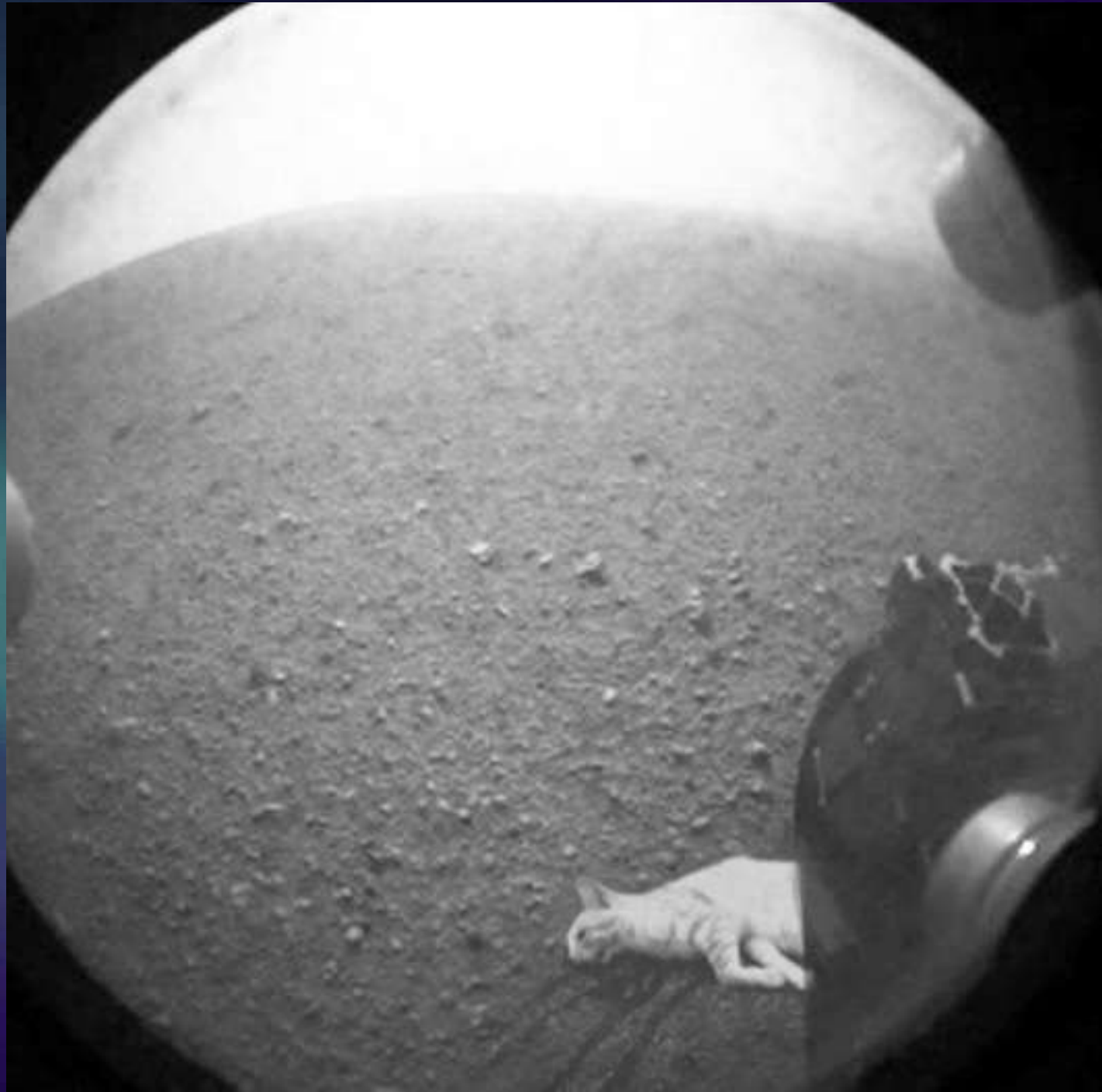


Interference

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BURGER KING

HAVE IT YOUR WAY





STEP LADDER

Interference

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Interference

in·ter·fer·ence *noun* /,ɪn.tə'fɪə.rənt s/

- confusion of a received radio signal due to the presence of noise (as atmospherics) or signals from two or more transmitters on a single frequency (*Merriam-Webster*)
- radio signals that make the sound or picture of a radio or television program difficult to hear or see clearly, or the noise caused by this (*MacMillan*)
- static, unwanted signals, etc., producing a distortion as of sounds or images and preventing good reception (*yourdictionary.com*)
- Interference is the interaction of two or more waves passing the same point. (*Wolfram Research Dictionary*)

Interference

- Any condition in which the undesired to desired (U/D) ratio between two “signals” is exceeded.
- Can be caused by natural “signals”.
- Is frequently caused by man-made “signals”.
- Similar signal type not required.
- Cross-service interference can and does occur.

Natural "Signals"

- Lightning.
- Wind.
- The Sun.
- Thermal.
- Cosmic Background Radiation.
- Other Stuff.

Lightning

- Creates powerful radio signals in the 3 kHz to 10 MHz range.
- VLF signatures (3 kHz to 30 kHz) can travel around the entire world.
- Shortwave signatures (30 kHz to 10 MHz) routinely travel half the world.
- Red sprite lightning travels from the top of thunderstorms to the ionosphere.
- Red sprite creates extremely powerful signals from 1 kHz thru VHF frequencies.
- No way to mitigate. Transient in nature.



Wind

- Wind interference functions similarly to lightning.
- High winds create static buildup on towers, which can effectively create a spark-gap discharge.
- This type of interference tends to be highly localized in nature due to size of discharge.
- Effects can be substantially reduced through static discharge schemes.
- The same schemes can also reduce the likelihood of damage from lightning strikes.
- Transient in nature.



The Sun

- The sun radiates across the spectrum.
- Satellite outage occurs around equinoxes.
- Typical outage time 12 minutes or less.
- GPS can be affected.
- Typically HF frequencies are most affected.
- Other frequencies can be affected with the strongest “storms”.
- Northern Lights.
- Other interference comes from radio bursts.



Thermal

- Also known as Johnson-Nyquist Noise.
- Occurs in ANY circuit at a temperature above absolute zero (-459.67°F)
- Results from the motion of atoms.
- Passive components on a shelf will generate.
- Contributor to system noise floor.
- Tends to be low level affecting only very sensitive systems.



Cosmic Background Radiation



- Discovered in 1964.
- Radiation left over from the early universe.
- Intensity is roughly uniform across the sky.
- Contributes to “static” in receivers.
- CMBR currently has black body spectrum at 2.725 K.
- Spectrum peak is 160.2 GHz where $\lambda = 1.873$ mm.
- Described as most perfect black body ever measured in nature.
- Very low level in nature.

Other Stuff

- We always have to have a “catch-all” category.
- This is it.
- Any other process that causes interference, and not already described would be lumped into here.

Man-Made Signals

- Intentional interference.
- Unintentional interference.
- Nearly anything that uses electricity in one way or another can be a potential source.
- Localization varies with source.

Unintentional Interference

- Fluorescent, including CFL, lighting.
- Motors.
- Electrical contacts.
- Dimmer switches.
- Electric fences.
- Power lines.
- Numerous others.
- Many mimic synchrotron type radiation.
- Non-broadcast communication facilities.
- AM, FM, and TV stations.

The Commission

- Radio Act of 1912 begins regulation.
- 1912 act comes in wake of sinking of *Titanic*.
- Requires *all* radio stations to be licensed.
- Radio Act of 1927 supersedes 1912 law.
- 1927 law creates Federal Radio Commission.
- Communications Act of 1934 creates current FCC.
- 1934 law abolishes the FRC.
- Interference protection ties in with fair distribution.
- Rules established to regulate interference (obviously).

AM Station Interference

- Three primary conditions.
- Daytime.
- Nighttime.
- Critical Hours.

Daytime AM Interference

- Two main items determine.
- Antenna efficiency.
- Ground conductivity.

AM Antenna Efficiency

- Function of radiator height.
- Stated in mV/m at 1 km.
- Maximum at 0.625λ .
- Equivalent to $5/8\lambda$.
- Corresponds to 225° .
- Why does the efficiency of the antenna drop above a radiator height of $5/8\lambda$?

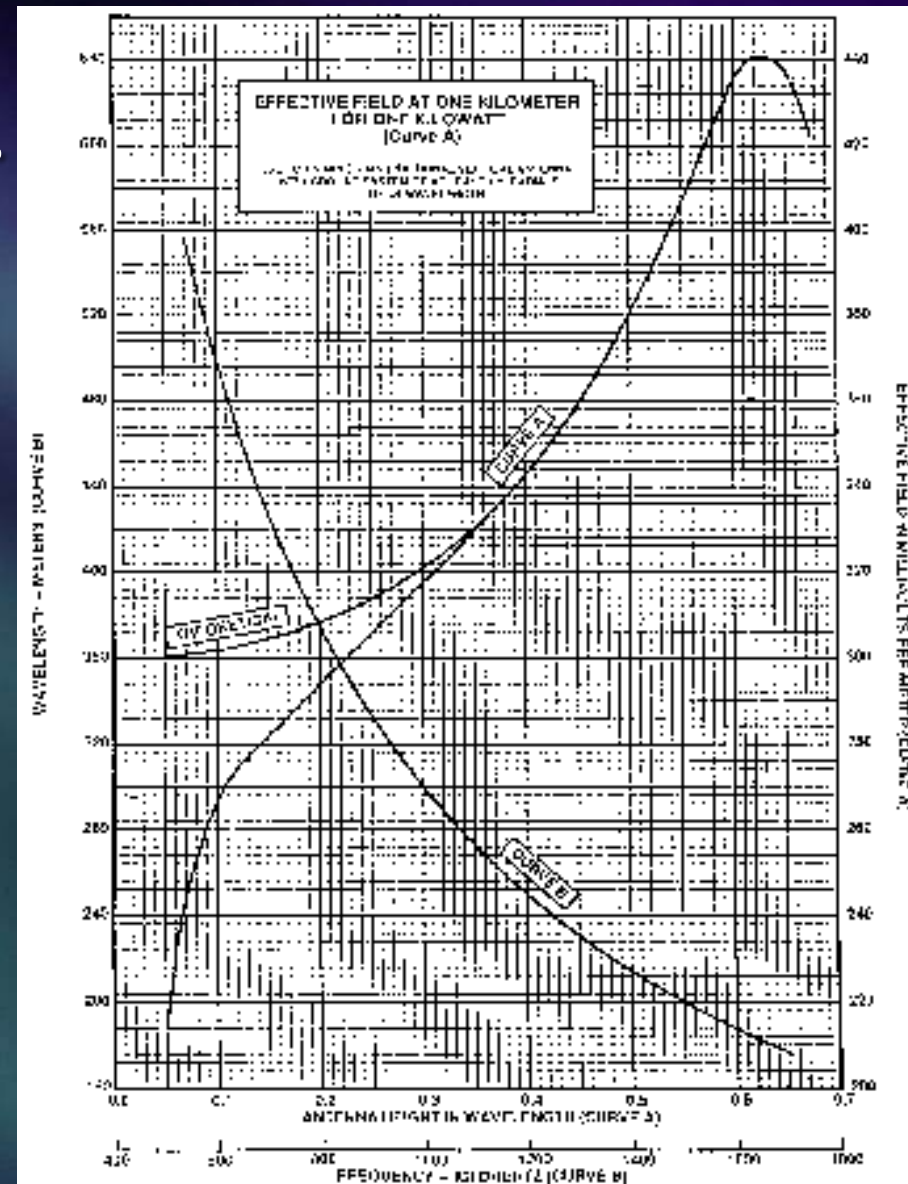


Figure B

Ground Conductivity

- Estimated values in units of mS/m or mmho/m.
- Values based on soil type. Recent climate affects.
- Digitized version in general use.
- Measured values trump M3 if available.
- Measured data usable +/- 10° radial measured.
- Proof data is usual source.
- Witness others measuring your data.
- Signal attenuation also frequency based.

Daytime Interference

- Currently defined in terms of contour overlap.
- Co-channel follows 1:20 (U/D) ratio (-26 dB).
- Non Class A situation is 0.025 to 0.5 mV/m.
- Class A is 0.005 to 0.1 mV/m.
- First adjacent follows 1:2 (U/D) ratio (- 6 dB).
- Second adjacent 1:1 – no overlap of 5 mV/m contours.
- Third adjacent 1:1 – no overlap of 25 mV/m contours.

Daytime Interference

- Stations considered at authorized power and field.
- Non-D uses theoretical values.
- DA uses authorized pattern...standard or augmented.
- Special case exists for Class C to Class C situations.
- Proposed facility considered at 250 Watts for protected and interfering contour.
- Other Class C considered at 250 Watts for interfering contour and 1000 Watts for protected contour.

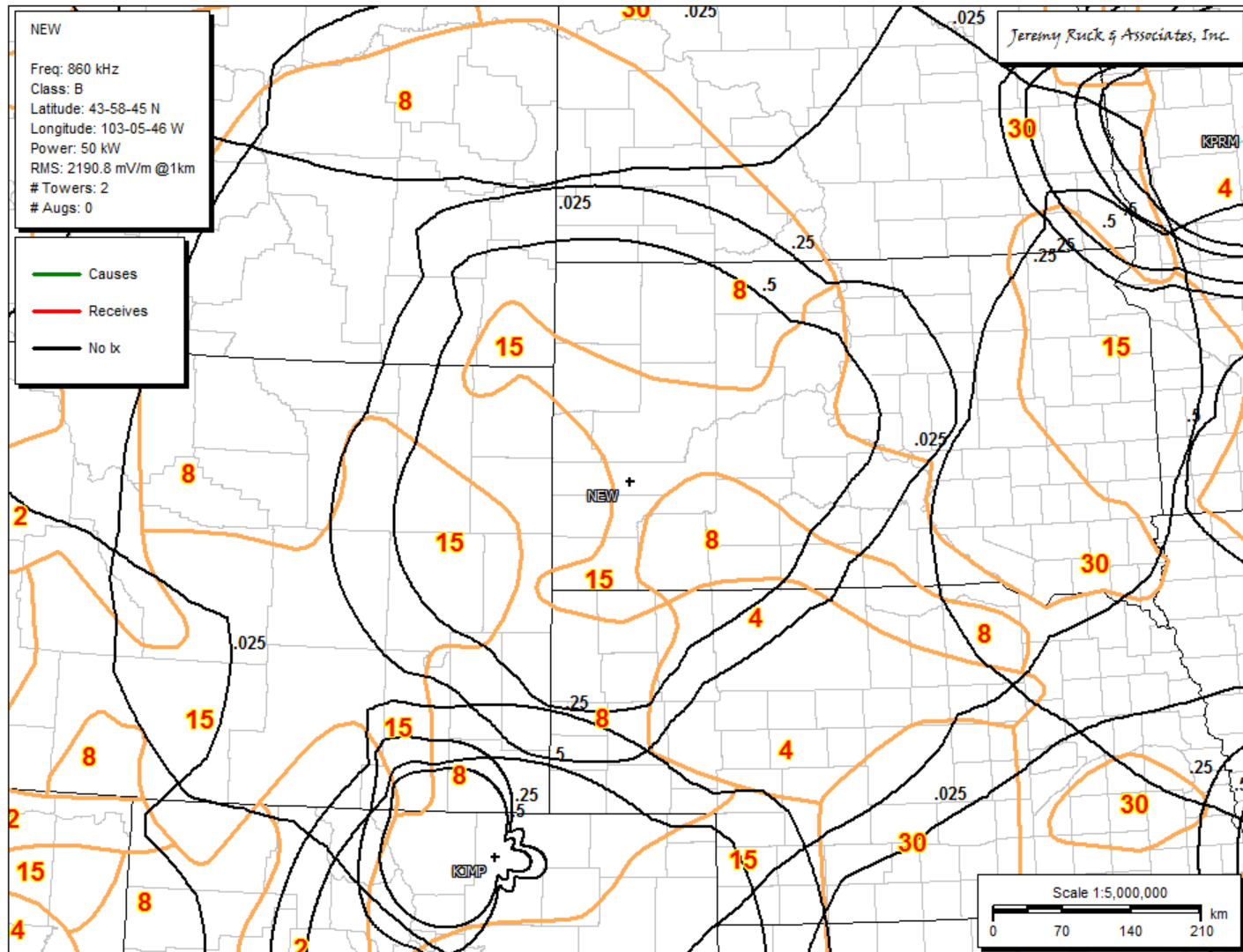
Daytime Interference

- A VERY important point to keep in mind:

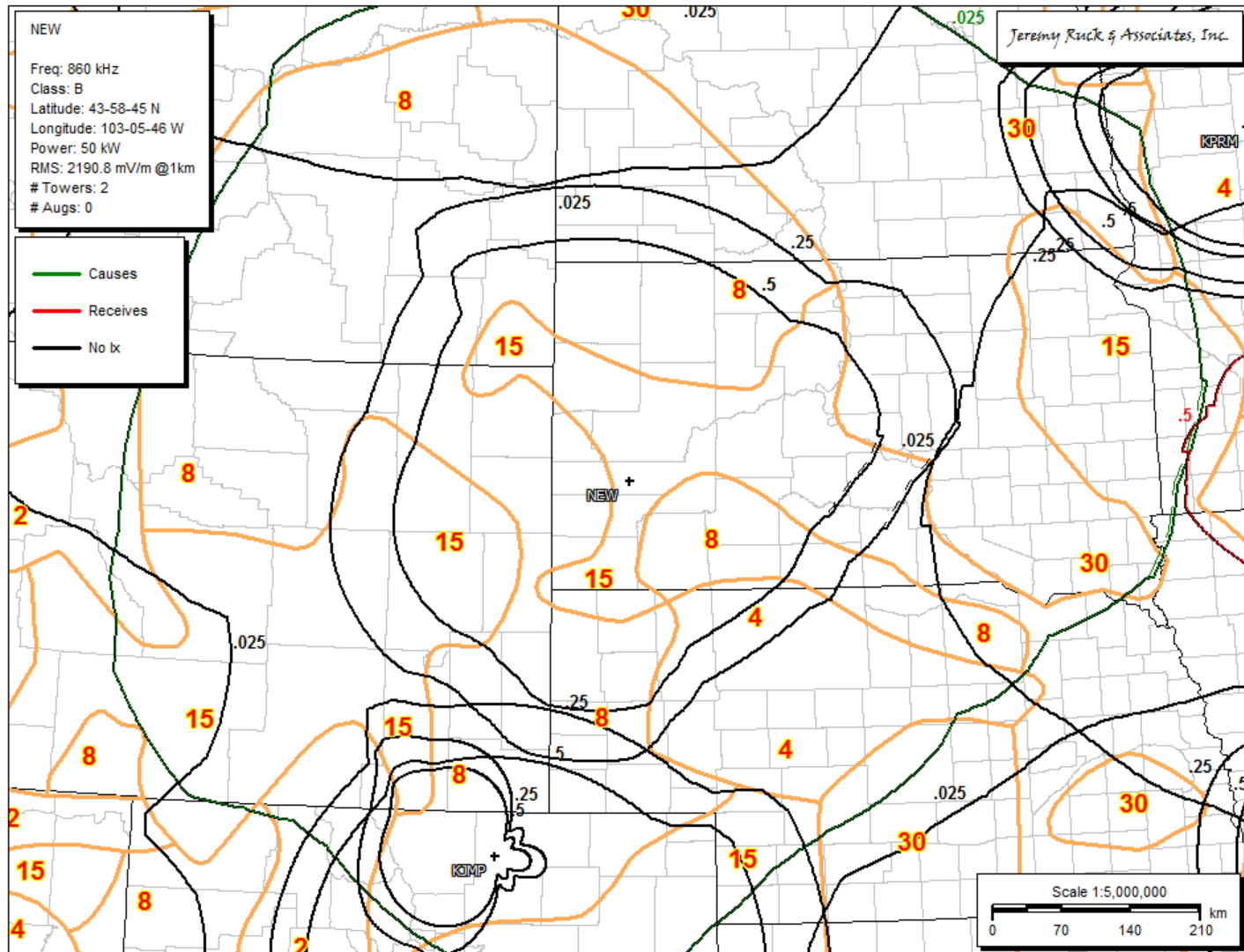
The authorization of a pattern without contour overlap does not necessarily imply that after construction there will be no contour overlap.

Why?

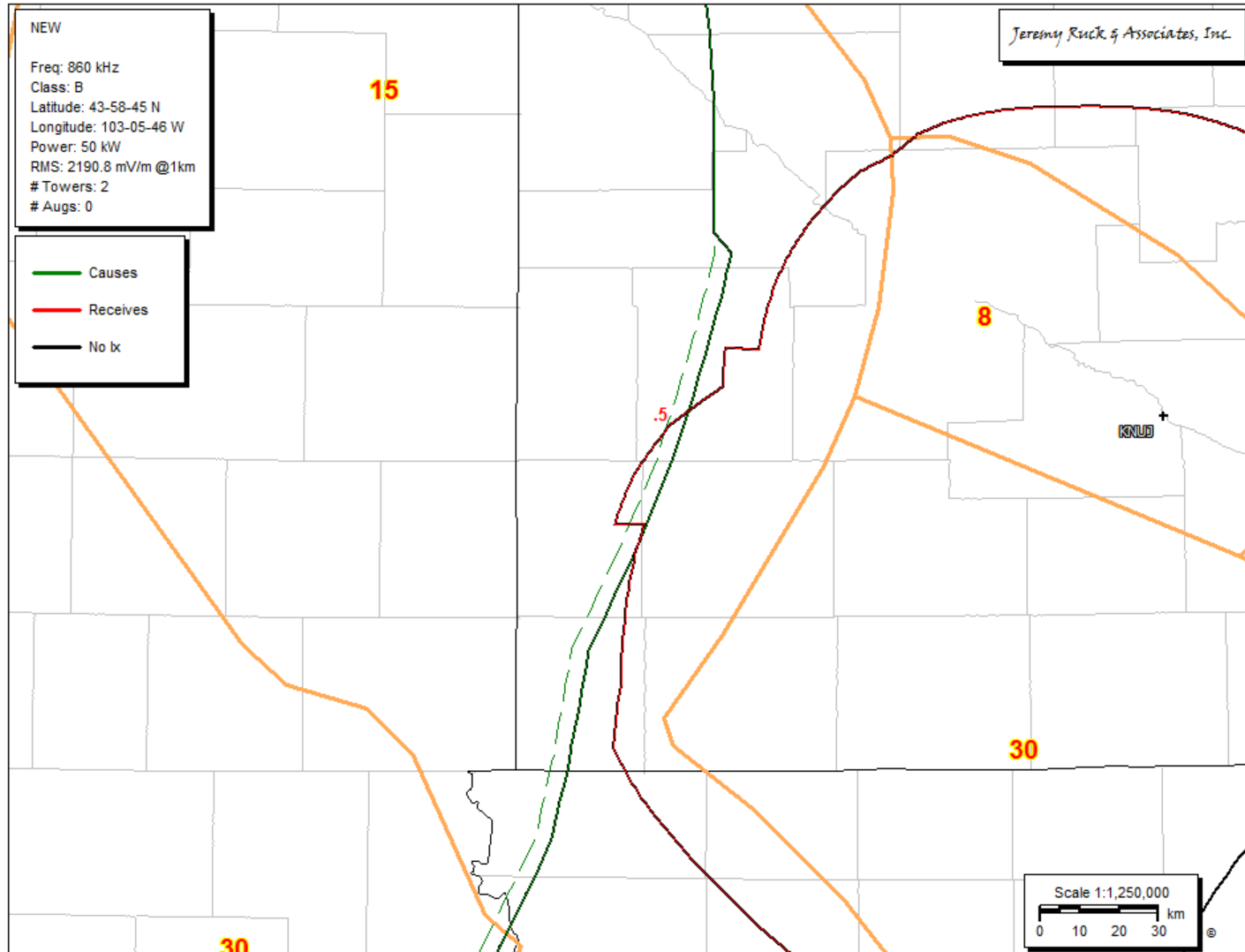
Daytime Interference



Daytime Interference



Daytime Interference



Nighttime Interference

- Site to site RSS calculations used in most cases.
- All co-channel Region II considered.
- Class A protected to 0.5 mV/m 50% skywave contour.
- First adjacent domestic also considered.
- Adjacent class A protected to 0.5 mV/m groundwave.
- No cross-border international protection.
- Nighttime interference-free contour is protected.
- Half this value is a reasonable limit of coverage.

Critical Hours Interference

- Special case to Class A facilities.
- Addresses effects of sunrise/sunset at different times.
- Sunrise to two hours after sunrise.
- Two hours before sunset to sunset.
- Rulemaking took 12 years to implement! (1947-1959)
- Co-channel considered.
- Calculations based on Section 73.187 and 73.190.
- Uses 2 of 3 graphs and interpolation factors.
- Limit from azimuth & distance to Class A 0.1 mV/m.

FM Interference

- Interference and coverage based on curve family.
- Non-reserved channels *primarily* use spacings.
- Reserved channels use contour based method.
- Interference may occur under either method.
- U/D Ratio for co-channel facilities is -20 dB.
- U/D Ratio for 1st adjacent facilities is -6 dB.
- U/D Ratio for 2nd and 3rd adjacent facilities is +40 dB.
- Protected value varies with class.

FM Interference

- Spacing table based on reference facilities with flat, uniform terrain.

Example:

Required spacings for two co-channel class A facilities is 115 km.

No overlap of either 40 dBu F(50,10) with other 60 dBu F(50,50).

Both facilities are standard i.e. 6 kW ERP at 100 meters HAAT.

60 dBu service contour distance = 28.3 km (28 km as the Commission rounds).

40 dBu interfering contour distance = 86.7 km (87 km rounded).

28 km + 87 km = 115 km

FM Interference

- Short spacings permitted with contour protection.
- Absolute minimum spacings are defined.
- Minimums factor in DA restrictions.
- Achieving spacings does not imply contour protection.
- In some cases of irregular terrain geographic spacings under 73.207 will be met, but contours will overlap.

FM Interference

- Interference can still exist even if both contour protection and spacings are met.
- Recall our definition of interference and U/D ratio.
- Commission's model is not real world.
- The Commission has an escape clause for this.

FM Interference

§ 73.209 Protection from interference.

- (a) Permittees and licensees of FM broadcast stations are not protected from any interference which may be caused by the grant of a new station, or of authority to modify the facilities of an existing station, in accordance with the provisions of this subpart. However, they are protected from interference caused by Class D (secondary) noncommercial educational FM stations. See §73.509.
- (b) The nature and extent of the protection from interference afforded FM broadcast stations operating on Channels 221–300 is limited to that which results when assignments are made in accordance with the rules in this subpart.

FM Interference

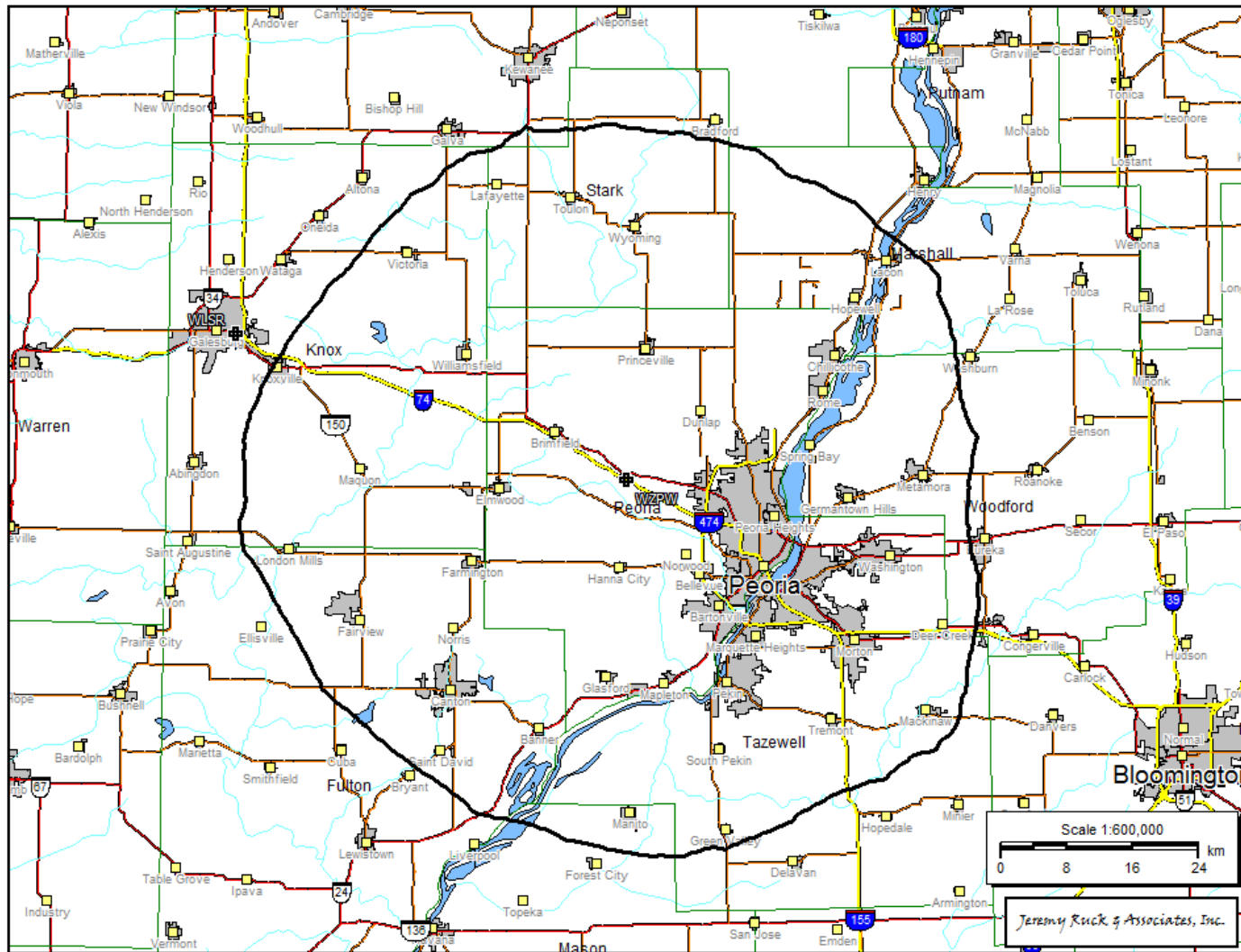
Jeremy Ruck & Associates, Inc.
Consulting Engineers - Canton, Illinois
WZPW - Single Channel Spacing Study
WBA Presentation October, 2012

REFERENCE 40 47 10.0 N. CLASS = B1 DISPLAY DATES
89 47 01.0 W. Current Spacings to 3rd Adj. DATA 10-05-12
SEARCH 10-05-12
----- Channel 222 - 92.3 MHz -----

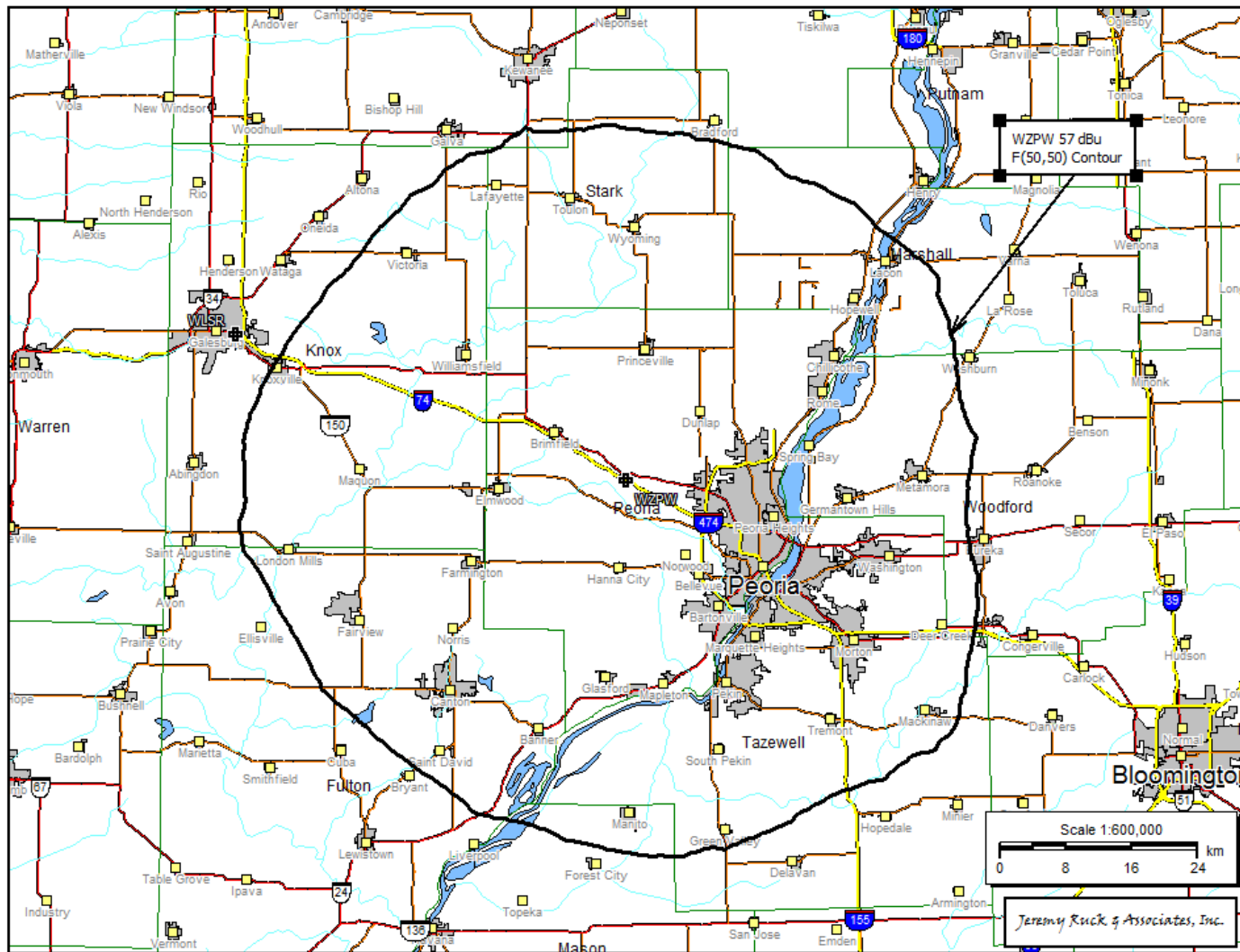
Call	Channel	Location	Azi	Dist	FCC	Margin
WZPW	LIC 222B1	Peoria	IL 0.0	0.00	175.0	-174.5
WPWX	LIC-D 222B	Hammond	IN 62.8	211.16	211.0	0.7
WQKQ	LIC 221B1	Carthage	IL 259.6	114.41	114.0	0.9
WLSR	LIC 224A	Galesburg	IL 290.5	50.36	48.0	2.9
WCPY	LIC 223B	Dekalb	IL 35.0	148.55	145.0	4.1
WKXQ	LIC 223A	Rushville	IL 226.0	103.22	96.0	7.7
W222BG	LIC 222D	Clinton	IL 137.7	103.52	93.0	11.0
WIL-FM	LIC 222C0	St. Louis	MO 191.8	261.17	248.0	13.7
KKHQ-FM	LIC 222C	Oelwein	IA 321.1	273.42	259.0	14.9
WWKJ-LP	LIC 275L1	Peoria	IL 59.2	27.49	9.0	19.0
WGVV-LP	LIC 223L1	Rock Island	IL 321.4	100.57	74.0	27.1
638365	APP 221D	Bloomington	IL 118.0	78.50	49.0	30.0
636357	APP 221D	Bloomington	IL 112.8	78.90	49.0	30.4
628827	APP 221D	Normal	IL 113.4	79.03	49.0	30.5
WUIS	LIC 220B	Springfield	IL 165.5	114.95	71.0	44.5
WRPW	LIC 225A	Colfax	IL 109.7	95.70	48.0	48.2
KXJX-LP	LIC 223L1	Clinton	IA 344.0	122.07	74.0	48.6

All separation margins include rounding

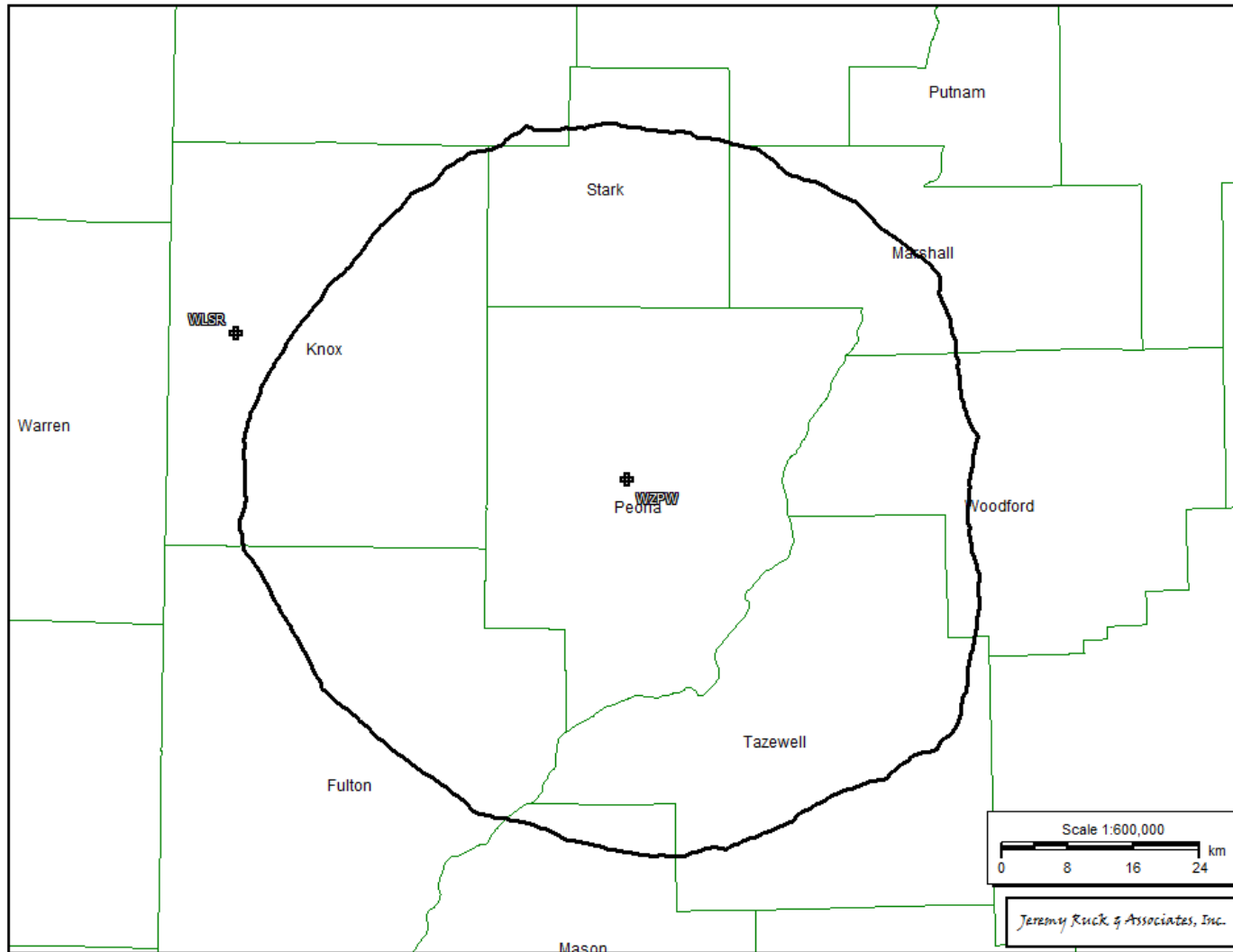
FM Interference



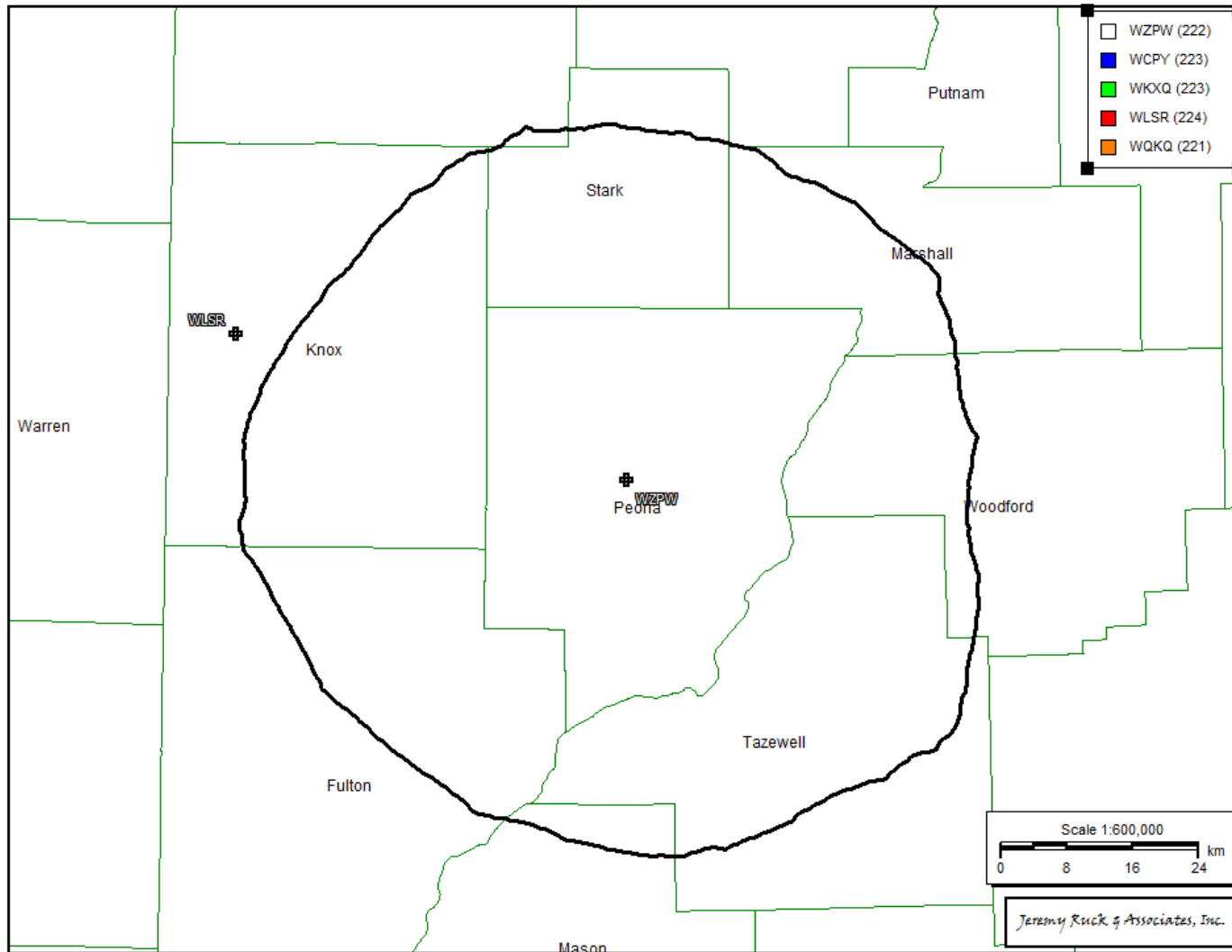
FM Interference



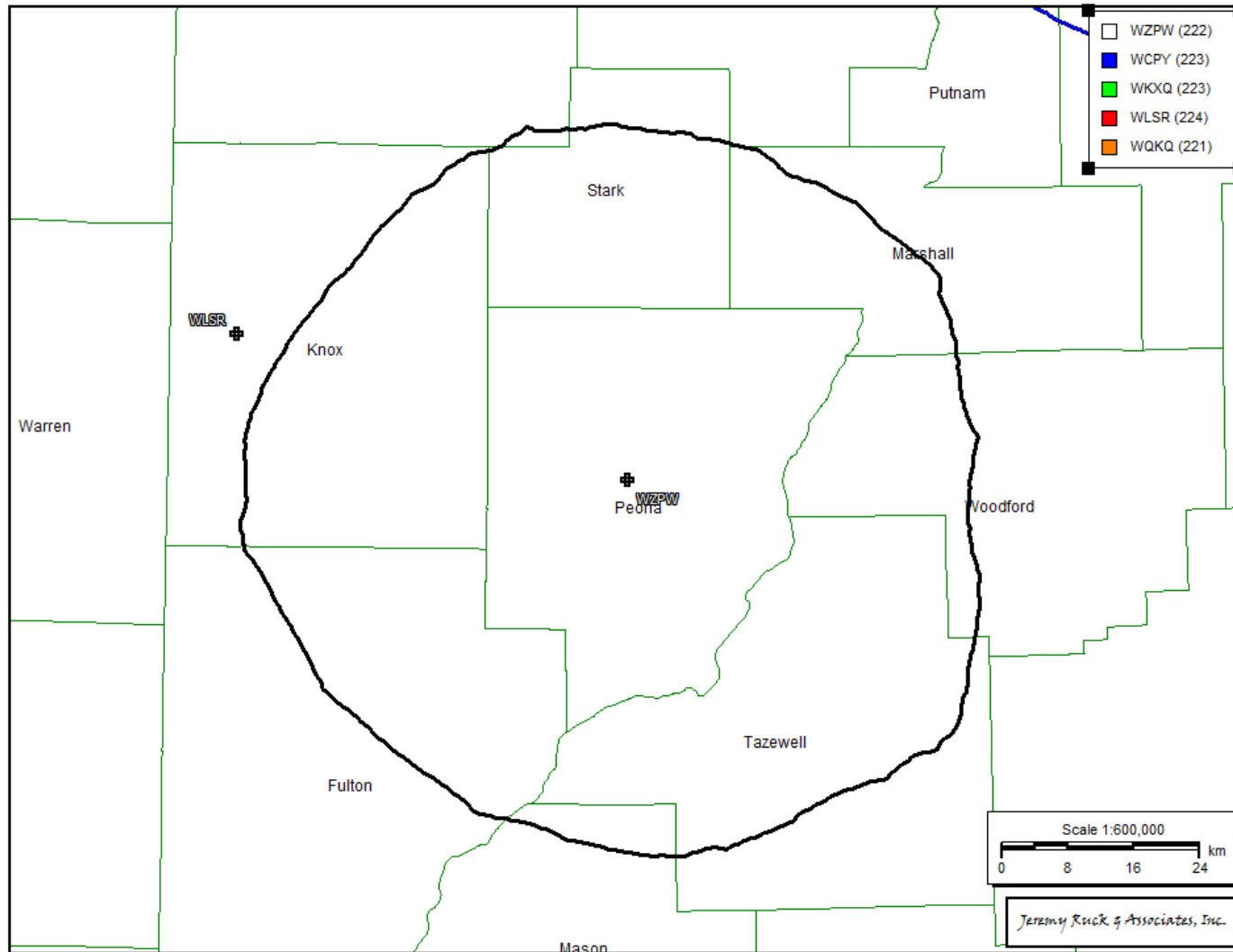
FM Interference



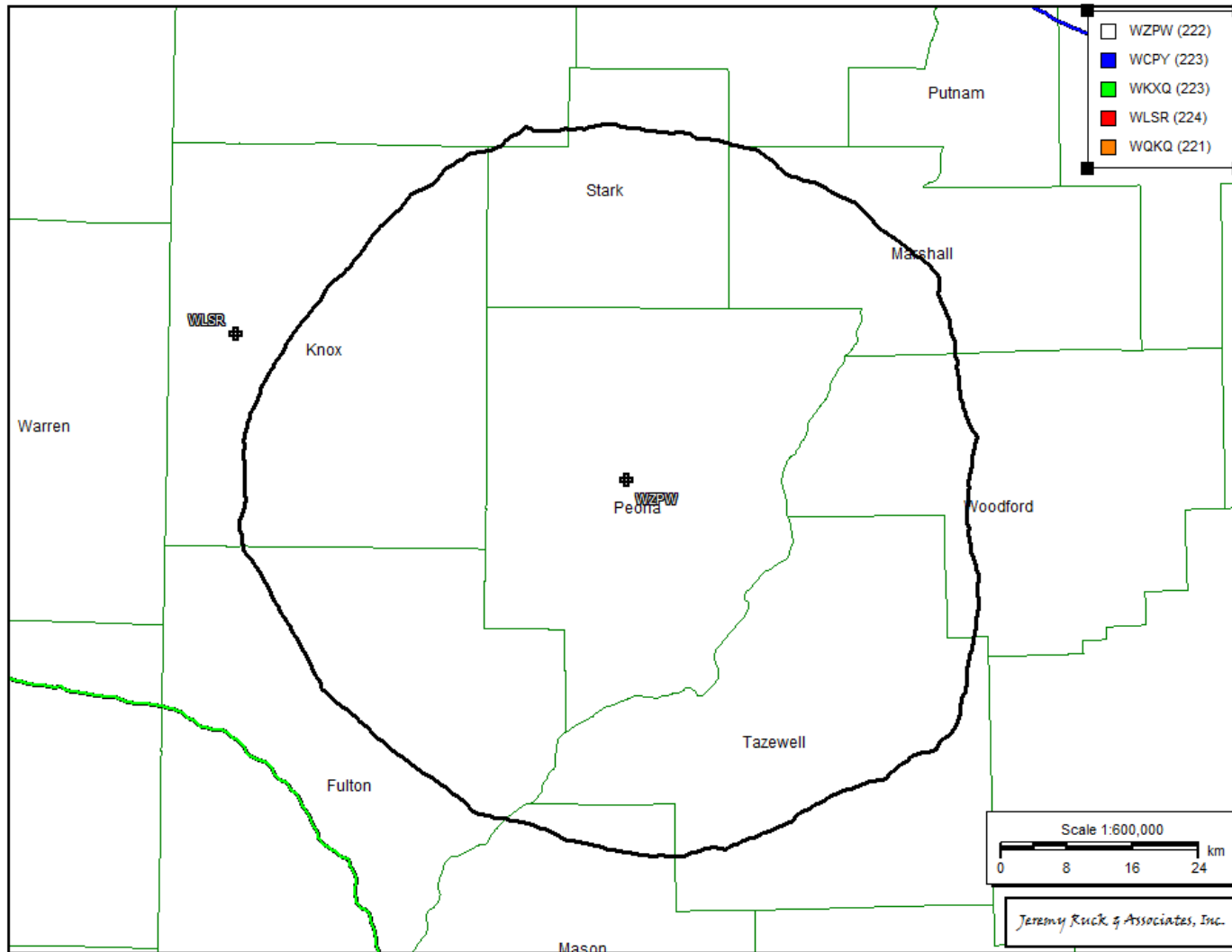
FM Interference



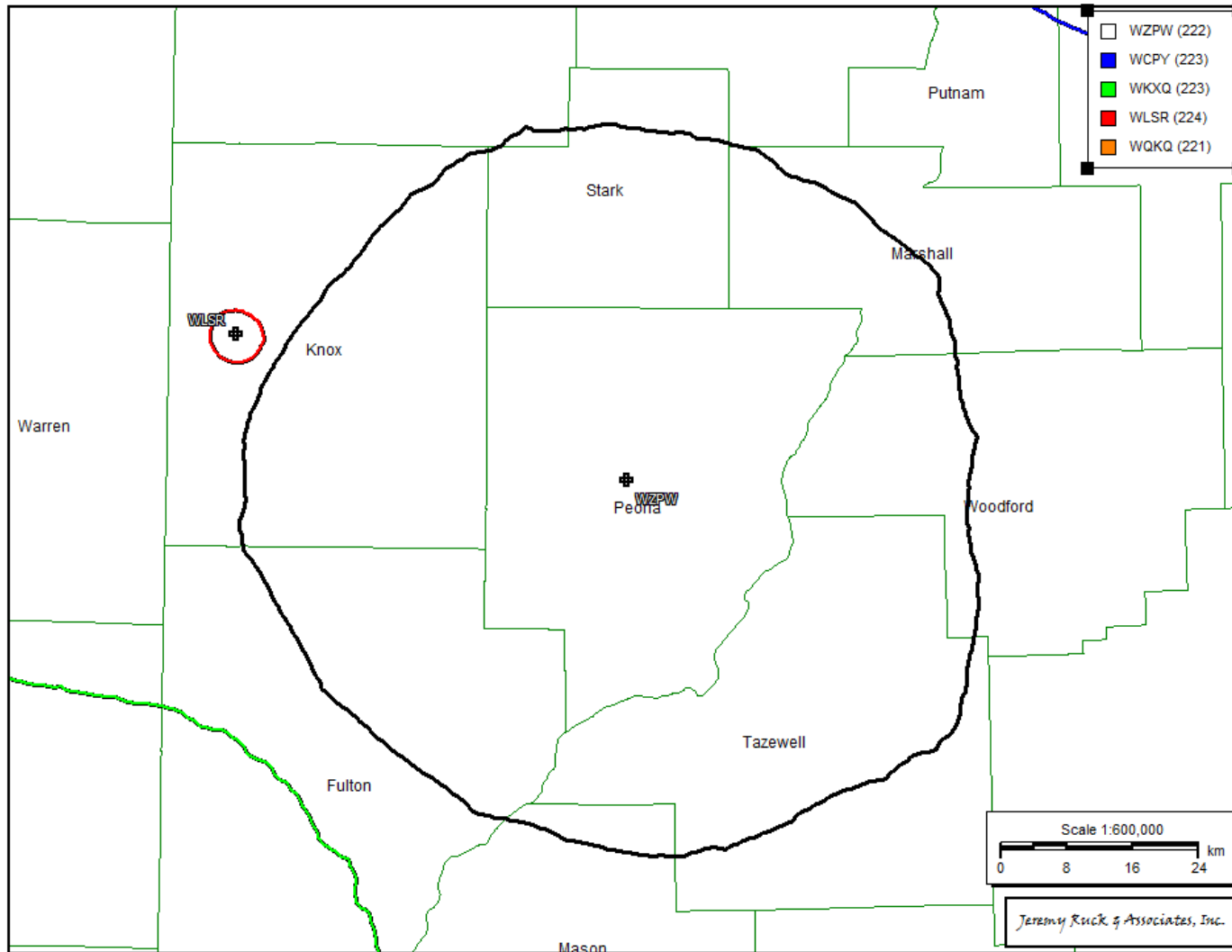
FM Interference



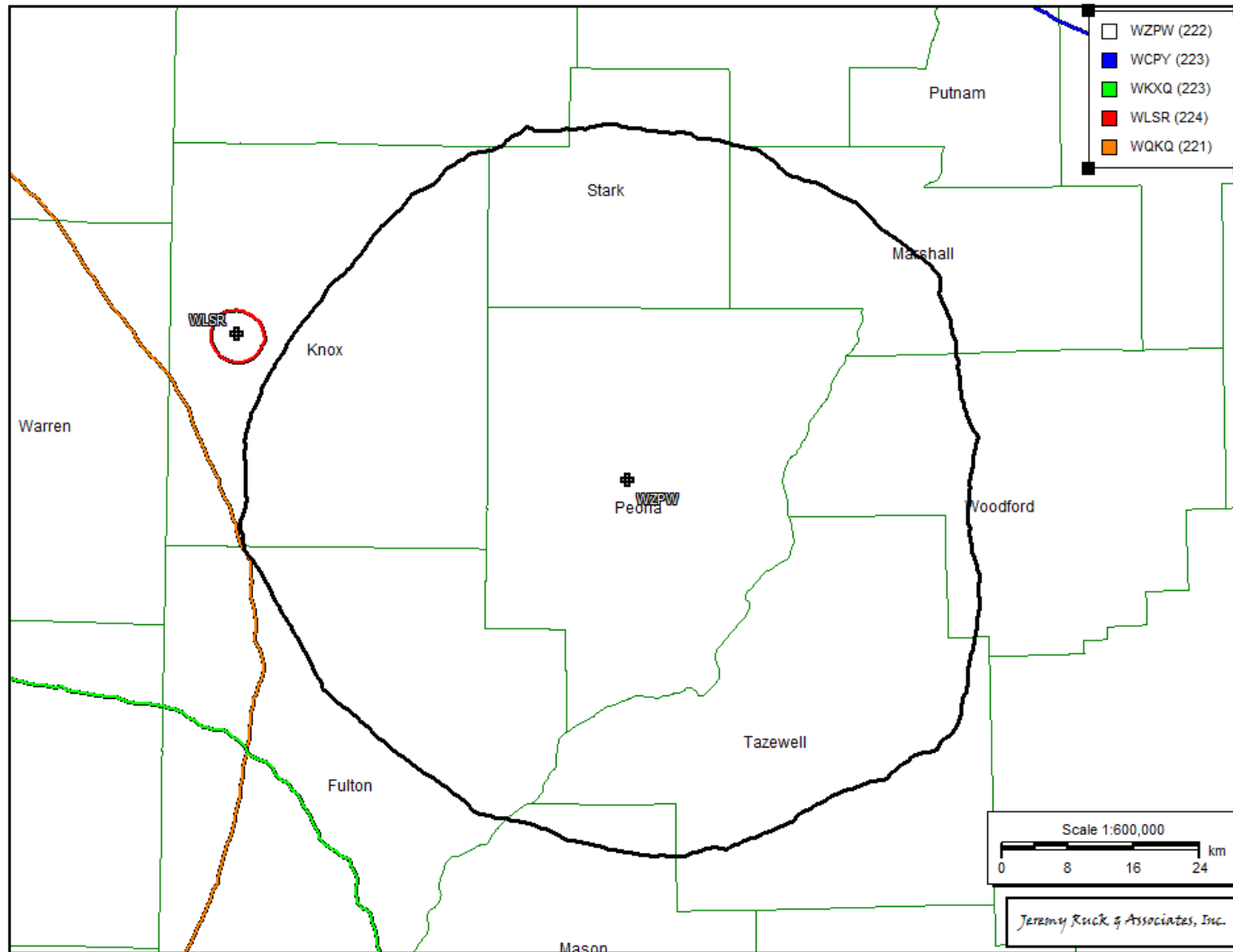
FM Interference



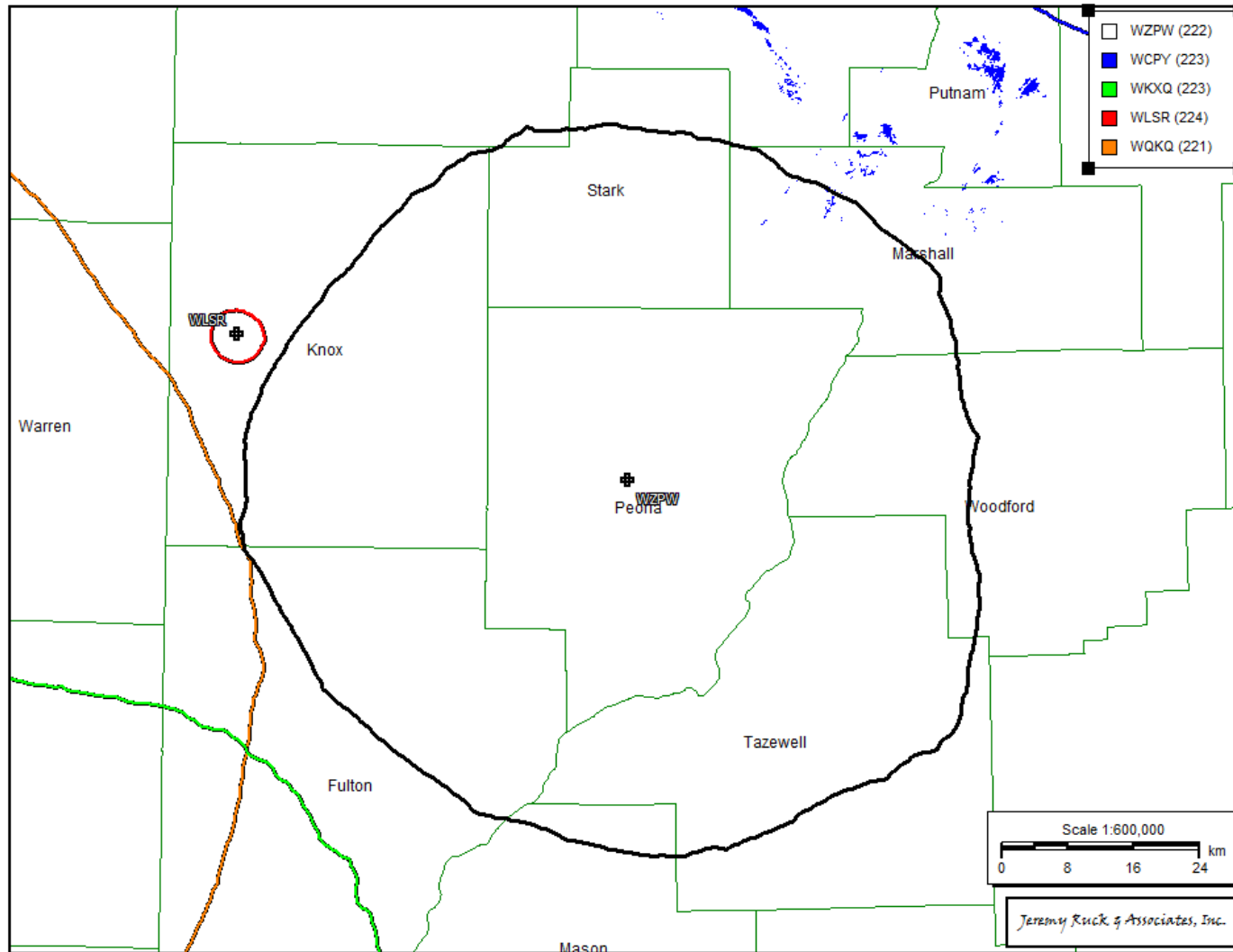
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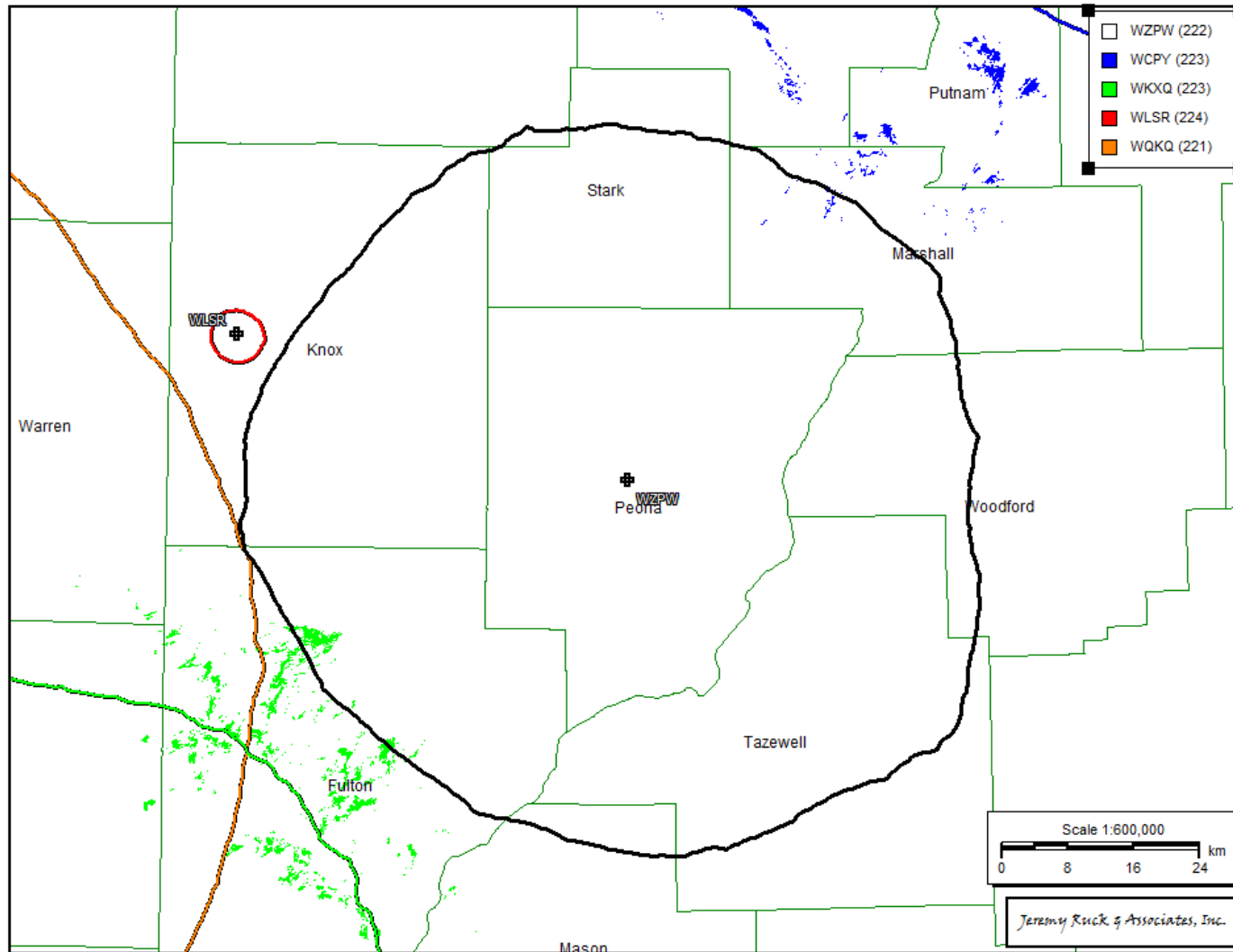
FM Interference



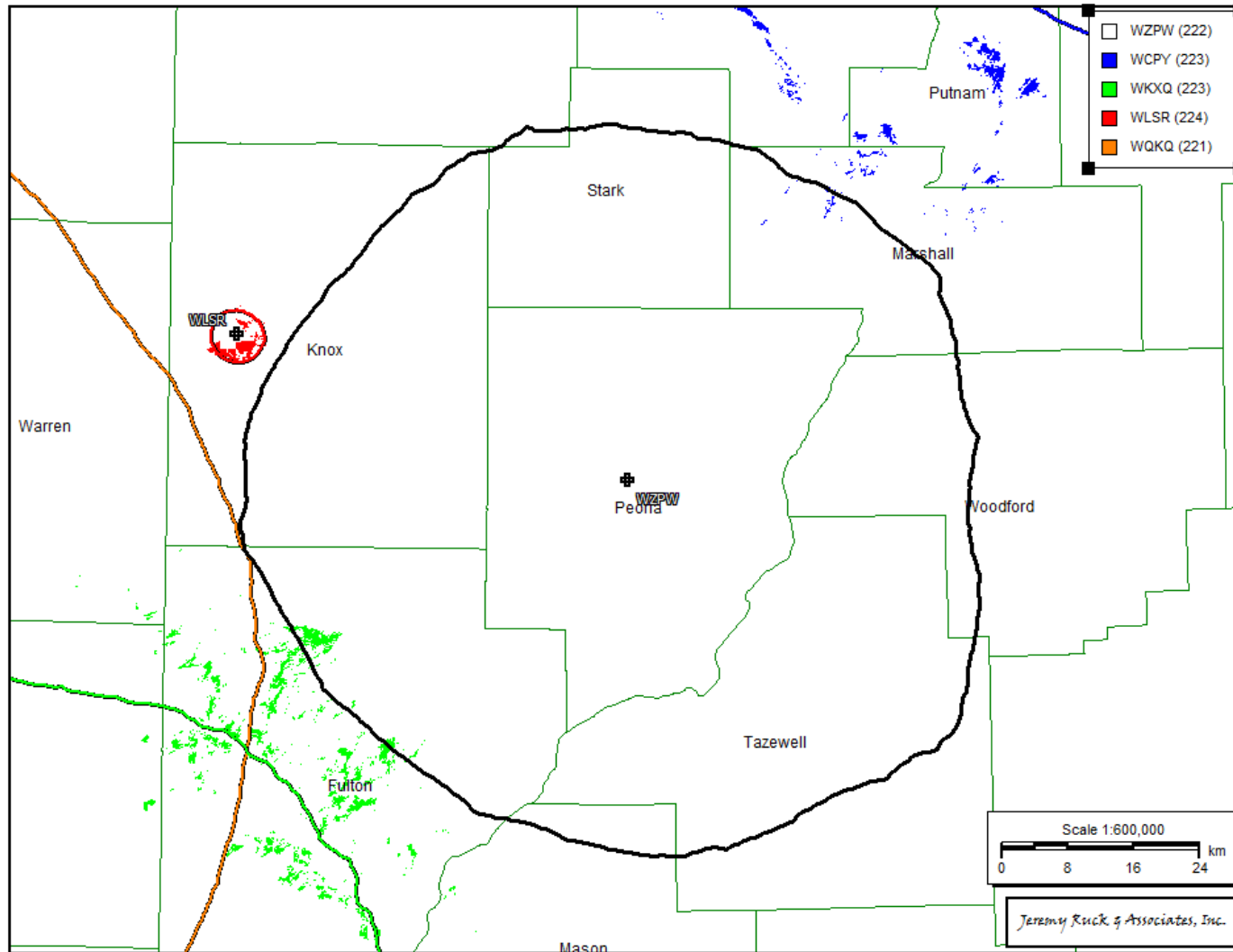
FM Interference



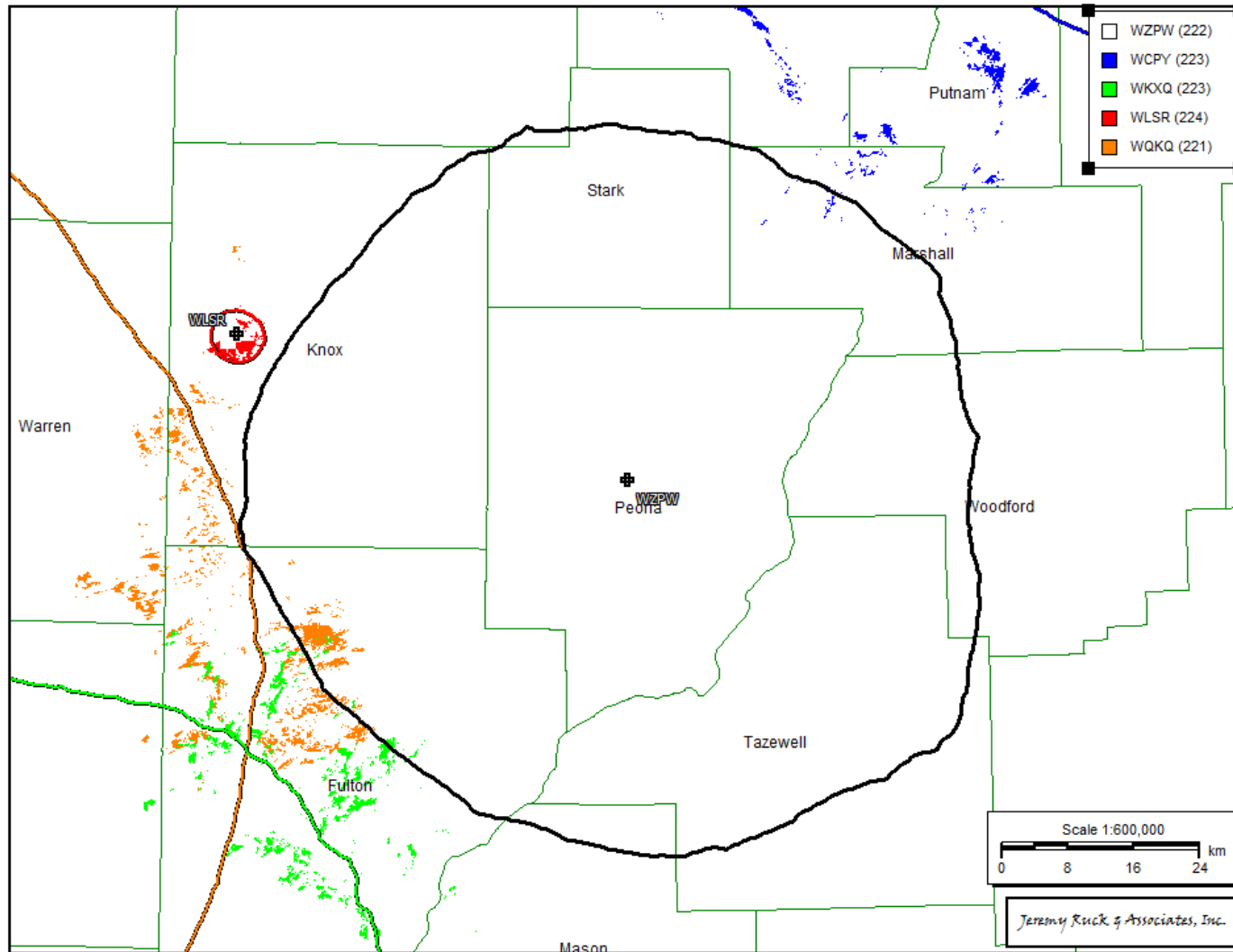
FM Interference



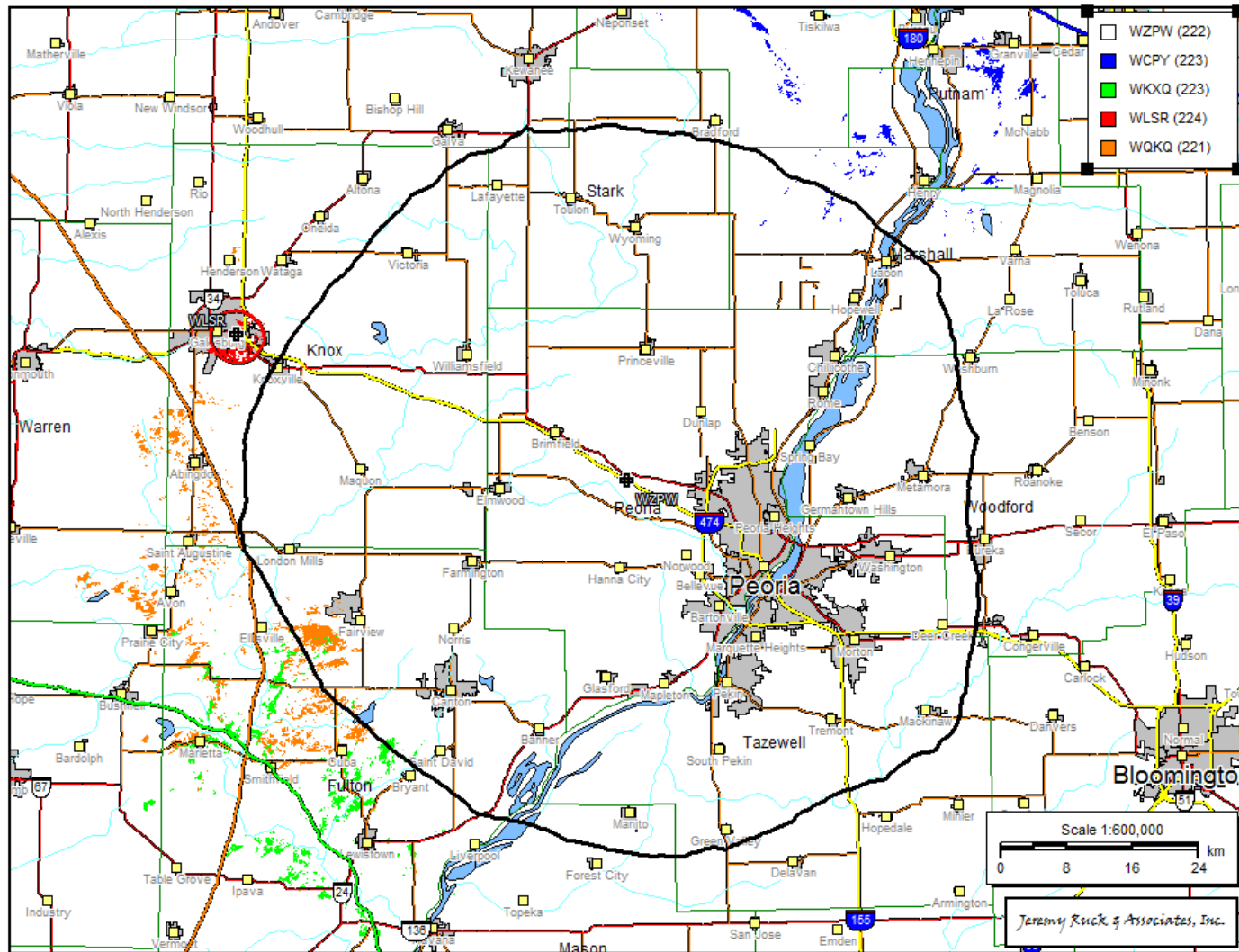
FM Interference



FM Interference



FM Interference



FM Interference

- Translators have gained a renewed interest.
- Extra caution is required when acquiring translators.
- Translators are secondary service.
- Prediction of interference given latitude before FCC.
- Translators are always at fault in causing interference to full-power stations.
- “Grantability” vs. Survivability.
- Review any proposed translator facility carefully to evaluate interference.
- Contours alone are insufficient.

FM Interference

W276BH - Tabular Allocation Study
WBA Presentation October, 2012

REFERENCE: 35 09 16.0 N.
89 49 20.0 W.

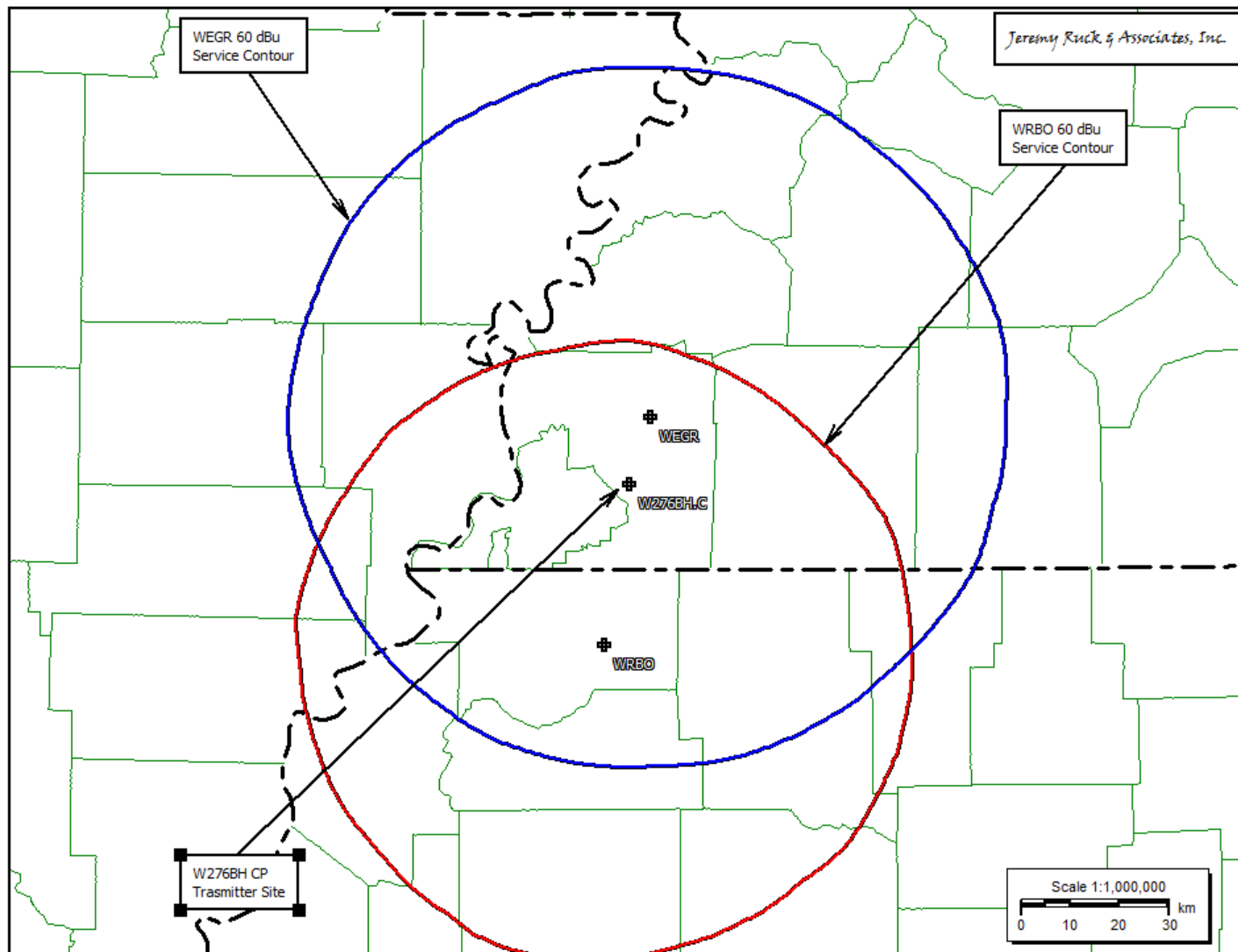
CH **276D** - 103.1 MHz, Pwr= 0.25 kW DA, HAAT= 0.0 M, COR= 403 M
Average Protected F(50-50)= 7.09 km
Standard Directional

DISPLAY DATES
DATA 10-03-12
SEARCH 10-07-12

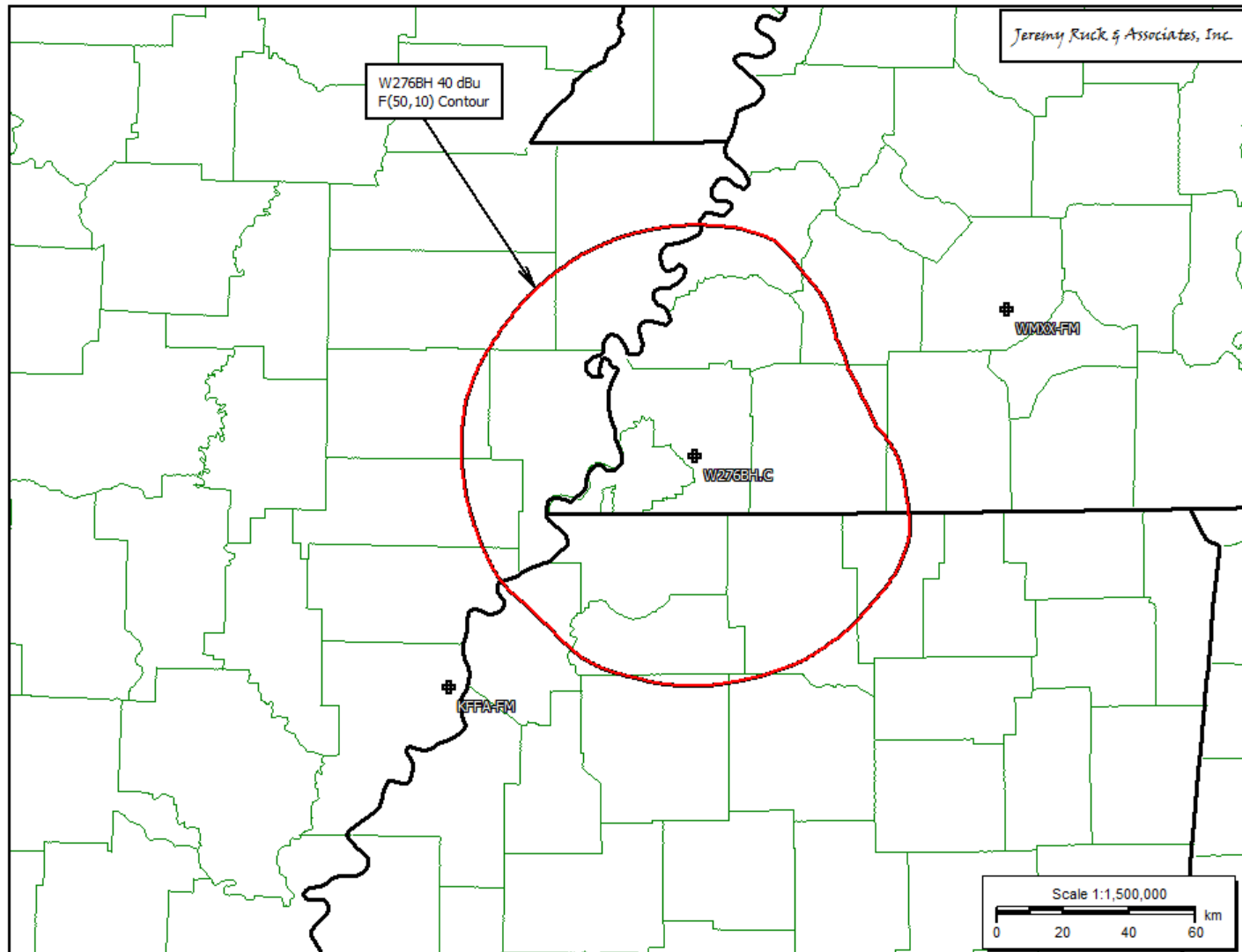
CH CITY	CALL	TYPE STATE	ANT AZI --	DIST FILE #	LAT LNG	PWR(kw) HAAT(M)	INT(km) COR(M)	PRO(km) LICENSEE	*IN* (Overlap in km)	*OUT*
276D Memphis	W276BH	CP DC TN	0.0 0.0	0.00 BPFT20111222AXO	35 09 16.0 89 49 20.0	0.250	69.7 403	23.2 Radio Power, Inc.	-92.9*	-92.9*
274C1 Arlington	WEGR	LIC_CX TN	16.8 196.9	14.10 BLH20061114ACK	35 16 33.0 89 46 38.0	100.000 287	9.9 379	71.3 Cc Licenses, Llc	-18.9*	-58.3*
276C2 Jackson	WDDX-FM	LIC_C TN	64.9 245.5	103.28 BLH20040315AAU	35 32 39.0 88 47 18.0	42.000 164	132.9 296	48.7 Gerald W. Hunt	-46.9*	1.1
276D Byhalia	W276BH	LIC_V MS	151.7 331.8	29.59 BLFT20111012ABU	34 55 12.0 89 40 06.0	0.250	23.8 90	7.1 Radio Power, Inc.	-17.1	-46.5
278C1 Cone	WRBO	LIC_CN MS	189.0 8.9	32.88 BLH19980617KC	34 51 44.0 89 52 42.0	100.000 179	7.7 275	61.4 Radio License Holding Cbc,	2.3	-29.6*
276C3 Helena	KFFA-FM	LIC_WN AR	226.8 46.4	101.41 BLH19940902KGG	34 31 39.0 90 37 46.0	13.000 97	98.7 152	32.8 Delta Broadcasting, Inc.	-19.7	1.0
275D Wynne	K221FN	CP_C AR	277.6 97.0	89.24 BMPFT20110513ADY	35 15 22.0 90 47 48.0	0.250	19.5 177	13.0 East Arkansas Broadcasters	46.3	40.9

Terrain database is NED 03 SEC , R= 73.215 qualifying spacings or FCC minimum Spacings in KM, M= Margin in KM
In & Out distances between contours are shown at closest points. Reference zone= East Zone, Co to 3rd adjacent.
All separation margins (if shown) include rounding
Ant Column: (D= DA Standard, Z= DA 73.215, N= Not DA 73.215, _= Omni), Polarization (C,H,V,E), Beamtilt(Y,N,X)
**affixed to 'IN' or 'OUT' values = site inside protected contour.

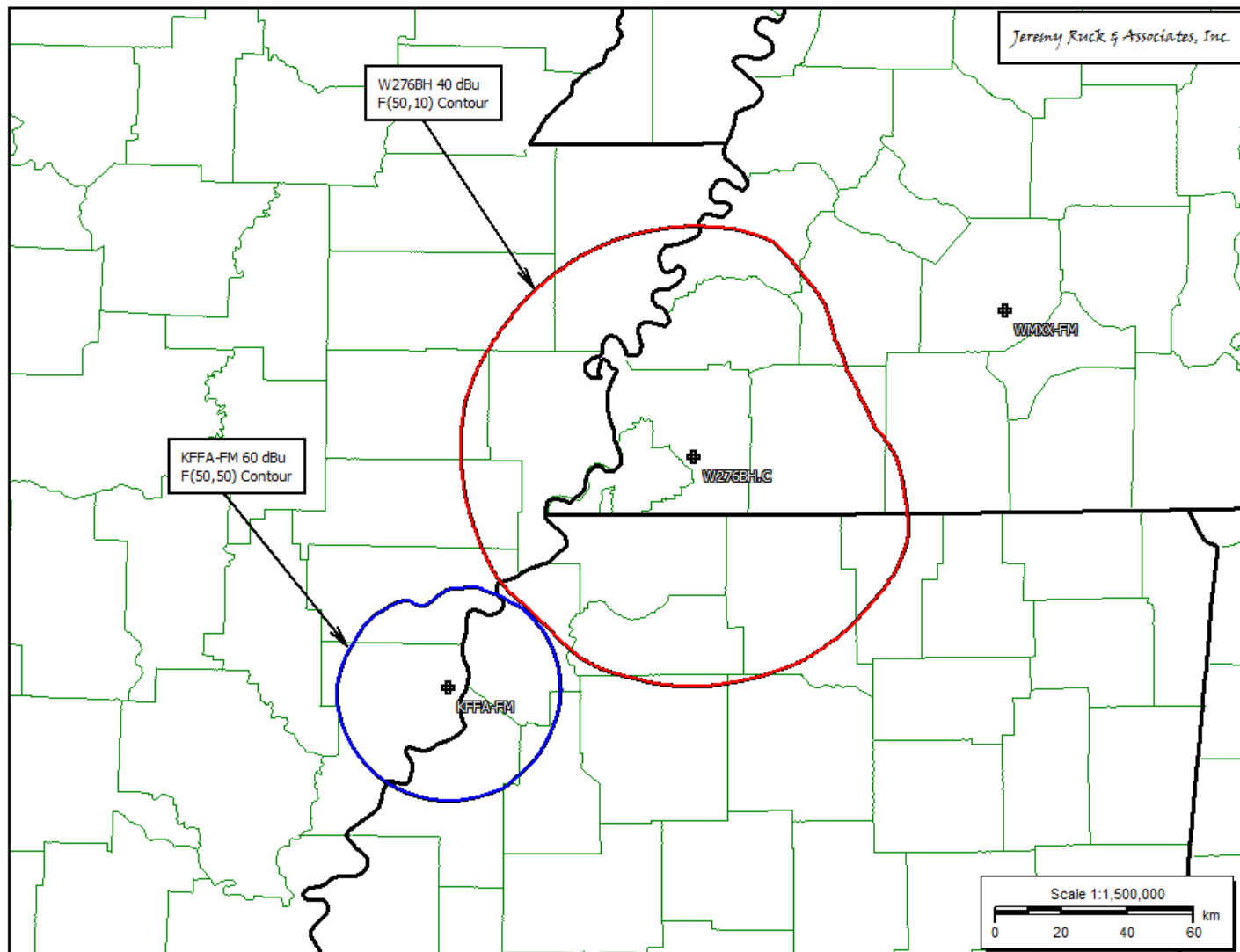
FM Interference



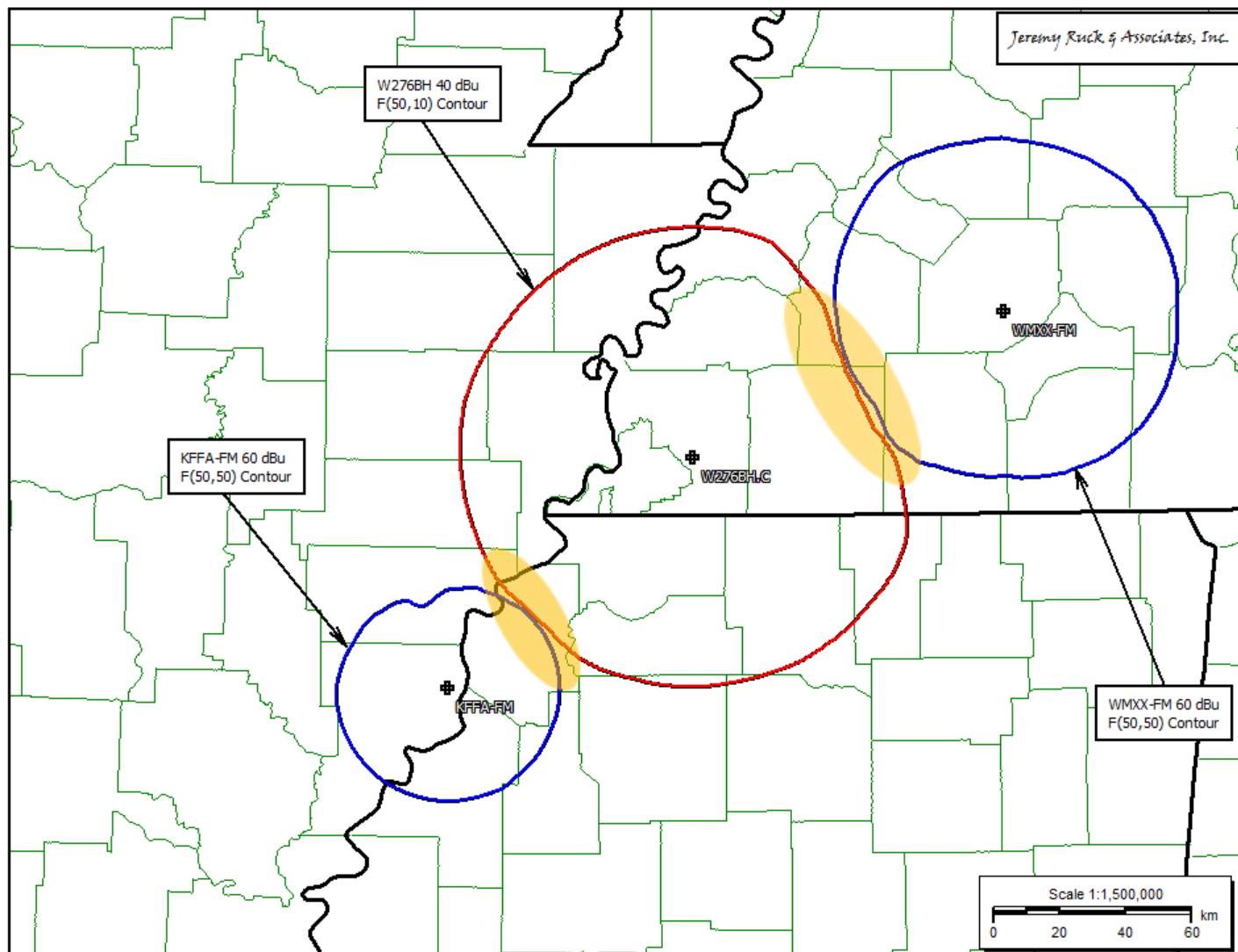
FM Interference



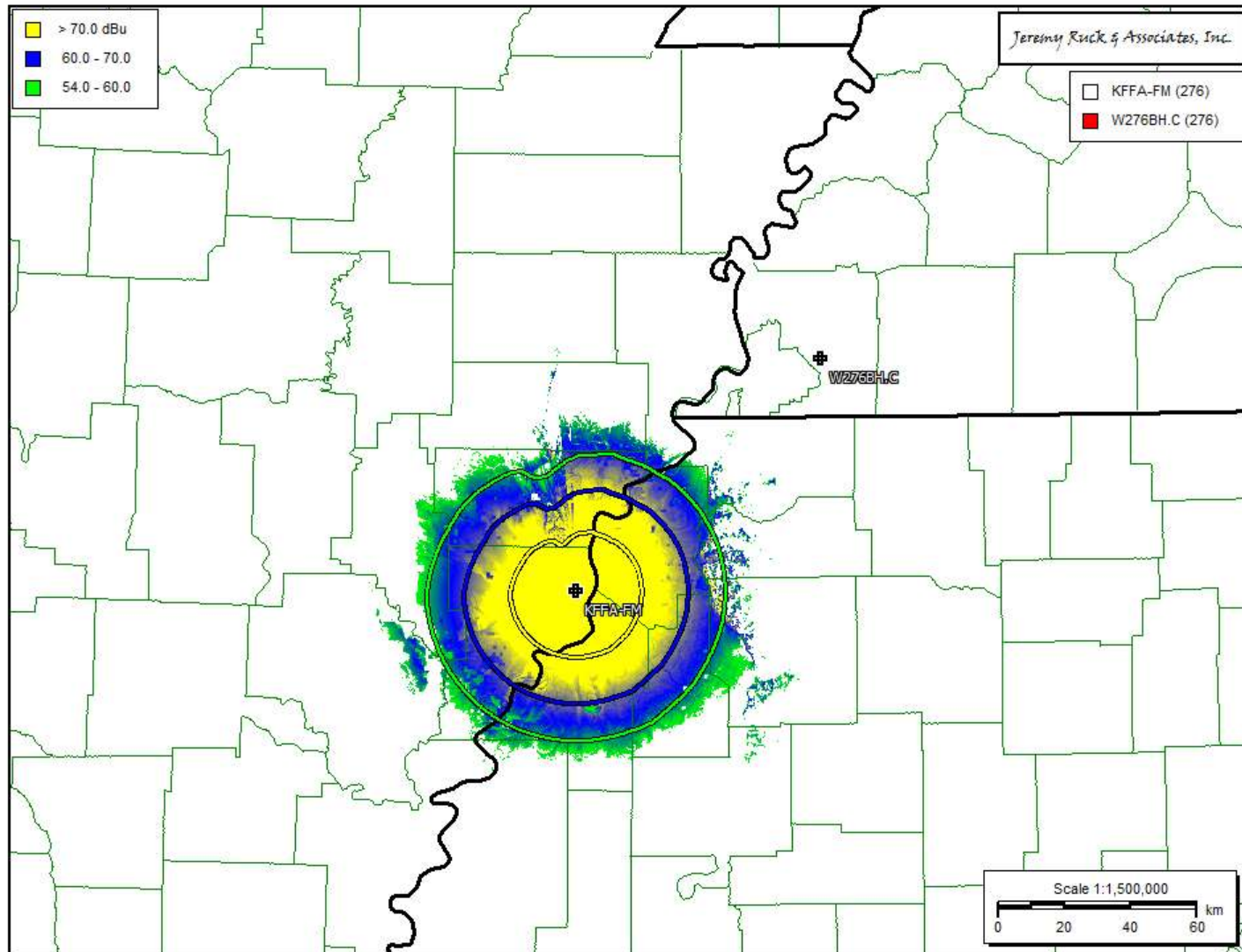
FM Interference



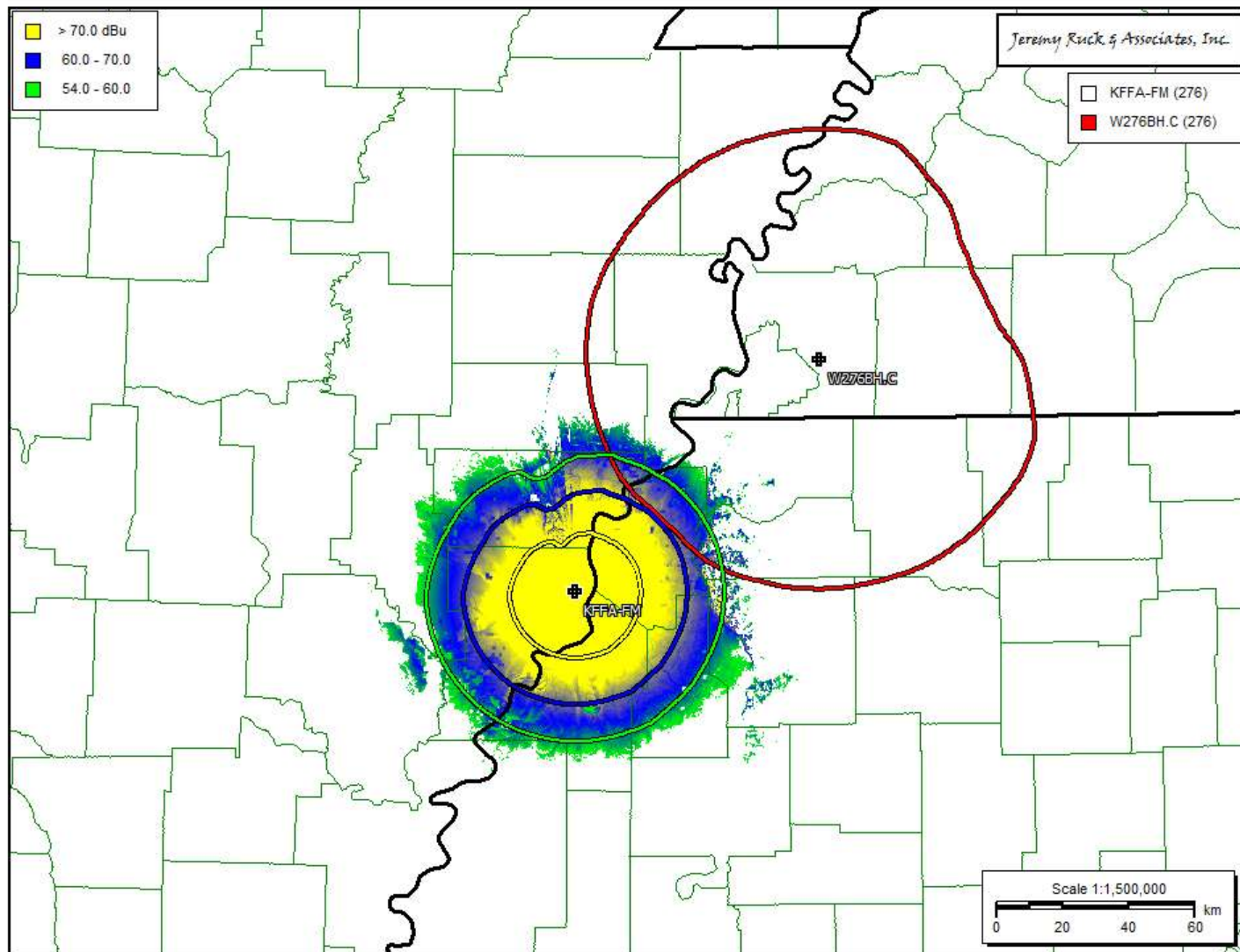
FM Interference



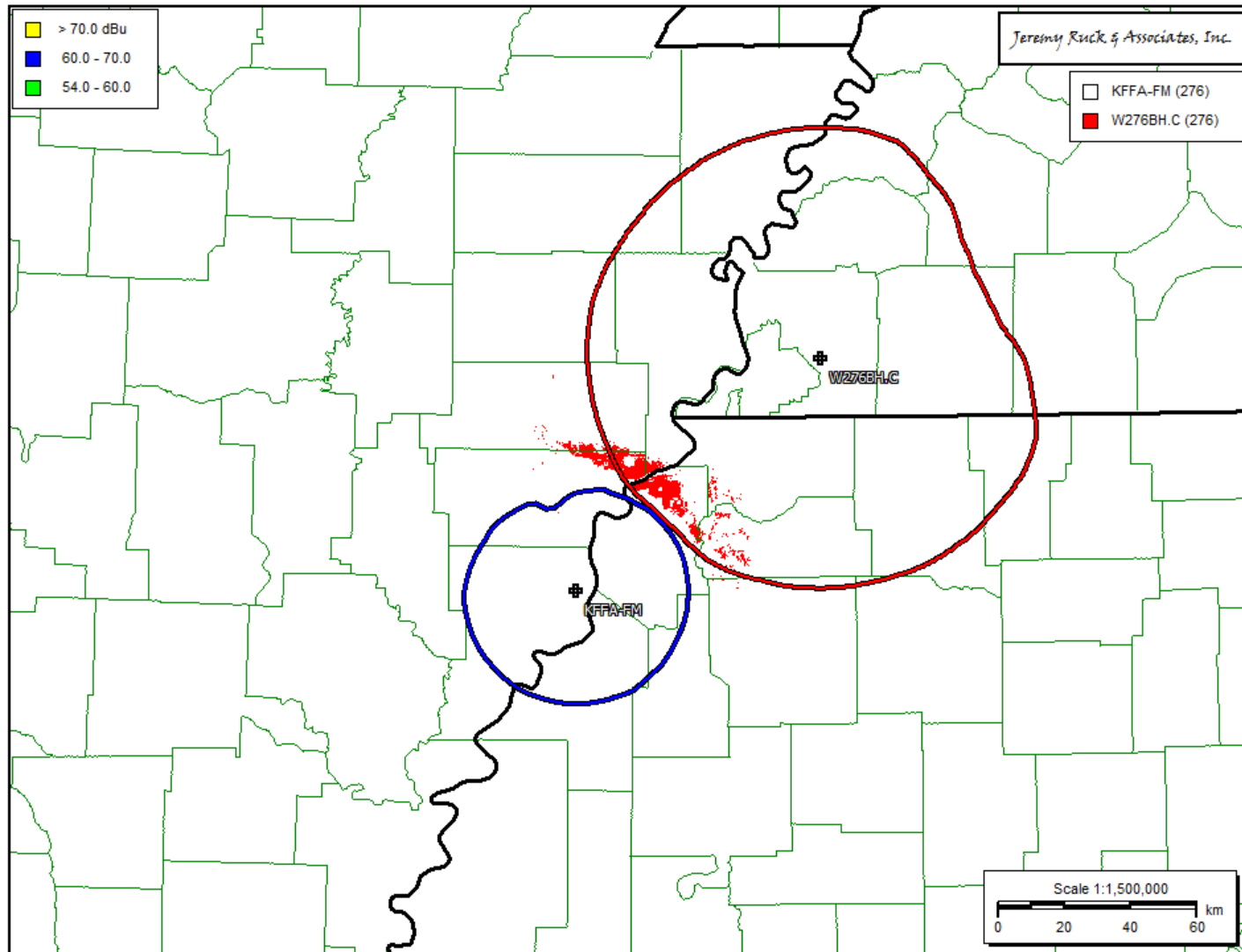
FM Interference



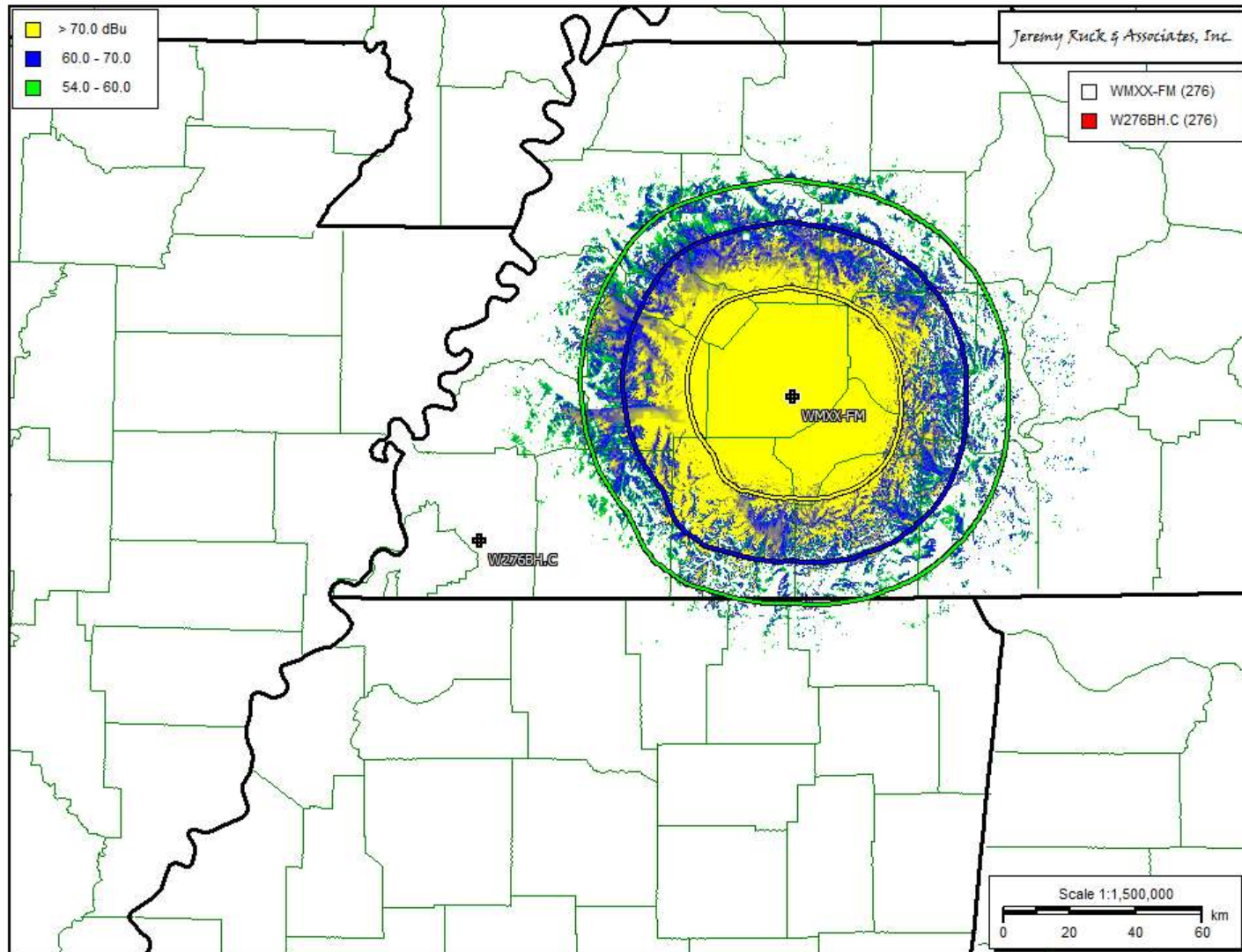
FM Interference



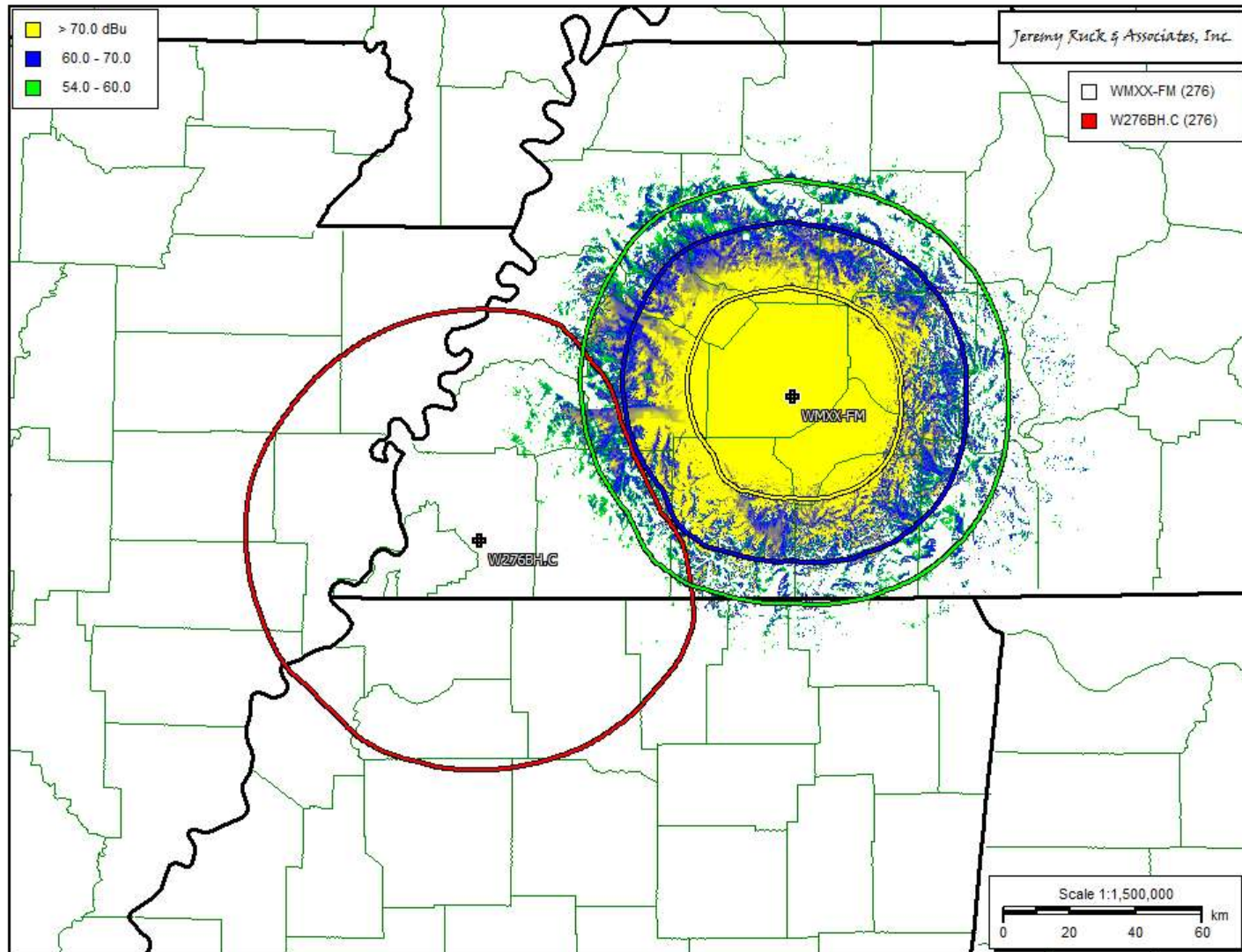
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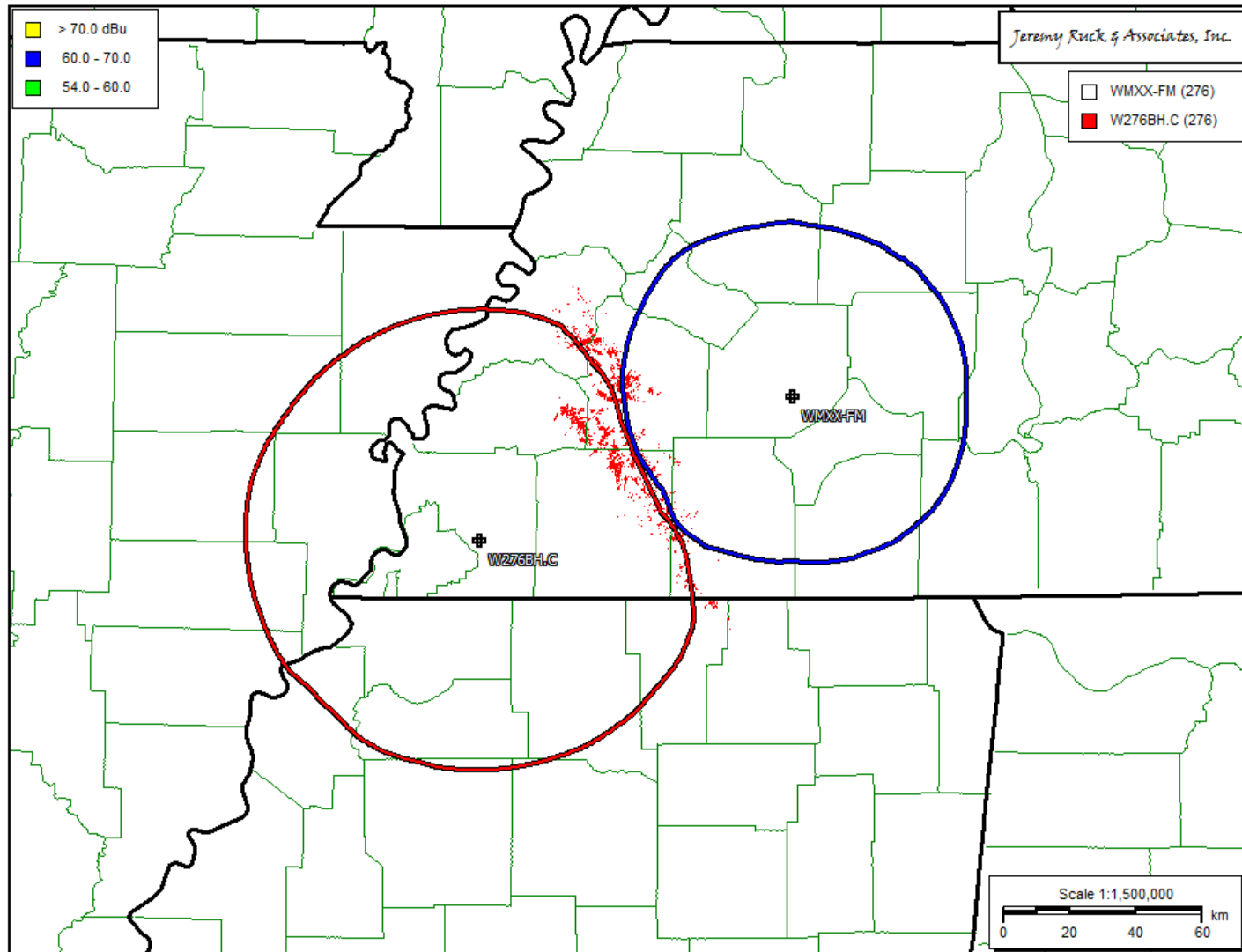
FM Interference



FM Interference



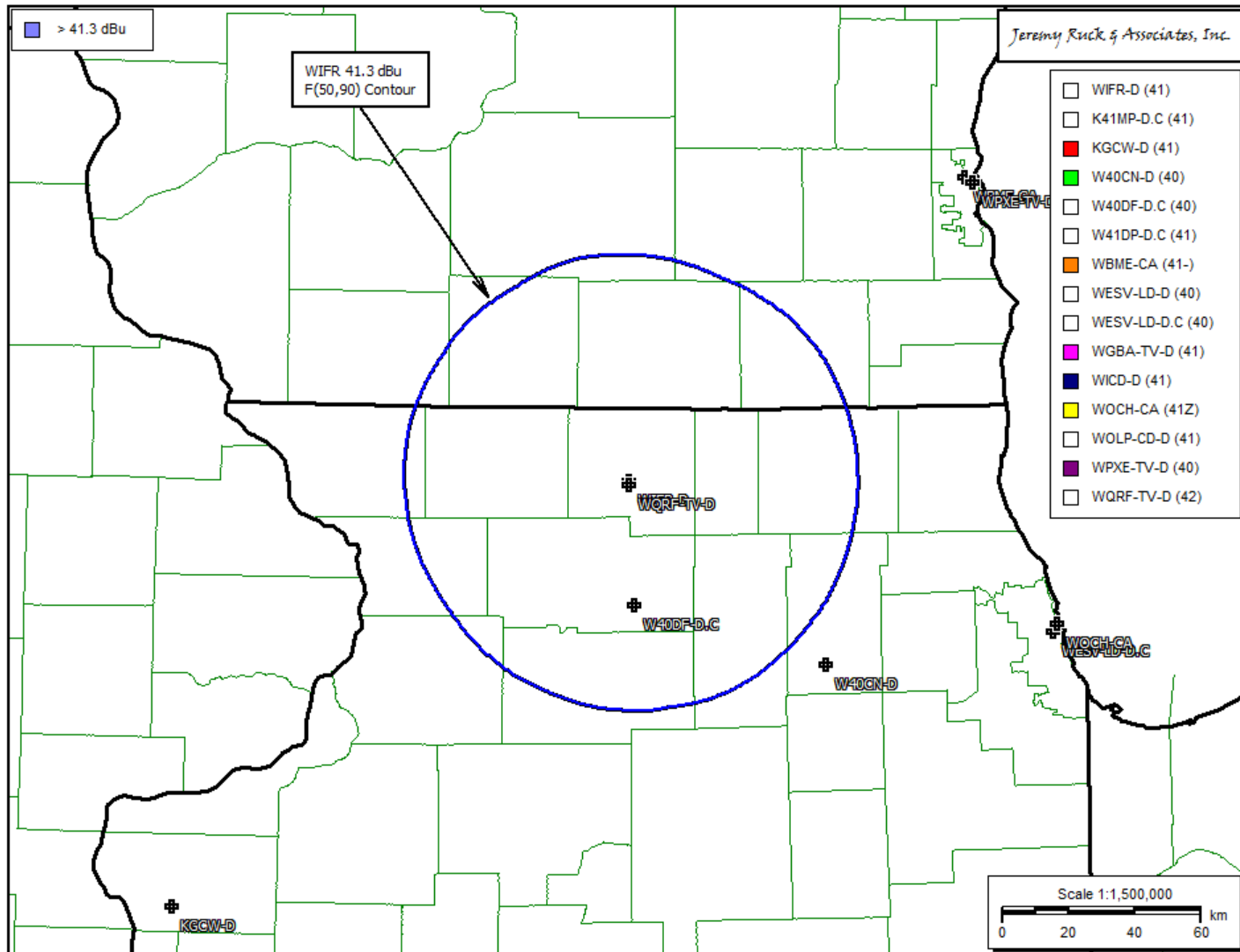
FM Interference



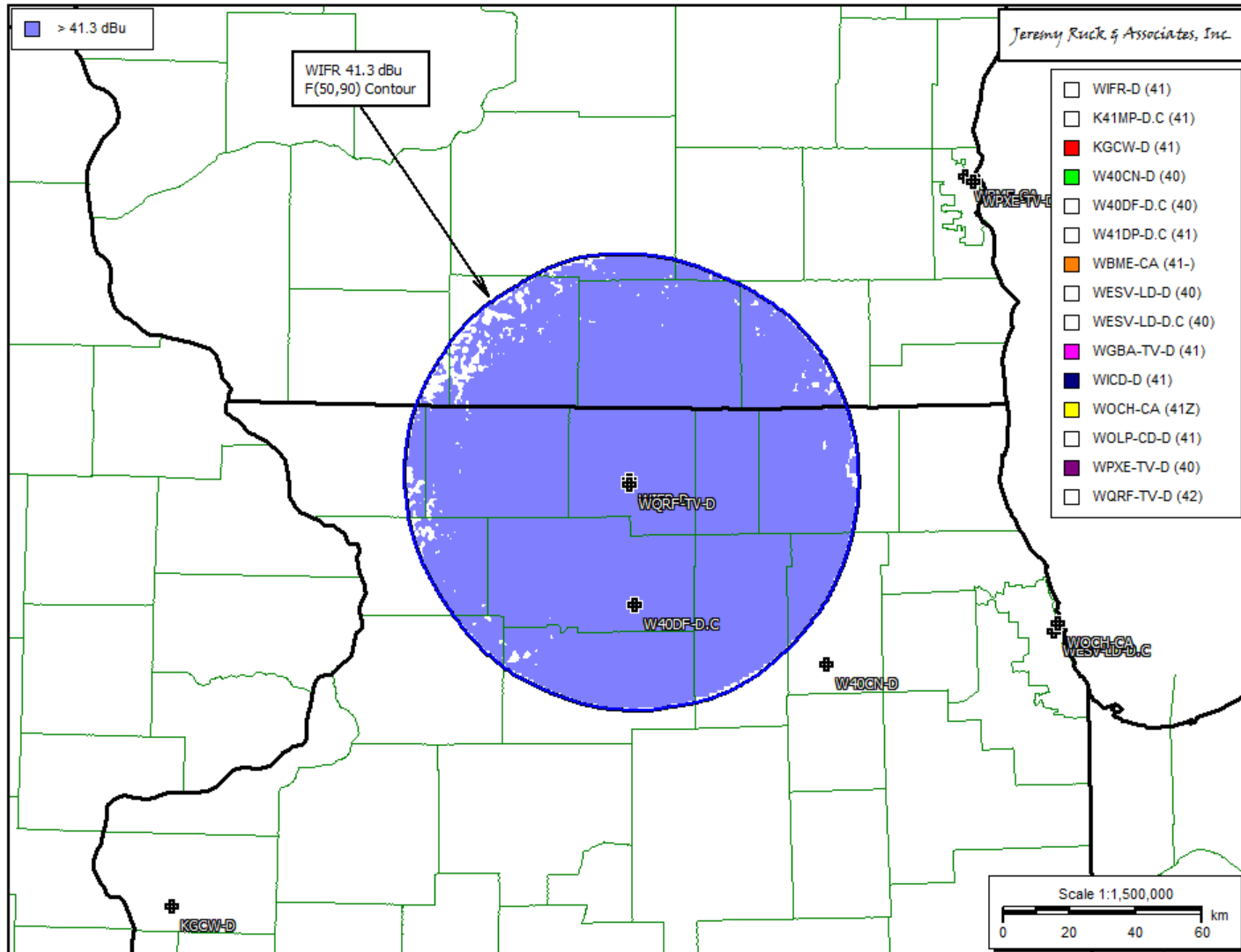
DTV Interference

- DTV interference specifically uses Longley-Rice.
- Service area begins with noise limited contour.
- Values are 28, 36, and 41 dBu F(50,90).
- This contour is intended to replicate old Grade B.
- Includes location where field strength exceeds value.
- Service considered “available” if location is interference free.
- Note that this definition tends to truncate usable area.
- Empirical data confirms this fact.

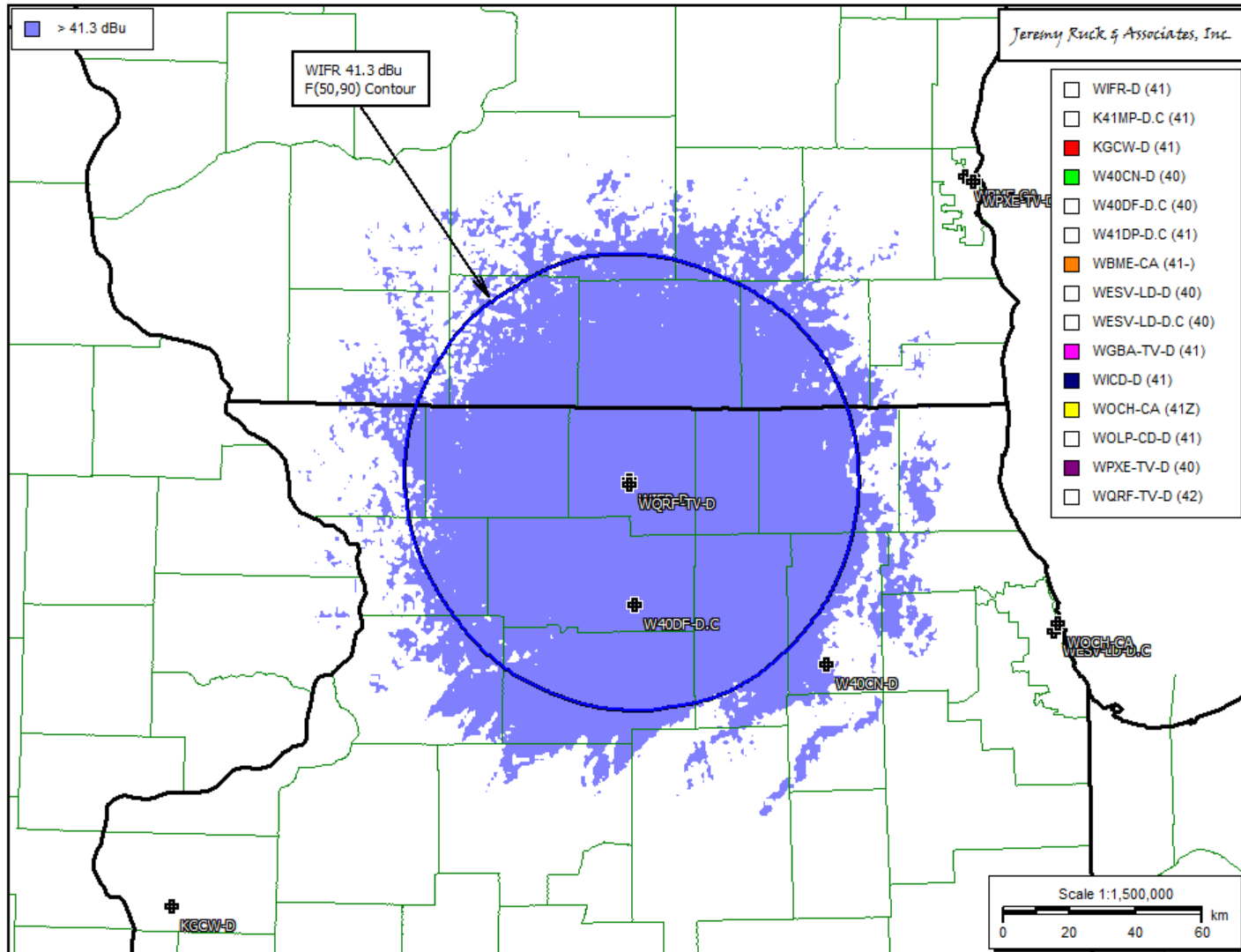
DTV Interference



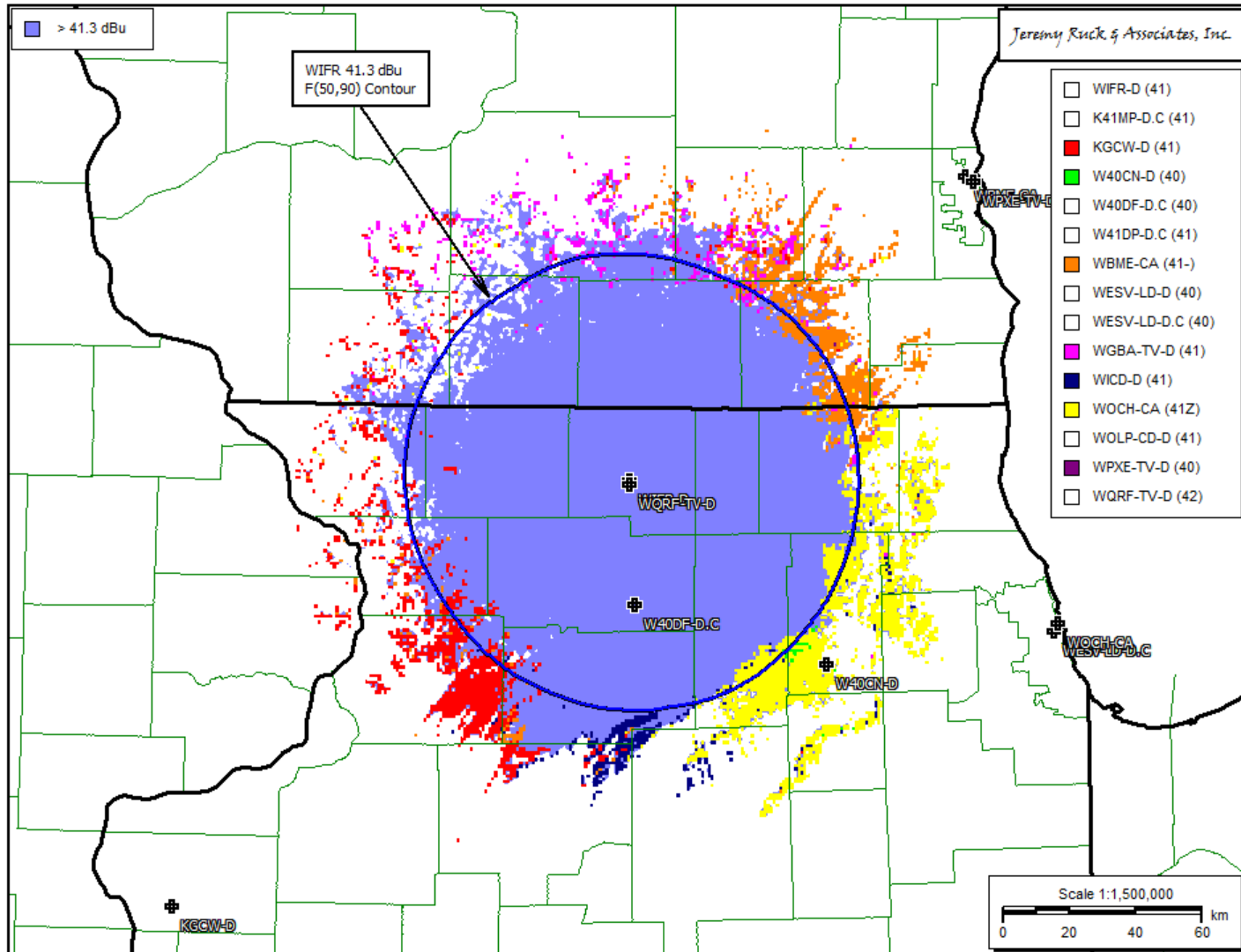
DTV Interference



DTV Interference



DTV Interference



Microwave Interference

- STL and ICR bands are congested.
- Coordination is required for applications.
- Self coordination can be performed.
- Always design for most robust fade margin.
- 6 dB loss functions as doubling path length.
- Digital links can be a double edged sword.
- Squatters.
- Temperature inversions.
- Troposphere ducting.
- Spatial diversity.

Final Thoughts and Questions...