

TV White Spaces

(TVWS)

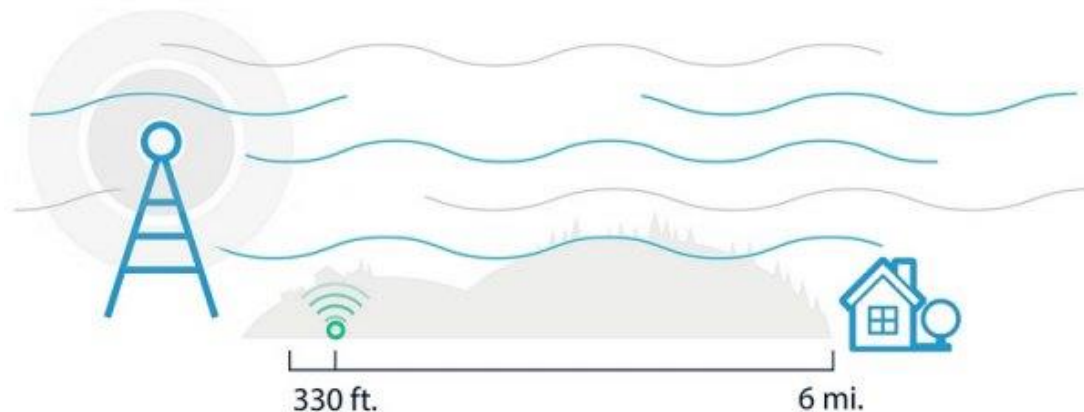
Wireless Internet Solutions

TVWS Low Frequency Signals

Travel Long distances

+

Non-Line-of-Sight Connectivity



PENETRATES
TREES



CONNECTS
OVER HILLS

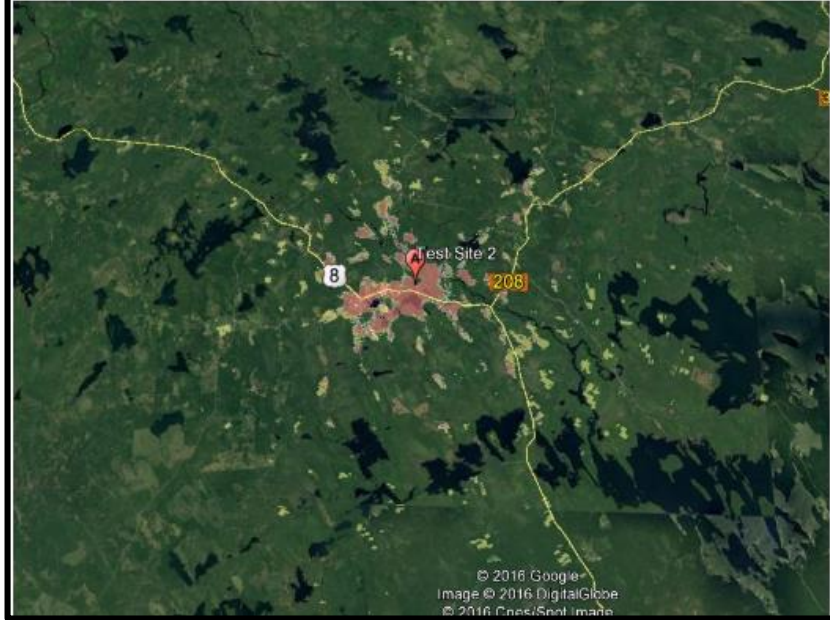


MOUNT CPEs ON ROOFTOPS
OR OTHER STRUCTURES

TVWS provides Internet service for hard-to-reach areas. It achieves connectivity where other unlicensed spectrum frequencies can't.

Unlicensed Spectrum: Lower Frequency = More Coverage

25 dBi Antenna Gain 3.65Ghz



CBRS 3.65 GHz
Data Base Administered

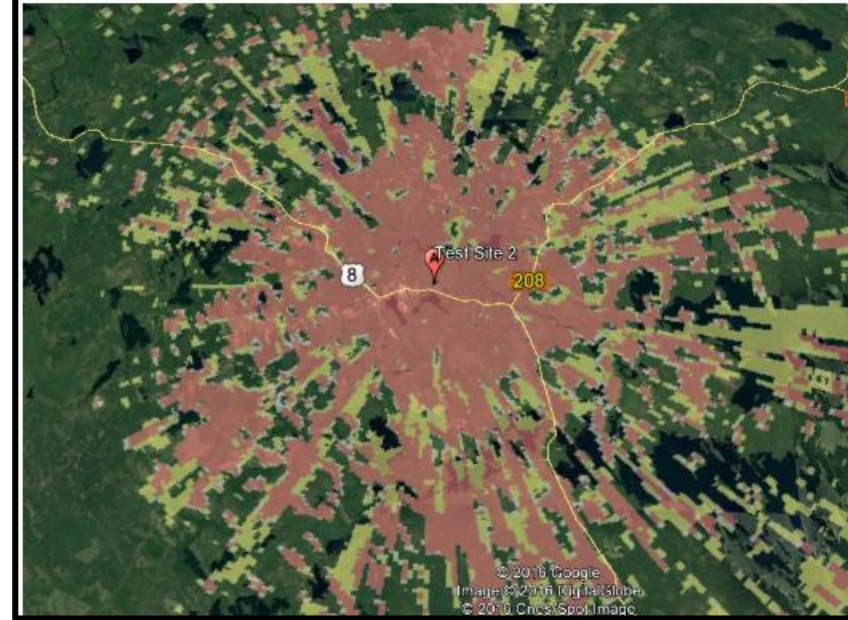
11dBi Antenna Gain 900Mhz



900 MHz
No Administration

Location: Nova Scotia, Canada

11 dBi Antenna Gain, TVWS 497Mhz



TVWS 470-608 MHz
Data Base Administered

<http://queenstvws.com/TVWS%20Coverage%20New.htm>

TVWS Field Performance is Affected by Variables

1. TVWS SPECTRUM AVAILABILITY IS A LOCATION-SPECIFIC RESOURCE. Many areas have little or no TVWS resources.
2. Amount of ambient “noise” or unintentional interference in an area from nearby wireless spectrum usage.
3. Area non-line-of-sight (NLOS) vs. line-of-sight (LOS) terrain challenges relative to vertical asset availability.
4. 6Harmonics TVWS radios are specialized for quality performance critical to maximize the spectrum opportunity.

TVWS GWS5000 Series

FCC Certified 5th Generation Version for 2020

- 6Harmonics since 2010 - Ottawa, Ontario based
- Highest FCC certified power for 4 Channel bonding
- Power increases built in when/if rules permit
- Wi-Fi protocol – ideal for unlicensed use
- Throughput 4 Channel (UDP)
 - Max 100 / 100 Mbps MIMO-MIMO
 - Typical 95DL / 70UL MIMO-SISO
- Goodput 4 Channel (TCP/IP)
 - Max 75/75 Mbps MIMO-MIMO
 - Typical 65DL / 45UL MIMO-SISO
- 3 channels + MIMO >25 / 3 real world
- MIMO downlink / SISO uplink
- Conducted max 27.8dBm / SS with 4 contiguous channels



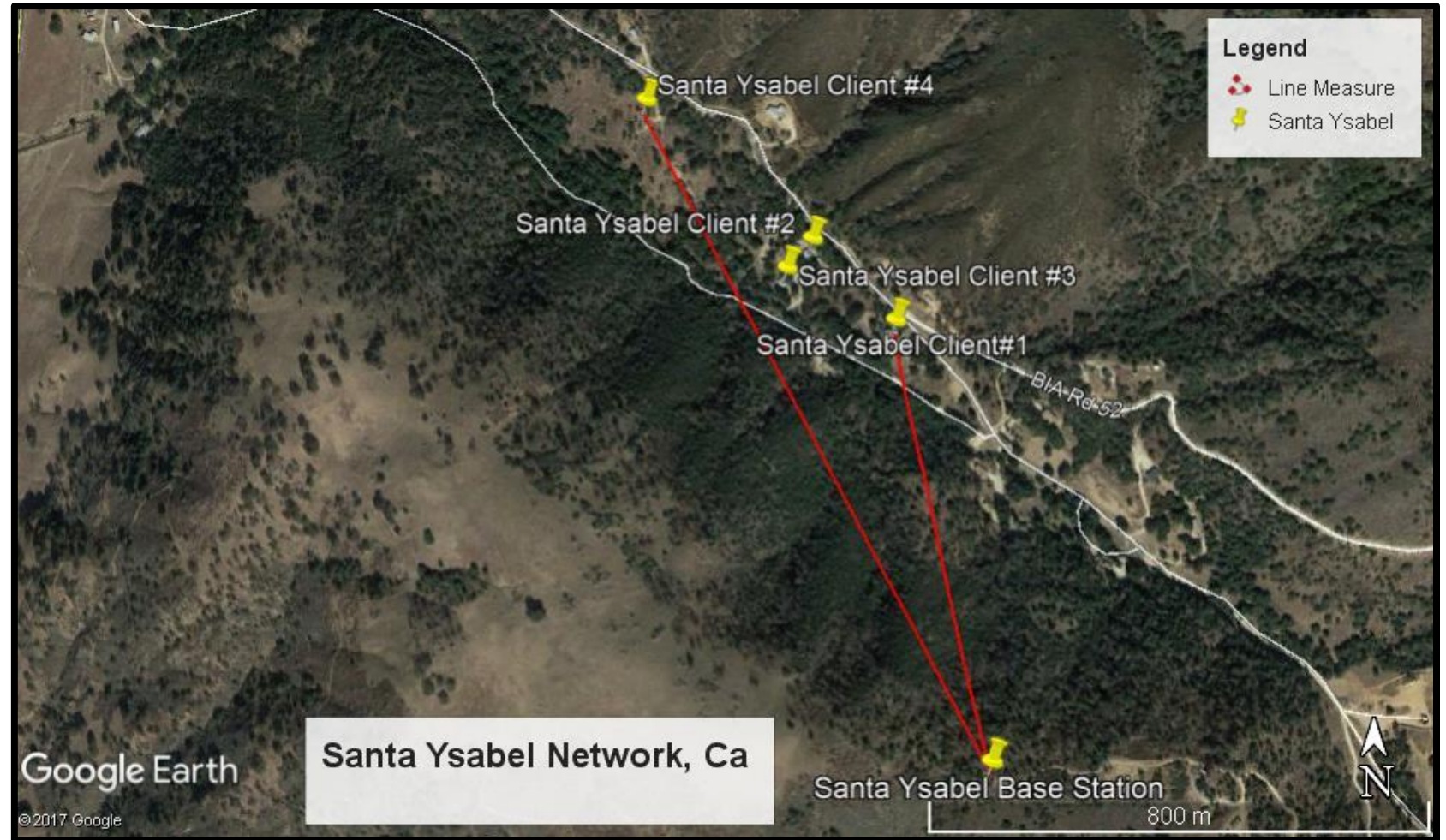
Hillman, Michigan

- 5 TVWS BTSs on a water tower
- Operating since Sept 2017
- Hybrid Unlicensed Network:
 - 5 GHz (LOS)
 - TVWS (NLOS)
 - TVWS service range: 500 yards to 6 miles
- Terrain:
 - Low hills
 - Dense trees including pine
 - 100' forest canopy
- Successfully co-located with:
 - FM radio
 - 156MHz public safety
 - 5GHz fixed access
 - 700MHz and 800MHz cellular



Santa Ysabel, CA

TOTAL NLOS: CPEs in a canyon, need to overcome large hill with small trees that separate BTS from CPEs. Range from 0.4 to 0.8 miles.



Carp, Ontario

Four (2 channel bonded) BTSs with 24 CPEs about .5 miles to 1.2 miles from BTS in heavily forested area. BTS and treeline 100 ft. high. Clients streaming Netflix and use online gaming since 2017. Expanding network to upgrade TVWS and include 5 GHz & 3.65 GHz radios.

