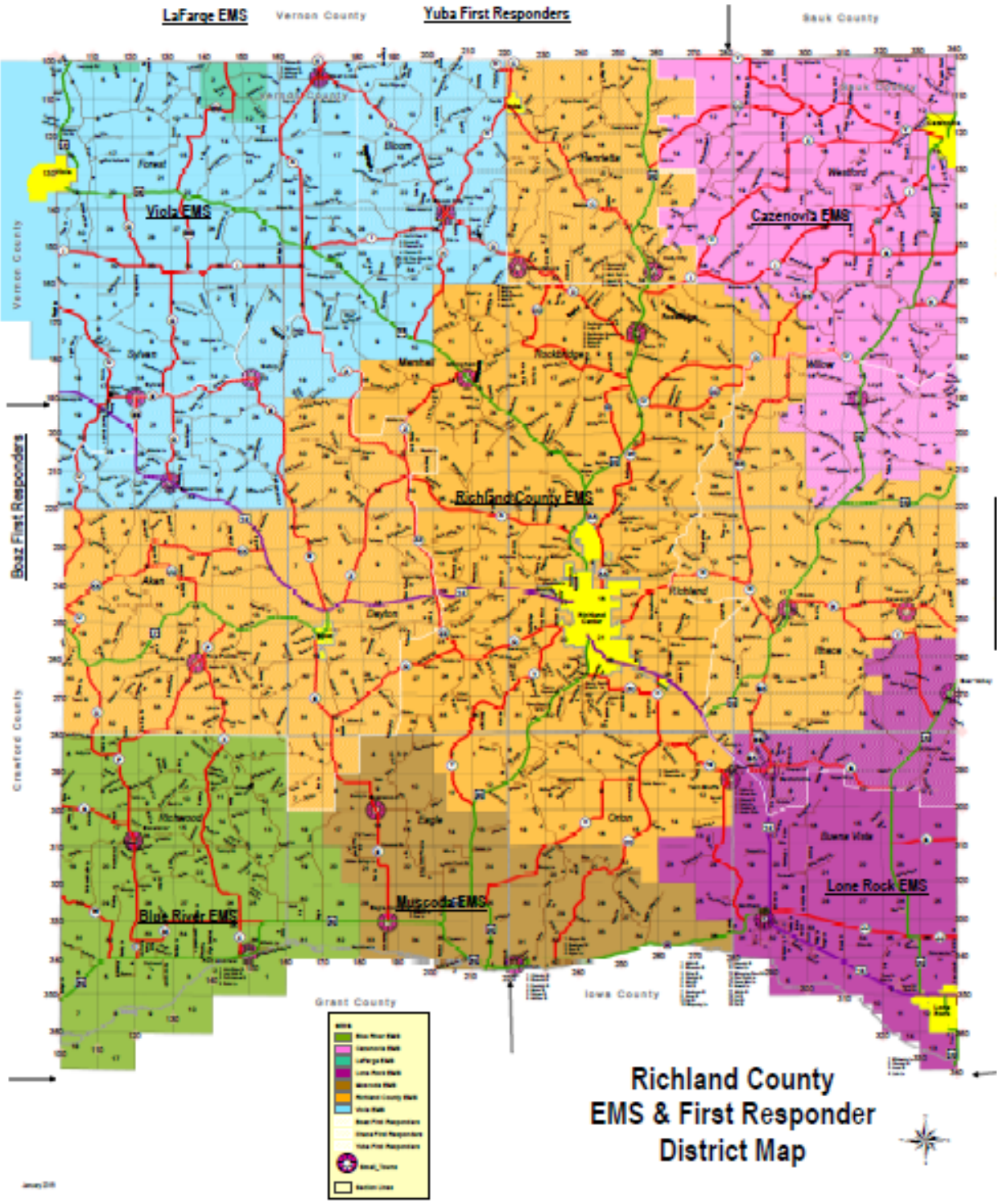
	Registration Number	Status	File Number	Owner Name	Latitude/Longitude	Structure City/State	Overall Height Above Ground (AGL)
1	1000186	Constructed	A0925062	UNITED STATES CELLULAR CORPORATION	43-20-15.0N 090-22-41.0W	RICHLAND CENTER, WI	97.5
2	1003387	Constructed	A1060338	WISCONSIN RSA NO. 8 LIMITED PARTNERSHIP	43-21-35.6N 090-21-32.2W	RICHLAND CENTER, WI	130.7
3	1034924	Constructed	A1182798	WISCONSIN, STATE OF	43-29-54.0N 090-32-25.0W	ASHRIDGE, WI	98.1
4	1035400	Granted	A1186469	Wisconsin Power and Light Company	43-16-07.0N 090-25-02.5W	RICHLAND CENTER, WI	79.2
5	1050690	Constructed	A0937540	UNITED STATES CELLULAR CORPORATION	43-32-08.1N 090-27-55.0W	YUBA, WI	47.2
6	1054198	Granted	A0063721	RICHLAND CENTER FELLOWSHIP	43-18-51.0N 090-23-03.0W	RICHLAND CENTER, WI	152.4
7	1243602	Constructed	A1060321	WISCONSIN RSA NO. 8 LIMITED PARTNERSHIP	43-18-17.8N 090-23-16.7W	Richland Center, WI	49.9
8	1244050	Cancelled	A0586242	Fruit Broadcasting, LLC	43-20-13.1N 090-22-44.3W	Richland Center, WI	66.4
9	1255589	Constructed	A0937535	UNITED STATES CELLULAR CORPORATION	43-20-26.6N 090-32-20.5W	MUSCODA, WI	94.4
10	1256425	Constructed	A0972471	UNITED STATES CELLULAR CORPORATION	43-31-12.4N 090-11-39.4W	CAZENOVIA, WI	94.4
11	1257097	Constructed	A0626849	FRUIT BROADCASTING, LLC	43-18-55.4N 090-25-35.0W	RICHLAND CENTER, WI	106.4
12	1265016	Constructed	A0617990	Village of Lone Rock	43-10-50.3N 090-11-58.2W	Lone Rock, WI	50.9
13	1298241	Cancelled	A1133256	SBA Towers VI, LLC	43-21-07.9N 090-25-35.5W	Richland Center, WI	91.4
14	1299583	Constructed	A1054369	Cloud 1	43-31-25.9N 090-24-04.2W	Hillsboro, WI	92.9
15	1300397	Constructed	A1062671	Cloud 1	43-19-28.6N 090-29-55.7W	Richland Center, WI	92.9
16	1302404	Granted	A1104980	M3 Hilbert Towers, LLC	43-19-52.9N 090-21-32.2W	Richland Center, WI	77.7

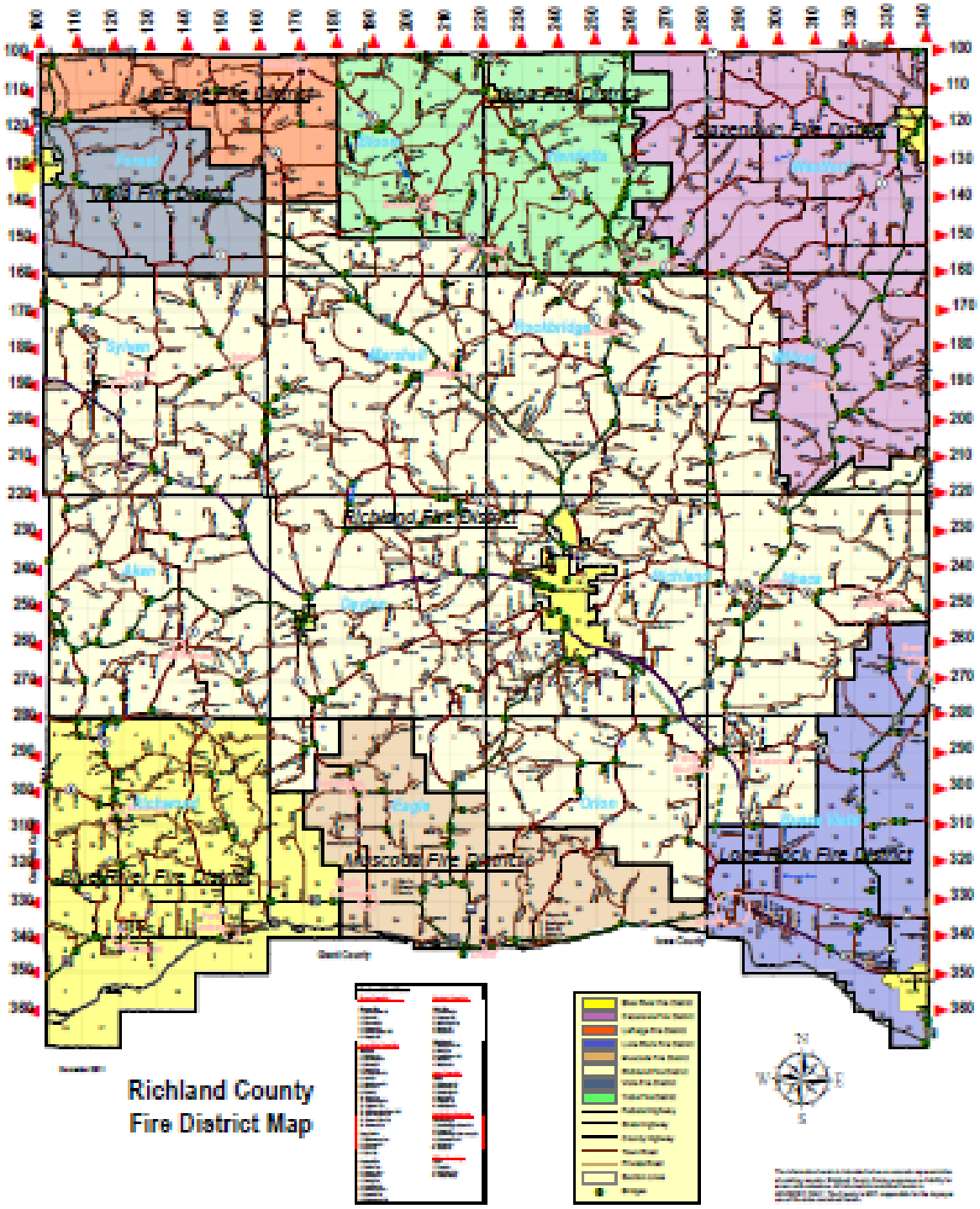
6/4/2021 ASR Registration Search Results

17	1302650	Granted	A1104983	M3 Hilbert Towers, LLC	43-22-49.0N 090-36-43.7W	Richland Center, WI	74.6
18	1302652	Constructed	A1104984	M3 Hilbert Towers, LLC	43-21-29.9N 090-16-32.6W	Ithaca, WI	92.9
19	1302968	Constructed	A1104986	M3 Hilbert Towers, LLC	43-25-17.9N 090-37-36.4W	Richland Center, WI	77.7
20	1303491	Constructed	A1136179	M3 Hilbert Towers, LLC	43-15-50.9N 090-19-02.6W	Richland Center, WI	54.9
21	1308125	Constructed	A1166352	VBHV, LLC	43-11-17.6N 090-12-35.9W	Lone Rock, WI	47.2
22	1310721	Constructed	A1151702	Cloud 1	43-32-33.5N 090-31-46.3W	LaFarge, WI	93.0
23	1310722	Constructed	A1174292	M3 Hilbert Towers, LLC	43-13-22.6N 090-23-47.5W	Muscoda, WI	93.0
24	1310935	Constructed	A1167410	M3 Hilbert Towers, LLC	43-29-10.4N 090-26-28.9W	Richland Center, WI	93.0
25	1310937	Constructed	A1167418	M3 Hilbert Towers, LLC	43-28-35.9N 090-32-55.0W	Viola, WI	93.0
26	1311638	Constructed	A1180364	M3 Hilbert Towers, LLC	43-24-39.8N 090-26-12.3W	Richland Center, WI	93.0
27	1311751	Constructed	A1167404	M3 Hilbert Towers, LLC	43-31-30.0N 090-12-32.2W	Cazenovia, WI	93.0
28	1311997	Constructed	A1174307	M3 Hilbert Towers, LLC	43-26-33.0N 090-22-01.0W	Richland Center, WI	93.0
29	1312798	Constructed	A1174309	M3 Hilbert Towers, LLC	43-19-06.0N 090-35-30.7W	Blue River, WI	71.3
30	1314193	Constructed	A1180414	M3 Hilbert Towers, LLC	43-13-16.1N 090-35-55.6W	Blue River, WI	77.4
31	1315052	Constructed	A1180379	M3 Hilbert Towers, LLC	43-25-22.9N 090-16-16.5W	Cazenovia, WI	92.7

CLOSE WINDOW

23 APPENDIX 6 – AGENCY BOUNDARY MAPS




Richland County
Fire District Map

24 APPENDIX 7 – FIRSTNET UPDATE

25 APPENDIX 8 – COUNTY MAP