



Overview and Forward for the Assessment and Recommendations for Broadband Infrastructure In Custer County, Colorado

Prepared For
Custer County Economic Development Board

24 March 2017

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Overview

The Custer County Economic Development Corporation (CCEDC) desires to improve broadband availability and wireless service throughout Custer County. Because the County is rural and sparsely populated, commercial entities hesitate to invest capital to improve service due to low return on investment concerns. CCEDC wishes to proactively encourage expansion by providing the tower assets needed to serve all its constituents. Centerline Solutions performed a comprehensive study in three parts:

- Needs Assessment
- Site Selection and Modeling
- Cost Modeling

During the Needs Assessment Phase, Centerline undertook tasks to familiarize themselves with the current situation and needs in Custer County. We extensively drove the back roads looking for towers and residences. We also searched public and private databases for towers within the county. The existing Wireless Internet Service Providers were interviewed to understand their systems, needs and requirements. The commercial cellular carrier coverage was mapped within the county. All of this data gave us a strong understanding of the wireless picture in Custer County.

In the next phase of the project we modeled Line of Site (LOS) coverage from existing and proposed sites over address locations provided by the county. The objective was to find sites that covered a high number of addresses especially those addresses that had no coverage currently. Assumptions were made about the tower height, service distance of the equipment, subscriber antenna height and other variables. Sites were ranked based on overall coverage and new coverage. Centerline also modeled the connectivity of these sites to existing sites in the WISPS networks to ensure the site could be serviced with backhaul.

For the Cost Modeling Phase of the project we sent teams to evaluate the constructability of the most effective sites selected in the previous phase. Sites were evaluated for access, constructability and availability of commercial power. Along with those evaluations a cost estimate to develop and construct the sites was prepared based on the best available information. These cost estimates will be used to justify funding for the sites moving forward in future phases of the Broadband Improvement initiative.

Forward

The following pages represent the discovery of a micro economic climate in one county of Colorado and the subsequent analysis and recommendations that resulted. The overall goal is to improve the economic viability of Custer County through the improvement in what some are calling the fourth utility, broadband internet access.

Through the phases of this project we have had to make assumptions about a great many things and those are clearly stated in the appropriate sections. The overall implication of those assumptions and a common-sense observation is that things can change as we move forward. Property owners may decline, zoning may hinder and power companies may disagree, but this is common with developing any communications site. The measure of a successful team will be the ability of that team to adapt but keep their eye on the overall objective of covering the residents of Custer County with Broadband.

We may also encounter those who don't agree with the plan or cannot see the wisdom of improving the infrastructure in the county. To those people I encourage them to read the wealth of studies directly related to Custer County and for the general topic overall. Debate is healthy and welcome but should always be conducted in an open, positive and informed manner.

I believe the final measure of success will be twofold: The first, with the satisfaction of those that this project can bring broad band to and the second in the recognition that a public/private partnership can yield success to all parties involved. The first point is self-evident in that the end customer is happy. The second point is a little less obvious but just as important. The demonstration of success of the public/private partnership in stimulating growth in rural areas is paramount to the continued support for these projects statewide and nationwide.

Tab 1

Phase 1 Needs Analysis



Assessment of Current Broadband Infrastructure Custer County, Colorado

Prepared For
Custer County Economic Development Board

23 November 2016

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Executive Summary

The Custer County Economic Development Corporation (CCEDC) desires to improve broadband availability and wireless service throughout Custer County. Because the County is rural and sparsely populated, commercial entities hesitate to invest capital to improve service due to low return on investment concerns. CCEDC wishes to proactively encourage expansion by providing the tower assets needed to serve all its constituents. To that end Centerline Solutions is providing in this report of the feasibility study the following results:

- Interview Broadband ISPs
- Map Existing Towers
- Drive Test Cellular
- Identify Potential Sites

The broadband Wireless Internet Service Providers (WISPs) were interviewed and provided information about their systems. This information included current site locations, future site requirements and technical specifications. The areas of interest for the two current providers are:

- Jose Flats,
- Rosita,
- Oak Creek,
- Galena
- Centennial,
- San Isabel
- Verdemont Tower

The current tower assets were mapped for the county and included FAA/FCC registered towers, locations provided by the WISPs and sites located using satellite imagery. A map has been provided the body of this report and a KML file will be provided of all locations.

The cellular drive test confirmed that only two providers currently have coverage in the county; AT&T and Verizon. Coverage is limited to the valley area for the most part with some spill over into the foothills. Verizon is heavily shadowed in the Westcliff and Silver Cliff townships.

Centerline made three visits the Custer County examining locations that had towers already and potential areas for towers. These site visits confirmed some of the selected sites and refuted other sites as infeasible and allowed us to identify alternates. A map of the selected sites is provided in the body of this report as well as a table with physical coordinates.

The address maps we have created using county provided data have provided great insight into where the population is clustered in the county. The central valley contains by far the largest amount of the resident population with the two towns being the densest. Outside of those areas the Rosita and Centennial areas along with the areas along county road 255 going north out of Silver Cliff show the highest density

Centerline has evaluated the wireless broadband infrastructure in Custer County using input from the providers and other wireless asset location databases. Relatively few tower locations exist currently that would provide line of sight coverage to a large number of addresses within Custer County. An exception to that is the number of sites used by SECOM who has aggressively deployed sites in the county. The only drawback to SECOMs deployment is their relative height above terrain, which does not exceed twenty feet.

Commercial wireless service in the county is fair for a rural area, but could be greatly improved. The two major carriers each have a site in the county, but both sites are located well away from population centers and only provide service in the central valley area of the county. Additional sites located in outlying population clusters will be attractive to carriers if there is a low cost of entry and demonstrated population coverage.

The data gathered during this phase has shed a great deal of light on the current state of broadband in Custer County. It has provided us with the data to move forward and model sites that would be of the greatest benefit to the county and its residents in the future. The next phases of the project will provide the detail needed to seek funding for the most effective solution for the residents of Custer County.

Project Overview

The Custer County Economic Development Corporation (CCEDC) desires to improve broadband availability and wireless service throughout Custer County. Because the County is rural and sparsely populated, commercial entities hesitate to invest capital to improve service due to low return on investment concerns. CCEDC wishes to proactively encourage expansion by providing the tower assets needed to serve all its constituents.

Currently two Wireless Internet Service Providers (WISPs) are operating in Custer County, DD Wireless (recently acquired by SECOM) and Hilltop Wireless. Both providers were contacted via telephone and interviewed regarding their current systems and desired outcome from this project. Those interviews are summarized in the following report.

Two visits were made to the County so far that included a kickoff meeting and a comprehensive drive of the county. During the second visit all WISP sites and Centerline selected potential sites were mapped out and the drive included seeing as many of these as possible. The Centerline selected sites were based on possible locations that had good line of site (LOS) to addresses provided by the county.

Finally, during this phase, a drive test of commercial wireless coverage was completed with the results presented later in this report. As originally suspected, commercial wireless coverage in the county is poor and the drive data will provide ample talking points with the commercial carriers regarding improvement for the future.

Existing WISP Input

Summary of WISP requirements

Two WISPs who provide wireless services in the county were interviewed regarding their current systems. Each WISP was asked the following:

1. Is a coverage map available?
2. Can a detailed site list be provided?
3. What are your areas of desired coverage?
4. What is your link distance or maximum site distance assuming 25 mbps down?
5. What are your site requirements?
 - a. Power
 - b. Access
 - c. Backhaul

Some of the data supplied by the WISPs was requested to be considered as confidential and can not be disclosed in this report. Additional information provided in the interview is included here as well.

SECOM

Mr. Mike Sanders

Wireless Manager

Tel: 877-945-7873 (W); 719-371-7070 (M)

Email: mikes@secom.net

Coverage Map: SECOM did not have a coverage map

Site List: Provided KML file.

Desired areas of coverage: Verdemont Tower, Jose Flats, Rosita

Link Distance: 10-12 miles 5.8 GHz with panel

19 miles 5.8 GHz with dish

9 miles .35 GHz with panel

Site Requirements:

Power; Currently uses all solar or other renewable. Commercial power not a requirement.

Access: ATV minimum

Backhaul: Provide own microwave links

In addition, SECOM had concerns with co-location on towers specifically with elevated noise floors. In general, their sites were no more than 20 feet high for ease of maintenance and lower installation cost. SECOM is also concerned about cost of going on others towers and would have to feed that into their business model.

SECOM provides capacity to its distribution locations with unlicensed microwave and typically provides 200 mbps to each location. This capacity is aggregated at the Arlie tower on to a 1 Gbps backbone which is transported via multiple microwave hops to Walsenburg, Colorado where it is connected to fiber optic backhaul. In addition, SECOM provides a loop path to north which eventually terminates to fiber at Pueblo West.

Hilltop Broadband

Mr. Eric Ryplewski

Principal

Tel: 877-783-2889 (W)

Email: eric@hilltop-broadband.com

Coverage Map: Would have to dig to find one. Action item

Site List: Provided Site List (Not to be disclosed)

Desired Areas of Coverage: Rosita, Oak Creek, Galena, possible Centennial, consider San Isabel.

Link Budget: 4-6 miles LOS for 25 mbps down.

Site Requirements:

Power: Prefer commercial, good solar is expensive.

Access: ATV ok, Snowmobile OK. Prefer road.

Backhaul: Microwave to existing sites

Hilltop Wireless is supportive of the project but is concerned about costs to go on tower. This cost must fit within the business case for Hilltop to consider going on. Hilltop has provided a site list with details but has required that the list be kept confidential.

Hilltop indicated during the initial interview they indicated that they bring all sites to 410 Main Street and use CenturyLink for middle mile connectivity out of the valley.

Mapping Existing Towers

Existing tower data was mapped from several sources. The FCC/FAA database provided information on towers that were registered with the federal government. Centerline proprietary tower databases were also used for several commercial carriers. Finally, both wireless ISPs provided tower locations. Hilltop Wireless stipulated that their tower locations not be made public but have been used in the overall evaluation of coverage for this project.

The map give below contains the towers that were located within the county that have been allowed to be disclosed.

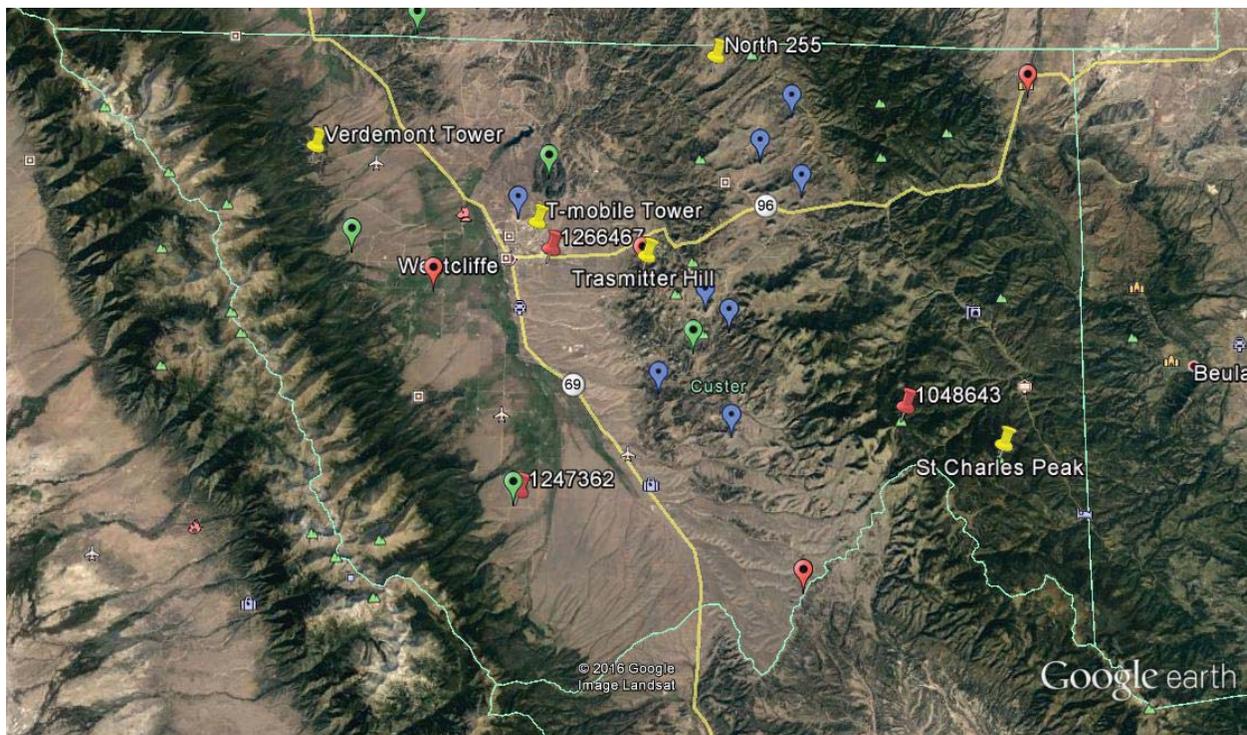


Figure 1 Towers Identified in Custer County

The legend for the map is as follows:

- Yellow push pins – Towers Identified by Centerline not in other data bases
- Red push pins – Towers Identified on FCC data base.

- Various colored balloons – SECOM DD Wireless provided sites

Centerline has visually verified many of these towers, while the rest were verified using satellite imagery. A Google Earth™ compatible file with these sites will be provided as an addendum to this report.

Target Areas

Centerline has examined potential target areas using terrain, satellite and population data. The approach was to first look at the county population/address distribution and then locate potential sites with coverage, power and access as qualifiers. A Line of Sight (LOS) coverage prediction program was used as a preliminary assessment tool to narrow down the number of candidates that will be used in the propagation study. WISP information was obtained after the initial assessment and surprisingly many of their existing locations coincided closely with some of those identified by Centerline. These existing sites used very low towers however, and current coverage from these locations by the WISP would be less than our initial assessment.

With all existing locations mapped, the county was toured and Centerline-selected target areas were assessed, existing WISP sites and potential new target sites. Table 1 is a list of sites that are candidates to provide new coverage or enhance existing coverage of addresses in Custer County.

| Site Name | Latitude | Longitude | Notes |
|-------------------------|-----------------|------------------|--|
| Junkins High Point | 38° 6'41.09"N | 105°17'37.73"W | Great Site for covering north Rosita |
| East of Domingo 2 | 38°11'25.61"N | 105°21'52.31"W | Small house on hill substitute for E of Domingo |
| East of Domingo | 38°11'44.52"N | 105°22'39.03"W | Lots of addresses. Two good spots |
| North 255 Unidentified | 38°14'36.10"N | 105°19'7.12"W | Also known as Mikes Secret Site sub for Durfee |
| Clay Tower/Bull | 38°10'52.27"N | 105°26'15.98"W | CL selected as well |
| Rosita Tower | 38° 6'14.73"N | 105°19'25.62"W | DD site but very low. Will move and raise site |
| Tom Tower | 38° 4'47.80"N | 105°19'59.38"W | CL selected site/DD-Secom |
| Horn Creek | 38° 3'9.95"N | 105°32'12.49"W | Cluster of addresses, high activity area |
| South Ranch | 38° 0'18.57"N | 105°17'29.49"W | Lots of addresses. Still north of Centennial tower |
| North 165 | 38° 6'17.65"N | 105° 7'23.99"W | Developed but low address. Difficult build |
| San Isabele | 38° 0'45.07"N | 105° 3'41.35"W | Backhaul is an issue |
| Beddows | 38°13'33.71"N | 105°32'19.13"W | Possible difficult land lord |
| Buck Mountain Potential | 38°14'24.48"N | 105°31'38.23"W | Alternate to Beddows/Difficult build |
| Hermit Basin | 38° 7'16.49"N | 105°35'16.56"W | Not Hilltop Site. On Ridge with addresses |
| Bullard Mtn | 38°12'56.95"N | 105°15'35.54"W | Good DD site. Need to go higher |
| Myron Mtn | 38°10'9.76"N | 105°15'12.04"W | Good DD site. Need to go higher |
| Transmitter Hill | 38°7'39.39"N | 105°22'10.83"W | Major Hub. For evaluation purpose |
| Water Tanks | 38° 8'19.56"N | 105°26'38.70"W | Coverage for both towns |
| Verdemont Tower | 38° 11' 50"N | 105°34'28"W | County Tower |
| Sperry Peak | 38° 5'35.63"N | 38° 5'35.63"N | Potential High Site |
| Centennial Tower | 37° 56' 42.52"N | 105° 15' 18.42"W | Long shot |

Table 1. Target Site List.

Once the sites are modeled the list can be prioritized either by total number of addresses covered or additional addresses covered based on assumptions for existing sites.

Cellular Drive Test

A drive test was performed October 31st 2016 to map coverage on the four major carriers in Custer County. Figure 2 shows the drive route that was used to map coverage in the county. Viera Wireless and Commnet Wireless were also driven but no significant coverage was found from either of those carriers.

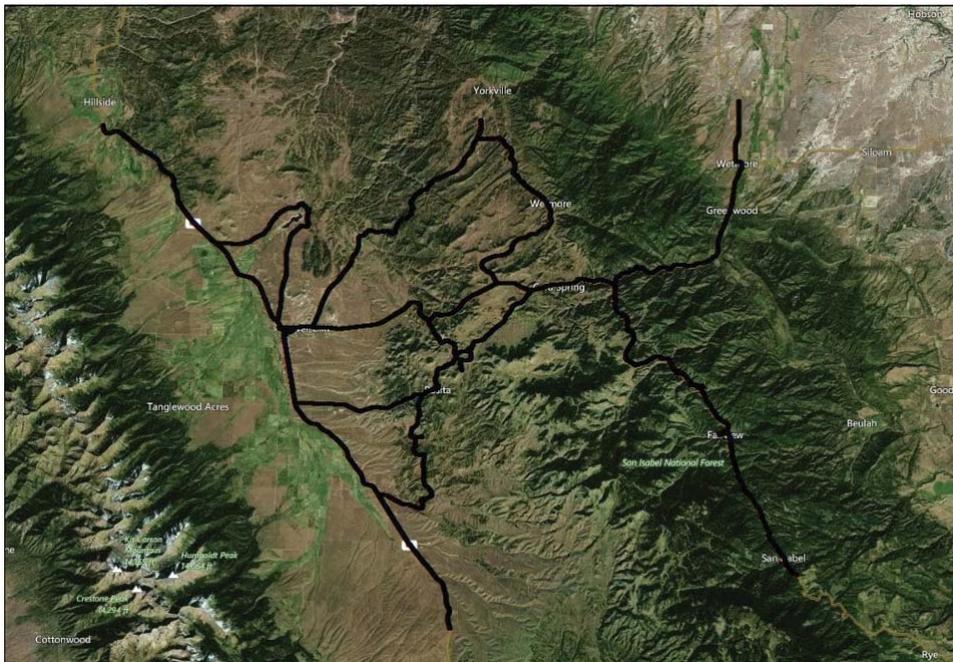


Figure 2. Drive Route

As a point of note, County Roads 387 and 386 were originally on the drive route, but because there were road closures from wild fires these secondary roads were not driven.

Results

The coverage areas from the two major providers AT&T and Verizon were as expected from user experience. The Figure 3 gives the coverage for AT&T UMTS in the 850 MHz band. Figure 4 gives Verizon's LTE coverage in the 700 MHz band. In these figures the red represents marginal coverage, yellow is fair outdoor coverage and green is strong coverage. Note here as well that the two scales are different because the carriers are using different technologies. Scales appropriate to LTE and UMTS were used and adjusted for a relative comparison. Areas that were driven but were below the usable threshold are not shown on the below maps.

Users that are roaming on either carrier may not experience this coverage depending on what band each of the providing carriers allows roaming users to occupy. Often because of phone types or carrier preference the lower frequency bands may not be available to roamers. Higher frequency bands tend to have reduced outdoor and indoor coverage.

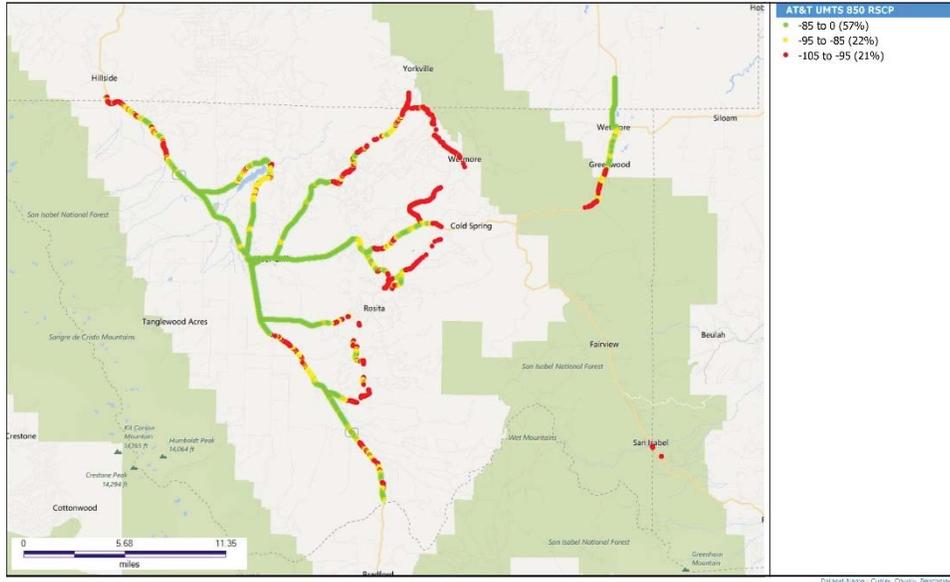


Figure 3. AT&T UMTS 850 Coverage Custer County 10/31/16

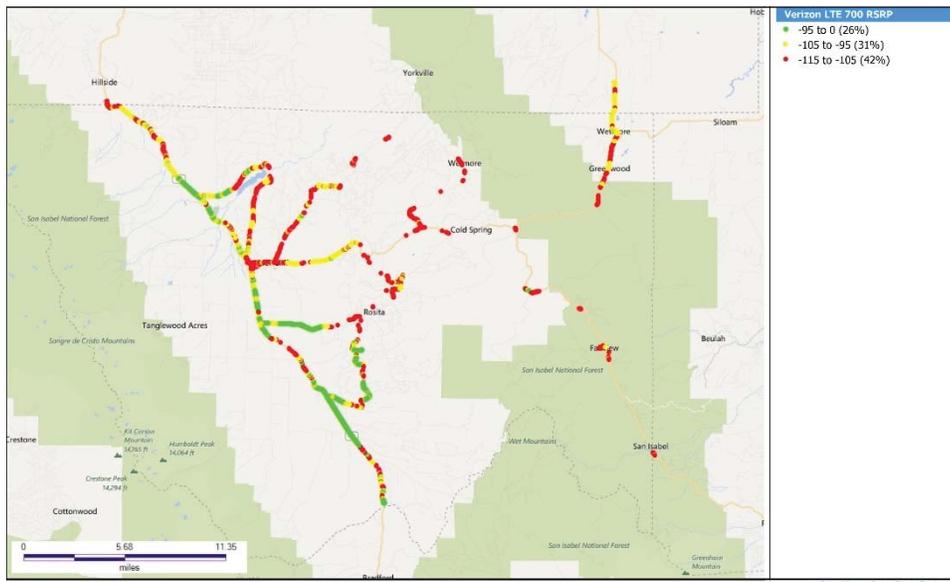


Figure 4 Verizon LTE 700 Coverage Custer County 10/31/16

Both Sprint and T-Mobile unsurprisingly showed no coverage in the central part of the county. Both did show coverage coming into Wetmore from sites in the Highway 50 corridor. T-Mobile coverage will improve dramatically when the site in Silver Cliff goes on air. Figure 5 shows the current coverage for T-Mobile while Figure 6 shows Sprint coverage.

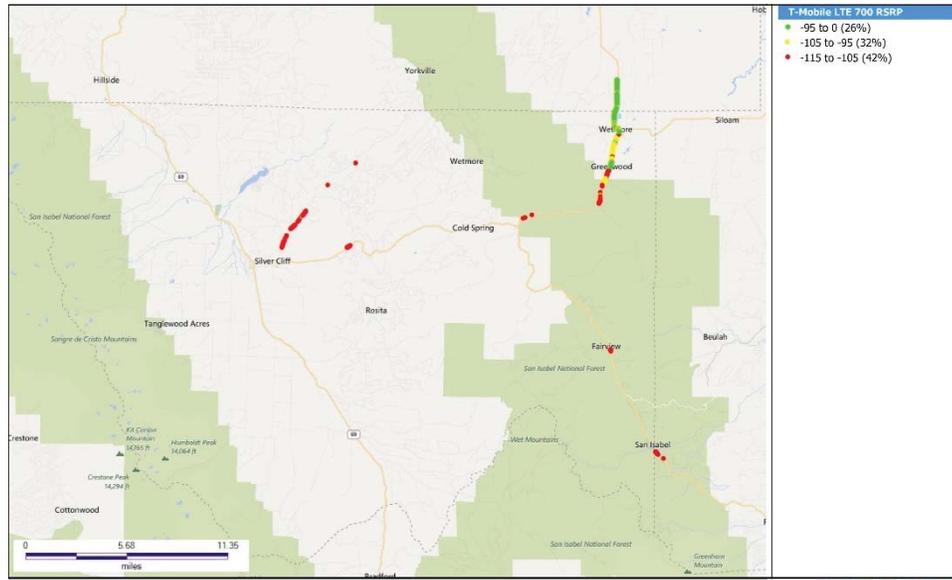


Figure 5 T-Mobile Coverage Custer County 10/31/16

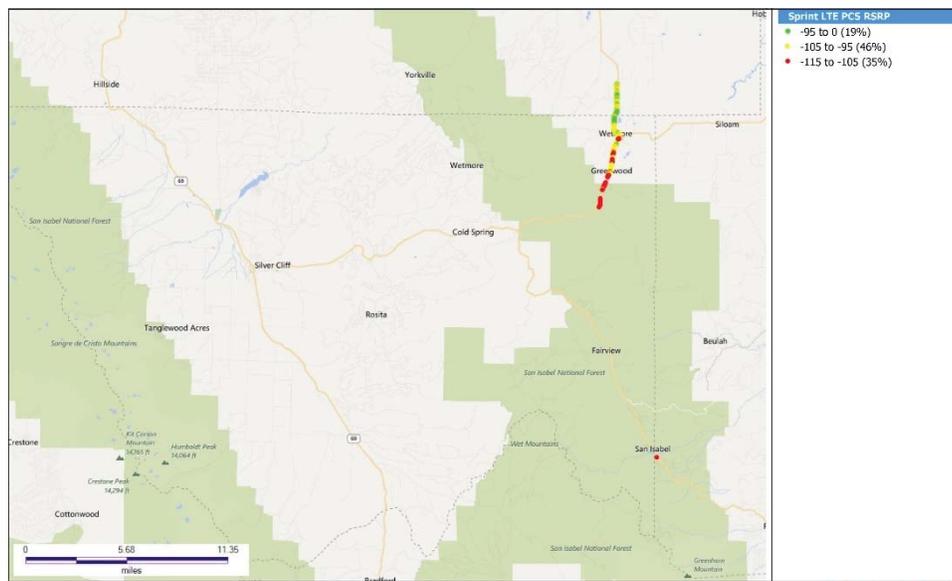


Figure 6 Sprint Coverage in Custer County 10/31/16

Conclusion

While two of the major carriers each have one site in the county and with one new expected carrier to turn up, coverage in the county is well below the 50% threshold. Because of the mountainous terrain 80% coverage would be a high expectation, but this project may provide the wireless carriers a chance to cover the populous areas of the county much better. The greatest opportunity for improvement over population lies in the Northeast and Eastern portions of the county, while signal strength could certainly be improved in Westcliff and Silver Cliff for indoor coverage.

Summary of Findings

Centerline has evaluated the wireless broadband infrastructure in Custer County using input from the providers and other wireless asset location databases. Relatively few tower locations exist currently that would provide line of sight coverage to a large number of addresses within Custer County. An exception to that is the number of sites used by SECOM who has aggressively deployed sites in the county. The only drawback to SECOMs deployment is their relative height above terrain, which does not exceed twenty feet.

Commercial wireless service in the county is fair for a rural area, but could be greatly improved. The two major carriers each have a site in the county, but both sites are located well away from population centers and only provide service in the central valley area of the county. Additional sites located in outlying population clusters will be attractive to carriers if there is a low cost of entry and demonstrated population coverage.

Both WISPs are cautiously supportive of the project. Hilltop wireless has fewer sites in the county than their competitor and is interested in expanding if it meets their business case. SECOM likewise is interested in expanding but already serves more addresses. Because the SECOM towers are relatively short, their service area is limited. Prior to knowing the locations, Centerline had selected several locations at or near the SECOM sites, but assumed much higher towers to maximize coverage. We have found that some of these locations could be much more useful with taller towers and would eliminate the need for several small towers. As we move forward we will consider taller towers at these locations even though some coverage already exists.

The address maps have provided great insight into where the population is clustered in the county. The central valley contains by far the largest amount of the resident population with the two towns being the densest. Outside of those areas the Rosita and Centennial areas along with the areas along county road 255 going north out of Silver Cliff show the highest density. The map in Figure 7 shows the address distribution in Custer County on a very coarse scale.

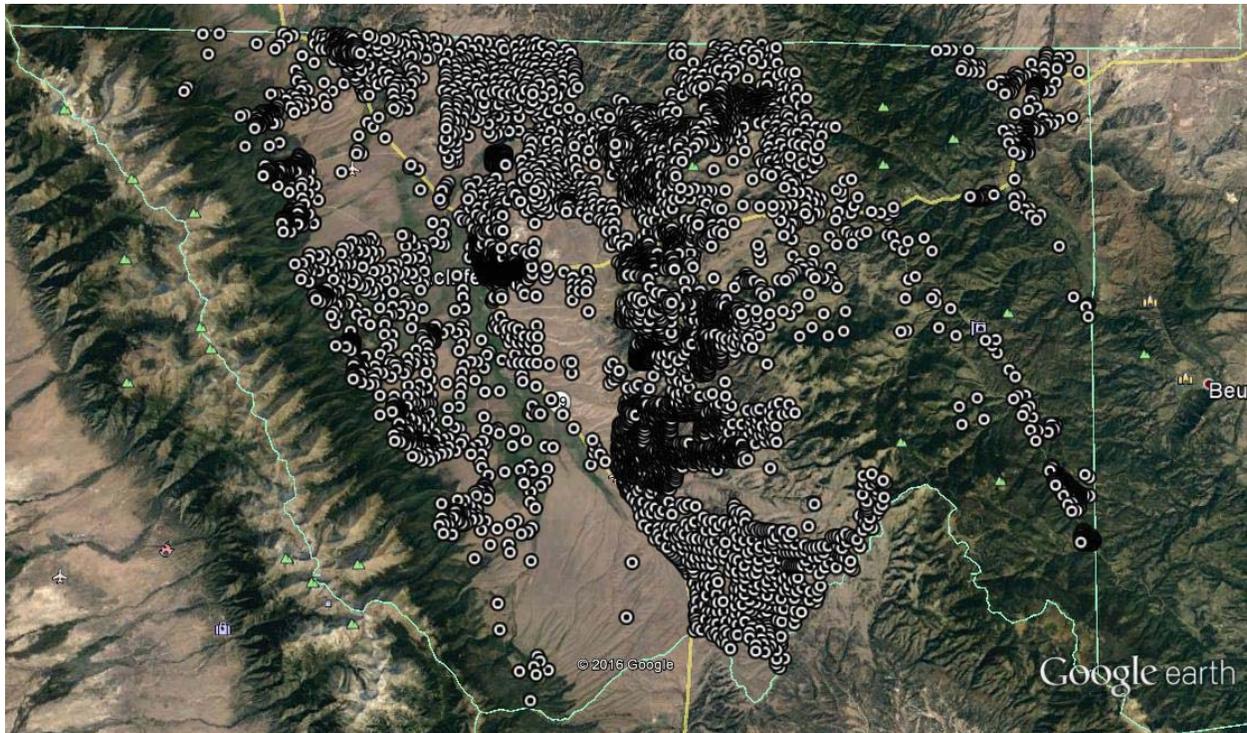


Figure 7Addresses in Custer County

The darker areas on the map are where the highest density of addresses exist. This information will be used in the coverage map to determine the effectiveness of each site modeled using addresses covered as a metric. We will be able to prioritize sites based on number of new addresses covered.

The data gathered during this phase has shed a great deal of light on the current state of broadband in Custer County. It has provided us with the data to move forward and model sites that would be of the greatest benefit to the county and its residents in the future. The next phases of the project will provide the detail needed to seek funding for the most effective solution for the residents of Custer County.

APPENDIX A – Additional Files



Assessment of Current Broadband Infrastructure Phase I

Prepared For:
Custer County BOCC & CCEDC
Wednesday November 23, 2016



Welcome

Dan Mieszala

BSEE, MBA

Principal Engineer

Manager of Public Vertical
Markets

Centerline Solutions



Agenda

- ◆ Project Overview
- ◆ Wireless Internet Service Providers
- ◆ Existing Towers in the County
- ◆ Candidate Sites for Next Phase
- ◆ Cellular Drive Test



Project Overview

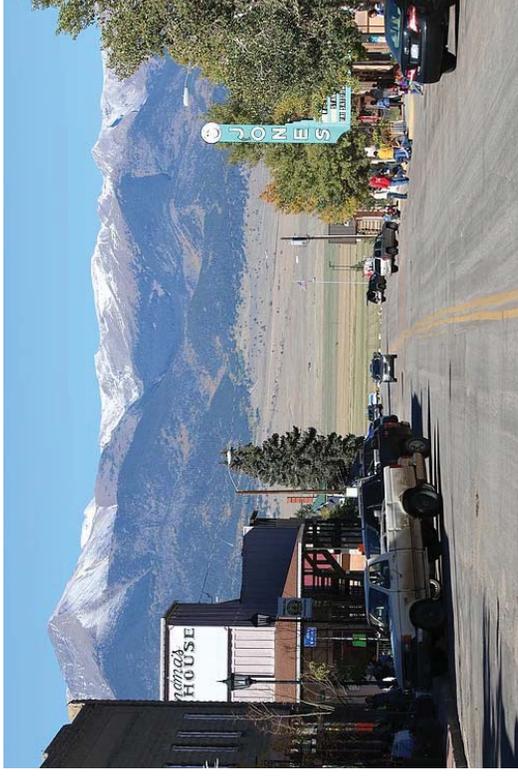
- ◆ Current broadband access is limited in the county.
- ◆ Broadband is defined by FCC as 25 mbps down/3 mbps up.
- ◆ Private industry hesitant to invest because of low density.
- ◆ Public/Private partnership to stimulate investment by providing tower space.

Custer County Statistics

- ◆ Population: 4,255 (2010 data; Census)
- ◆ Households: 2,125 (2014 estimate; Census)
- ◆ Persons Per Households: 2.0 (2014 estimate; Census)
- ◆ Households with Internet Access: 60% (1,275)
 - (DSL; FWISP; Satellite)
- ◆ Households with Broadband: 8-9% (175-200)

Project Approach Phase I

- ◆ Interview Wireless ISPs
- ◆ Map Existing Towers
- ◆ Drive Test Cellular
- ◆ Identify Potential Sites



Wireless ISPs –Common Ground

- ◆◆ Good Access- Road preferred
- ◆◆ Commercial power.
- ◆◆ New/Improved coverage.
- ◆◆ Provide own backhaul

Wireless ISPs -SECOM

- ◆ Site List: Provided KML file.
- ◆ Desired areas of coverage: Vermont
Tower, Jose Flats, Rosita
- ◆ Link Distance:
 - 10-12 miles 5.8 GHz with panel
 - 19 miles 5.8 GHz with dish
 - 9 miles .35 GHz with panel

Wireless ISPs - Hilltop

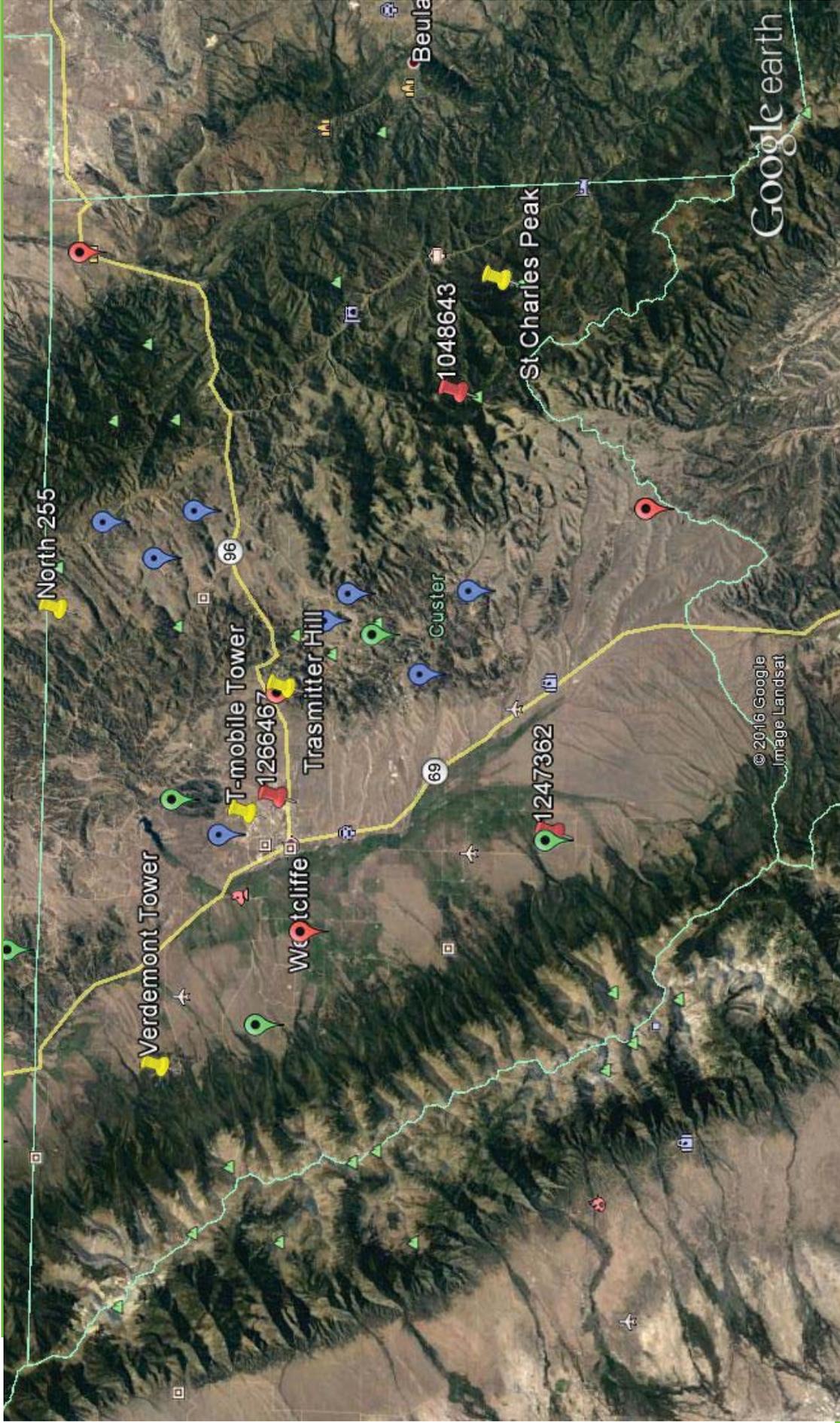
- ◆ Site List: Provided Site List (Not disclosed)
- ◆ Desired Areas of Coverage: Rosita, Oak Creek, Galena, possible Centennial, consider San Isabel.
- ◆ Link Budget: 4-6 miles LOS for 25 mbps down.

Map Existing Towers

- ◆ Several Sources used:
 - FCC database
 - Centerline proprietary database
 - WISPs submittal
 - Tribal knowledge
 - Site surveys

- Yellow push pins – Towers Identified by Centerline not in other data bases
- Red push pins – Towers Identified on FCC data base.
- Various colored balloons – SECOM DD Wireless provided sites

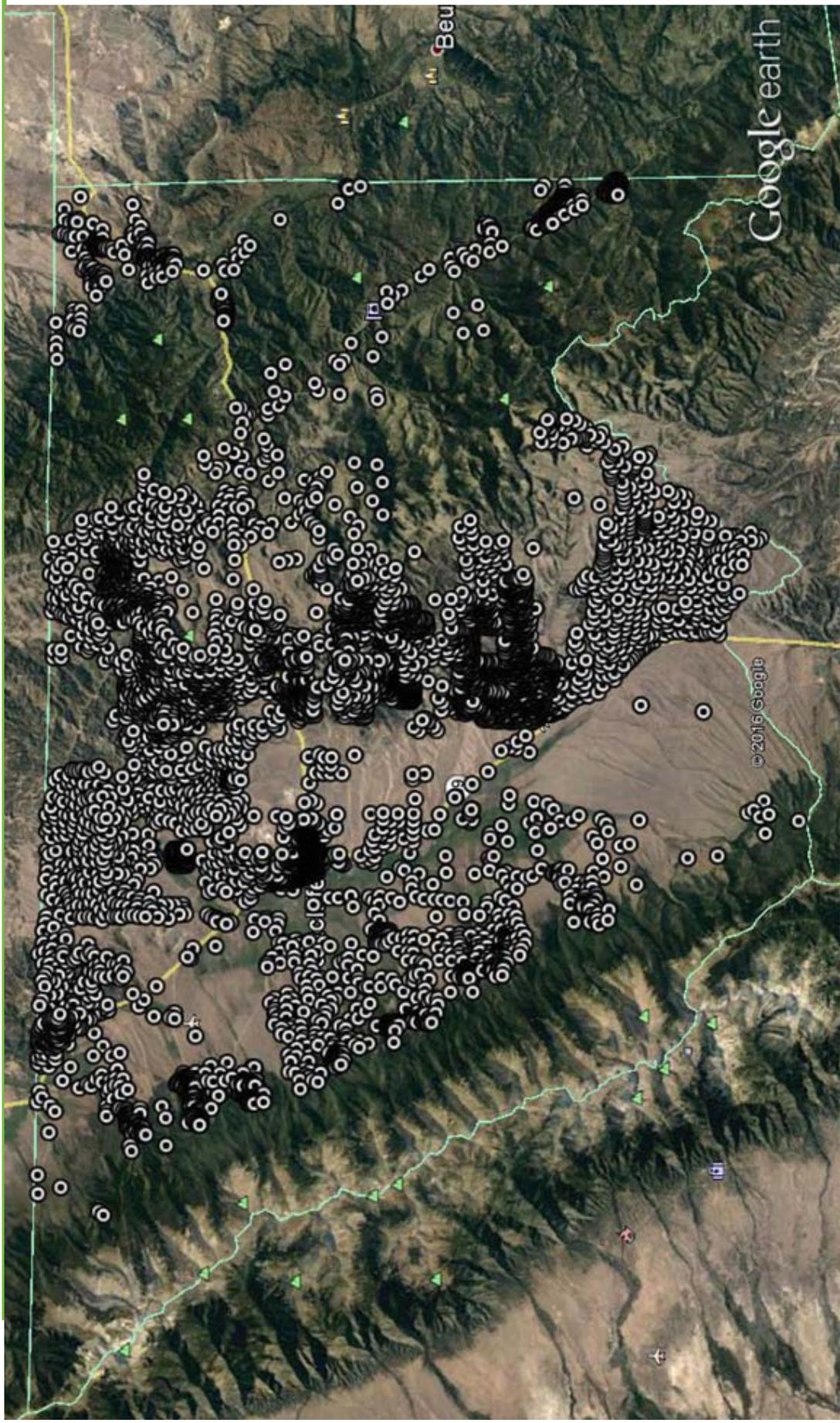
Site Map



Target Areas

- ◆ Preliminary site candidates were chosen with satellite imagery and existing tower databases.
- ◆ Address data was used to select targets as well
- ◆ Site Visits were made to entire county.
 - Some sites were eliminated
 - New sites were found
- ◆ Overlap of Centerline selected sites and existing WISP sites.
- ◆ Extensive candidate list developed and will be prioritized in next phase. Not all sites can be funded.

Address Locations



Candidate Site List

| Site Name | Latitude | Longitude | Notes |
|-------------------------|-----------------|------------------|--|
| Junkins High Point | 38° 6'41.09"N | 105°17'37.73"W | Great Site for covering north Rosita |
| East of Domingo 2 | 38°11'25.61"N | 105°21'52.31"W | Small house on hill substitute for E of Domingo |
| East of Domingo | 38°11'44.52"N | 105°22'39.03"W | Lots of addresses. Two good spots |
| North 255 Unidentified | 38°14'36.10"N | 105°19'7.12"W | Also known as Mikes Secret Site subj for Durfee |
| Clay Tower/Bull | 38°10'52.27"N | 105°26'15.98"W | CL selected as well |
| Rosita Tower | 38° 0'14.73"N | 105°19'25.02"W | DD site but very low. Will move and raise site |
| Tom Tower | 38° 4'47.80"N | 105°19'59.38"W | CL selected site/DD-Second |
| Horn Creek | 38° 3'9.95"N | 105°32'12.19"W | Cluster of addresses, high activity area |
| South Ranch | 38° 0'18.57"N | 105°17'29.49"W | Lots of addresses. Still north of Centennial tower |
| North 165 | 38° 6'17.65"N | 105° 7'73.99"W | Developed but low address. Difficult build |
| San Isabele | 38° 0'45.07"N | 105° 3'41.35"W | Backhaul is an issue |
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| Buck Mountain Potential | 38°14'24.48"N | 105°31'38.23"W | Alternate to Beccows/Difficult build |
| Hermit Basin | 38° 7'16.49"N | 105°35'16.56"W | Not Hilltop Site. On Ridge w/tn addresses |
| Bulard Mtn | 38°12'56.95"N | 105°15'35.54"W | Good DD site. Need to go higher |
| Myron Mtn | 38°10'9.76"N | 105°15'12.04"W | Good DD site. Need to go higher |
| Transmitter Hill | 38°7'39.39"N | 105°22'10.83"W | Major Hub. For evaluation on purpose |
| Water Tanks | 38° 8'19.56"N | 105°26'38.70"W | Coverage for both towns |
| Verdemont lower | 38° 11' 50"N | 105°34'28"W | County lower |
| Sperry Peak | 38° 5'35.63"N | 38° 5'35.63"N | Potential High Site |
| Centennial Tower | 37° 56' 42.52"N | 105° 15' 18.42 W | Long shot |

Cellular Drive Test

◆ 6 Carriers Driven

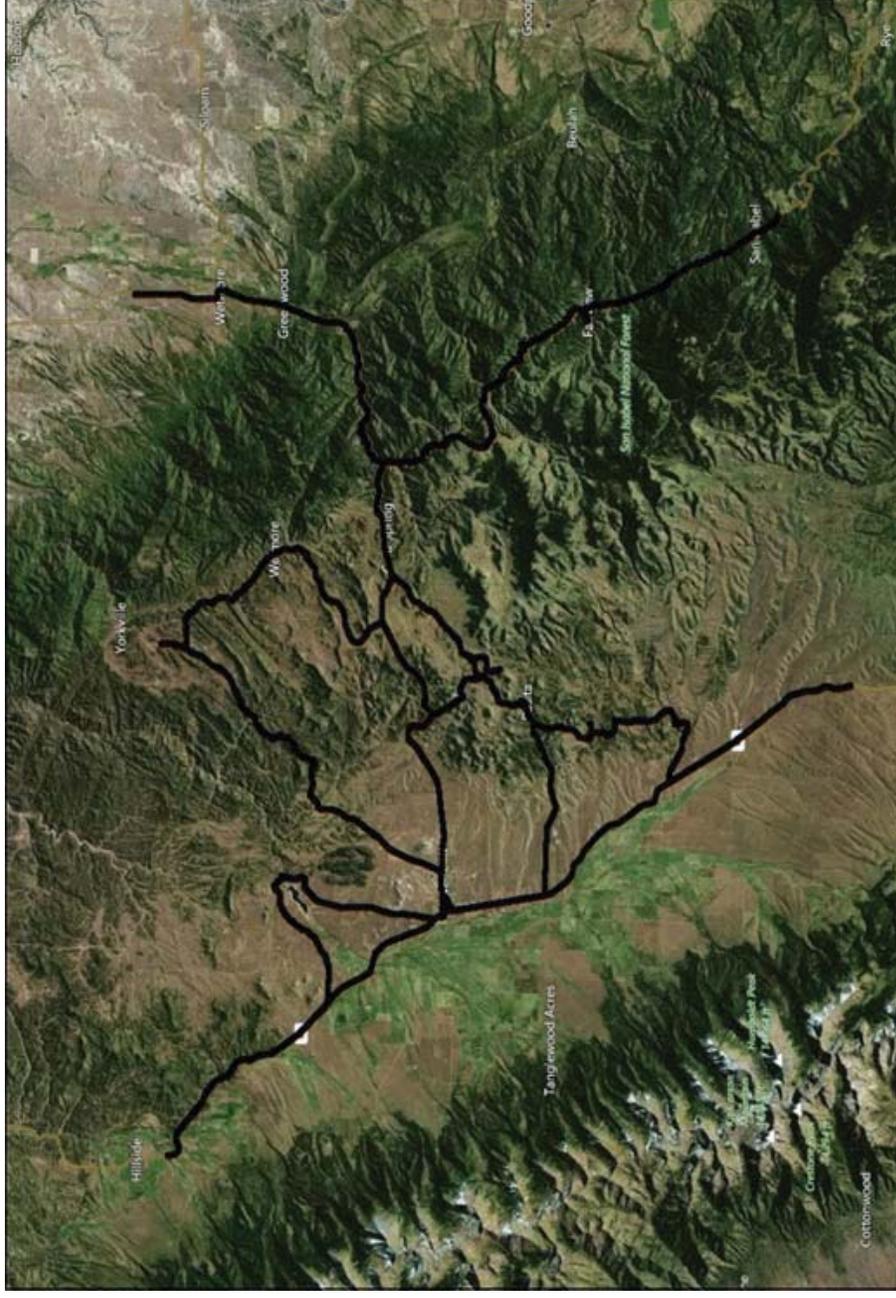
- AT&T
- Verizon
- T-Mobile
- Sprint
- Commnet
- Viero

◆ No Coverage

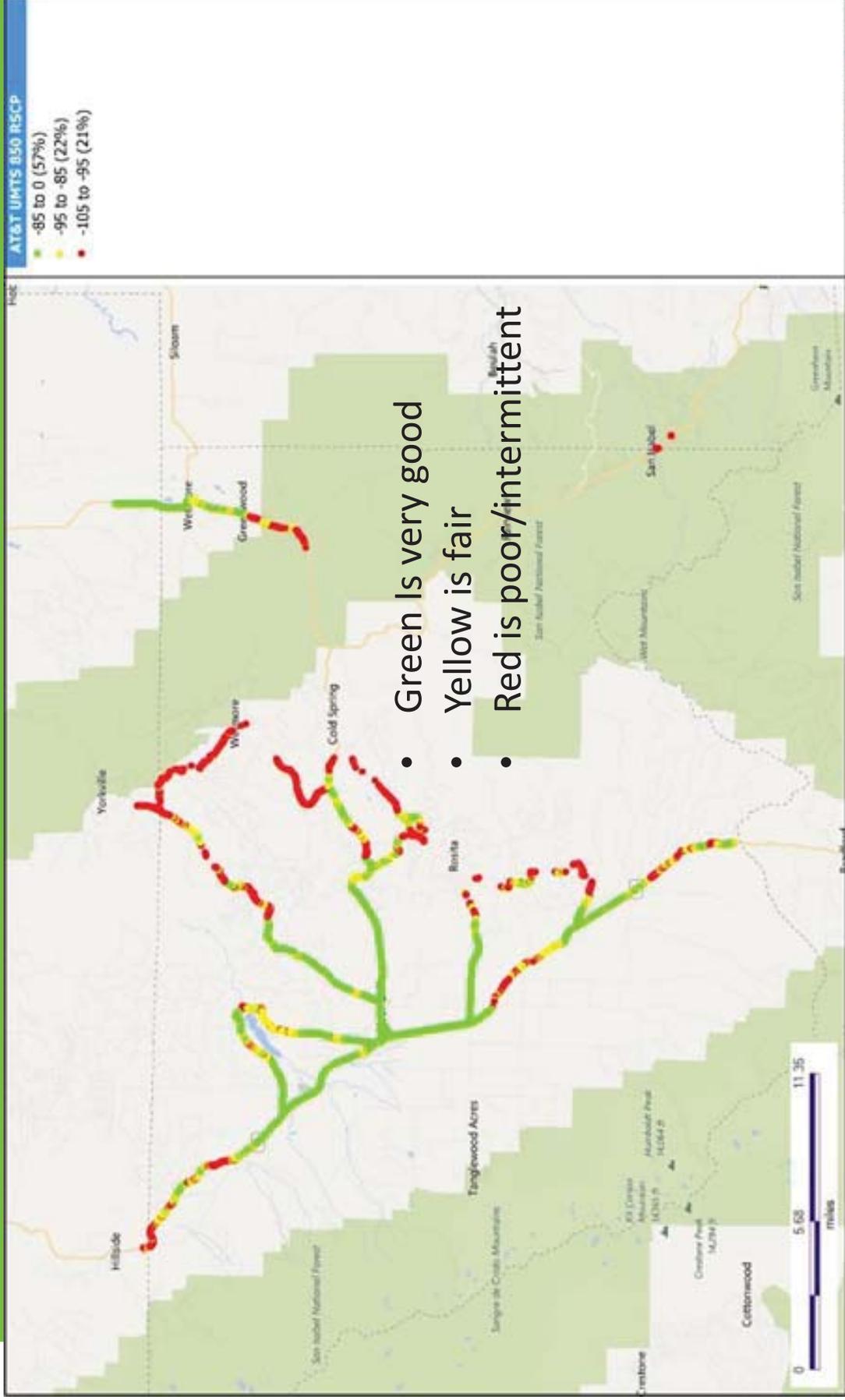
- Viero
- Commnet

◆ Little Coverage

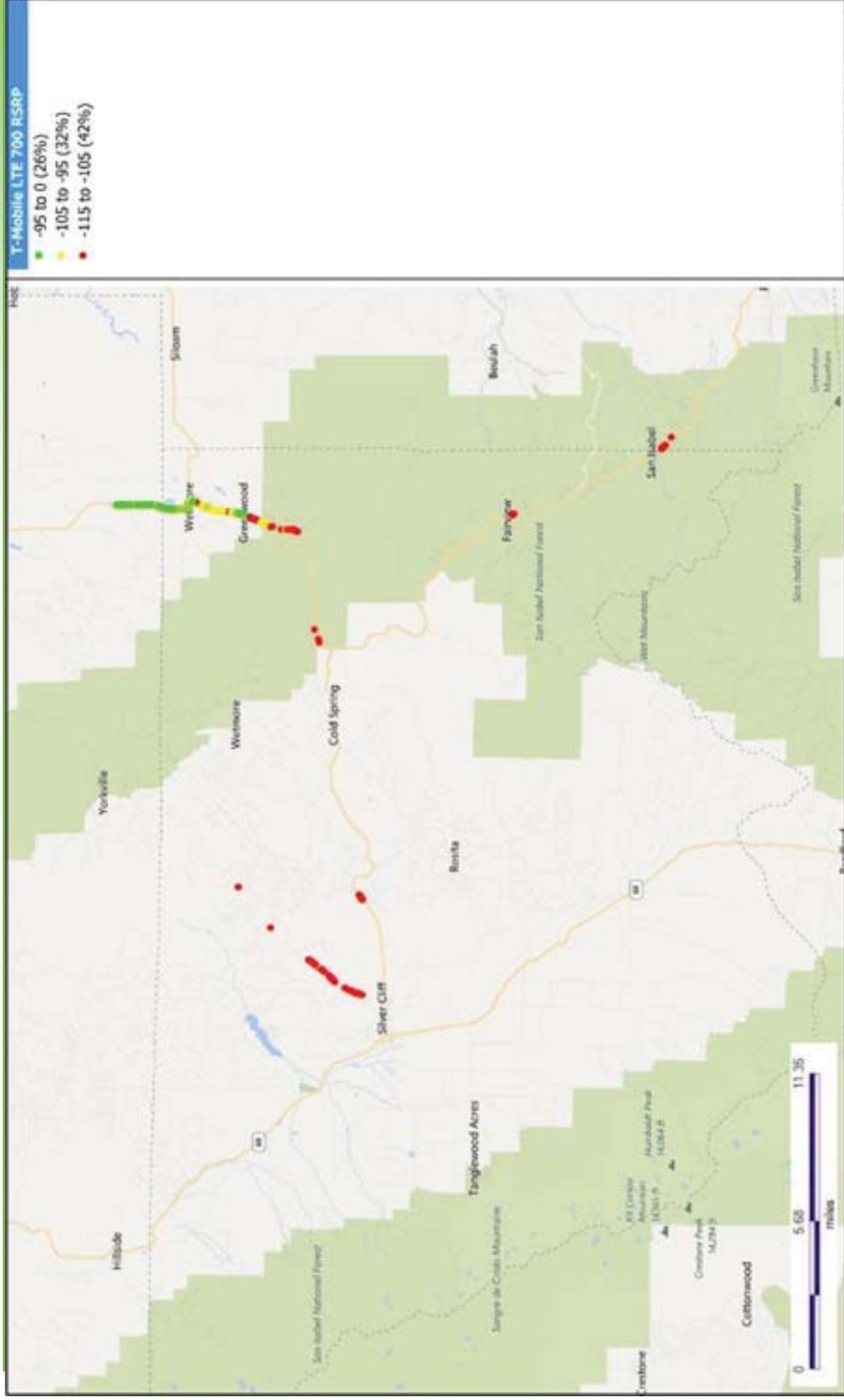
- T-Mobile
- Sprint



AT&T-850 UMTS



T-Mobile







Questions?

Dan Mieszala

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Tab 2

Phase 2 Propagation Modeling



Propagation Analysis
And Site Recommendation
For Broadband Towers

Prepared For:
Custer County BOCC & CCEDC
Friday January 6th



Overview

- ◆ Approach
 - Standalone Coverage
 - Incremental Gain
- ◆ Assumptions
 - 7 mile Line of Site (LOS) to get 25 mbps down
 - 20 foot subscriber height
 - Clear local obstructions

Standalone Coverage Analysis

- ◆ Analyze coverage from 32 new and existing sites
- ◆ Coverage over address locations that were provided by the county
- ◆ Start with 100 foot towers. Tower height will be dependent on final site location.

Sites analyzed Covered Addresses

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Exsting covered addresses | Add Addresses | Comments |
|--------------------------|-------------------|----------------------|-----------------|---------------------------|---------------|---|
| West Rosita Tower 100 | 1,039 | 15.86 | 6,553 | | 1039 | Did not compare against Rosita, Toms, Anderson |
| Water Tank 100 | 983 | 15 | 6,553 | | 983 | Did not compare against JJ Courtyard |
| Buck Mountain 100 | 915 | 13.96 | 6,553 | | 915 | |
| Beddows 100 | 851 | 12.99 | 6,553 | | 851 | |
| Sperry Peak 100 | 654 | 9.98 | 6,553 | | 654 | Coverage into Antelope Butte (S. of Rosita) at distance |
| Junkins High Point | 651 | 9.93 | 6,553 | | 651 | |
| East of Domingo 100 | 647 | 9.87 | 6,553 | | 647 | |
| East of Domingo 2 100 | 631 | 9.63 | 6,553 | | 631 | |
| Gene Tower 100 | 704 | 10.74 | 6,553 | 223 | 481 | Overlap with Sperry but in better position |
| Verdemont Tower 100 | 443 | 6.76 | 6,553 | | 443 | Some overlap with Beddows and Buck |
| South Ranch 100 | 348 | 5.31 | 6,553 | | 348 | |
| Mild 255 Tower at 100 ft | 316 | 4.82 | 6,553 | | 316 | |
| Toms Tower 100 | 788 | 12.03 | 6,553 | 513 | 275 | |
| Bullard Mountain 100 | 227 | 3.46 | 6,553 | | 227 | |
| Centennial Tower 100 | 197 | 3.01 | 6,553 | | 197 | |
| Transmitter Hill 100 | 1,150 | 17.55 | 6,553 | 955 | 195 | Includes Population to the West |
| Move Toms Tower 100 | 695 | 10.61 | 6,553 | 513 | 182 | |
| Myron Mountain 100 | 161 | 2.46 | 6,553 | | 161 | |
| Rosita Tower 100 | 370 | 5.65 | 6,553 | 233 | 137 | |
| North 255 100 | 129 | 1.97 | 6,553 | | 129 | |
| Antelope Tower 100 | 417 | 6.36 | 6,553 | 293 | 124 | |
| San Isabele 100 | 118 | 1.8 | 6,553 | | 118 | |
| Anderson Tower 100 | 478 | 7.29 | 6,553 | 368 | 110 | |
| Arlie 100 | 1,053 | 16.07 | 6,553 | 987 | 66 | Secom Microwave Hub, may build second tower |
| Horn Creek 100 | 564 | 8.61 | 6,553 | 503 | 61 | Site not yet active . Arlie covers into this area. |
| South Colony Tower 100 | 394 | 6.01 | 6,553 | 333 | 61 | |
| Clay Tower 100 | 1,574 | 24.02 | 6,553 | 1,514 | 60 | Assumes existing tower clears local obstucitons |
| Hermit Basin 100 | 540 | 8.24 | 6,553 | 484 | 56 | Arlie covers into this area |
| Hal Tower at 100 ft | 240 | 3.66 | 6,553 | 195 | 45 | |
| Wetmore 100 | 124 | 1.89 | 6,553 | 91 | 33 | |
| Stoneman Tower 100 | 735 | 11.22 | 6,553 | 708 | 27 | |
| North 165 100 | 13 | 0.2 | 6,553 | | 13 | |

Incremental Gains

- ◆ Model existing coverage
 - This may be more than the incumbent carrier thinks he has
 - Covered addresses even though they may not be built yet
 - Assumes subscriber equipment at 20 feet and no local obstructions
- ◆ Both systems cover 63 percent of addresses in county at 7 miles!

Incremental Gains

- ◆ Add New Sites and measure percentage of covered addresses
 - Many iterations of site progression
 - Some new sites overlap other new site coverage thus it does not directly correlate to the total addresses covered.

Sequence 1

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Incremental increase | Incremental percentage |
|--|-------------------|----------------------|-----------------|----------------------|------------------------|
| Both Systems | 4,140 | 63.18 | 6,553 | 129 | 1.97 |
| Both System Plus Buck | 4,309 | 65.76 | 6,553 | 169 | 2.58 |
| Both Buck Sperry | 4,467 | 68.17 | 6,553 | 158 | 2.41 |
| Both Buck Sperry Junkins | 4,498 | 68.64 | 6,553 | 31 | 0.47 |
| Both Buck Sperry Junkins Domingo | 4,593 | 70.09 | 6,553 | 95 | 1.45 |
| Both Buck Sperry Junkins Domingo Verdemont | 4,598 | 70.17 | 6,553 | 5 | 0.08 |
| Both Buck Sperry Junkins Domingo Verdemont Sranch | 4,687 | 71.52 | 6,553 | 89 | 1.35 |
| Both Buck Sperry Junk Dom Verd Sranch Cent | 4,778 | 72.91 | 6,553 | 91 | 1.39 |
| Both Buck Sperry Junk Dom Verd Sranch Cent MTom | 4,795 | 73.17 | 6,553 | 17 | 0.26 |
| Both Buck Sperry Junk Dom Verd Sranch Cent MTom Rose 100 | 4,815 | 73.48 | 6,553 | 20 | 0.31 |
| Both Buck Sperry Junk Dom Verd Sranch Cent MTom Rose 100 San Isabell | 4,933 | 75.28 | 6,553 | 118 | 1.8 |
| Copy of Both Buck Sperry Junk Dom Verd Sranch Cent MTom Rose 100 SI | 5,048 | 77.03 | 6,553 | 115 | 1.75 |

Sequence 2 with Sperry

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Incremental increase | Incremental percentage |
|---|-------------------|----------------------|-----------------|----------------------|------------------------|
| Both Systems | 4,140 | 63.18 | 6,553 | | |
| Both System Plus Buck | 4,309 | 65.76 | 6,553 | 169 | 2.58 |
| Both Systems Buck Junkins | 4,394 | 67.05 | 6,553 | 85 | 1.29 |
| Both Systems Buck Junkins Sperry | 4,498 | 68.64 | 6,553 | 104 | 1.59 |
| Both Systems Buck Junkins Sperry Mid255 | 4,638 | 70.78 | 6,553 | 140 | 2.14 |
| Both Systems Buck Junkins Sperry Mid255 Domingo | 4,708 | 71.84 | 6,553 | 70 | 1.06 |
| Both Systems Buck Junkins Sperry Domingo Mid255 Cent | 4,845 | 73.94 | 6,553 | 137 | 2.1 |
| Both Systems Buck Junkins Sperry Domingo Mid255 Cent Sranch | 4,888 | 74.59 | 6,553 | 43 | 0.65 |
| Both Systems Buck Junkins Sperry Domingo Mid255 Cent Sranch SIsab | 5,006 | 76.39 | 6,553 | 118 | 1.8 |

Sequence 3 with Sperry

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Incremental increase | Incremental percentage |
|---|-------------------|----------------------|-----------------|----------------------|------------------------|
| Both Systems | 4,140 | 63.18 | 6,553 | | |
| Both System Plus Buck | 4,309 | 65.76 | 6,553 | 169 | 2.58 |
| Both Systems Buck Junkins | 4,394 | 67.05 | 6,553 | 85 | 1.29 |
| Both Systems Buck Junkins Sperry | 4,498 | 68.64 | 6,553 | 104 | 1.59 |
| Both Systems Buck Junkins Sperry Mid255 | 4,638 | 70.78 | 6,553 | 140 | 2.14 |
| Both Systems Buck Junkins Sperry Mid255 Domingo | 4,708 | 71.84 | 6,553 | 70 | 1.06 |
| Both Systems Buck Junkins Sperry Domingo Mid255 Cent | 4,845 | 73.94 | 6,553 | 137 | 2.1 |
| Both Systems Buck Junkins Sperry Domingo Mid255 Cent Sranch | 4,888 | 74.59 | 6,553 | 43 | 0.65 |
| Both Systems Buck Junkins Sperry Domingo Mid255 Cent Sranch Sisab | 5,006 | 76.39 | 6,553 | 118 | 1.8 |

Sequence 4 with Sperry

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Incremental increase | Incremental percentage |
|--|-------------------|----------------------|-----------------|----------------------|------------------------|
| Both Systems | 4,140 | 63.18 | 6,553 | #VALUE! | #VALUE! |
| Both System Plus Buck | 4,309 | 65.76 | 6,553 | 169 | 2.58 |
| Both Systems Buck Sperry | 4,467 | 68.17 | 6,553 | 158 | 2.41 |
| Both Systems Buck Sperry Mid255 | 4,609 | 70.33 | 6,553 | 142 | 2.16 |
| Both Systems Buck Sperry Mid255 Cent | 4,746 | 72.42 | 6,553 | 137 | 2.09 |
| Both Systems Buck Sperry Mid255 Cent SanIsa | 4,864 | 74.23 | 6,553 | 118 | 1.81 |
| Both Systems Buck Sperry Mid255 Cent SanIsa Dom | 4,934 | 75.29 | 6,553 | 70 | 1.06 |
| Both Systems Buck Sperry Mid255 Cent SanIsa Dom Sranch | 4,979 | 75.98 | 6,553 | 45 | 0.69 |
| Both Systems Buck Sperry Mid255 Cent SanIsa Dom Sranch WRosita | 5,062 | 77.25 | 6,553 | 83 | 1.27 |

Final Optimal Sequence

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Incremental increase | Incremental percentage |
|---|-------------------|----------------------|-----------------|----------------------|------------------------|
| Both Systems | 4,140 | 63.18 | 6,553 | | |
| Both System Plus Buck | 4,309 | 65.76 | 6,553 | 169 | 2.58 |
| Both Systems Buck Cent | 4,448 | 67.88 | 6,553 | 139 | 2.12 |
| Both Systems Buck Cent Mid255 | 4,597 | 70.15 | 6,553 | 149 | 2.27 |
| Both Systems Buck Cent Mid255 SanIs | 4,715 | 71.95 | 6,553 | 118 | 1.8 |
| Both Systems Buck Cent Mid255 SanIs WRosit | 4,816 | 73.49 | 6,553 | 101 | 1.54 |
| Both Systems Buck Cent Mid255 SanIs WRosit Dom | 4,886 | 74.56 | 6,553 | 70 | 1.07 |
| Both Systems Buck Cent Mid255 SanIs WRosit Dom Junkins | 4,958 | 75.66 | 6,553 | 72 | 1.1 |
| Both Systems Buck Cent Mid255 SanIs WRosit Dom Junkins Sranch | 5,010 | 76.45 | 6,553 | 52 | 0.79 |

Recommendation Basis

- ◆ Sites that cover the most addresses offer value both in new addresses and in secondary paths for other addresses.
- ◆ Sites should be from the final sequence of incremental gains.
- ◆ Certain areas of the county have higher concentration of addresses not yet built but towers serving those areas will be valuable in the future.

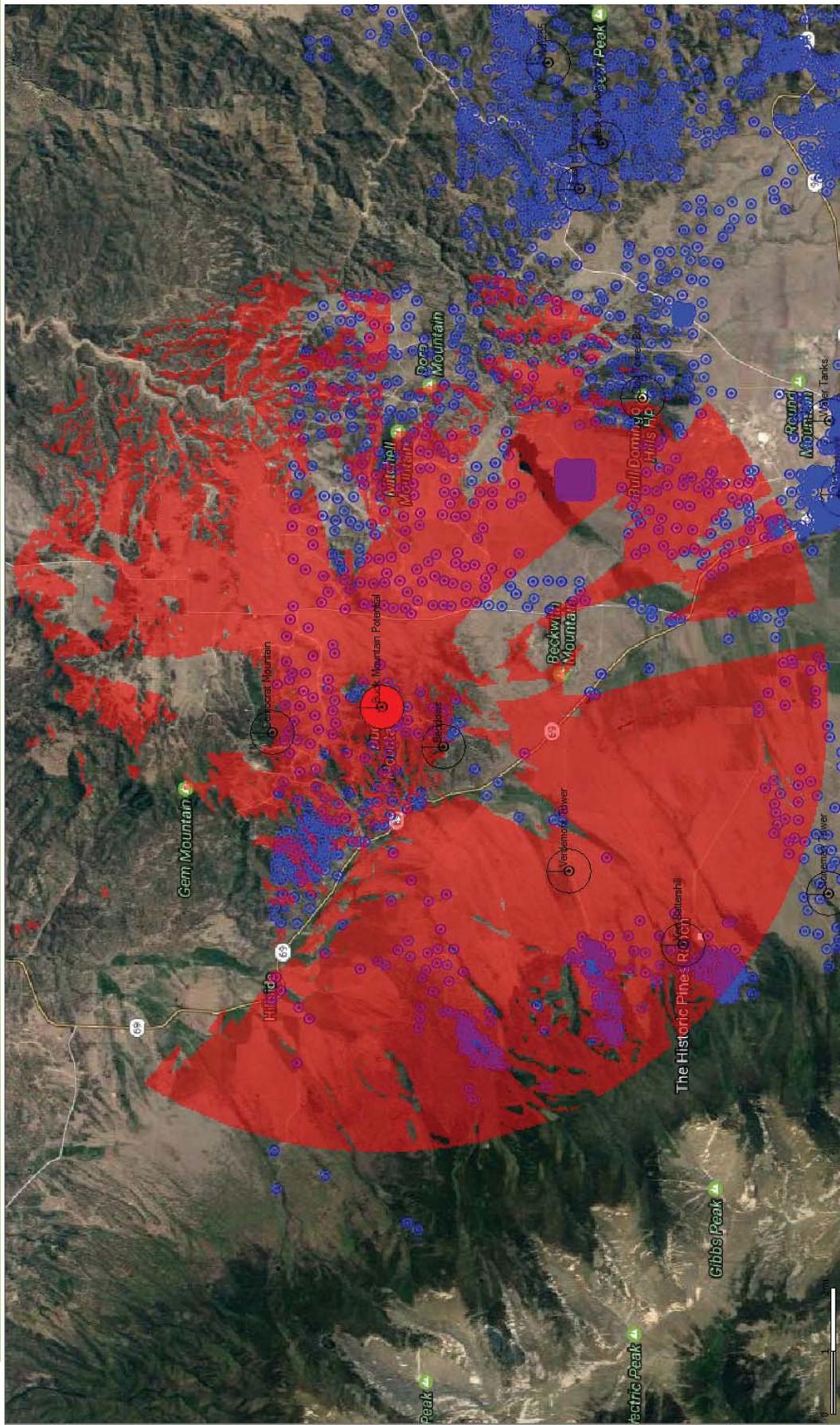
Recommendations – Priority 1

- ◆ Buck/Beddows
 - Biggest bang for the buck
 - Largest amount of covered pops
 - Indicated support from incumbent carriers
- ◆ Challenges
 - Difficult Build
 - Possible uninterested landlord

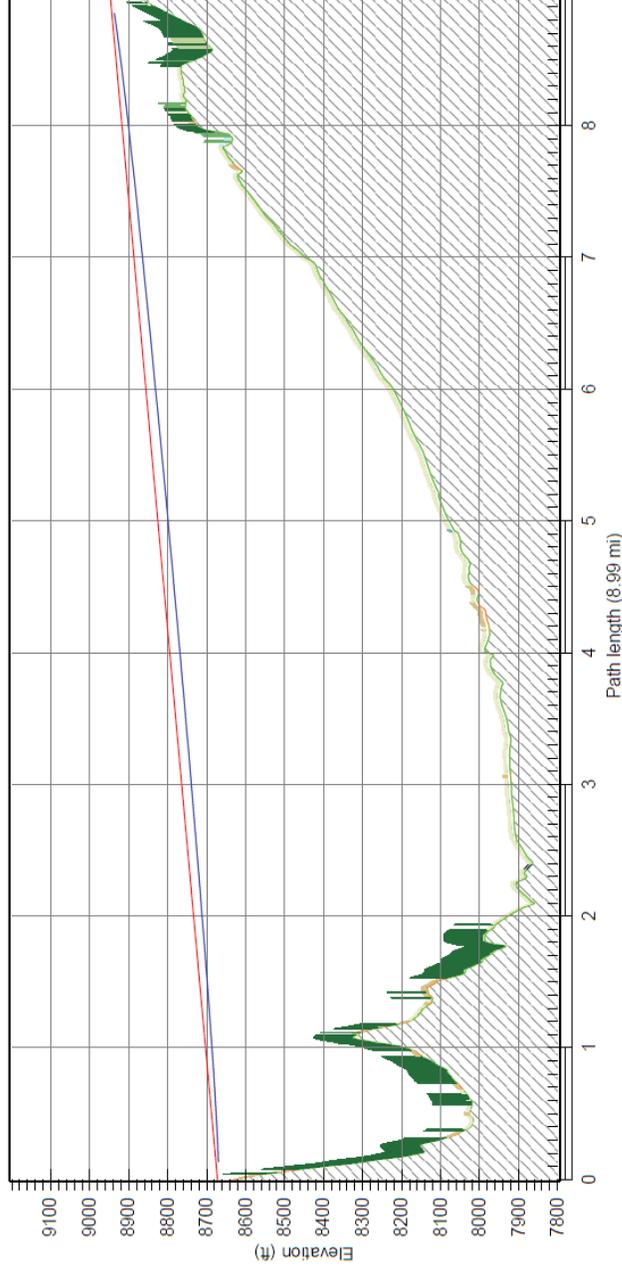
Buck Location



Buck Mountain Coverage



Hilltop Connectivity



Buck Mountain Potential
 Latitude 38 14 24.48 N
 Longitude 105 31 38.23 W
 Azimuth 200.14°
 Elevation 8628 ft ASL
 Antenna CL 45.0 ft AGL

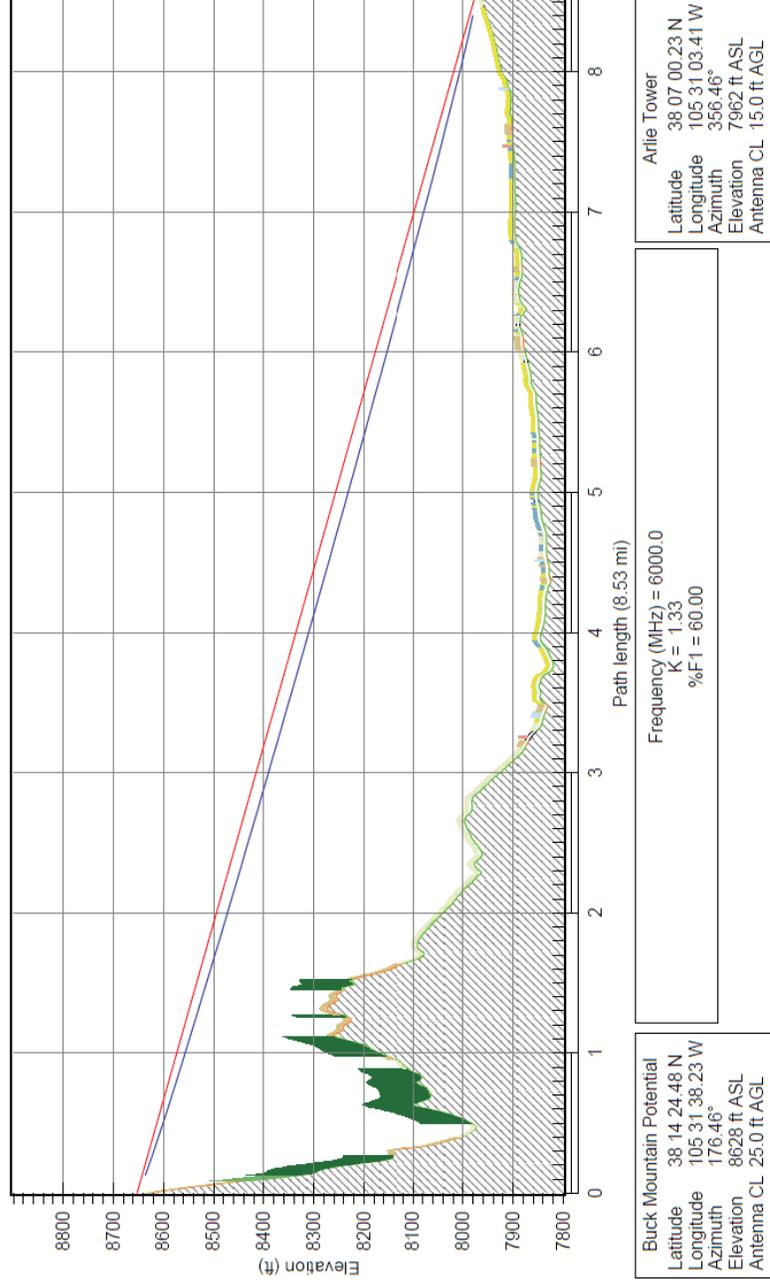
Frequency (MHz) = 6000.0
 K = 1.33
 %F1 = 60.00

Hilltop Hermit Basin
 Latitude 38 07 04.08 N
 Longitude 105 35 02.62 W
 Azimuth 20.10°
 Elevation 8887 ft ASL
 Antenna CL 60.0 ft AGL

Buck Mountain Potential-Hilltop Hermit Basin.pl5

December 15, 2016

SECOM Connectivity

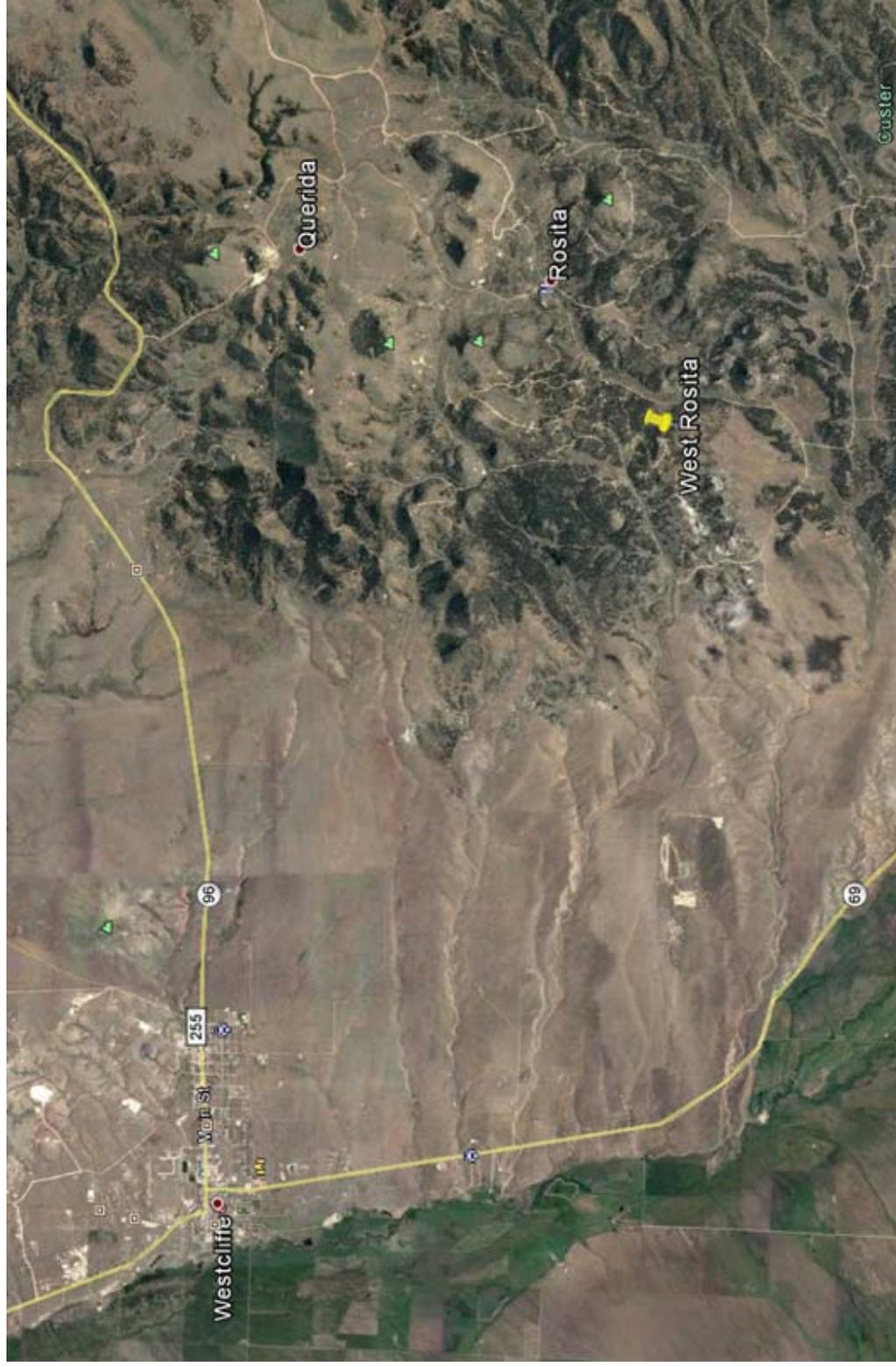


Buck Mountain Potential-Arlie Tower.pl5
December 15, 2016

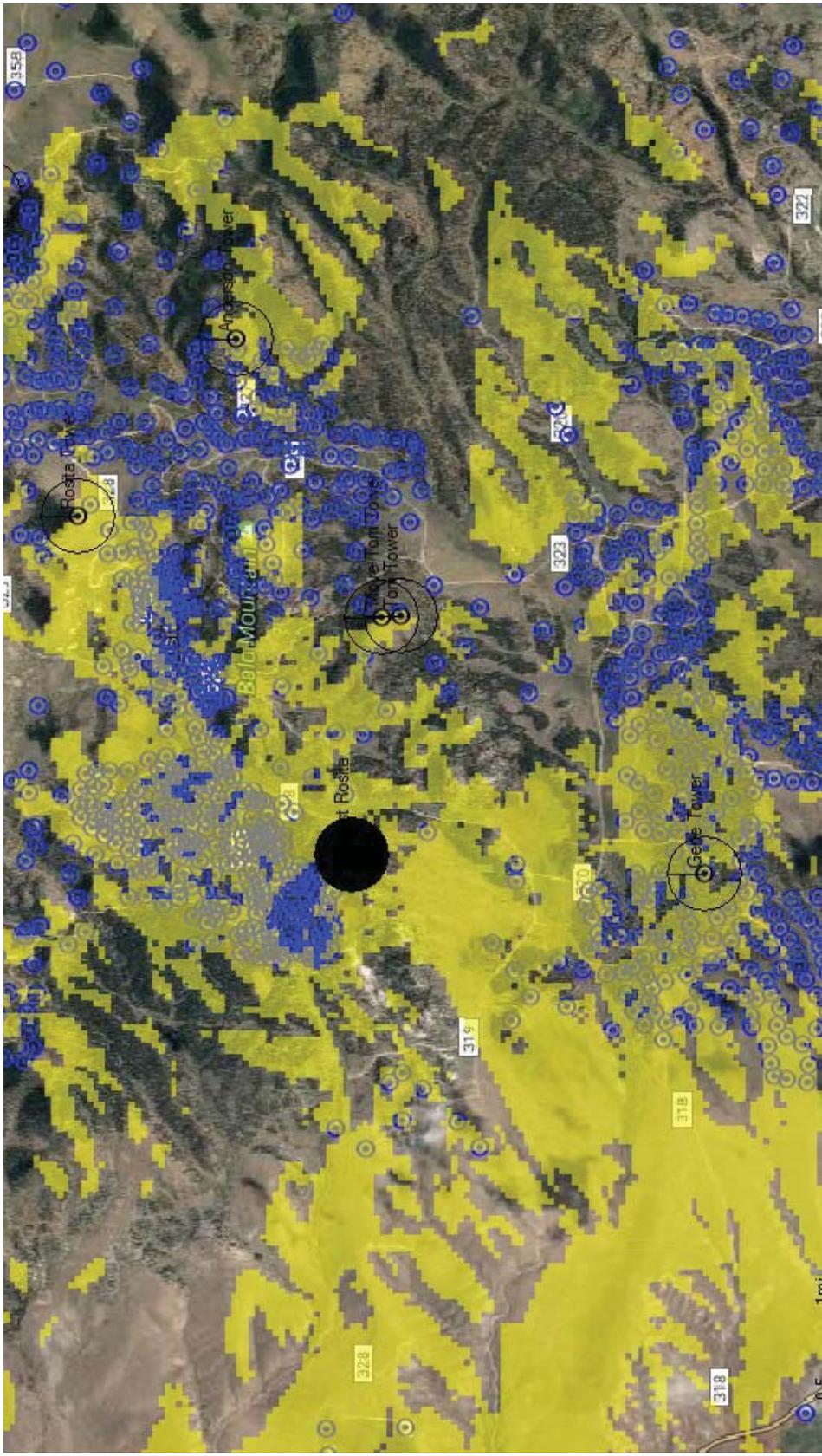
Recommendation Priority 2

- ◆ West Rosita
 - Very large number of covered addresses
 - Covers area not reached by any existing sites
 - Good market demand
 - Both carriers enthusiastic about area
- ◆ Challenges
 - Terrain limits site options
 - Overlap with other sites in adjacent areas

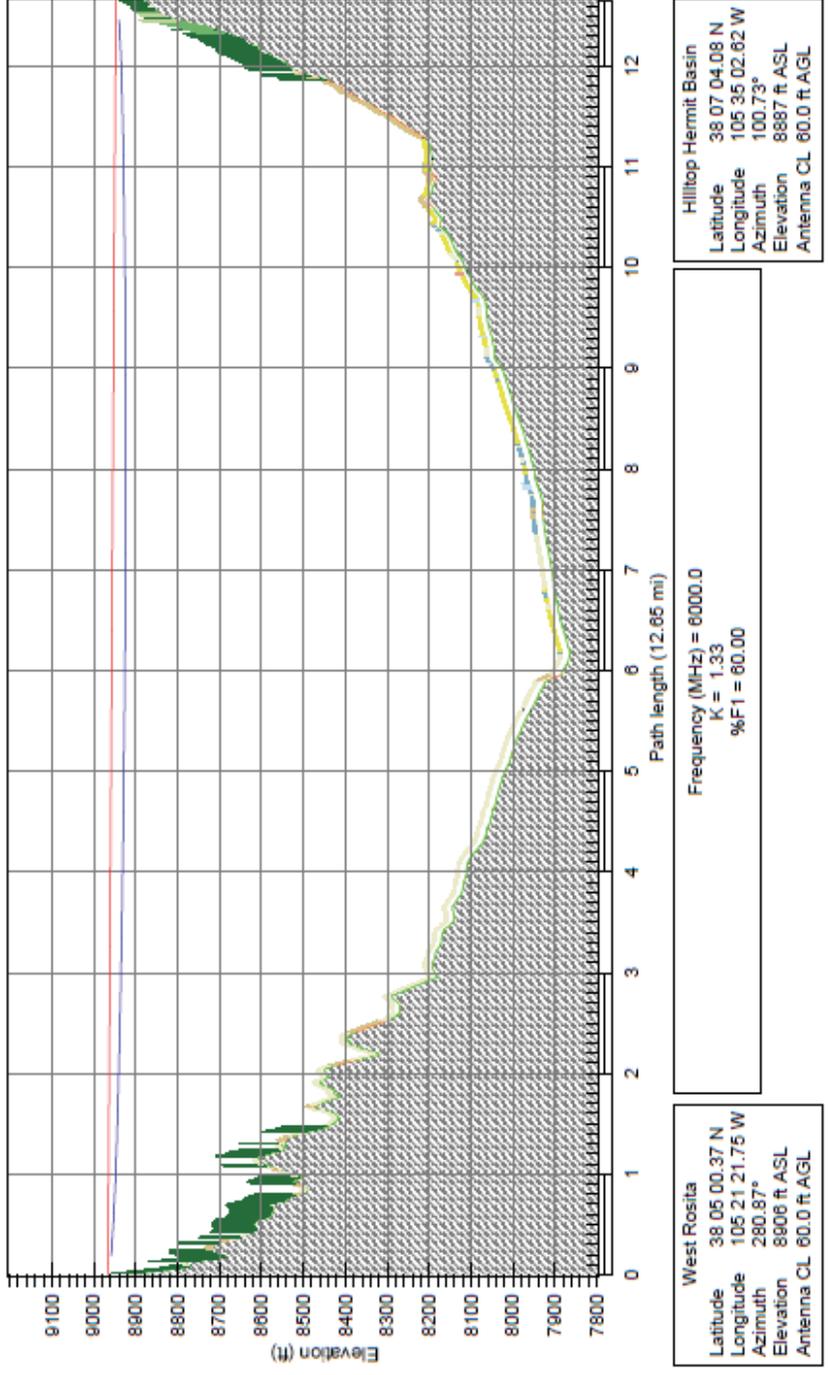
West Rosita Location



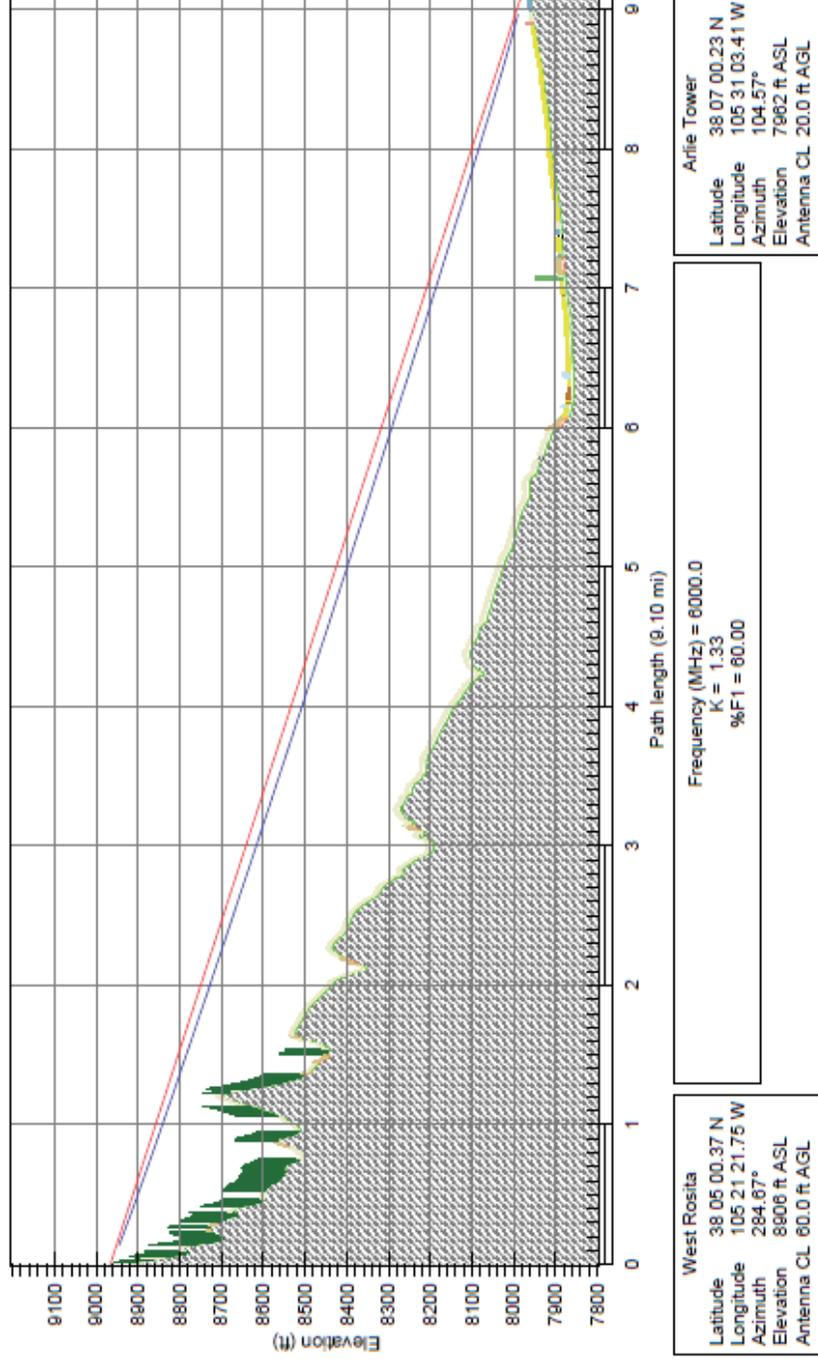
West Rosita Zoom



Hilltop Connectivity



SECOM Connectivity



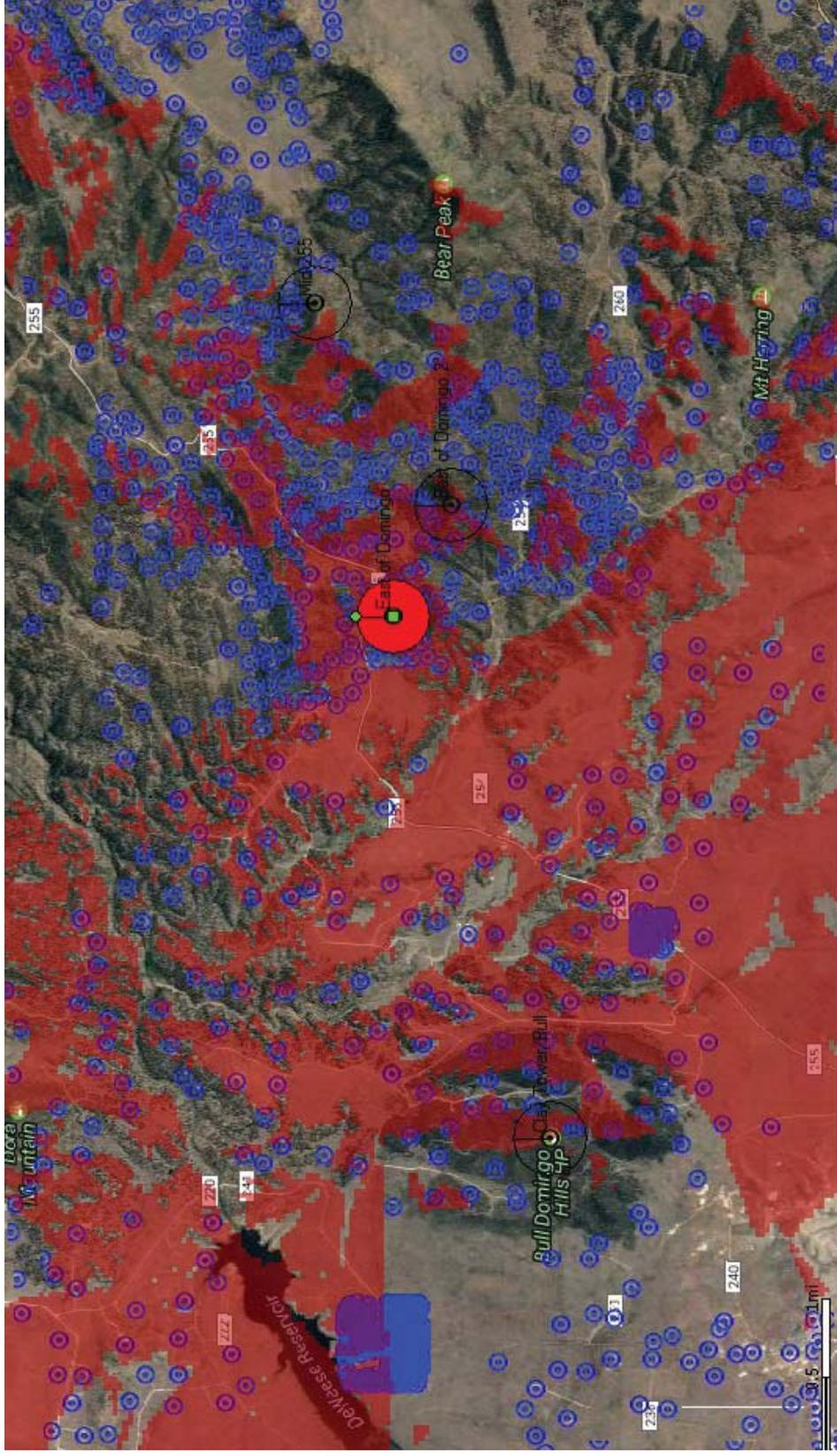
Recommendations Priority 3

- ◆ East of Domingo
 - Good Density of Addresses
 - Current residents served from Clay at distance
 - Two identified potential sites
 - Targets have power and fair access
- ◆ Challenges
 - Difficult terrain for LOS coverage

East of Domingo Location

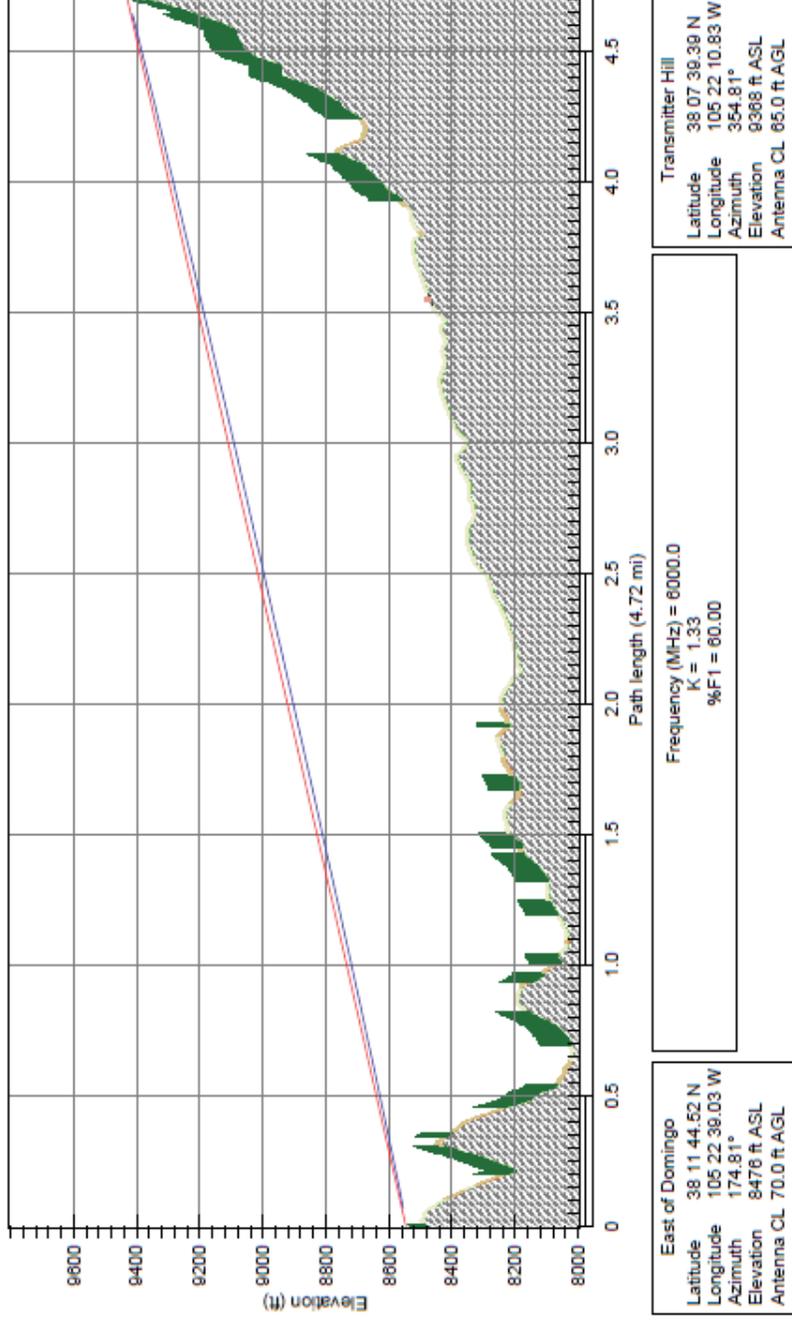


East of Domingo Zoom



East of Domingo Connectivity

Pathloss



East of Domingo-Transmitter Hill.pl5

December 15, 2016

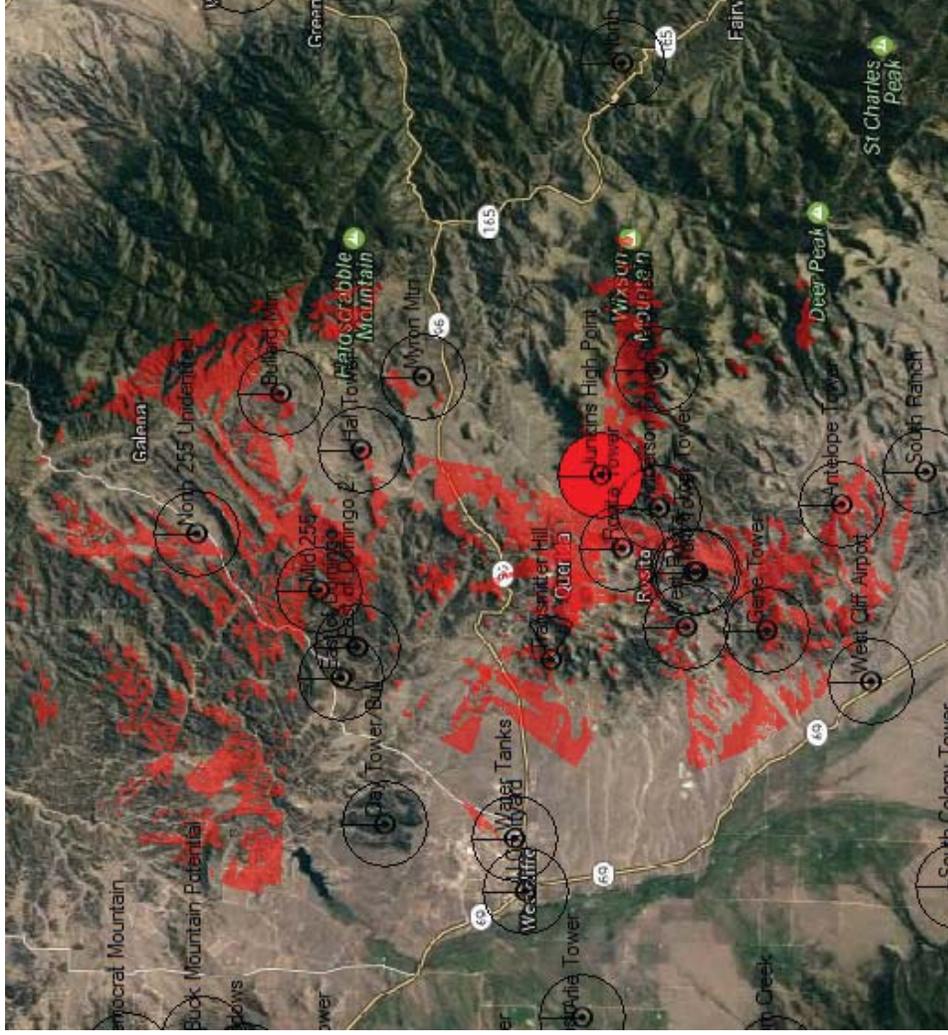
Recommendations Priority 4

- ◆ Junkins High Point
 - High address count
 - Identified private property
 - Gives SECOM multiple LOS in Rosita
 - Gives Hilltop access to area
- ◆ Challenges
 - Site placement is critical due to terrain
 - Address Visibility to other sites dilutes value

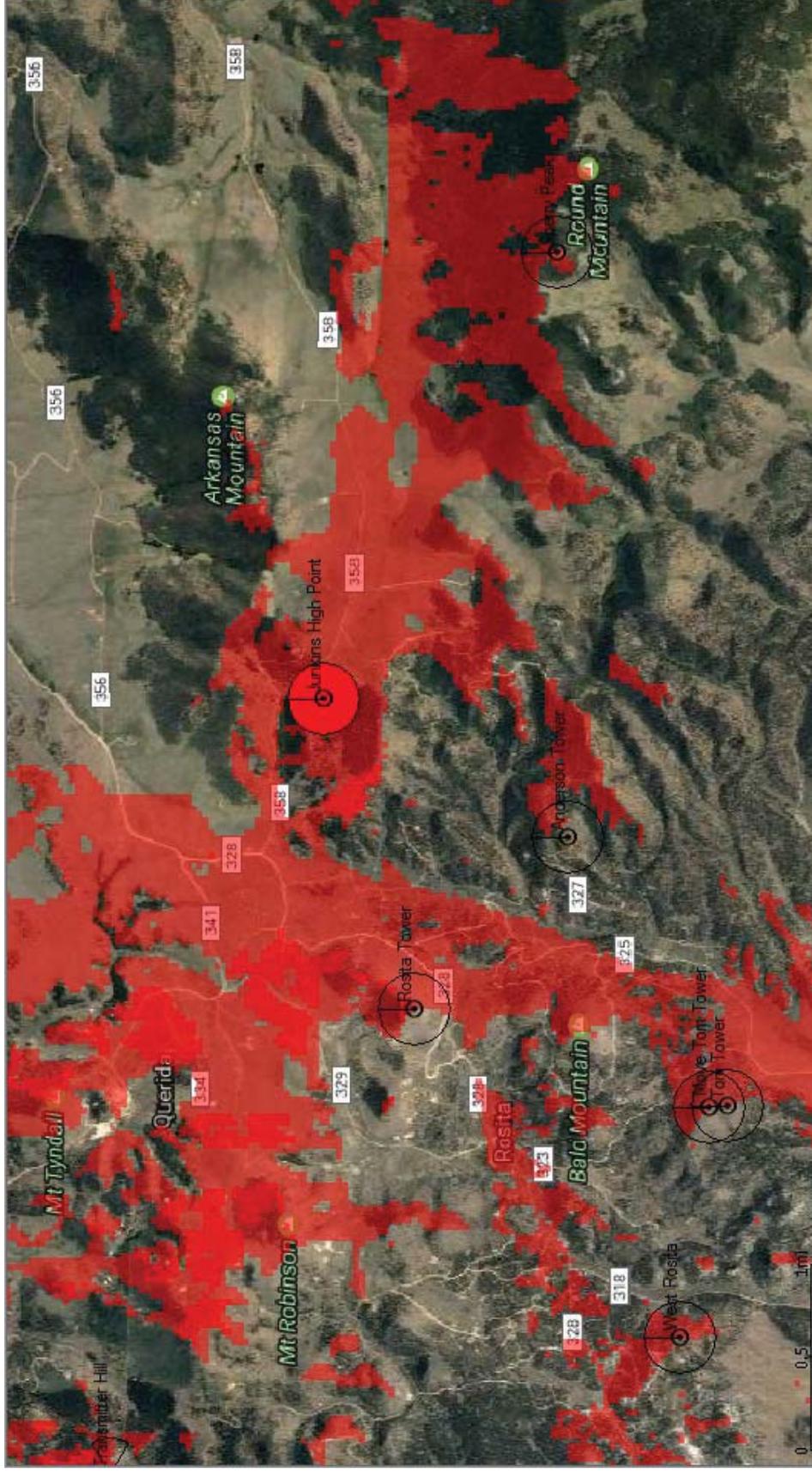
Junkins High Point Location



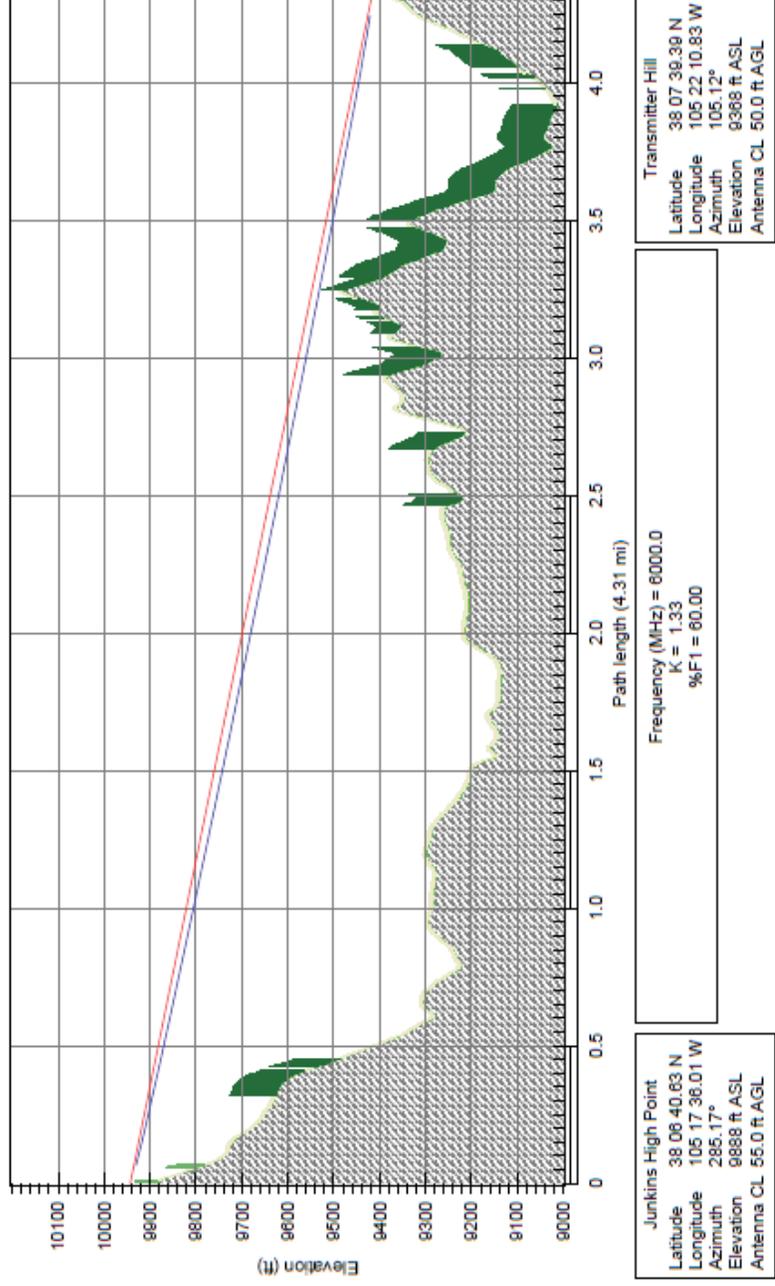
Junkins High Point Coverage



Junkins Zoom



Junkins High Point Connectivity



Junkins High Point-Transmitter Hill.pl6

December 15, 2016

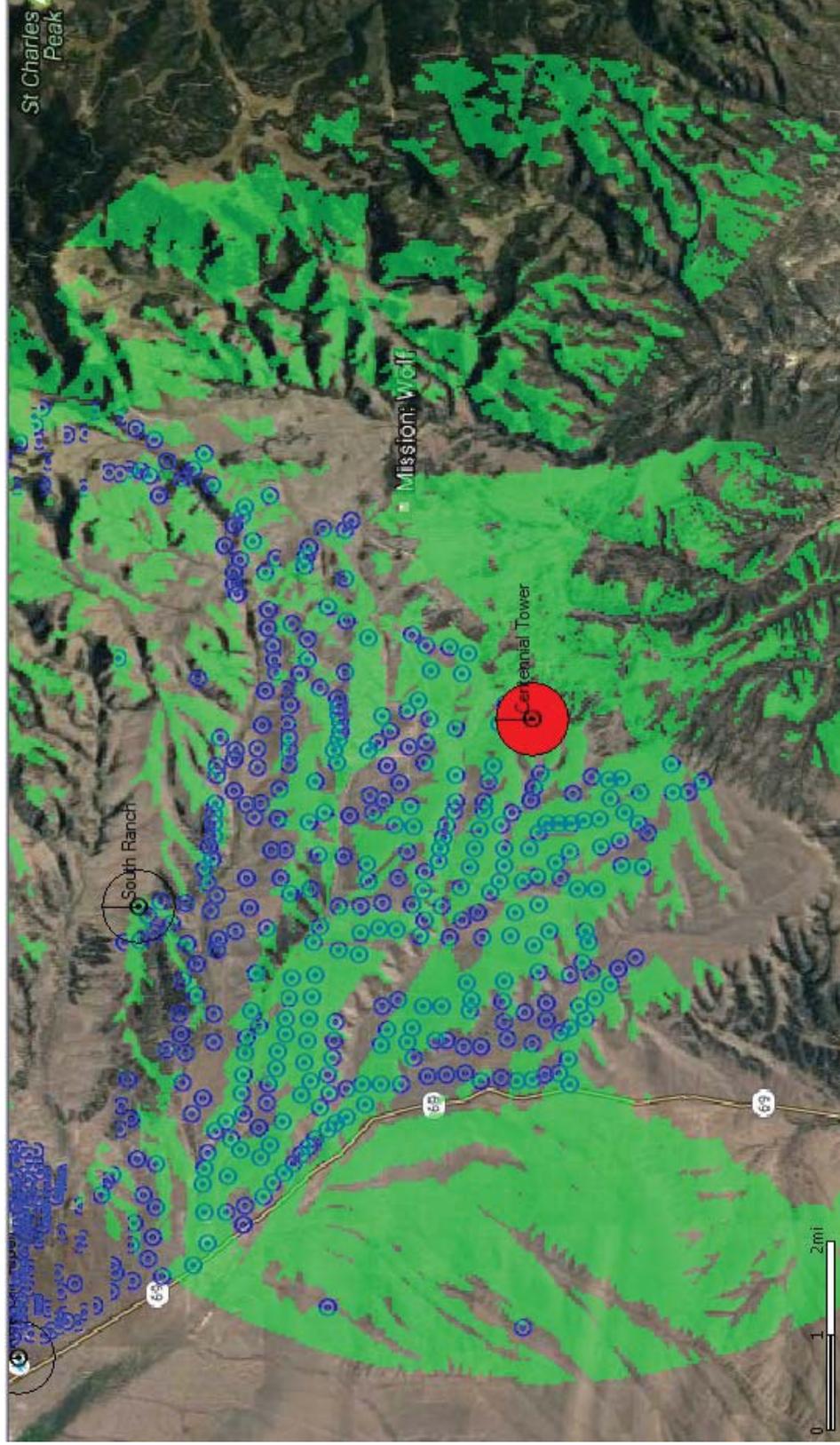
Recommendation Priority 5

- ◆ Centennial
 - Very good incremental coverage for uncovered addresses.
 - Existing SECOM Site
- ◆ Challenges
 - Existing SECOM site
 - Many addresses not yet built
 - Section of County “off grid”

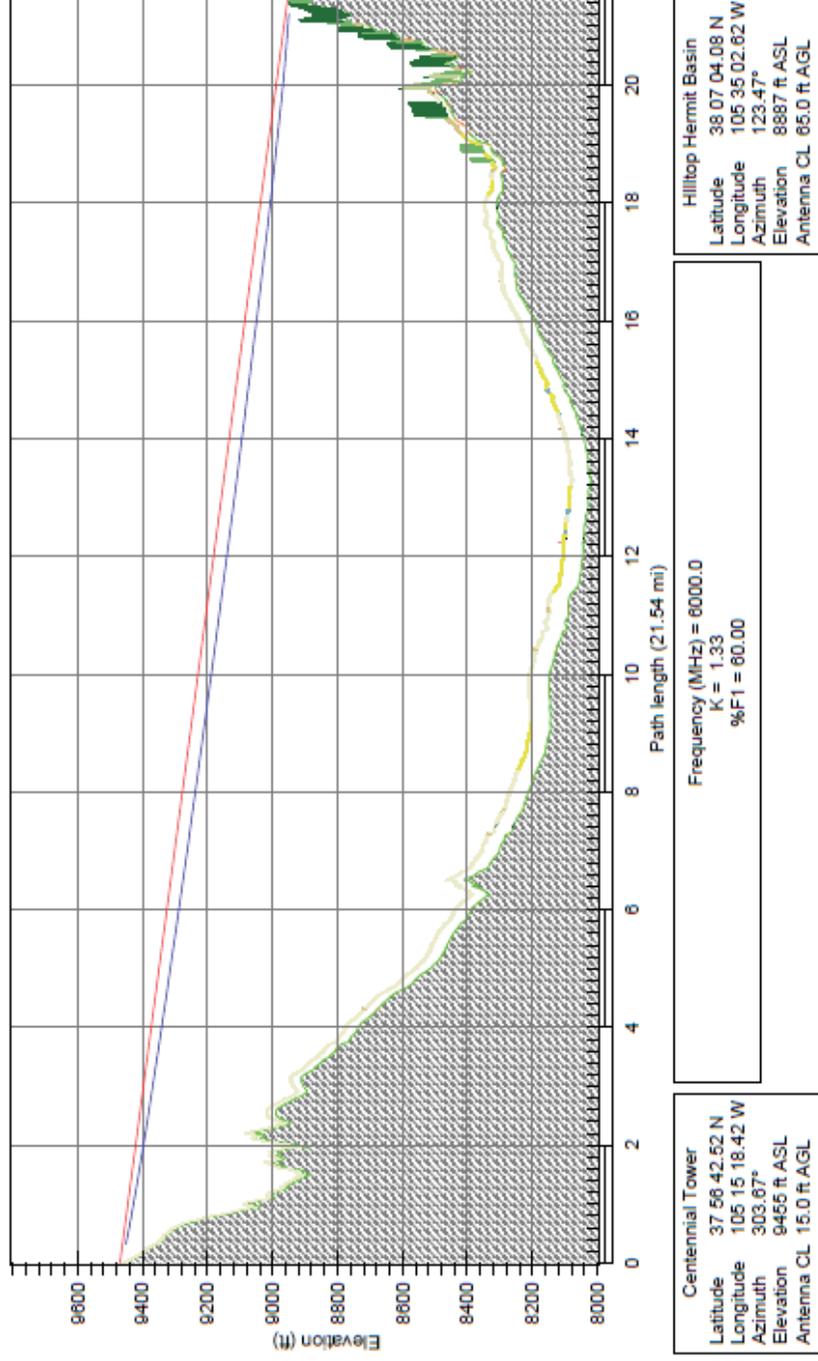
Centennial Location



Centennial Coverage



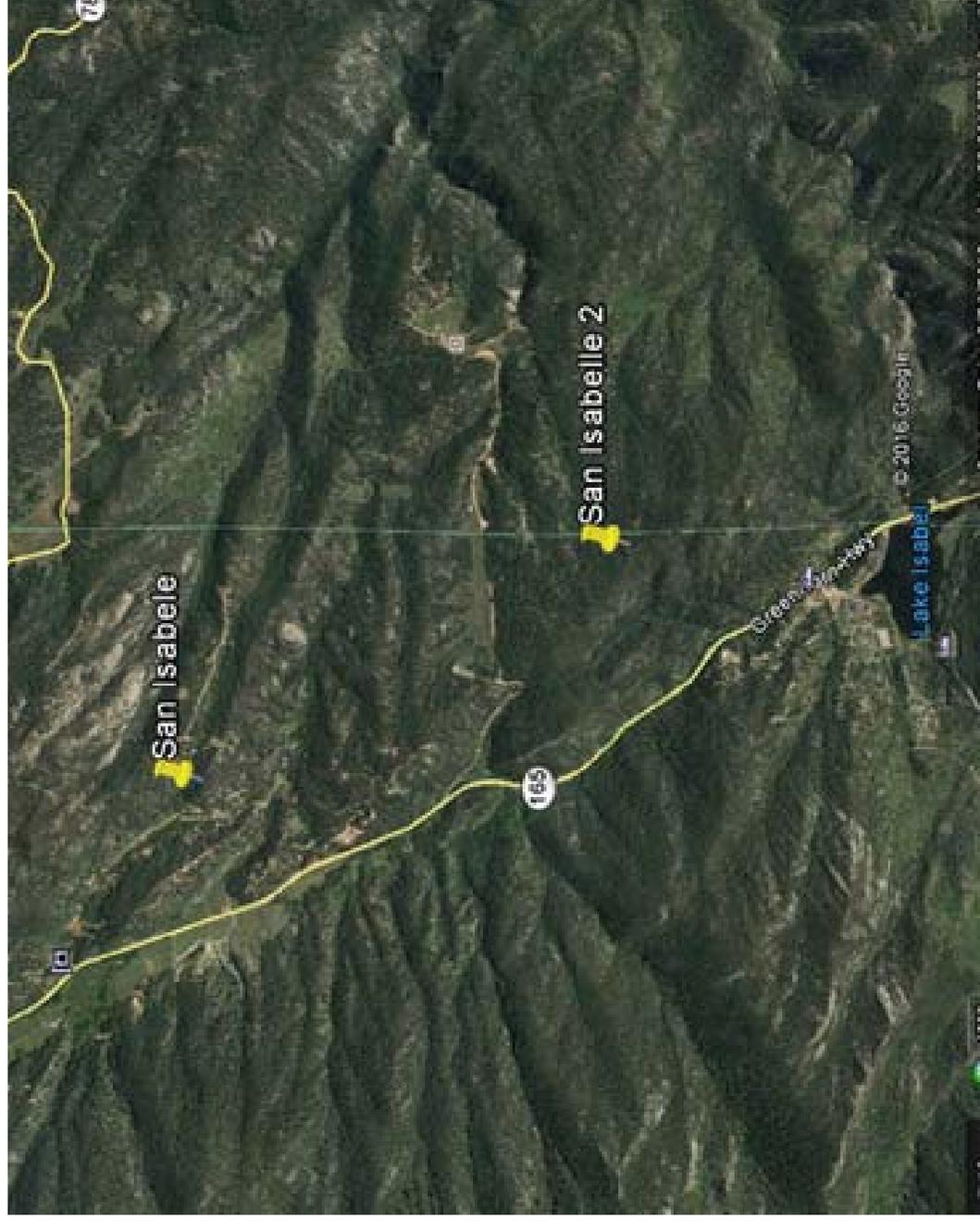
Hilltop Connectivity Centennial



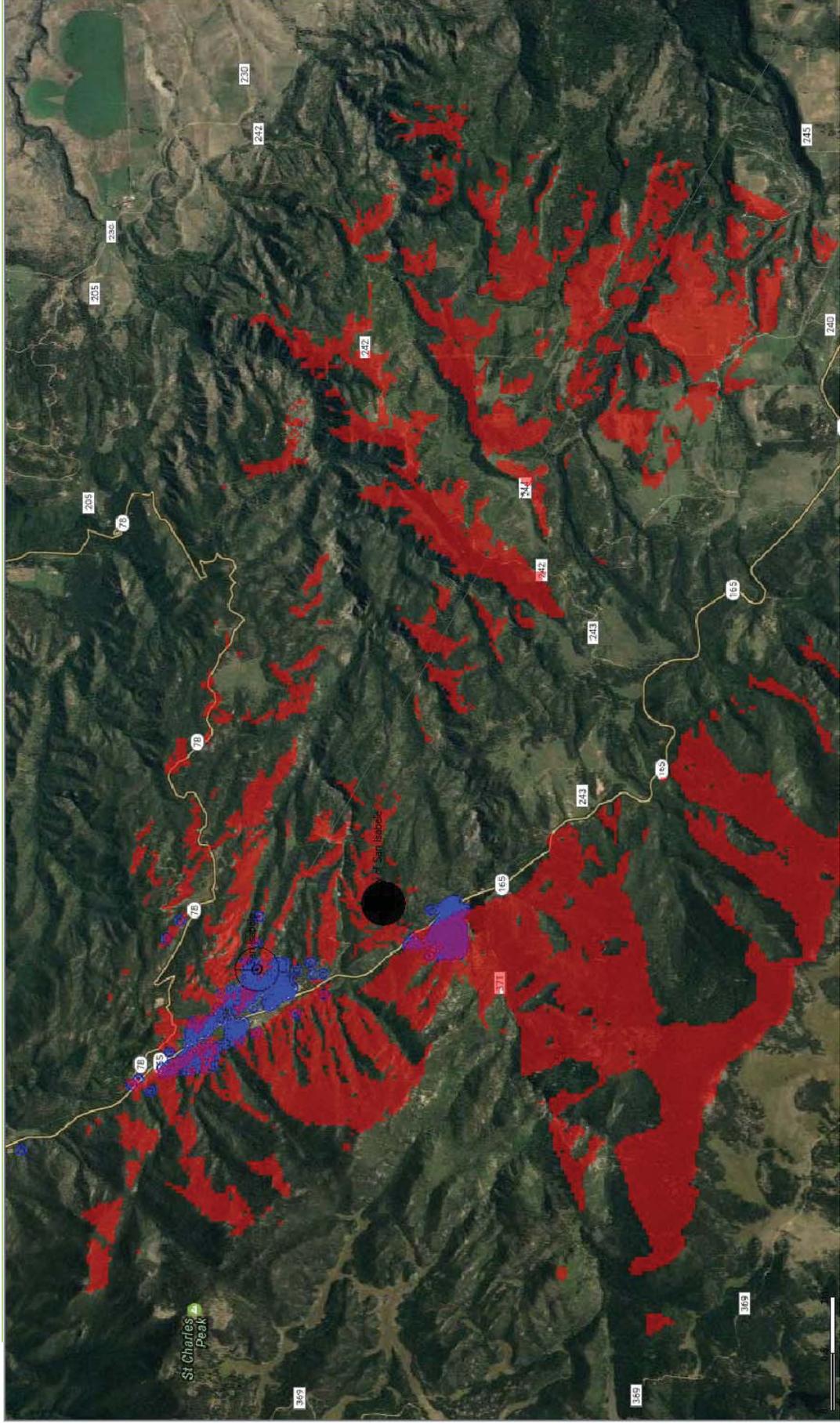
Recommendation 6

- ◆ San Isabelle
 - Not covered now
 - Fair amount of population
 - We found connectivity
- ◆ Challenges
 - Very difficult terrain makes site selection critical
 - Selected site covers addresses in town but not north of town.
 - Connectivity to SECOM tower

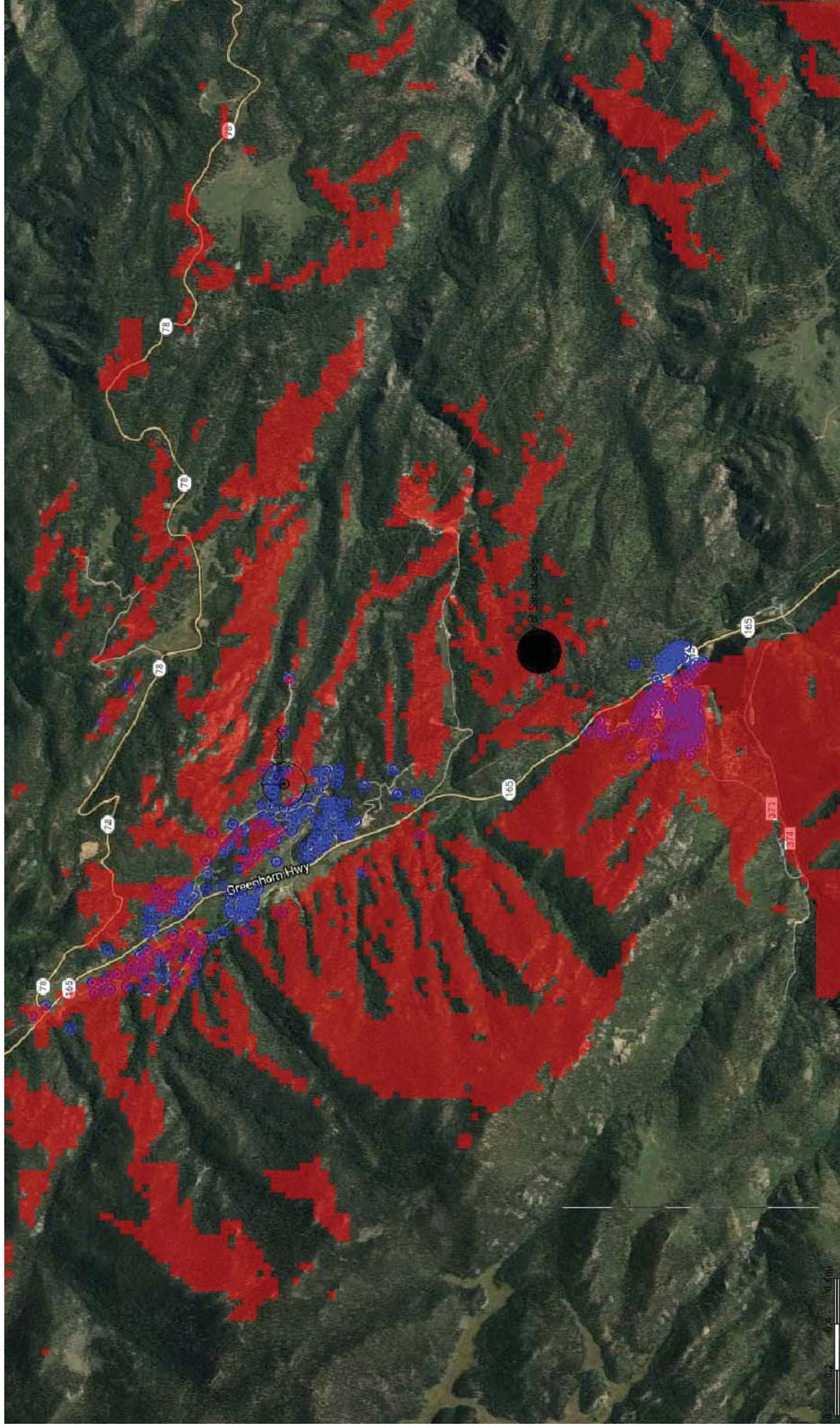
San Isabel Location



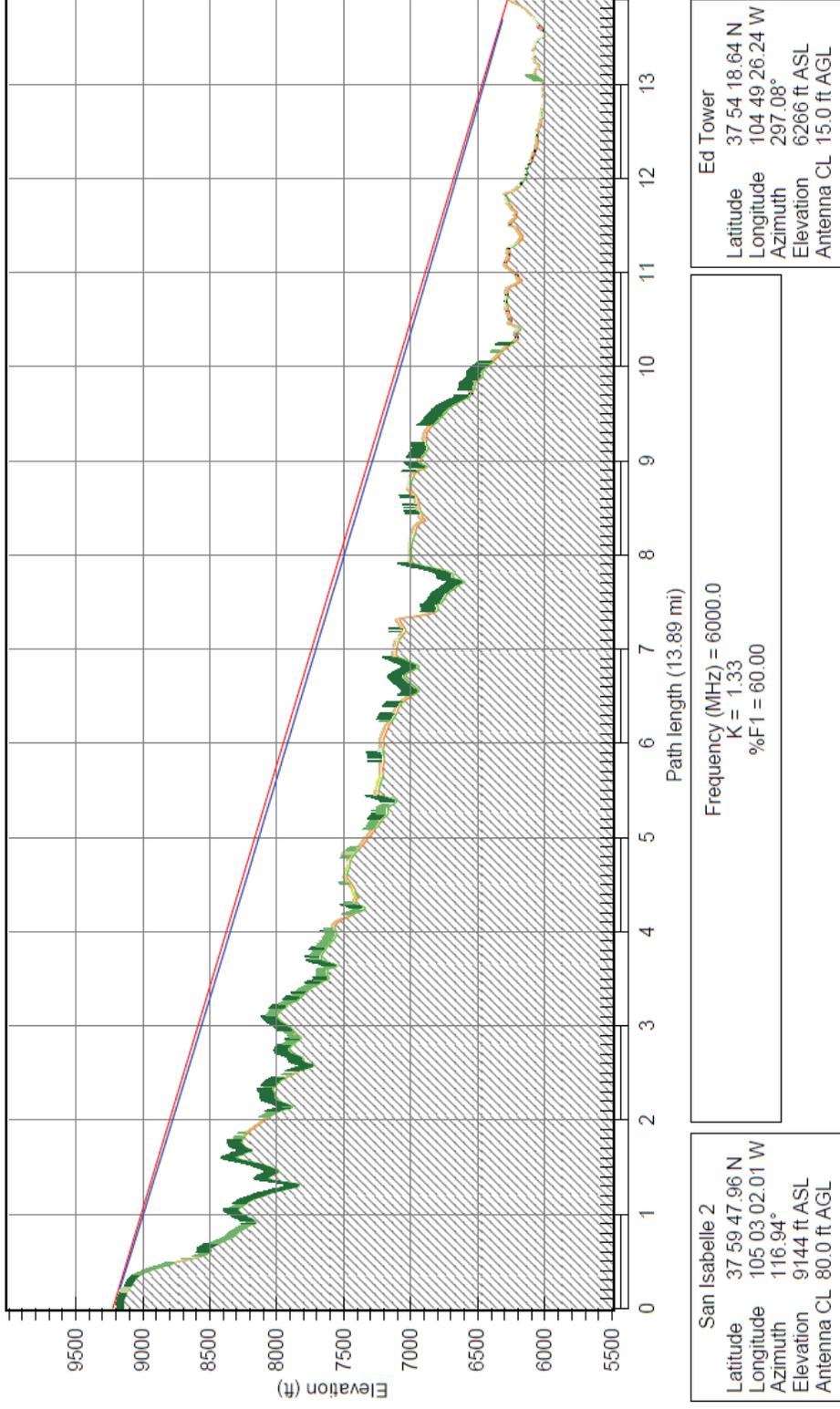
San Isabelle Coverage



San Isabelle Zoom



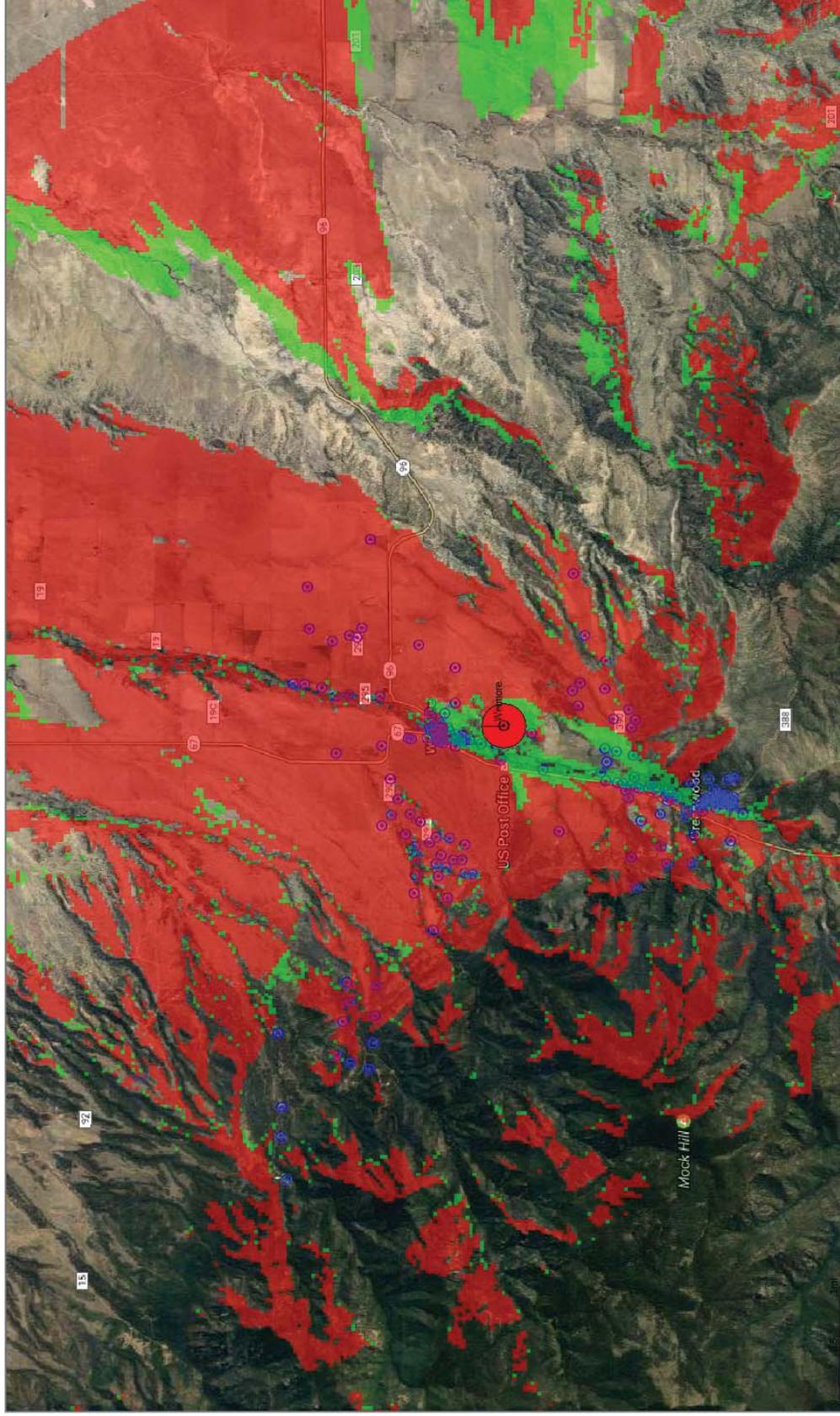
Connectivity to SECOM Ed



Additional Site Considered

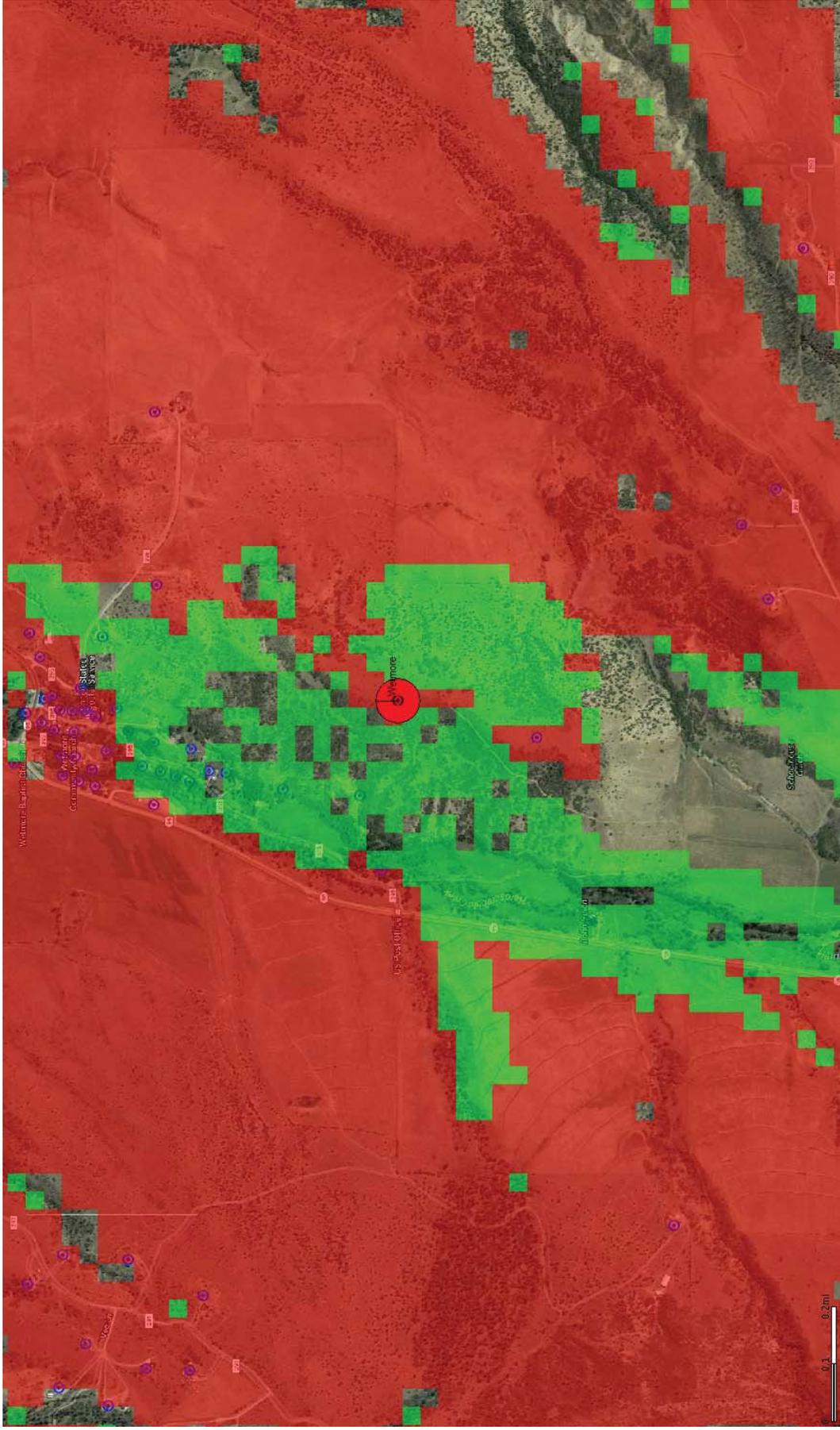
- ◆ Wetmore
 - Existing SECOM site
 - Site is back on a ridge with some addresses blocked by terrain
 - Raising tower adds 33 new addresses.
- ◆ Challenges
 - Raising the tower height only gets a few addresses
 - In prominent view area

Wetmore additional coverage



Green denotes additional coverage with 100 foot tower

Wetmore additional coverage zoom



Wetmore Connectivity

- ◆ Existing coverage to SECOM West Pueblo site for SECOM.
- ◆ Hilltop would have to identify connectivity.

Coverage to tower height sensitivity

- ◆ Tower height will be determined when locations are finalized.
- ◆ Tower cost will have to be considered as well
- ◆ The following sensitivity analysis can be used when the location is finalized:

| Name | Addresses Covered | Addresses Percentage | Total Addresses |
|-------------|-------------------|----------------------|-----------------|
| Buck at 160 | 936 | 14.28 | 6,553 |
| Buck at 140 | 931 | 14.21 | 6,553 |
| Buck at 120 | 924 | 14.1 | 6,553 |
| Buck at 100 | 915 | 13.96 | 6,553 |
| Buck at 80 | 912 | 13.92 | 6,553 |
| Buck at 60 | 905 | 13.81 | 6,553 |
| Buck at 40 | 892 | 13.61 | 6,553 |



Site Modeling and Initial Recommendations
Custer County, Colorado

Prepared For
Custer County Economic Development
Board

28 December 2016

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Executive Summary

The Custer County Economic Development Corporation (CCEDC) desires to improve broadband availability and wireless service throughout Custer County. Because the County is rural and sparsely populated, commercial entities hesitate to invest capital to improve service due to low return on investment concerns. CCEDC wishes to proactively encourage expansion by providing the tower assets needed to serve all its constituents. This report builds on the previous Broadband Assessment by modeling the Line of Sight (LOS) coverage from existing and proposed sites.

To estimate those addresses potentially covered from existing sites with the incumbent carriers, coverage was modeled at 360 degrees from the current sites at existing elevations. Coverage distance was limited to 7 miles Line of Sight (LOS), both as a compromise between the two link budgets given by the carriers previously and also because this distance is a common industry standard. Additionally, it is assumed that a subscriber's antenna can be mounted at 20 feet Above Ground Level (AGL), which is a common height for a roof peak of a single-story residence. Finally, the model assumes that immediate obstructions such as large rocks, unusually large trees and manmade structures will not block the antenna's LOS.

Coverage from proposed locations and some existing locations was modeled at 100 feet AGL. Final antenna height will be determined as a function of exact tower placement and final design. Except for the antenna height, the assumptions used for the existing sites—as stated previously—all apply for this analysis, as well, with the most important assumption being that the address count per site as given is exclusive of coverage from other sites.

The next step in the analysis was to evaluate incremental gain in overall addresses covered above and beyond the existing coverage. For this analysis, all existing sites were modeled using the assumptions stated above, then incrementally adding the proposed sites to gain the addresses covered by the additional sites. This approach illustrates the value of the proposed site over the potential coverage from existing sites. This correlates with the value offered to the existing wireless operators in the county.

The sites that would require connectivity were evaluated for feasible links against all sites in the surrounding area. Hub sites for each incumbent carrier were chosen as primary targets for backhaul.

Based on the aforementioned methods and criteria, six sites were chosen as the primary locations for possible towers. These sites are:

- Buck/Beddows
- West Rosita
- East of Domingo
- Junkins (Loop) High Point
- Centennial
- San Isabel

Project Overview

The Custer County Economic Development Corporation (CCEDC) desires to improve broadband availability and wireless service throughout Custer County. Because the County is rural and sparsely populated, commercial entities hesitate to invest capital to improve service due to low return on investment concerns. CCEDC wishes to proactively encourage expansion by providing the tower assets needed to serve all its constituents.

Currently, two Wireless Internet Service Providers (WISPs) are operating in Custer County: DD Wireless (recently acquired by SECOM) and Hilltop Wireless. Both provider's systems were modeled assuming 360-degree (omni) coverage.

Three visits were made to the County, including a kickoff meeting and a comprehensive drive of the county. During the second and third visits, all WISP sites and Centerline-selected potential sites were mapped out, and the drive included seeing as many of these as possible. The Centerline-selected sites were based on possible locations that had good line of sight (LOS) to addresses provided by the county.

Existing WISP Coverage

To estimate those addresses potentially covered from existing sites with the incumbent carriers, coverage was modeled at 360 degrees from the current sites at existing elevations. Coverage distance was limited to 7 miles Line of Sight (LOS), both as a compromise between the two link budgets given by the carriers previously and also because this distance is a common industry standard of coverage. Additionally, it is assumed that the subscriber antenna can be mounted at 20 feet AGL, which is a common height for a roof peak of a single-story residence. Finally, the model assumes that local obstructions such as large rocks, unusually large trees and manmade structures are cleared by the antenna.

Table 1 gives the sites used for existing carrier coverage along with the number of addresses covered. The addresses given in the table are exclusive of any other coverage and provide a good reference point of the coverage over addresses from that location. The total addresses column gives the total number of addresses provided in the County database. The county database provides all registered addresses in the county with an approximate latitude and longitude. In some cases, the structure is not located exactly as indicated by the database, but it was beyond the scope of this project to adjust all the data to match satellite imagery. Also, some of the addresses issued have not been built yet, but it was agreed that the addresses should be considered for future growth.

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Comments |
|-------------------------------|-------------------|----------------------|-----------------|---|
| Clay Tower 20 | 1,514 | 23.1 | 6,553 | Assumes clears all local obstructions |
| JJ Courtyard at 30 ft Hilltop | 1,118 | 17.06 | 6,553 | Many addresses at distance. Local coverage obstructed |
| Arlie30 | 987 | 15.06 | 6,553 | |
| Transmitter Hill D at 20 ft | 955 | 14.57 | 6,553 | |
| Stoneman Tower 20 | 708 | 10.8 | 6,553 | |
| Democrat Mt 20 | 650 | 9.92 | 6,553 | |
| Toms Tower 20 | 513 | 7.83 | 6,553 | |
| Horn Creek 30 Hilltop | 503 | 7.68 | 6,553 | |
| Hilltop Hermit 30 Hilltop | 484 | 7.39 | 6,553 | |
| Anderson Tower 20 | 368 | 5.62 | 6,553 | |
| South Colony Tower 20 | 333 | 5.08 | 6,553 | |
| Antelope Tower 20 | 293 | 4.47 | 6,553 | |
| Rosita Tower at 20 ft | 233 | 3.56 | 6,553 | |
| Gene Tower20 | 223 | 3.4 | 6,553 | |
| Hal Tower at 20 ft | 195 | 2.98 | 6,553 | |
| Centennial at 20 | 160 | 2.44 | 6,553 | |
| Wetmore 20 | 91 | 1.39 | 6,553 | |

Table 1. Addresses Covered by Existing Towers

Coverage from proposed locations

Coverage from those proposed locations and some existing locations was modeled at 100 feet AGL. Final antenna height will be determined as a function of exact tower placement and final design. Except for the antenna height, the assumptions used for the existing sites—as stated previously—all apply for this analysis, as well, with the most assumption important being that the address count per site as given is exclusive of coverage from other sites. The exception to this is the extra column that has been added to the table for those sites that have been modeled with higher antenna structures at existing locations. This column provides the difference between the new coverage and the existing coverage.

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Existing covered addresses | Add Addresses | Comments |
|-------------------------|-------------------|----------------------|-----------------|----------------------------|---------------|---|
| West Rosita Tower 100 | 1,039 | 15.86 | 6,553 | | 1039 | Did not compare against Rosita, Toms, Anderson |
| Water Tank 100 | 983 | 15 | 6,553 | | 983 | Did not compare against JJ Courtyard |
| Buck Mountain 100 | 915 | 13.96 | 6,553 | | 915 | |
| Beddows 100 | 851 | 12.99 | 6,553 | | 851 | Alternate to Buck |
| Sperry Peak 100 | 654 | 9.98 | 6,553 | | 654 | Coverage into Antelope Butte (S. of Rosita) at distance |
| Junkins High Point | 651 | 9.93 | 6,553 | | 651 | |
| East of Domingo 100 | 647 | 9.87 | 6,553 | | 647 | |
| East of Domingo 2 100 | 631 | 9.63 | 6,553 | | 631 | Alternate to East of Domingo |
| Gene Tower 100 | 704 | 10.74 | 6,553 | 223 | 481 | Overlap with Sperry but in better position |
| Verdemont Tower 100 | 443 | 6.76 | 6,553 | | 443 | Some overlap with Beddows and Buck |
| South Ranch 100 | 348 | 5.31 | 6,553 | | 348 | |
| Mld 255 Tower at 100 ft | 316 | 4.82 | 6,553 | | 316 | |
| Toms Tower 100 | 788 | 12.03 | 6,553 | 513 | 275 | |
| Bullard Mountain 100 | 227 | 3.46 | 6,553 | | 227 | |
| Centennial Tower 100 | 197 | 3.01 | 6,553 | | 197 | |
| Transmitter Hill 100 | 1,150 | 17.55 | 6,553 | 955 | 195 | Includes Population to the West |
| Move Toms Tower 100 | 695 | 10.61 | 6,553 | 513 | 182 | |
| Myron Mountain 100 | 161 | 2.46 | 6,553 | | 161 | |
| Rosita Tower 100 | 370 | 5.65 | 6,553 | 233 | 137 | |
| North 255 100 | 129 | 1.97 | 6,553 | | 129 | |
| Antelope Tower 100 | 417 | 6.36 | 6,553 | 293 | 124 | |
| San Isabele 100 | 118 | 1.8 | 6,553 | | 118 | |
| Anderson Tower 100 | 478 | 7.29 | 6,553 | 368 | 110 | |
| Arlie 100 | 1,053 | 16.07 | 6,553 | 987 | 66 | Secom Microwave Hub, may build second tower |
| Horn Creek 100 | 564 | 8.61 | 6,553 | 503 | 61 | Site not yet active. Arlie covers into this area. |
| South Colony Tower 100 | 394 | 6.01 | 6,553 | 333 | 61 | |
| Clay Tower 100 | 1,574 | 24.02 | 6,553 | 1,514 | 60 | Assumes existing tower clears local obstucitons |
| Hermit Basin 100 | 540 | 8.24 | 6,553 | 484 | 56 | Arlie covers into this area |
| Hal Tower at 100 ft | 240 | 3.66 | 6,553 | 195 | 45 | |
| Wetmore 100 | 124 | 1.89 | 6,553 | | 91 | 33 |
| Stoneman Tower 100 | 735 | 11.22 | 6,553 | 708 | 27 | |
| North 165 100 | 13 | 0.2 | 6,553 | | 13 | |

Table 2. Addresses Covered by Proposed Towers

Of note here is that some of the sites show great coverage (i.e. Transmitter Hill, Arlie and Clay), but raising the site provided relatively few additional addresses. The implications of this are detailed later in this report.

Progressive Analysis of New and Existing Coverage

The next step in the analysis was to evaluate incremental gain in overall addresses covered above and beyond the existing coverage. For this analysis, all existing sites were modeled using the assumptions stated above, then incrementally adding the proposed sites to gain the addresses covered by the additional sites. This approach illustrates the value of the proposed site over the potential coverage from existing sites. This correlates with the value offered to the existing wireless operators in the county.

Because coverage from the proposed sites will interact with the existing sites and the other proposed sites that might be built before it, an iterative process was used to determine the overall incremental gain of each site add. This process also revealed the diminishing returns of the less-effective sites on the overall percentage covered in the county. Appendix A provides the iteration sequences that were performed for this analysis, with the final recommended sequence provided in Table 3.

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Incremental increase | Incremental percentage |
|---|-------------------|----------------------|-----------------|----------------------|------------------------|
| Both Systems | 4,140 | 63.18 | 6,553 | | |
| Both System Plus Buck | 4,309 | 65.76 | 6,553 | 169 | 2.58 |
| Both Systems Buck Cent | 4,448 | 67.88 | 6,553 | 139 | 2.12 |
| Both Systems Buck Cent Mid255 | 4,597 | 70.15 | 6,553 | 149 | 2.27 |
| Both Systems Buck Cent Mid255 SanIs | 4,715 | 71.95 | 6,553 | 118 | 1.8 |
| Both Systems Buck Cent Mid255 SanIs WRosit | 4,816 | 73.49 | 6,553 | 101 | 1.54 |
| Both Systems Buck Cent Mid255 SanIs WRosit Dom | 4,886 | 74.56 | 6,553 | 70 | 1.07 |
| Both Systems Buck Cent Mid255 SanIs WRosit Dom Junkins | 4,958 | 75.66 | 6,553 | 72 | 1.1 |
| Both Systems Buck Cent Mid255 SanIs WRosit Dom Junkins SRanch | 5,010 | 76.45 | 6,553 | 52 | 0.79 |

Table 3. Optimal Incremental Addition Analysis

For reference, the site names are abbreviated for practicality and are as follows:

- Buck: Buck Mountain
- Cent: Centennial Tower
- Mid255: Mid 255 Tower (located on CR 255 midway between Silver Cliff and county line)
- SanIs: San Isabelle
- WRosit: West Rosita Tower
- Dom: East of Domingo
- Junkins: Junkins High Point
- SRanch: South Ranch

After going through the exercise, the eight sites listed provide the greatest additional coverage over addresses in the county.

Site Connectivity

The sites that would require connectivity were evaluated for feasible links against all sites in the surrounding area. In choosing the best practical method to backhaul a site, the following assumptions and considerations were applied:

- Dense trees and foliage in the area will be no higher than 50' AGL.
- Reasonable tower heights will be available for each location, not to exceed 80' AGL.
- Spacing exists or will exist at each site to accommodate the new link antennas.
- The terrain profiles were generated with 1/3 arc second terrain and 2011 NLCD clutter data.
- The Fresnel Zones for 6 GHz will suffice to determine antenna height required.
- Any path beyond 25 miles will be determined as non-feasible for 6 GHz.
- Climatic Factor and Terrain Roughness will not generate a C factor higher than 0.25.
- K factor will not refract beyond the range of 1.333 (4/3) to 1.0.
- Co-channel interference will be a non-issue because of availability of licenses for upper and lower 6 GHz in the service area.

- Transmitter Hill acts as a backup service point for both the Hilltop Hermit Basin and Arlie sites.
- The area seems very arid, drastically reducing the concern for multipath and reflection. For those feasible links where this could be an issue, potential reflection is adequately blocked by tree lines and practical design.

Against these considerations, feasible microwave paths were found for each of the sites in question. Figure 1 is the representation of these optimal paths:

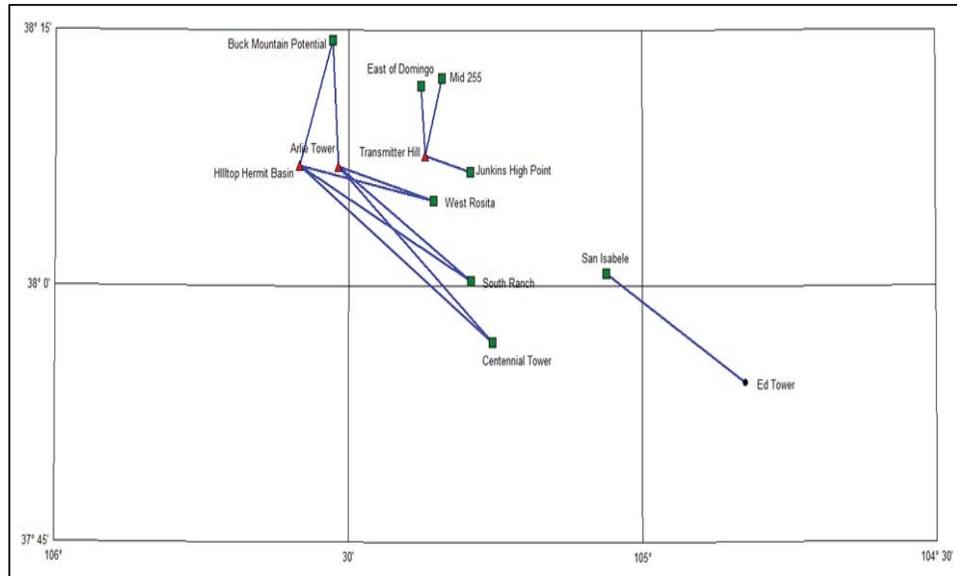


Figure 1. Overall Connectivity Feasible Network

Each subsequent site was evaluated against terrain and clutter, and these profiles can be found in the following section, “Site Recommendations”.

San Isabel Isolation

Issues arose when attempting to connect San Isabel to the primary Points of Presence (Hermit Basin, Arlie Tower, Transmitter Hill), or even to any point West of the site. Refer to the following Figure 2, of which RED links are not feasible.

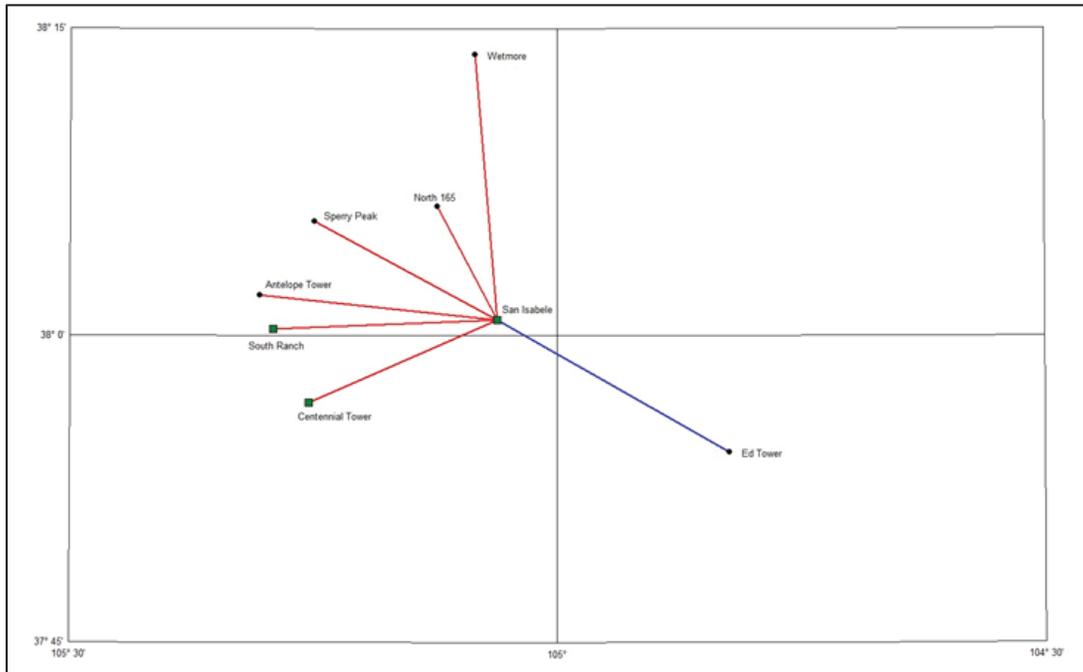


Figure 2. San Isabel Isolation

The primary driver for determining that a nearby site was non-feasible was the required antenna height to attain any form of Line of Sight. Table 4 is a breakdown of the required heights for the sites described above, illustrating the reasoning for them having no practical consideration:

| Site 1 | Required Height (ft. AGL) | Site 2 | Required Height (ft. AGL) |
|------------|---------------------------|------------------|---------------------------|
| San Isabel | 2333.3 | Centennial Tower | 1195.0 |
| | 2913.0 | South Ranch | 1583.6 |
| | 2930.1 | Antelope Tower | 937.9 |
| | 1958.8 | Sperry Peak | 738.7 |
| | 681.3 | North 165 | 110.8 |
| | 1560.7 | Wetmore | 924.0 |

Table 4. Antenna Height for Connectivity to San Isabel

The best available path for connectivity to San Isabel was determined to be Ed Tower. Reasonable antenna heights would be required for this path to be feasible, as seen in Figure 3:



Figure 3. San Isabel Feasible Path

Site Recommendations

The analysis of total covered addresses gave us good insight to the visibility of the site to potential subscribers, which in turn provides value to the operator. The incremental addresses analysis shows us which sites will help us attempt to reach the goal of 80 percent of the addresses covered in the county. Finally, subjective criteria must be considered, such as:

- Constructability
- Accessibility
- Marketability
- Connectivity
- Industry Experience

The following site recommendations are based on all the above criteria.

Site 1: Buck/Beddows

Buck Mountain is given as the primary site, with Beddows Mountain as a backup. Construction may be difficult on Buck, and Beddows will require leasable property. These two sites (shown in Figure 4) were third on the list of total covered addresses and first on the list of incremental addresses. In addition, potential subscribers and incumbent providers in this area have expressed demand for new infrastructure. All these factors combined make this an easy choice for the first site to pursue.



Figure 4. Location of Buck and Beddows

Coverage for Buck, shown in Figure 5, extends beyond the immediate area of difficult terrain to both the east and the west. The following coverage plot shows Line of Sight (LOS) for Buck at a 7-mile radius. The blue circles indicate addresses from the county data base.

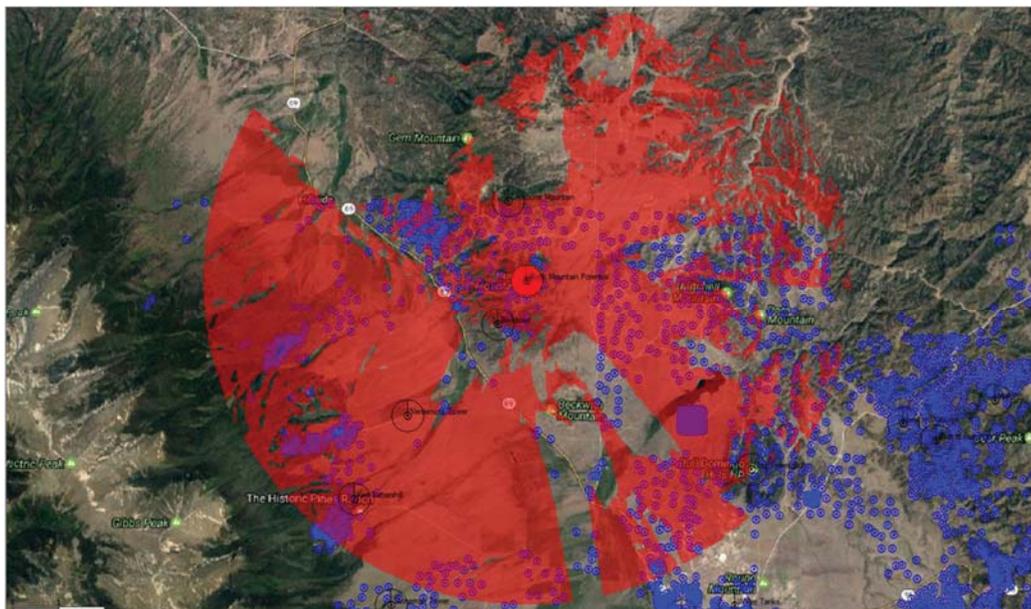


Figure 5. Buck Mountain Coverage

Connectivity to each provider's networks is provided through existing sites located at Hermit Basin and the Arlie tower. Figure 6 and Figure 7 show potential connection links for the respective carriers to the target sites.

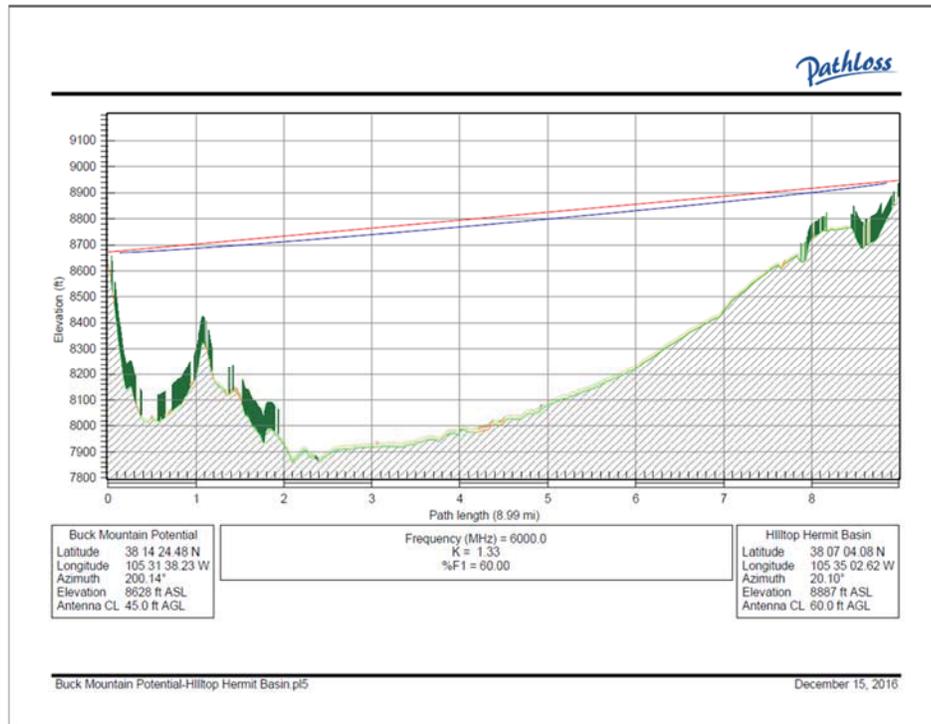


Figure 6. Microwave connectivity for Hilltop Wireless

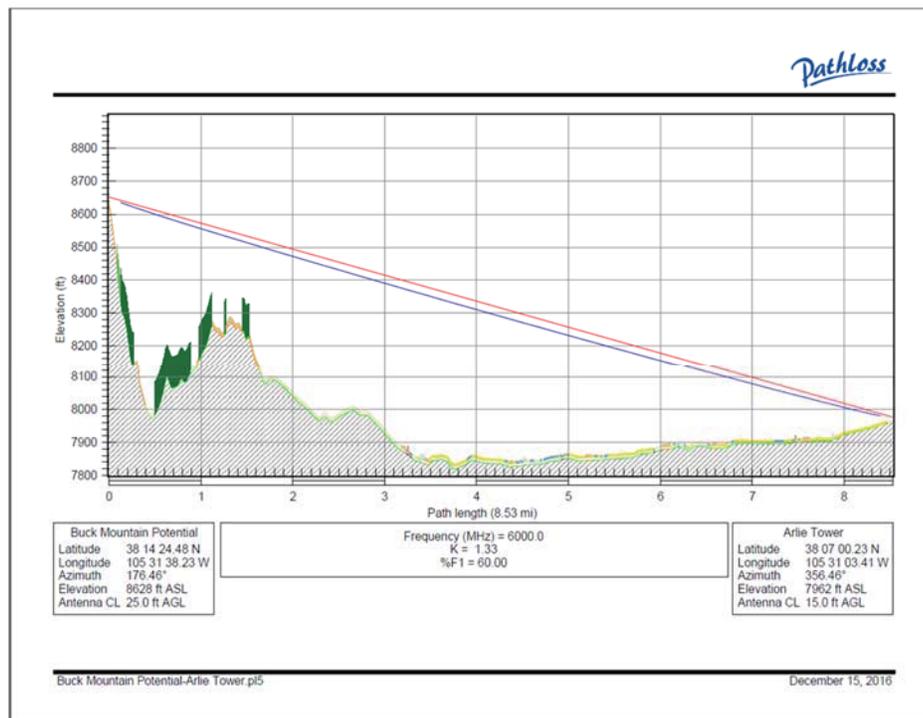


Figure 7. Microwave connectivity for SECOM

Site 2: West Rosita

The West Rosita site will provide new coverage to an area along Rosita road, leading in from the west near the intersection with CR 318. The approximate location of this site is shown on Figure 8. The site was the top contributor on the address covered list sees many addresses and was a strong contributor to the incremental address list. The site can also add a redundant connection over a large area as indicated by the coverage plot shown in Figure 9.



Figure 8 West Rosita Site Location (approximate)

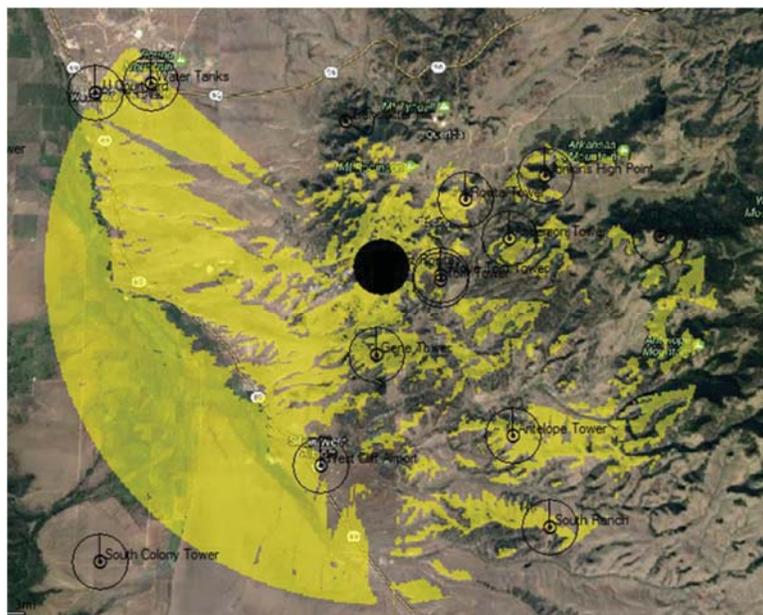


Figure 9. West Rosita Site Coverage

Figure 10 and Figure 11 show microwave connectivity into both SECOM's and Hilltop Wireless' existing hubs. In addition, Hilltop may be able to connect directly to Westcliffe.

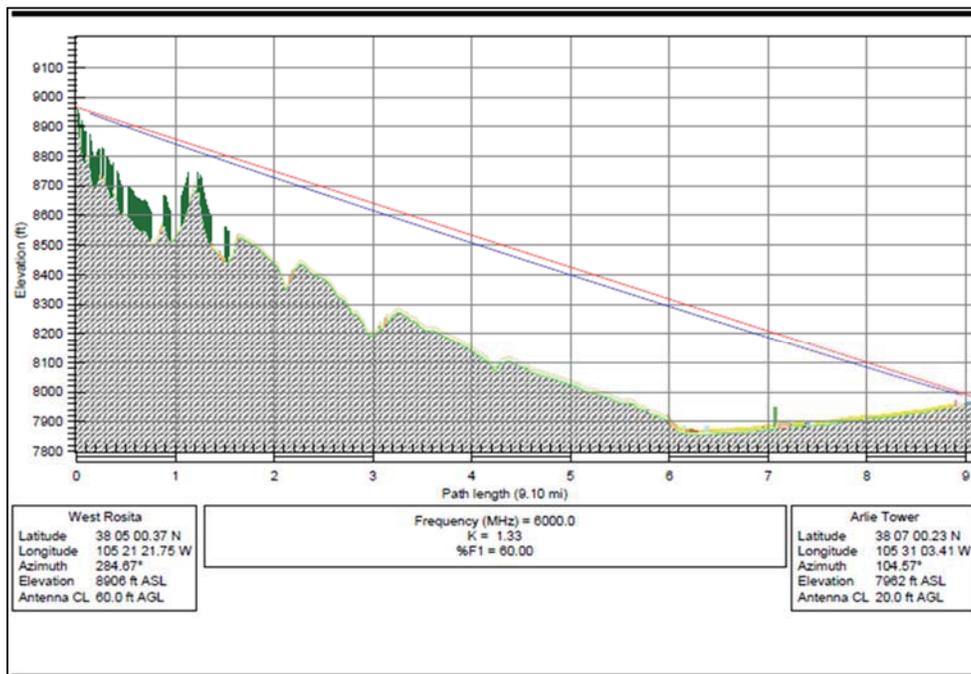


Figure 10. Microwave connectivity SECOM

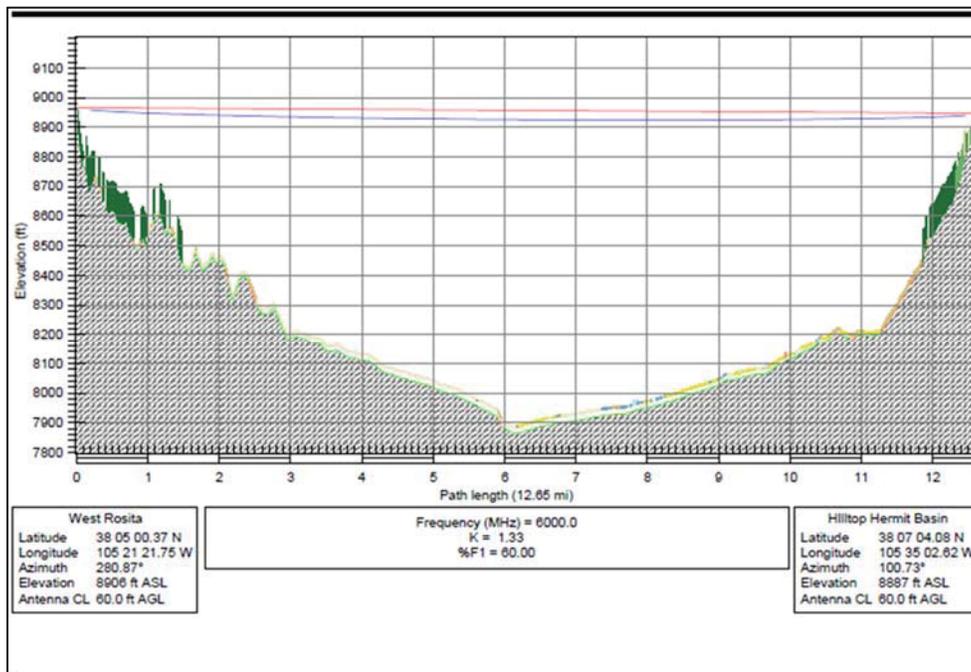


Figure 11. Microwave connectivity Hilltop

Site 3: East of Domingo

This proposed site is east of Domingo High Point in the North-East part of the county. Coverage in this area is made difficult by terrain. The site is sixth on the number of list of covered addresses for the candidates we analyzed and was a strong contributor to the incremental number of addresses covered in the county. There are two good identified locations for this site that have good access and power. Figure 12 shows the approximate locations of those two sites in relation to Westcliffe.



Figure 12. East of Domingo Locations

Coverage from this site adds many addresses that were not served due to terrain blockage. Figure 13 shows the 7-mile coverage radius from the primary site choice East of Domingo 1.

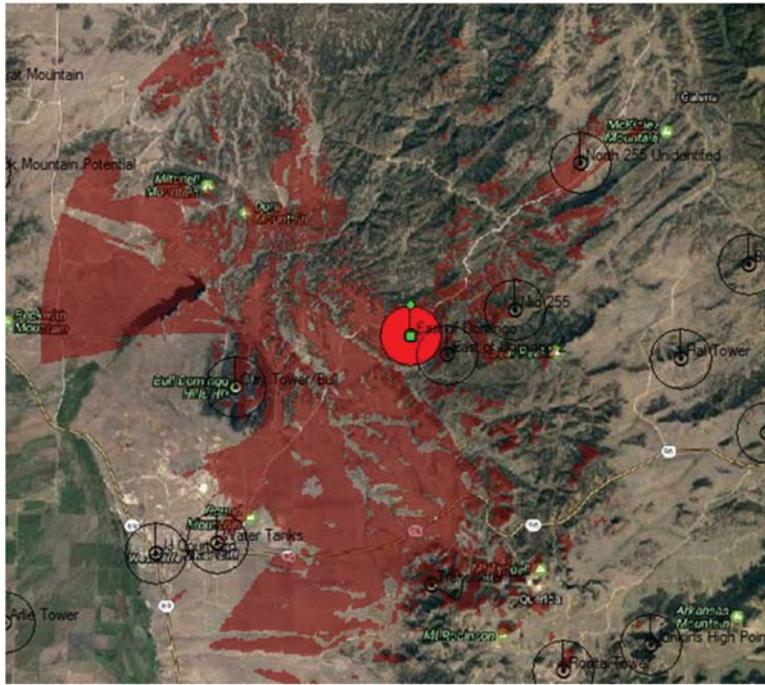


Figure 13. East of Domingo Coverage

Figure 14 shows connectivity for the site through Transmitter Hill, just east of Silver Cliff and Westcliffe. This location has existing towers with broadcast and commercial wireless along with both carriers. The incumbent carriers could elect to route through other existing sites that are LOS to East of Domingo.

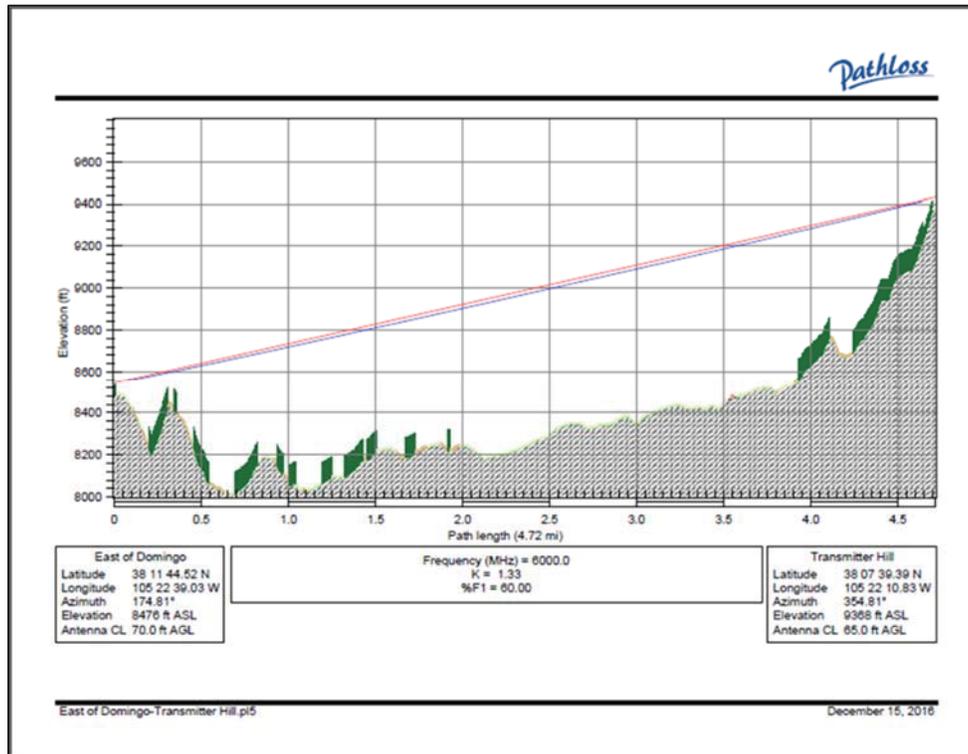


Figure 14. East of Domingo Microwave Connectivity

Site 4: Junkins High Point

Junkins High Point is another site that had a very high address coverage count, coming in 5th on that list, with a strong contribution to picking up uncovered addresses. There is a high density of addresses in the area, and both incumbent providers expressed interest in improving coverage in that area. Figure 15 shows the approximate location of the site in relation to Westcliffe and Silver Cliff.



Figure 15. Approximate location of Junkins High Point

The site provides coverage for the north Rosita and Querida areas extending west and north from the site. To the east, the site provides good coverage up CR 358 to several residences in that valley. Figure 16 shows the coverage from the site in a zoomed-in view. The spottiness of the coverage gives a good idea of the difficult terrain we are dealing with in this area.

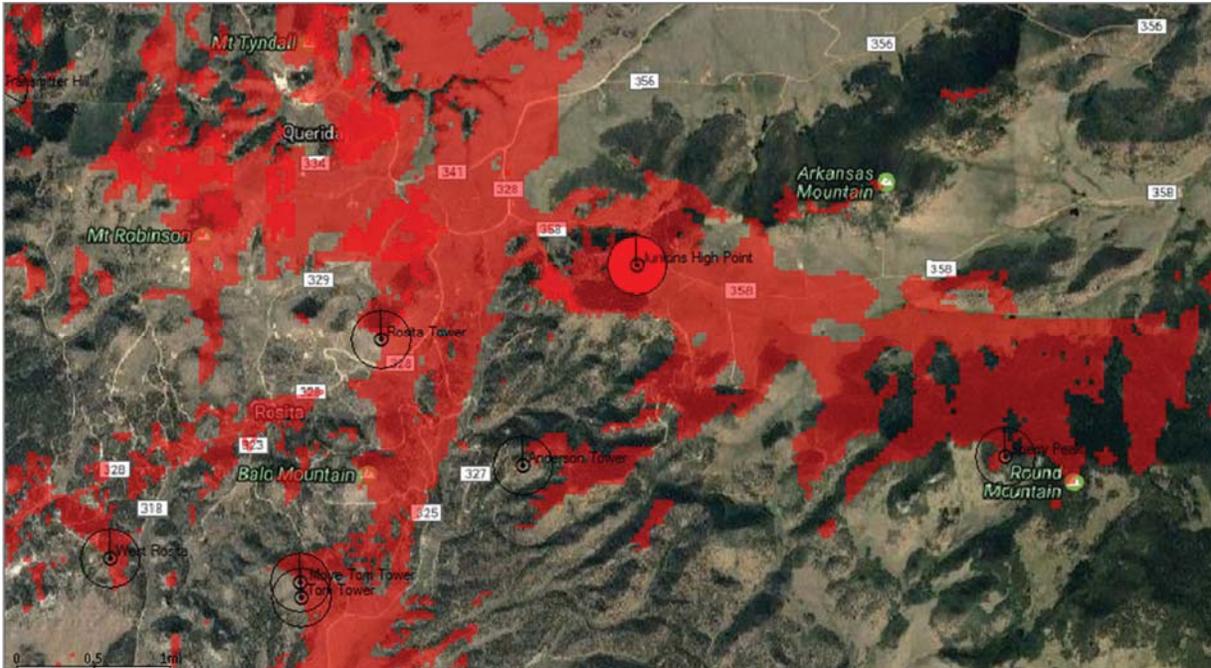


Figure 16. Zoomed coverage of Junkins High Point

Junkins has good connectivity to the existing network through the Transmitter Hill site. The path is only 4 miles, allowing for numerous types of solutions for backhaul.

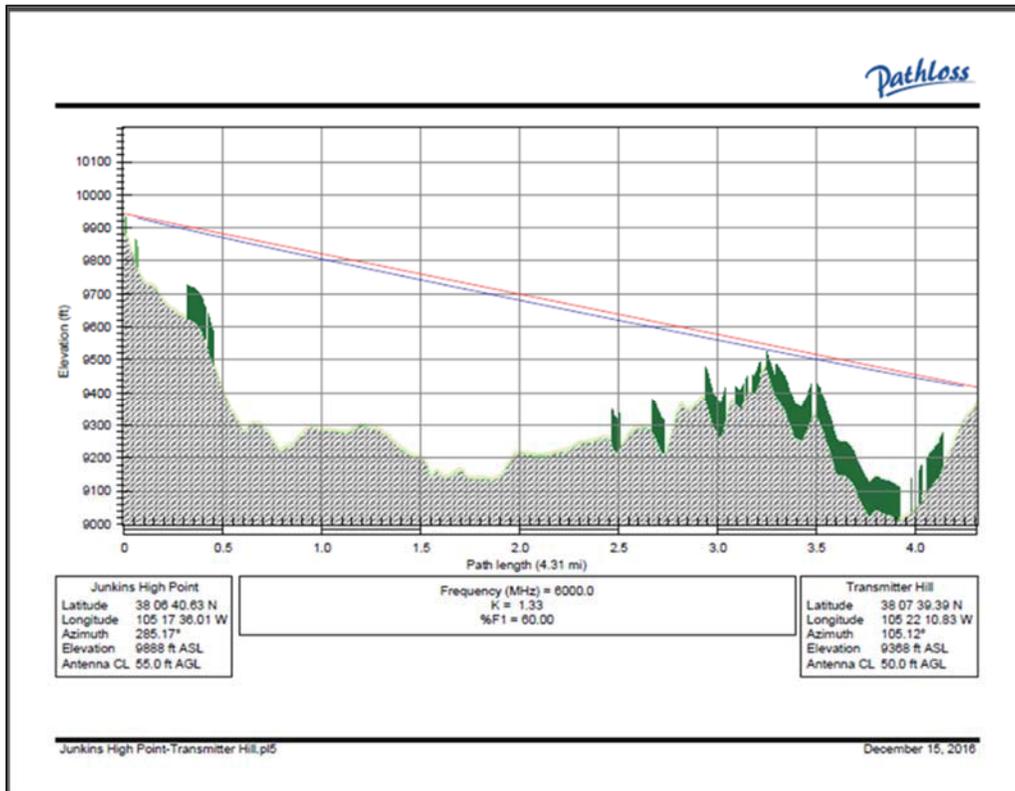


Figure 17. Microwave Connectivity Junkins High Point

Site 5: Centennial

Centennial was modeled from the existing SECOM site at a height of 100 feet AGL. This site provided coverage on the south end of the county, which has rolling terrain as shown in Figure 18. While not a particularly high address count site, the addresses covered were, for the most part, all new coverage. The counterpoint to this is that a higher percentage of these addresses are not yet built, as compared to other areas of the county. This assessment was made using satellite imagery from 2013 and new homes may have been built since then. Also, this area of the county is off the power grid and the homes rely on solar, generator, or other alternative means of power; this does not, however, preclude them from the need for broadband. While Centennial is part of the recommendation, it is moved to a lower priority due to the above factors.

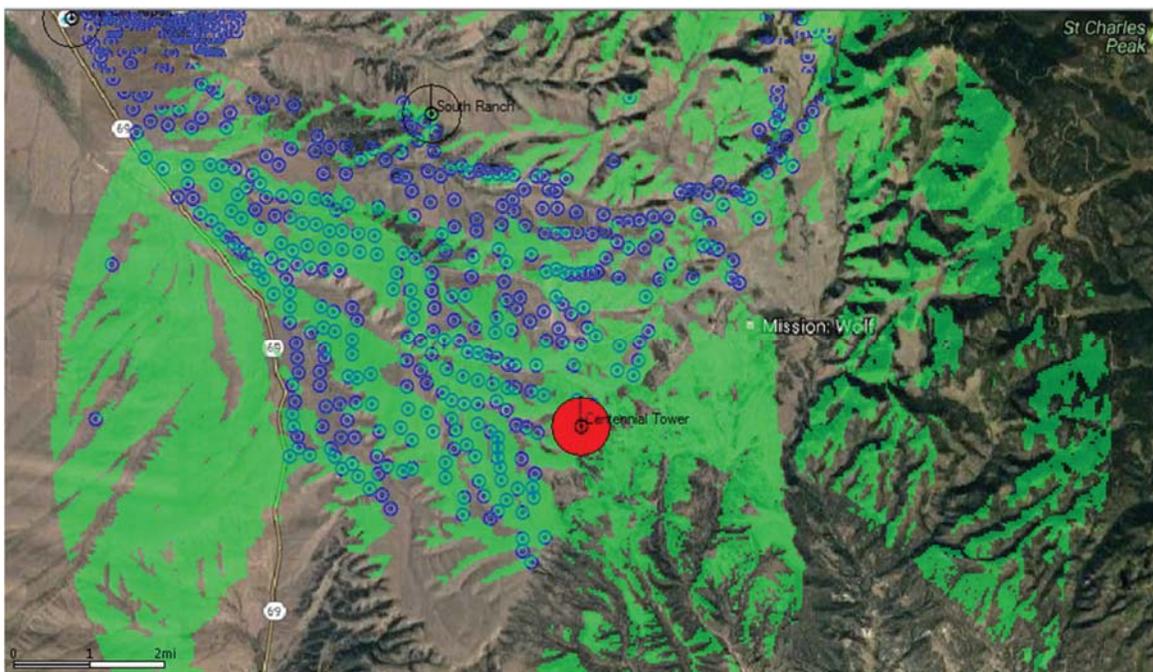


Figure 18. Coverage of the Centennial Site

Since this is an existing SECOM site, we did not assess their connectivity. For Hilltop, there is connectivity to Hermit Basin. Figure 19 shows the connectivity path for Hilltop to Hermit Basin.

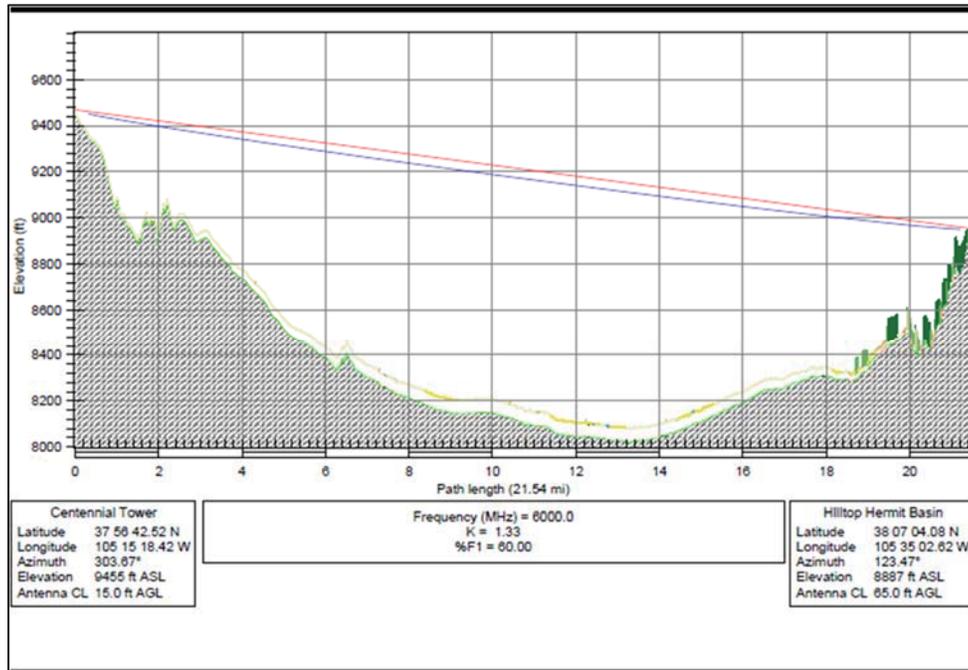


Figure 19. Microwave Connectivity Hilltop Centennial to Hermit Basin

Site 6: San Isabel

Two sites shown in Figure 20 were modeled for coverage in the San Isabel area, which shows a good concentration of addresses. The proposed San Isabel site provides coverage to the town, which is currently not covered by either of the incumbent providers. Because there is no coverage currently, a site in this area would add significantly to the overall percentage of addresses covered in the county. One of the challenges for this area is the difficult terrain, which limits coverage and makes connectivity especially tenuous. Figure 21 shows the coverage for the San Isabelle site.

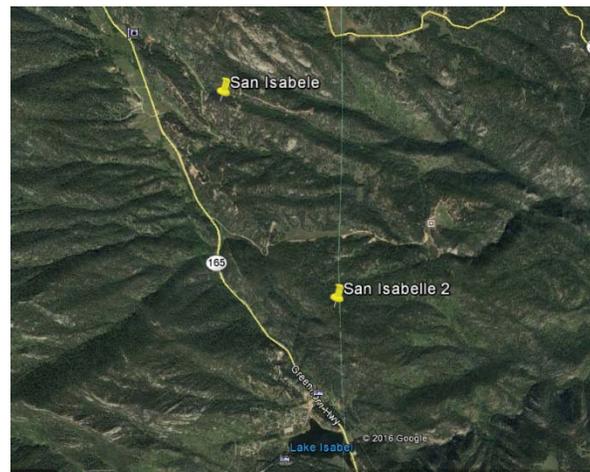


Figure 20. San Isabel Site Locations

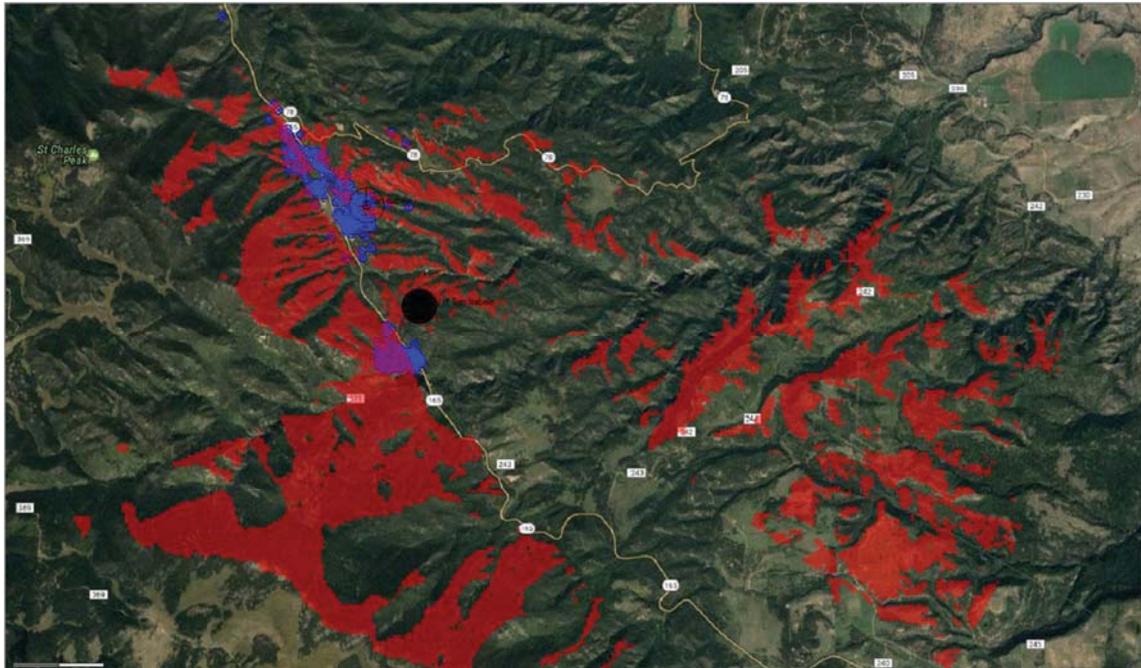


Figure 21. Coverage of the Centennial Site

Connectivity for the San Isabel site was described above as an exception to our original approach of tying into existing hub sites. Because of the area’s isolation, we were unable to connect to the hub sites, but we did find connectivity to a location provided by SECOM in Huerfano County. Because there are no Hilltop facilities provided for that area, we cannot address connectivity for San Isabel to their system.



Figure 22. Microwave Connectivity San Isabel to Ed

Other Site Considerations

Wetmore

The town of Wetmore is located on the northeastern corner of Custer County and is one the primary routes into the county. Like San Isabel, it is isolated from the rest of the county by the Wet Mountains, but unlike its sister town, it currently has service through SECOM and others. We analyzed the existing site, which is located on a ridge to the south at 20 feet AGL. We modeled this site at 100 feet AGL and found that it gave us an additional 33 addresses. Figure 23 shows the difference in the coverage from both sites (red) and the additional coverage (green).

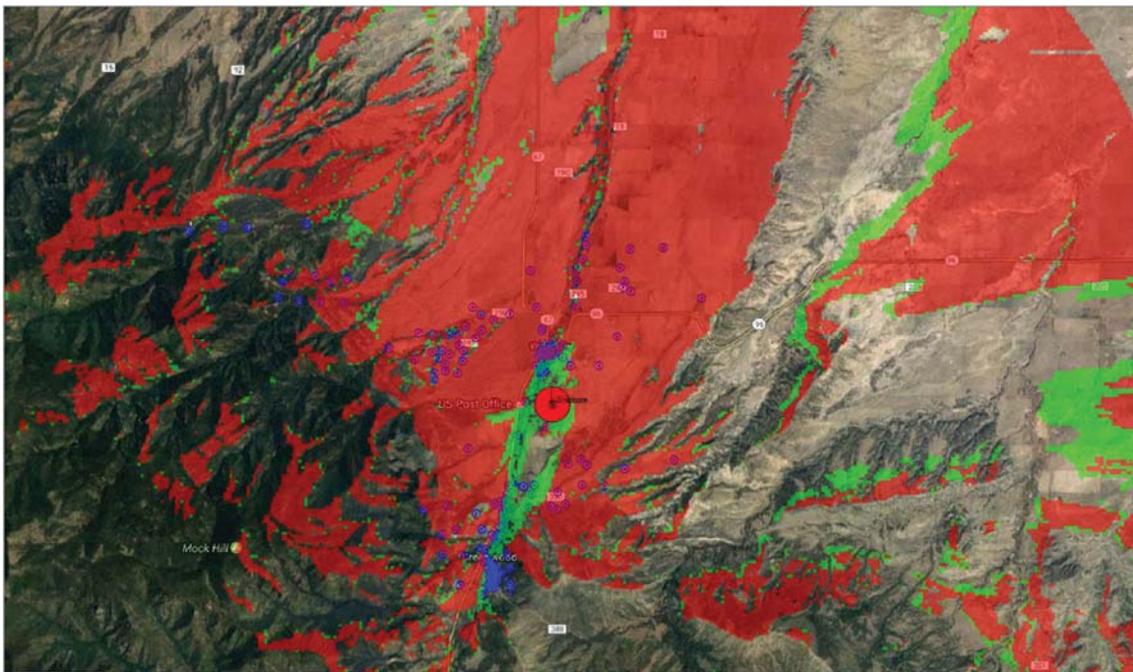


Figure 23. Coverage Difference Wetmore 20 ft. (red) and 100 ft. (green)

Because of the relatively few addresses gained and the fact that there is an existing carrier already providing service from the current sites, this site is not recommended for near-term consideration.

Water Tanks

The Water Tanks site was considered for its proximity and coverage potential for the towns of Westcliffe and Silver Cliff, especially those areas just outside the two towns. As we see in Figure 24, the site that is just to the north and east of the towns covers those areas well but does not see to the north and duplicates coverage of site such as Arlie and Transmitter Hill. Also, the aperture angle to most of the addresses covered by this site about 100 degrees. This means that all subscribers are in one area of coverage, which presents a problem to the providers, since each sector of the site has finite capacity. The typical sector for WISP application is about 60 degrees

but can go as low as 30 degrees with special antennas. A major consideration for this site was the fact that financial incentive exists for the incumbent carrier to invest in infrastructure in this area, because the density of addresses would meet the typical business case for return on investment. In this case, the use of public funds for wireless enhancement are better spent in more rural areas.

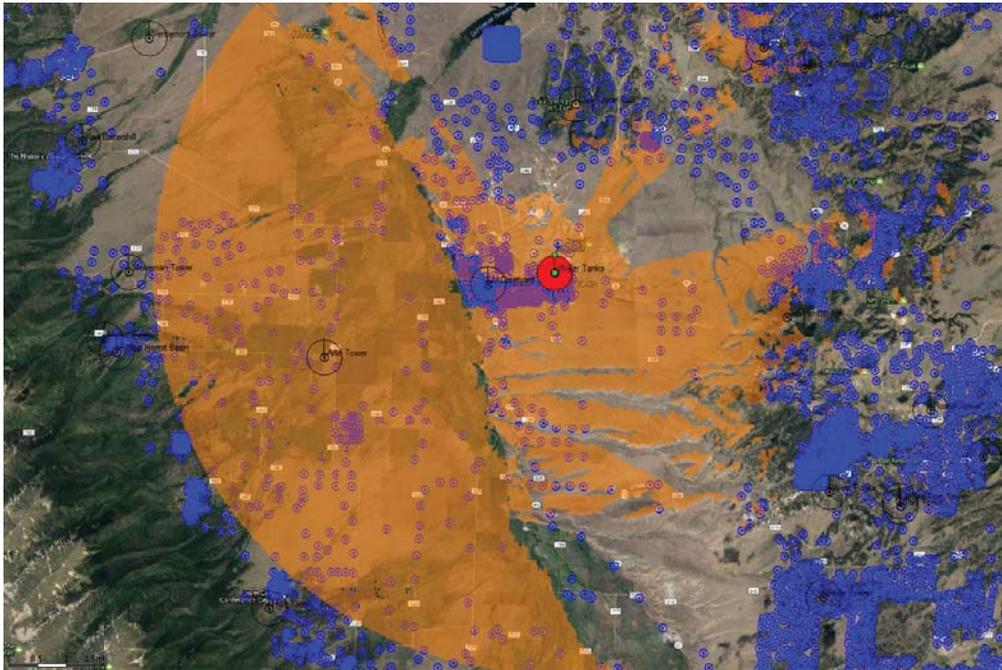


Figure 24. Coverage of Water Tanks over addresses

Coverage to Height Sensitivity Analysis

As stated previously, tower height will be determined by the final location of the site. Furthermore, sites that are located on places that have good height above average terrain (HAAT) generally don't require especially tall towers. These are the type of sites we have examined during this study. For the study, we assumed 100-foot tower heights as an equal point of reference for all site studies.

The determination for the final tower heights will be guided by the optimal number of addresses covered versus the cost to build the tower. The higher the tower goes, the more the tower costs, and the more visible it becomes due to its height and width.

We can certainly analyze the addresses that will be covered through our propagation model. In the table below, we varied the height of the antenna on an example tower and measured the number of addresses we gained and lost. While not dramatic, it gave us good reference points during the site costing process.

| Name | Addresses Covered | Addresses Percentage | Total Addresses |
|-------------|-------------------|----------------------|-----------------|
| Buck at 160 | 936 | 14.28 | 6,553 |
| Buck at 140 | 931 | 14.21 | 6,553 |
| Buck at 120 | 924 | 14.1 | 6,553 |
| Buck at 100 | 915 | 13.96 | 6,553 |
| Buck at 80 | 912 | 13.92 | 6,553 |
| Buck at 60 | 905 | 13.81 | 6,553 |
| Buck at 40 | 892 | 13.61 | 6,553 |

Table 5. Tower Height to Addresses Covered

In this analysis, we see that as we increase our height from 100 feet, we gain about 7 to 8 subscribers for every 20 feet AGL. The difference between 100 and 80 feet only loses three addresses.

A final consideration for the tower is minimum height. For this, we have considered it a good height to have all the antennas mounted above local obstructions such as trees, and to have enough room for all planned carriers to keep their antennas on separate elevations of the tower.

APPENDIX A – Additional Site Information

Candidate Site Locations and Elevations

| Name | Longitude | Latitude | Altitude (ft) |
|-------------------------|--------------|-------------|---------------|
| Move Tom Tower | -105.3334432 | 38.08120389 | [9,154.48] |
| Anderson Tower | -105.30683 | 38.092316 | [9,361.12] |
| Antelope Tower | -105.305307 | 38.032577 | [9,003.6] |
| Arlie Tower | -105.517614 | 38.11673188 | [7,960.56] |
| Beddows | -105.5386472 | 38.22603056 | [8,495.2] |
| Buck Mountain Potential | -105.5272861 | 38.24013333 | [8,619.84] |
| Bullard Mtn | -105.2598722 | 38.21581944 | [8,869.12] |
| Centennial Tower | -105.2551167 | 37.94514444 | [9,449.68] |
| Clay Tower/Bull | -105.4377722 | 38.18118611 | [8,675.6] |
| Democrat Mountain | -105.534851 | 38.26506 | [8,541.12] |
| East of Domingo | -105.3775083 | 38.1957 | [8,478.8] |
| East of Domingo 2 | -105.3645306 | 38.19044722 | [8,718.24] |
| Gene Tower | -105.357715 | 38.056867 | [8,705.12] |
| Hal Tower | -105.283316 | 38.189688 | [9,167.6] |
| Hermit Basin | -105.5881 | 38.121312 | 9,000 |
| Hilltop Hermit Basin | -105.5840618 | 38.11779926 | [8,882.24] |
| Horn Creek | -105.534914 | 38.05334937 | [9,033.12] |
| JJ Courtyard | -105.4654 | 38.13568 | [7,868.72] |
| Junkins High Point | -105.2933357 | 38.11128715 | [9,885.92] |
| Ken Battershill | -105.5954 | 38.17118 | [8,600.16] |
| Mid 255 | -105.341258 | 38.203042 | [8,901.92] |
| Myron Mtn | -105.2533444 | 38.16937778 | [9,275.84] |
| North 165 | -105.1233306 | 38.10490278 | [9,758] |
| North 255 Unidentified | -105.3186444 | 38.24336111 | [8,462.4] |
| Rosita Tower | -105.323783 | 38.104091 | 9,555 |
| San Isabele | -105.0614861 | 38.01251944 | [9,213.52] |
| San Isabele 2 | -105.0509462 | 37.99648555 | [9,138.08] |
| South Colony Tower | -105.462785 | 37.994201 | [8,547.68] |
| South Ranch | -105.291525 | 38.00515833 | [9,124.96] |
| Sperry Peak | -105.249408 | 38.093231 | [10,932.24] |
| Stoneman Tower | -105.58051 | 38.138348 | [8,751.04] |
| Tom Tower | -105.333186 | 38.07980764 | [9,147.92] |
| Transmitter Hill | -105.369675 | 38.12760833 | [9,367.68] |
| Verdemont Tower | -105.5744444 | 38.19722222 | [8,032.72] |
| Water Tanks | -105.4440833 | 38.13876667 | [8,062.24] |
| West Cliff Airport | -105.3786969 | 38.02322282 | [8,226.24] |
| West Rosita | -105.356041 | 38.083437 | [8,905.2] |
| Wetmore | -105.084323 | 38.228865 | [6,504.24] |

Candidate Site Analysis

| Name | Addresses Covered | Addresses Percentage | Total Addresses | Existing covered addresses | Add Addresses |
|-------------------------|-------------------|----------------------|-----------------|----------------------------|---------------|
| West Rosita Tower 100 | 1,039 | 15.86 | 6,553 | | 1039 |
| Water Tank 100 | 983 | 15 | 6,553 | | 983 |
| Buck Mountain 100 | 915 | 13.96 | 6,553 | | 915 |
| Beddows 100 | 851 | 12.99 | 6,553 | | 851 |
| Sperry Peak 100 | 654 | 9.98 | 6,553 | | 654 |
| Junkins High Point | 651 | 9.93 | 6,553 | | 651 |
| East of Domingo 100 | 647 | 9.87 | 6,553 | | 647 |
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| Rosita Tower 100 | 370 | 5.65 | 6,553 | 233 | 137 |
| North 255 100 | 129 | 1.97 | 6,553 | | 129 |
| Antelope Tower 100 | 417 | 6.36 | 6,553 | 293 | 124 |
| San Isabele 100 | 118 | 1.8 | 6,553 | | 118 |
| Anderson Tower 100 | 478 | 7.29 | 6,553 | 368 | 110 |
| Arlie 100 | 1,053 | 16.07 | 6,553 | 987 | 66 |
| Horn Creek 100 | 564 | 8.61 | 6,553 | 503 | 61 |
| South Colony Tower 100 | 394 | 6.01 | 6,553 | 333 | 61 |
| Clay Tower 100 | 1,574 | 24.02 | 6,553 | 1,514 | 60 |
| Hermit Basin 100 | 540 | 8.24 | 6,553 | 484 | 56 |
| Hal Tower at 100 ft | 240 | 3.66 | 6,553 | 195 | 45 |
| Wetmore 100 | 124 | 1.89 | 6,553 | 91 | 33 |
| Stoneman Tower 100 | 735 | 11.22 | 6,553 | 708 | 27 |
| North 165 100 | 13 | 0.2 | 6,553 | | 13 |

Existing Site Analysis

| Name | Addresses Covered | Addresses Percentage | Total Addresses |
|-------------------------------|-------------------|----------------------|-----------------|
| Clay Tower 20 | 1,514 | 23.1 | 6,553 |
| JJ Courtyard at 30 ft Hilltop | 1,118 | 17.06 | 6,553 |
| Arlie30 | 987 | 15.06 | 6,553 |
| Transmitter Hill D at 20 ft | 955 | 14.57 | 6,553 |
| Stoneman Tower 20 | 708 | 10.8 | 6,553 |
| Democrat Mt 20 | 650 | 9.92 | 6,553 |
| Toms Tower 20 | 513 | 7.83 | 6,553 |
| Horn Creek 30 Hilltop | 503 | 7.68 | 6,553 |
| Hilltop Hermit 30 Hilltop | 484 | 7.39 | 6,553 |
| Anderson Tower 20 | 368 | 5.62 | 6,553 |
| South Colony Tower 20 | 333 | 5.08 | 6,553 |
| Antelope Tower 20 | 293 | 4.47 | 6,553 |
| Rosita Tower at 20 ft | 233 | 3.56 | 6,553 |
| Gene Tower20 | 223 | 3.4 | 6,553 |
| Hal Tower at 20 ft | 195 | 2.98 | 6,553 |
| Centennial at 20 | 160 | 2.44 | 6,553 |
| Wetmore 20 | 91 | 1.39 | 6,553 |

Tab 3

Phase 3 Cost Estimates



Site Cost Estimates for Initial
Recommendations
Custer County, Colorado

Prepared For
Custer County Economic Development
Board

3 March 2017

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Executive Summary

The Custer County Economic Development Corporation (CCEDC) desires to improve broadband availability and wireless service throughout Custer County. Because the County is rural and sparsely populated, commercial entities hesitate to invest capital to improve service due to low return on investment concerns. CCEDC wishes to proactively encourage expansion by providing the tower assets needed to serve all its constituents. To that end, Centerline Solutions is providing this report with applicable costing information to develop and utilize those sites determined via this effort.

These locations are as follows:

- Beddows or Buck Mountain
- West Rosita
- East of Domingo or East of Domingo 2
- Junkins (Loop) High Point
- Centennial
- San Isabel

Provided in this report is information regarding each site, information regarding physical visits, assumptions made, associated cost estimates and recommendations on how to proceed.

Project Overview

The Custer County Economic Development Corporation (CCEDC) desires to improve broadband availability and wireless service throughout Custer County. Because the County is rural and sparsely populated, commercial entities hesitate to invest capital to improve service due to low return on investment concerns. CCEDC wishes to proactively encourage expansion by providing the tower assets needed to serve all its constituents. To that end, Centerline Solutions is providing this report with applicable costing information to develop and utilize those sites determined via this effort.

The cost modeling generated for each tower site is budgetary, being estimated by experts at Centerline Solutions with the information available to them. Where applicable, information gleaned from physical visits to locations and assumptions are included with this report.

Site Cost Estimates

The Centerline team utilized data from field visits, interviews with Custer County residents, local stakeholders, and expert knowledge to generate the estimates for each coverage location. The costing information for each candidate presented as such:

- Field notes (when applicable)
- Stated Assumptions / Presumptions
- Costing Estimate Table
- Recommendations Following Site Details

Some site information is presented as part of the overall effort of discovery for this effort. This supplemental information includes location data and candidates for coverage can be found in APPENDIX A – Additional Site Information. A large number of sites were evaluated and the afore mentioned locations chosen as best to provide the prescribed coverage for Custer County. The cost estimates do not include some traditional site development costs specifically related to shelter design, installation and electrical service.

The site cost estimates also include a line for Site Acquisition/Development which covers the professional fees to correctly develop the site. This line item provides cost estimates that include

Lease preparation
Lease negotiation
NEPA screening
Zoning drawings
Zoning
Permitting
Architectural and Engineering Drawings
Professional Engineering Certifications

Beddows

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 100 Foot AGL Self-Support Tower
- **Site Shelter:** None
- **Site Access:** Medium difficulty for access.
- **Access distance:** Medium distance to access site, less than 2000 feet.
- **Immediate terrain:** Gentle terrain, some heavy rock but not enough to encumber access.
- **Distance to available power:** Confirmed that power is available at the nearby road.
- **Power install considerations:** Assumed power company able to deliver a transformer to the site. Ground ring to include one chemical rod only. Assumed that no tower lighting will be required.
- **Additional considerations:** Pricing includes cedar fence around tower. Assumed that site is engineered and built to support two cellular carriers and local WISPs. Site needs to be a self-support structure for the carriers.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Cost | Comments |
|-----------------------------------|--------------------------------|-------------------|--------------------------------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Road improvement | \$ 99,165 | |
| Civil | Site Grading | \$ 10,776 | |
| Civil | Tower FDN | \$ 57,500 | Pad |
| Civil | Compound Improvements | \$ 21,000 | Gravel, cedar fence, grounding |
| Elect | Service | \$ 95,000 | multi-meter bank |
| Tower | Cost | \$ 45,250 | |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 19,500 | |
| | Total | \$ 389,136 | |

Table 1: Beddows Cost Estimates

Buck Mountain

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 100 Foot AGL Self-Support Tower
- **Site Shelter:** None
- **Site Access:** Difficult, no paved roads or vehicle-friendly pathways up to the location.
- **Access distance:** Best determined path between 2300 feet and 2500 feet with an elevation increase of over 500 feet.
- **Immediate terrain:** Intermediate forest and heavy exterior and ingrained stone (“rocky”).
- **Distance to available power:** Assumed to be 2300 feet for budgeting.
- **Power install considerations:** 2300 feet of new road required. New overhead power from street with one power pole every 100 feet required.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Cost | Comments |
|-----------------------------------|--------------------------------|-------------------|----------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Road improvement | \$ 210,000 | |
| Civil | Site Grading | \$ 35,000 | |
| Civil | Tower FDN | \$ 59,000 | Pad |
| Civil | Compound Improvements | \$ 21,000 | |
| Elect | Service | \$ 250,000 | |
| Elect | Site Install | \$ - | |
| Tower | Cost | \$ 45,250 | |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 19,500 | |
| | Estimate Total | \$ 680,695 | |

Table 2: Buck Mountain Cost Estimates

West Rosita

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 100 Foot AGL Lite Site
- **Site Shelter:** None
- **Site Access:** Site is easily accessed via a nearby paved road.
- **Access distance:** Very close, existing roadway available all the way up to the nearby residence.
- **Immediate terrain:** Most elevated peak of location has no notable terrain considerations, very light forest nearby.
- **Distance to available power:** Nearby residence has available power (100 amp), less than 200 feet in distance.
- **Power install considerations:** Commercial power readily available at nearby residence.
- **Additional considerations:** Lite Site with fence around foundation located on vacant lot. One chemical rod ground required, blasting is not included in estimate and assumed not required.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Cost | Comments |
|-----------------------------------|--------------------------------|------------|-----------------------------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Road improvement | \$ 67,500 | |
| Civil | Site Grading | \$ 11,500 | |
| Civil | Tower FDN | \$ 12,500 | Pad |
| Civil | Compound Improvements | \$ - | |
| Elect | Service | \$ 35,000 | from transformer near house |
| Tower | Cost | \$ 115,000 | |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 10,500 | |
| Total Cost Estimate | | \$ 292,945 | |

Table 3: West Rosita Cost Estimates

East of Domingo

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 100 Foot AGL Lite Site
- **Site Shelter:** None
- **Site Access:** Minimal road improvements necessary, easy access.
- **Access distance:** Very close, existing roadway available all the way up to nearby residence.
- **Immediate terrain:** Very light forest.
- **Distance to available power:** Assumed that nearby residence has available power (100 amp), less than 300 feet at the most conservative measurement.
- **Power install considerations:** Assumed that commercial power readily available at nearby residence.
- **Additional considerations:** Lite site with fence around foundation needed. One chemical rod ground required.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Cost | Comments |
|-----------------------------------|--------------------------------|------------|----------------------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Road improvement | \$ 8,500 | |
| Civil | Site Grading | \$ 11,526 | |
| Civil | Tower FDN | \$ 12,309 | Pad |
| Civil | Compound Improvements | \$ - | |
| Elect | Service | \$ 15,000 | 100 amp single meter |
| Tower | Cost | \$ 115,000 | Lite Site |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 10,500 | |
| Total Cost Estimate | | \$ 213,780 | |

Table 4: East of Domingo Cost Estimates

East of Domingo 2

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 100 Foot AGL Lite Site
- **Site Shelter:** None
- **Site Access:** A nearby home with easy access exists; assumption is easy access to site available.
- **Access distance:** A nearby home with easy access exists; assumption is easy access to site available.
- **Immediate terrain:** Very light forest.
- **Distance to available power:** Assumed to be less than 300 feet to nearby home.
- **Power install considerations:** Assumed that nearby home has available 100 amps of power to facilitate commercial at the location.
- **Additional considerations:** The field crew was unable to visit this site in person; some assumptions reflect experience and assumptions. Lite site with fence around foundation needed. One chemical rod ground required.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Cost | Comments |
|-----------------------------------|--------------------------------|------------|----------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Road improvement | \$ 18,500 | |
| Civil | Site Grading | \$ 11,500 | |
| Civil | Tower FDN | \$ 12,500 | Pad |
| Civil | Compound Improvements | \$ - | |
| Elect | Service | \$ 20,000 | |
| Tower | Cost | \$ 115,000 | |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 10,500 | |
| Total Estimated Cost | | \$ 228,945 | |

Table 5: East of Domingo 2 Cost Estimates

Junkins High Point

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 100 Foot AGL Lite Site
- **Site Shelter:** None
- **Site Access:** Site is very close to a nearby home with existing road access.
- **Access distance:** Very close, existing roadway available all the way up to the nearby residence.
- **Immediate terrain:** Existing home just east of the location, but not high enough to encumber coverage or placement.
- **Distance to available power:** Assumed that nearby residence has available power (100 amp) considering its size.
- **Power install considerations:** Assumed that commercial power readily available at nearby residence.
- **Additional considerations:** Was not able to communicate with the nearby homeowner, which is very near the site.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Cost | Comments |
|-----------------------------------|--------------------------------|------------|----------------------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Road improvement | \$ 45,000 | |
| Civil | Site Grading | \$ 47,500 | |
| Civil | Tower FDN | \$ 12,500 | Pad |
| Civil | Compound Improvements | \$ - | |
| Elect | Service | \$ 30,000 | single meter 100 amp |
| Tower | Cost | \$ 115,000 | |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 10,500 | |
| Total Estimated Cost | | \$ 301,445 | |

Table 6: Junkins High Point Cost Estimates

Centennial

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 100 Foot AGL Lite Site
- **Site Shelter:** None
- **Site Access:** Existing road and pathways to site; assumption is that road will require no additional improvements.
- **Access distance:** N/A, existing road and pathways all the way to site.
- **Immediate terrain:** Area appears to have very little rock and is flat.
- **Distance to available power:** N/A, assumption is that contractor will provide and install a new power source.
- **Power install considerations:** Assumption is that site will require a hybrid solution between propane and solar; supply will be 48V DC.
- **Additional considerations:** The field crew was unable to visit this site in person; some assumptions reflect experience and assumptions. Lite site with fence around foundation needed. One chemical rod ground required.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Costs | Comments |
|-----------------------------------|--------------------------------|------------|--------------------------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Site Grading | \$ 500 | |
| Civil | Tower FDN | \$ 10,500 | Pad |
| Civil | Compound Improvements | \$ 2,500 | |
| Elect | Service | \$ 205,000 | hybrid solar/lpg dc only |
| Tower | Cost | \$ 115,000 | |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 10,500 | |
| Total Cost Estimate | | \$ 384,945 | |

Table 7: Centennial Cost Estimates

San Isabel

The estimates for this site were created under the followings notes or assumptions:

- **Site Type:** 120 Foot AGL Self-Support Tower
- **Site Shelter:** None
- **Site Access:** Assumption is that road improvements will be needed to develop access to site.
- **Access distance:** N/A
- **Immediate terrain:** Area appears to have very little rock with minimal tree cover.
- **Distance to available power:** Assumption is power is available with 350 feet.
- **Power install considerations:** Assumed that local power company will deliver a transformer to a nearby residence located southeast of the top of the hill on Wetmore Road.
- **Additional considerations:** The field crew was unable to visit this site in person; some assumptions reflect experience and assumptions. Lite site with fence around foundation included. One chemical rod ground required. Assumed that site is engineered and built to support two cellular carriers and local WISPs. Site needs to be a self-support structure for the carriers.

Against the stated notes and assumptions, refer to the following table for estimates:

| Equipment / Construction Estimate | | Cost | Comments |
|-----------------------------------|--------------------------------|-------------------|----------|
| Design | Site Acquisition / Development | \$ 33,925 | |
| Civil | Road improvement | \$ 75,550 | |
| Civil | Site Grading | \$ 10,776 | |
| Civil | Tower FDN | \$ 57,500 | Pad |
| Civil | Compound Improvements | \$ 21,000 | |
| Elect | Service | \$ 70,000 | |
| Tower | Cost | \$ 45,250 | |
| Tower | Delivery | \$ 7,020 | |
| Tower | Install | \$ 19,500 | |
| | Total Estimated Cost | \$ 340,521 | |

Table 8: San Isabel Cost Estimates

Recommendations

Considering the cost modeling information provided, the following is recommended to provide the best effective solution to satisfy the needs for Custer County. The following sites are recommended in order based on covered addresses, incremental covered addresses and constructability:

- Beddows or Buck Mountain
- West Rosita
- East of Domingo or East of Domingo 2
- Junkins (Loop) High Point
- Centennial
- San Isabel

Beddows versus Buck Mountain

It is recommended that the Beddows location be developed over Buck Mountain. The challenges present for Buck Mountain greatly outweigh it for viability, such as required cost to develop, engineering difficulty, and HOA constraints.

West Rosita

The original site designated for West Rosita is a viable site, but during the field visits we determined there was a property that would provide almost equivalent coverage and would be a much easier build. Finally, we had a local homeowner who indicated interest in allowing a tower on his property.

East of Domingo versus East of Domingo 2

It is recommended that the East of Domingo location be developed over East of Domingo 2. Geography, a higher elevation, ease of access, site development cost, and logistics make East of Domingo the superior location for a structure.

Junkins (Loop) High Point

The original selected Junkins High Point site is still the preferred location. A tower can be located Southeast of the residence at a slightly lower elevation that will serve the needed areas. Possible alternate locations were identified during the field visit as a backup to this location.

Centennial

Although we were not able to make it to the site during field visits we did get very close. Construction of this site will not be difficult although there is no available commercial power.

We have included in our cost estimate alternate energy sources sized to drive two small telecommunication sites.

Because Centennial is an existing site for one of the incumbent carriers it did not merit a higher ranking, but we feel that replacing or adding a TIA-222G compliant tower in this location may entice the incumbent to move to a more robust structure.

San Isabel

Although we were not able to make it to the site during field visits we were able to make a good assessment on San Isabel 1 using satellite data. This site was located fairly close to residential on a local high point. This site was set as a lower priority in the previous report due to difficult connectivity to the outside world

San Isabel 2 which is located on Boy Scout Camp property just inside the County line presented much more of a challenge. Access and power were harder to assess due to the amount of forest in the area. This site could be revisited in the future if needed as it would provide coverage to the town and lake areas.

APPENDIX A – Additional Site Information

Candidate Site Locations and Elevations

| Name | Longitude | Latitude | Altitude (ft) |
|-------------------------|--------------|-------------|---------------|
| Move Tom Tower | -105.3334432 | 38.08120389 | [9,154.48] |
| Anderson Tower | -105.30683 | 38.092316 | [9,361.12] |
| Antelope Tower | -105.305307 | 38.032577 | [9,003.6] |
| Arlie Tower | -105.517614 | 38.11673188 | [7,960.56] |
| Beddows | -105.5386472 | 38.22603056 | [8,495.2] |
| Buck Mountain Potential | -105.5272861 | 38.24013333 | [8,619.84] |
| Bullard Mtn | -105.2598722 | 38.21581944 | [8,869.12] |
| Centennial Tower | -105.2551167 | 37.94514444 | [9,449.68] |
| Clay Tower/Bull | -105.4377722 | 38.18118611 | [8,675.6] |
| Democrat Mountain | -105.534851 | 38.26506 | [8,541.12] |
| East of Domingo | -105.3775083 | 38.1957 | [8,478.8] |
| East of Domingo 2 | -105.3645306 | 38.19044722 | [8,718.24] |
| Gene Tower | -105.357715 | 38.056867 | [8,705.12] |
| Hal Tower | -105.283316 | 38.189688 | [9,167.6] |
| Hermit Basin | -105.5881 | 38.121312 | 9,000 |
| Hilltop Hermit Basin | -105.5840618 | 38.11779926 | [8,882.24] |
| Horn Creek | -105.534914 | 38.05334937 | [9,033.12] |
| JJ Courtyard | -105.4654 | 38.13568 | [7,868.72] |
| Junkins High Point | -105.2933357 | 38.11128715 | [9,885.92] |
| Ken Battershill | -105.5954 | 38.17118 | [8,600.16] |
| Mid 255 | -105.341258 | 38.203042 | [8,901.92] |
| Myron Mtn | -105.2533444 | 38.16937778 | [9,275.84] |
| North 165 | -105.1233306 | 38.10490278 | [9,758] |
| North 255 Unidentified | -105.3186444 | 38.24336111 | [8,462.4] |
| Rosita Tower | -105.323783 | 38.104091 | 9,555 |
| San Isabele | -105.0614861 | 38.01251944 | [9,213.52] |
| San Isabele 2 | -105.0509462 | 37.99648555 | [9,138.08] |
| South Colony Tower | -105.462785 | 37.994201 | [8,547.68] |
| South Ranch | -105.291525 | 38.00515833 | [9,124.96] |
| Sperry Peak | -105.249408 | 38.093231 | [10,932.24] |
| Stoneman Tower | -105.58051 | 38.138348 | [8,751.04] |
| Tom Tower | -105.333186 | 38.07980764 | [9,147.92] |
| Transmitter Hill | -105.369675 | 38.12760833 | [9,367.68] |
| Verdemont Tower | -105.5744444 | 38.19722222 | [8,032.72] |
| Water Tanks | -105.4440833 | 38.13876667 | [8,062.24] |
| West Cliff Airport | -105.3786969 | 38.02322282 | [8,226.24] |
| West Rosita | -105.356041 | 38.083437 | [8,905.2] |
| Wetmore | -105.084323 | 38.228865 | [6,504.24] |

Candidate Site Analysis

| Name | Addresses Covered of 6,553 total | Addresses Percentage (% of 6,553) | Existing covered addresses | Add Addresses |
|-------------------------|----------------------------------|-----------------------------------|----------------------------|---------------|
| West Rosita Tower 100 | 1,039 | 15.86 | | 1039 |
| Water Tank 100 | 983 | 15 | | 983 |
| Buck Mountain 100 | 915 | 13.96 | | 915 |
| Beddows 100 | 851 | 12.99 | | 851 |
| Sperry Peak 100 | 654 | 9.98 | | 654 |
| Junkins High Point | 651 | 9.93 | | 651 |
| East of Domingo 100 | 647 | 9.87 | | 647 |
| East of Domingo 2 100 | 631 | 9.63 | | 631 |
| Gene Tower 100 | 704 | 10.74 | 223 | 481 |
| Verdemont Tower 100 | 443 | 6.76 | | 443 |
| South Ranch 100 | 348 | 5.31 | | 348 |
| Mld 255 Tower at 100 ft | 316 | 4.82 | | 316 |
| Toms Tower 100 | 788 | 12.03 | 513 | 275 |
| Bullard Mountain 100 | 227 | 3.46 | | 227 |
| Centennial Tower 100 | 197 | 3.01 | | 197 |
| Transmitter Hill 100 | 1,150 | 17.55 | 955 | 195 |
| Move Toms Tower 100 | 695 | 10.61 | 513 | 182 |
| Myron Mountain 100 | 161 | 2.46 | | 161 |
| Rosita Tower 100 | 370 | 5.65 | 233 | 137 |
| North 255 100 | 129 | 1.97 | | 129 |
| Antelope Tower 100 | 417 | 6.36 | 293 | 124 |
| San Isabele 100 | 118 | 1.8 | | 118 |
| Anderson Tower 100 | 478 | 7.29 | 368 | 110 |
| Arlie 100 | 1,053 | 16.07 | 987 | 66 |
| Horn Creek 100 | 564 | 8.61 | 503 | 61 |
| South Colony Tower 100 | 394 | 6.01 | 333 | 61 |
| Clay Tower 100 | 1,574 | 24.02 | 1,514 | 60 |
| Hermit Basin 100 | 540 | 8.24 | 484 | 56 |
| Hal Tower at 100 ft | 240 | 3.66 | 195 | 45 |
| Wetmore 100 | 124 | 1.89 | 91 | 33 |
| Stoneman Tower 100 | 735 | 11.22 | 708 | 27 |
| North 165 100 | 13 | 0.2 | | 13 |

Existing Site Analysis

| Name | Addresses Covered of 6,553 total | Addresses Percentage (% of 6,553) |
|-------------------------------|----------------------------------|-----------------------------------|
| Clay Tower 20 | 1,514 | 23.1 |
| JJ Courtyard at 30 ft Hilltop | 1,118 | 17.06 |
| Arlie30 | 987 | 15.06 |
| Transmitter Hill D at 20 ft | 955 | 14.57 |
| Stoneman Tower 20 | 708 | 10.8 |
| Democrat Mt 20 | 650 | 9.92 |
| Toms Tower 20 | 513 | 7.83 |
| Horn Creek 30 Hilltop | 503 | 7.68 |
| Hilltop Hermit 30 Hilltop | 484 | 7.39 |
| Anderson Tower 20 | 368 | 5.62 |
| South Colony Tower 20 | 333 | 5.08 |
| Antelope Tower 20 | 293 | 4.47 |
| Rosita Tower at 20 ft | 233 | 3.56 |
| Gene Tower20 | 223 | 3.4 |
| Hal Tower at 20 ft | 195 | 2.98 |
| Centennial at 20 | 160 | 2.44 |
| Wetmore 20 | 91 | 1.39 |



Site Cost Estimates for Initial Recommendations

Prepared For:
Custer County BOCC & CCEDC
Friday March 3rd, 2017



Overview

- ◆ Background
 - **Phase I Assessment** – Evaluate broadband and cellular coverage, map existing towers, cellular drive test, identify potential sites
 - **Phase II Coverage and Backhaul Modeling**
 - Computer modeling of potential sites, backhaul connectivity analysis existing sites.
 - **Phase III Cost Modeling** – visit sites, conceptual design, cost estimates.

Cost Analysis Approach

- ◆ Visit Sites Identified in previous phase to identify:
 - Access
 - Power
 - Constructability
- ◆ “Lite Site” template used except for sites that are possible interest to cellular
- ◆ Assume 100 foot towers. Tower height will be dependent on final site location.

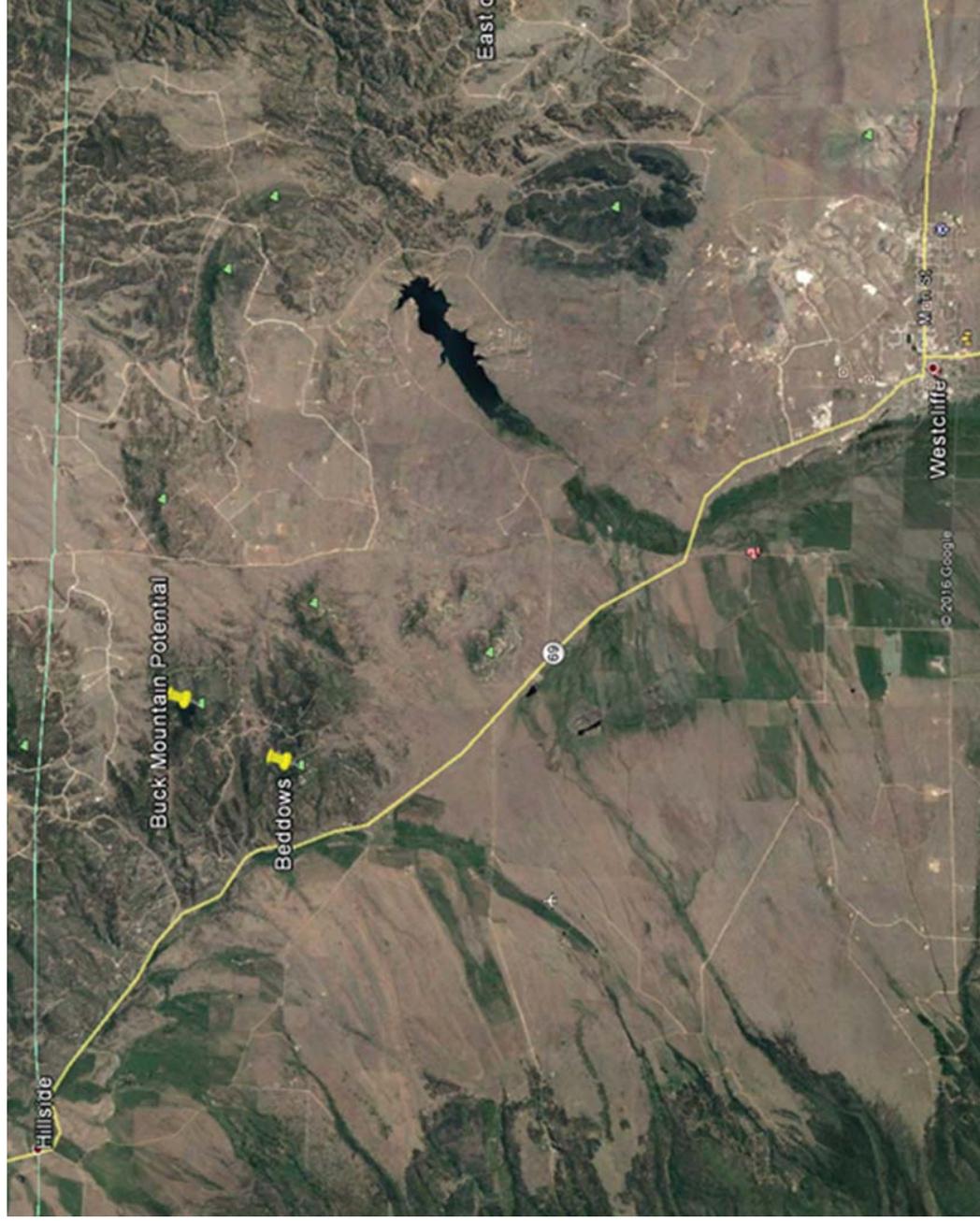
Selected Sites*

- Beddows** or Buck Mountain
- West Rosita
- East of Domingo** or East of Domingo 2
- Junkins (Loop) High Point
- Centennial
- San Isabel

*Sites are in order of recommendation

**Preferred Alternate

Beddows and Buck Location



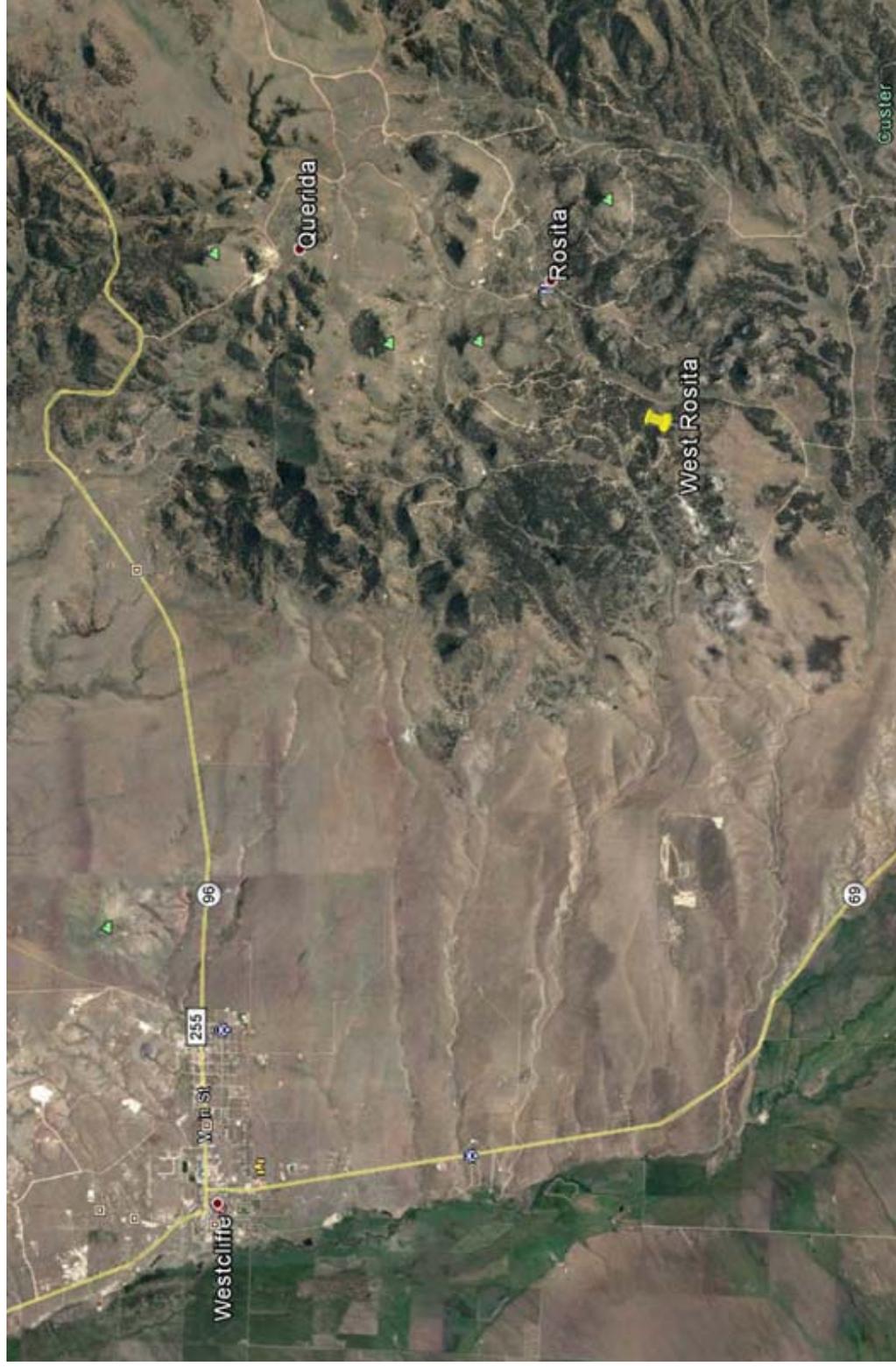
Beddows: \$389,136

- ◆ **Site Type:** 100 Foot AGL Self-Support Tower
- ◆ **Site Access:** Medium difficulty for access.
- ◆ **Access distance:** Medium distance to access site, less than 2000 feet.
- ◆ **Immediate terrain:** Gentle terrain, some heavy rock but not enough to encumber access.
- ◆ **Distance to available power:** Confirmed that power is available at the nearby road.
- ◆ **Additional considerations:** Pricing includes cedar fence around tower. Assumed that site is engineered and built to support two cellular carriers and local WISPs. Site needs to be a self-support structure for the carriers.

Buck: \$680,695

- ◆ **Site Type:** 100 Foot AGL Self-Support Tower
- ◆ **Site Access:** Difficult, no paved roads or vehicle-friendly pathways up to the location.
- ◆ **Access distance:** Best determined path between 2300 feet and 2500 feet with an elevation increase of over 500 feet.
- ◆ **Immediate terrain:** Intermediate forest and heavy exterior and ingrained stone (“rocky”).
- ◆ **Distance to available power:** Assumed to be 2300 feet for budgeting.
- ◆ **Power install considerations:** 2300 feet of new road required. New overhead power from street with one power pole every 100 feet required.

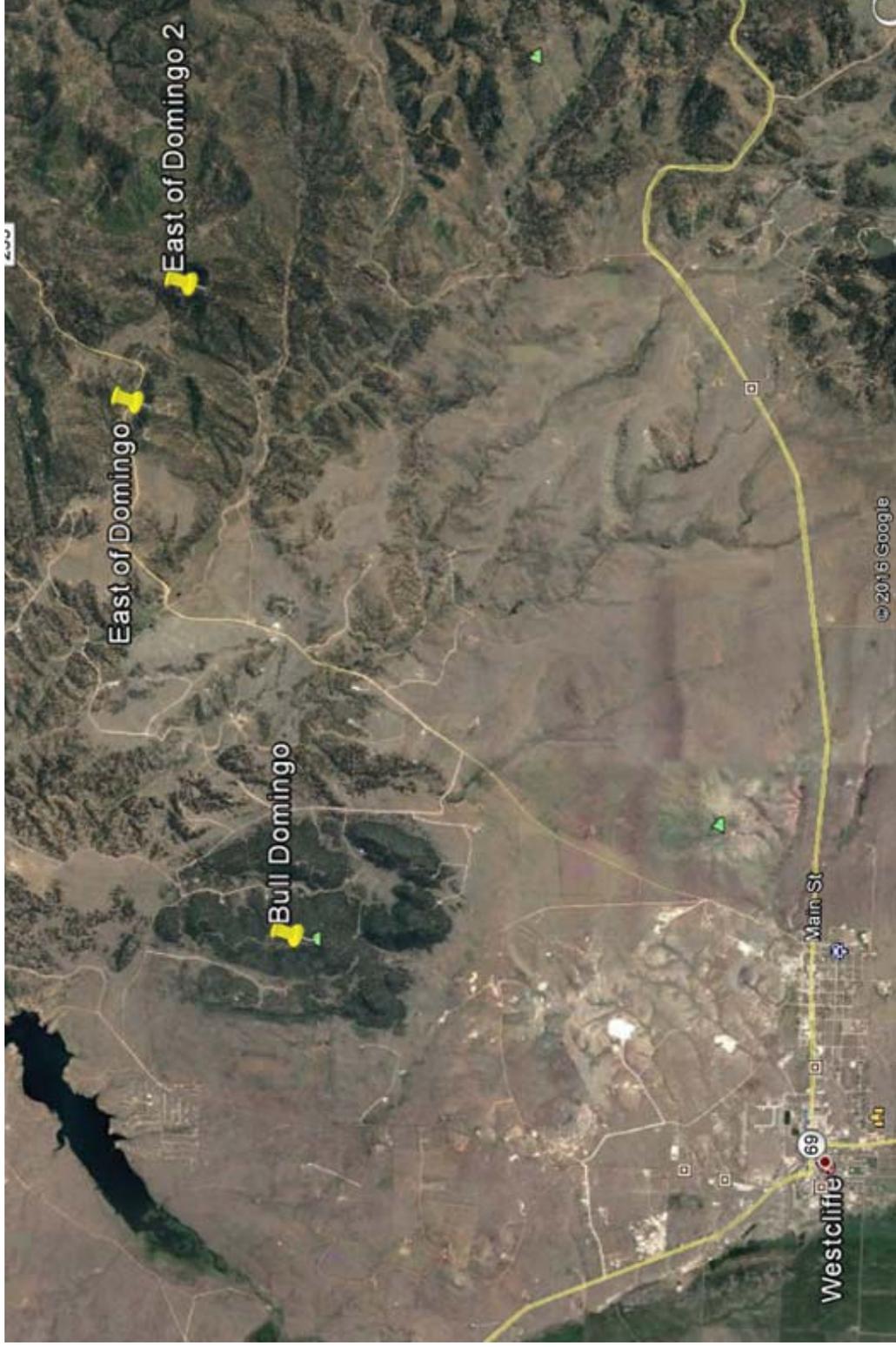
West Rosita Location



West Rosita: \$292,945

- ◆ **Site Type:** 100 Foot AGL Lite Site
- ◆ **Site Access:** Site is easily accessed via a nearby road.
- ◆ **Access distance:** Very close, existing roadway available all the way up to the nearby residence.
- ◆ **Distance to available power:** Nearby residence has available power (100 amp), less than 200 feet in distance.
- ◆ **Power install considerations:** Commercial power readily available at nearby residence.
- ◆ **Additional considerations:** Lite Site with fence around foundation located on vacant lot. One chemical rod ground required, blasting is not included in estimate and assumed not required.

East of Domingo Location



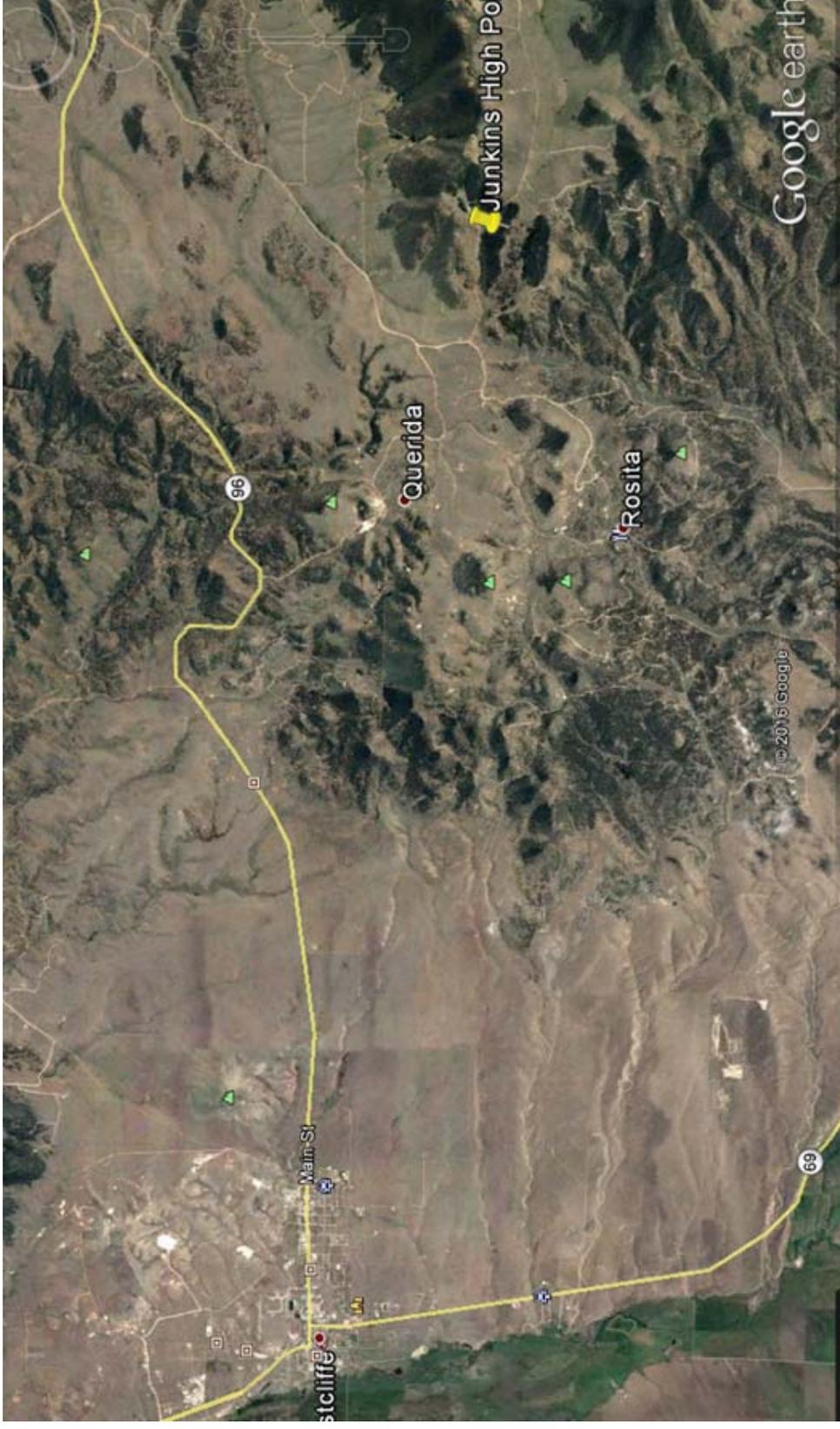
East of Domingo: \$213,780

- ◆ **Site Type:** 100 Foot AGL Lite Site
- ◆ **Site Access:** Minimal road improvements necessary, easy access.
- ◆ **Access distance:** Very close, existing roadway available all the way up to nearby residence.
- ◆ **Immediate terrain:** Very light forest.
- ◆ **Distance to available power:** Assumed that nearby residence has available power (100 amp), less than 300 feet at the most conservative measurement.
- ◆ **Power install considerations:** Assumed that commercial power readily available at nearby residence.
- ◆ **Additional considerations:** Lite site with fence around foundation needed. One chemical rod ground required.

East of Domingo 2:\$228,945

- ◆ **Site Type:** 100 Foot AGL Lite Site
- ◆ **Site Access:** A nearby home with easy access exists; assumption is easy access to site available.
- ◆ **Access distance:** A nearby home with easy access exists; assumption is easy access to site available.
- ◆ **Distance to available power:** Assumed to be less than 300 feet to nearby home.
- ◆ **Power install considerations:** Assumed that nearby home has available 100 amps of power to facilitate commercial at the location.
- ◆ **Additional considerations:** The field crew was unable to visit this site in person; some assumptions reflect experience and assumptions. Lite site with fence around foundation needed. One chemical rod ground required.

Junkins High Point Location



Junkins Loop High Point:\$301,445

- ◆ **Site Type:** 100 Foot AGL Lite Site
- ◆ **Site Access:** Site is very close to a nearby home with existing road access.
- ◆ **Access distance:** Very close, existing roadway available all the way up to the nearby residence.
- ◆ **Immediate terrain:** Existing home just east of the location, but not high enough to encumber coverage or placement.
- ◆ **Distance to available power:** Assumed that nearby residence has available power (100 amp) considering its size.
- ◆ **Power install considerations:** Assumed that commercial power readily available at nearby residence.

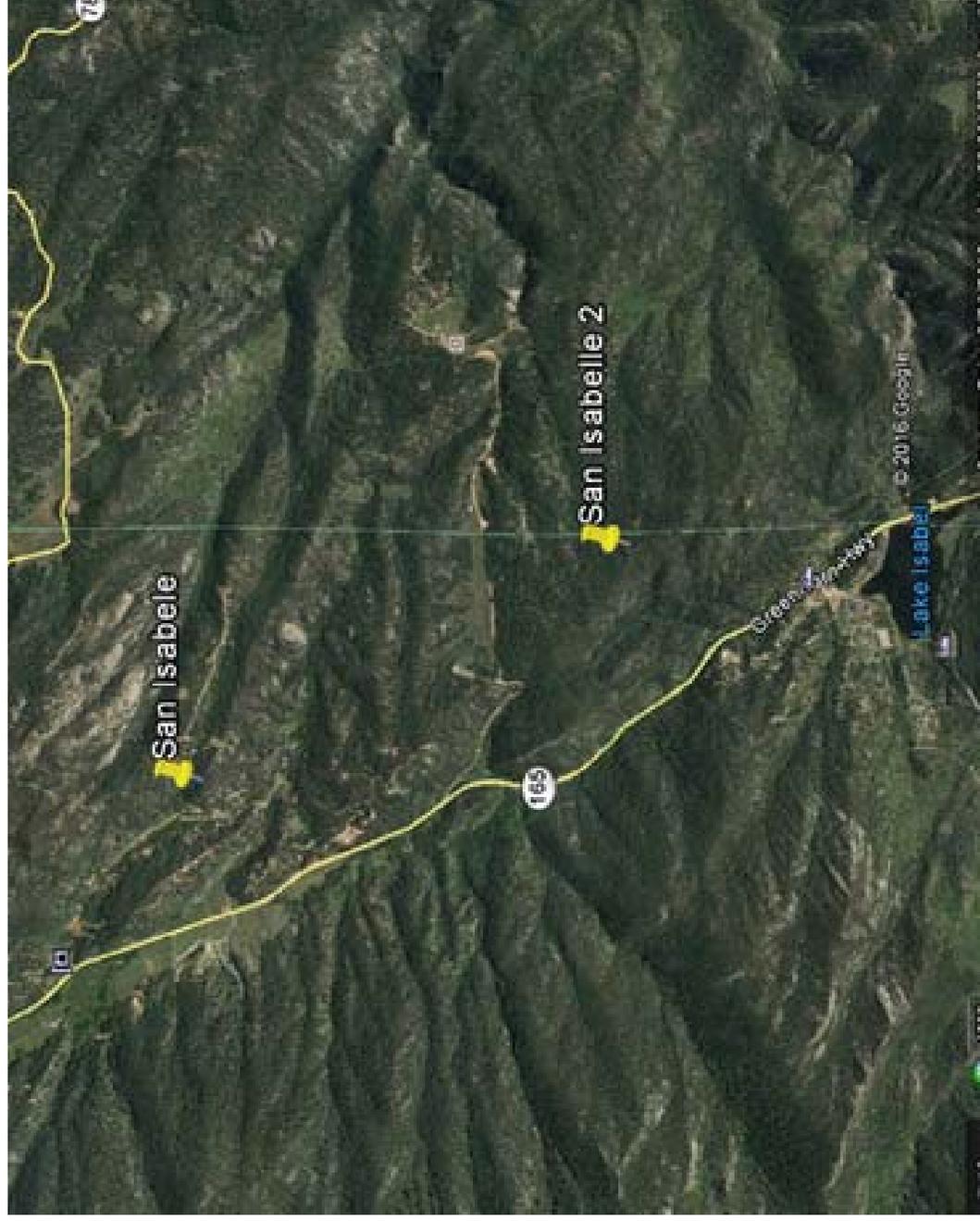
Centennial Location



Centennial:\$384,945

- ◆ **Site Type:** 100 Foot AGL Lite Site
- ◆ **Site Access:** Existing road and pathways to site; assumption is that road will require no additional improvements.
- ◆ **Immediate terrain:** Area appears to have very little rock and is flat.
- ◆ **Distance to available power:** N/A, assumption is that contractor will install a new power source.
- ◆ **Power install considerations:** Assumption is that site will require a hybrid solution between propane and solar; supply will be 48V DC.
- ◆ **Additional considerations:** The field crew was unable to visit this site in person; some assumptions reflect experience and assumptions. Lite site with fence around foundation needed. One chemical rod ground required.

San Isabel Location



San Isabel:\$340,521

- ◆ **Site Type:** 120 Foot AGL Self-Support Tower
- ◆ **Site Access:** Assumption is that road improvements will be needed to develop access to site.
- ◆ **Distance to available power:** Assumption is power is available with 350 feet.
- ◆ **Power install considerations:** Assumed that local power company will deliver a transformer to a nearby residence located southeast of the top of the hill on Wetmore Road.
- ◆ **Additional considerations:** The field crew was unable to visit this site in person; some assumptions reflect experience and assumptions. Lite site with fence around foundation included. One chemical rod ground required. Assumed that site is engineered and built to support two cellular carriers and local WISPs. Site needs to be a self-support structure for the carriers.

Coverage to tower height sensitivity

- ◆ Final Tower height will be determined when locations are finalized.
- ◆ The number of tenants influences tower height as well
- ◆ The following example of a sensitivity analysis can be used when the location is finalized:

| Name | Addresses Covered | Addresses Percentage | Total Addresses |
|-------------|-------------------|----------------------|-----------------|
| Buck at 160 | 936 | 14.28 | 6,553 |
| Buck at 140 | 931 | 14.21 | 6,553 |
| Buck at 120 | 924 | 14.1 | 6,553 |
| Buck at 100 | 915 | 13.96 | 6,553 |
| Buck at 80 | 912 | 13.92 | 6,553 |
| Buck at 60 | 905 | 13.81 | 6,553 |
| Buck at 40 | 892 | 13.61 | 6,553 |