Fiber Pre-Engineering Toolkit

Broadband Infrastructure Planning & Analysis

Introduction / User's Guide
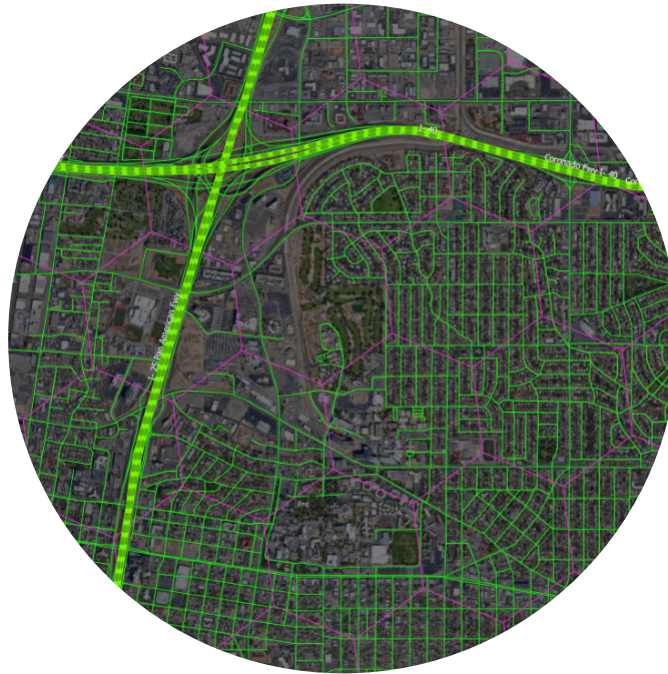
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Introduction

The Fiber Pre-Engineering Toolkit is a geospatial tool that enables the user to calculate the cost of a proposed fiber buildout based on actual road lengths. It also allows the user to select and export total road distances and costs (spreadsheet) and road segments (GIS and spreadsheet) to be used as inputs by a fiber design team in a new design.

An important goal is to shrink the time between developing an investment-driven fiber strategy, "What should I cover and why?" and the fiber design team beginning a detailed design. Historically, in many fiber projects a fiber design team begins with a number of promising candidate geographies. Some are abandoned because the business case proves unfavorable. The Fiber Pre-Engineering Toolkit seeks to provide the user with analytics that will enable more robust early decision-making that will save time and money.

The Fiber Pre-Engineering Toolkit can be used in conjunction with the Fiber Strategy Toolkit and the National Hex Toolkit:

- The Fiber Strategy Toolkit provides exhaustive analytics on the last mile fiber infrastructure deployed in the United States, including the presence and depth of fiber deployment at several different performance thresholds, residential vs. business deployments, changes in cumulative fiber deployment over a 6-month period in small areas (a powerful tool for seeing what has changed), and the footprint of major competitors. Additionally, fiber deployments can be inspected down to the location ID level. The most granular data sets include all of the fiber data released via the BDC (location ID, brand name, holding company ID, download speed, upload speed, latency, residential / business, etc.) visualized by level 8 hexagon.

- The National Hex Toolkit provides analytics on all BEAD-eligible technologies (fiber, cable, DSL/copper, and licensed fixed wireless). It also includes a large number of layers of other relevant planning information (demographics, economic KPIs, etc.). It is a recommended first step for anyone assessing broadband infrastructure needs.

Suggested reading: the Fiber Broadband Association released its first annual fiber cost study on January 24th, 2024. The FBA similarly released a report and model examining to the most appropriate "extremely high cost threshold" for each state. Each provides helpful context. Users must select an average cost per mile value for some calculations.

Key Features

Numerical Calculations: The toolkit calculates a range of KPIs using road lengths. The metrics enable the user to estimate fiber deployment costs and enable to user to identify potential fiber deployment opportunities in areas that do not yet have residential fiber. The KPIs include:

- *Cost per Unit Passed (Figure 1)*: these labels display the cost per unit passed, based on the assumed (user selected) cost of fiber ($30,000, $50,000, $70,000, or $100,000) per mile. The Toolkit includes three variations:

  - *No Cost Limit*. These labels produce a numerical result that could be close to zero or arbitrarily large (if there are many miles of road and a small number of units). In practice, areas with large numbers are unlikely to be built, either by a for-profit fiber operator or under BEAD.

Figure 1: Cost per Unit Passed (Label), Filtered at Max $2,000 per Unit and No Res Fiber (Mustard color), with Fiber at $70,000 per mile.

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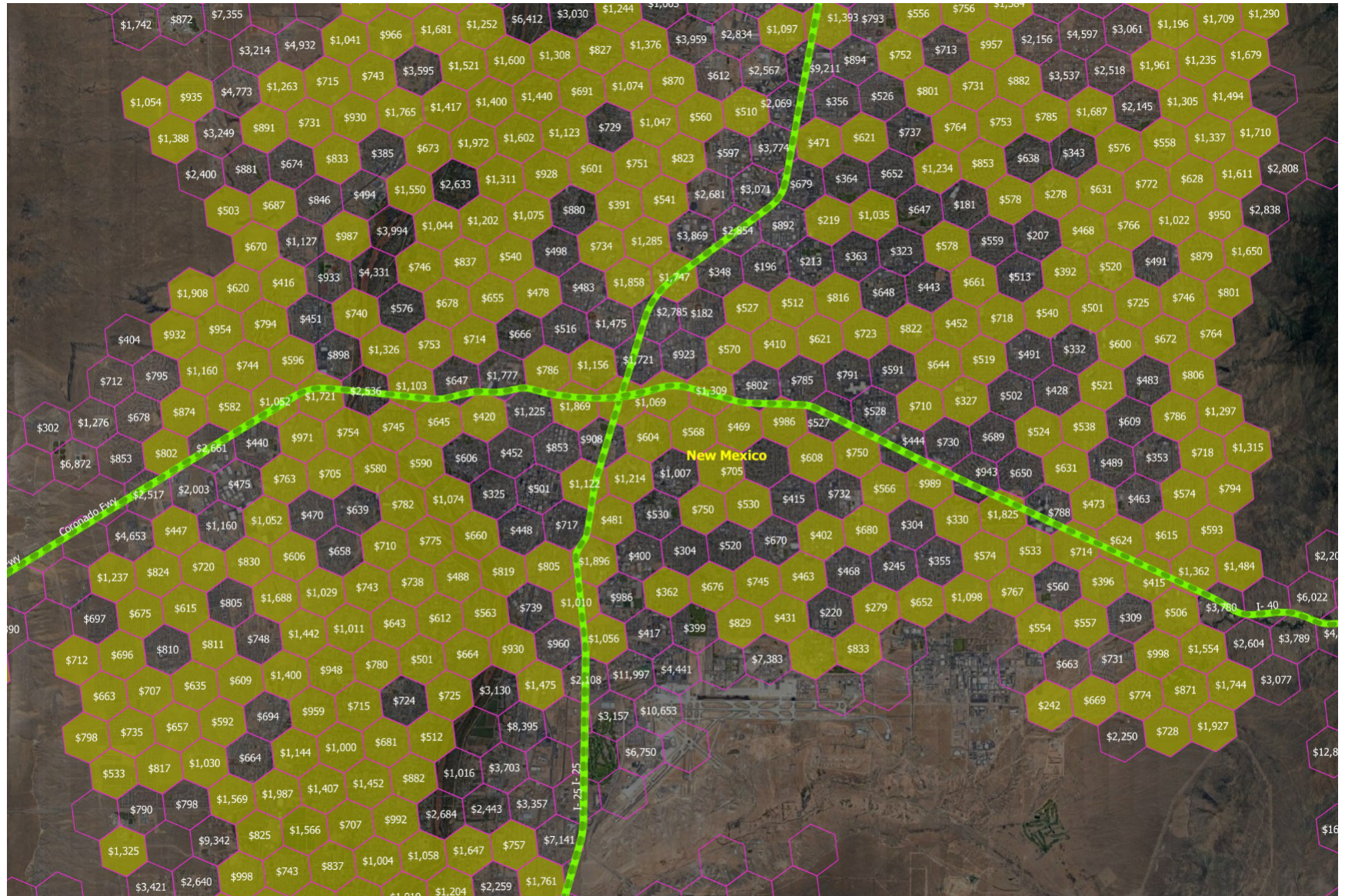
- $20k Extremely High Cost Threshold. BEAD requires Eligible Entities to identify an "extremely high cost threshold" above which non-fiber technologies may be deployed. This section suppresses results if the cost per location (not per unit) exceeds $20,000.

- $15k Extremely High Cost Threshold. BEAD requires Eligible Entities to identify an "extremely high cost threshold" above which non-fiber technologies may be deployed. This section suppresses results if the cost per location (not per unit) exceeds $15,000.

- $10k Extremely High Cost Threshold. BEAD requires Eligible Entities to identify an "extremely high cost threshold" above which non-fiber technologies may be deployed. This section suppresses results if the cost per location (not per unit) exceeds $10,000.

- *Passed per Mile (Figure 2)*: these labels display a numerical (vs. dollar) result that represents a linear density. The Toolkit includes two variations:

  - *Units passed per Mile*. This shows the number of units (housing units or businesses) passed per mile. This is commonly called "homes passed" or "premises passed". It relates directly to revenue potential.

  - *Locations passed per Mile*. Cost is often evaluated as "cost per location". This metric shows the number of locations passed per mile. It is most relevant as a cost (vs revenue) driver.

- *Road Lengths (Figure 3)*: the sum of the length of the road segments within the hexagon is an important metric. It can be displayed in several possible dimensions:
  - *Miles*
  - *Kilometers*
  - *Meters*
  - *Feet*

Filters: Each of these filters identifies hexagons that meet specific criteria. One can turn off all labels and hexagon boundaries and zoom out and quickly see where buildable areas exist over a large geographic area. The filters include:

- MAX Cost per Unit AND No Residential Fiber (Figure 1): this filter requires the user to select an average cost of fiber ($30,000, $50,000, $70,000, or $100,000) per mile then choose a maximum amount in dollars he or she is willing to spend per unit (home or business) passed.
  - The "qualifying" hexagons are colored mustard.
  - The calculation sums all of the road lengths in the hexagon, multiplies by the assumed cost per mile of fiber, then divides by the total number of units in the hexagon.
  - The results can be viewed close-up over a small area or zoomed-out over a large area.

- MIN Units per Mile. This filter identifies areas that are likely to have favorable economics, based on the simple criteria of units per mile of fiber, without distinguishing between covered and uncovered areas.

- MIN Units per Mile AND No Residential Fiber (Figure 2). This filter identifies areas that are likely to have favorable economics, based on the simple criteria of units per mile of fiber, considering

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Figure 2: Units Passed per Mile (Label), Filtered at 30 per Mile and No Res Fiber (Mustard color).
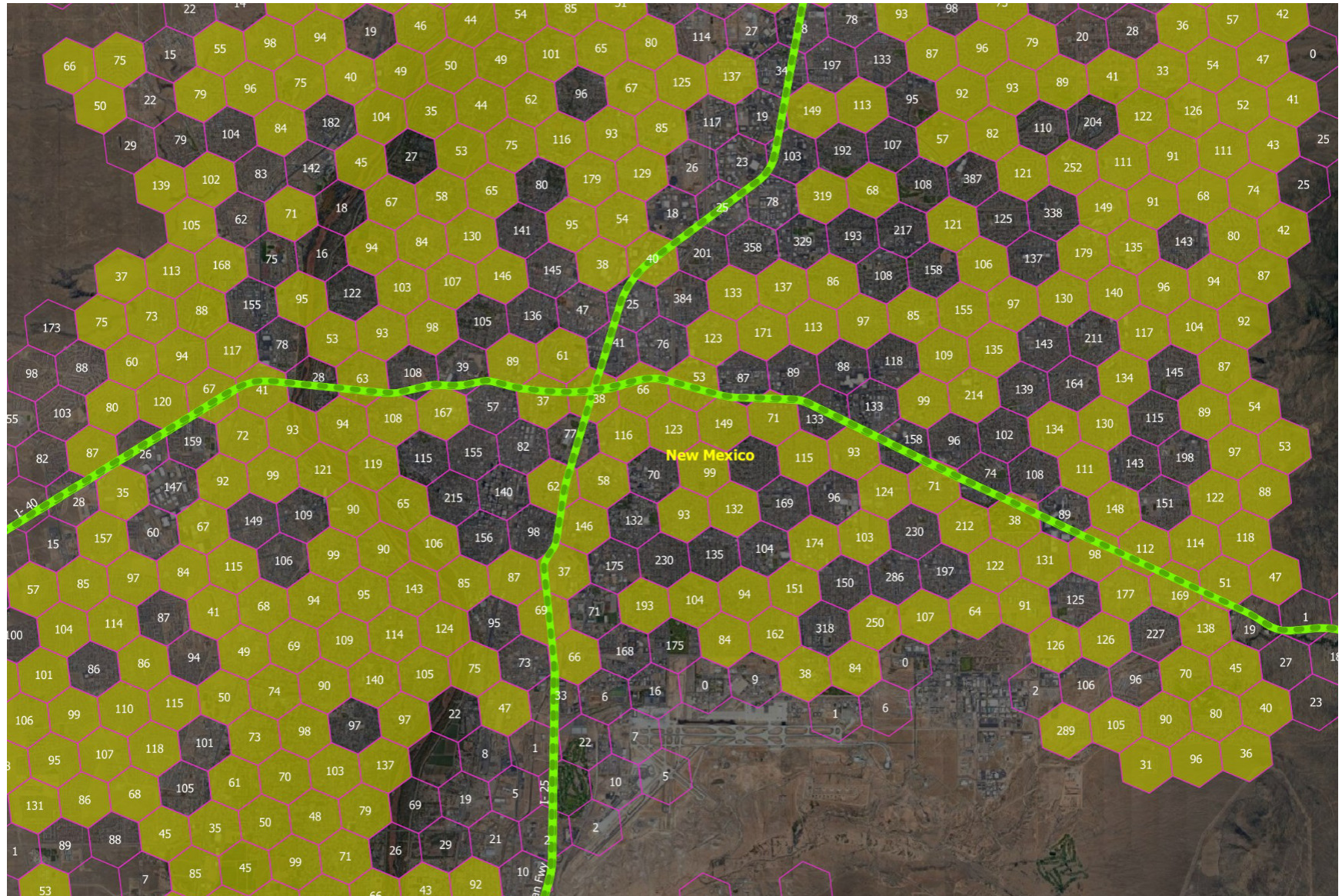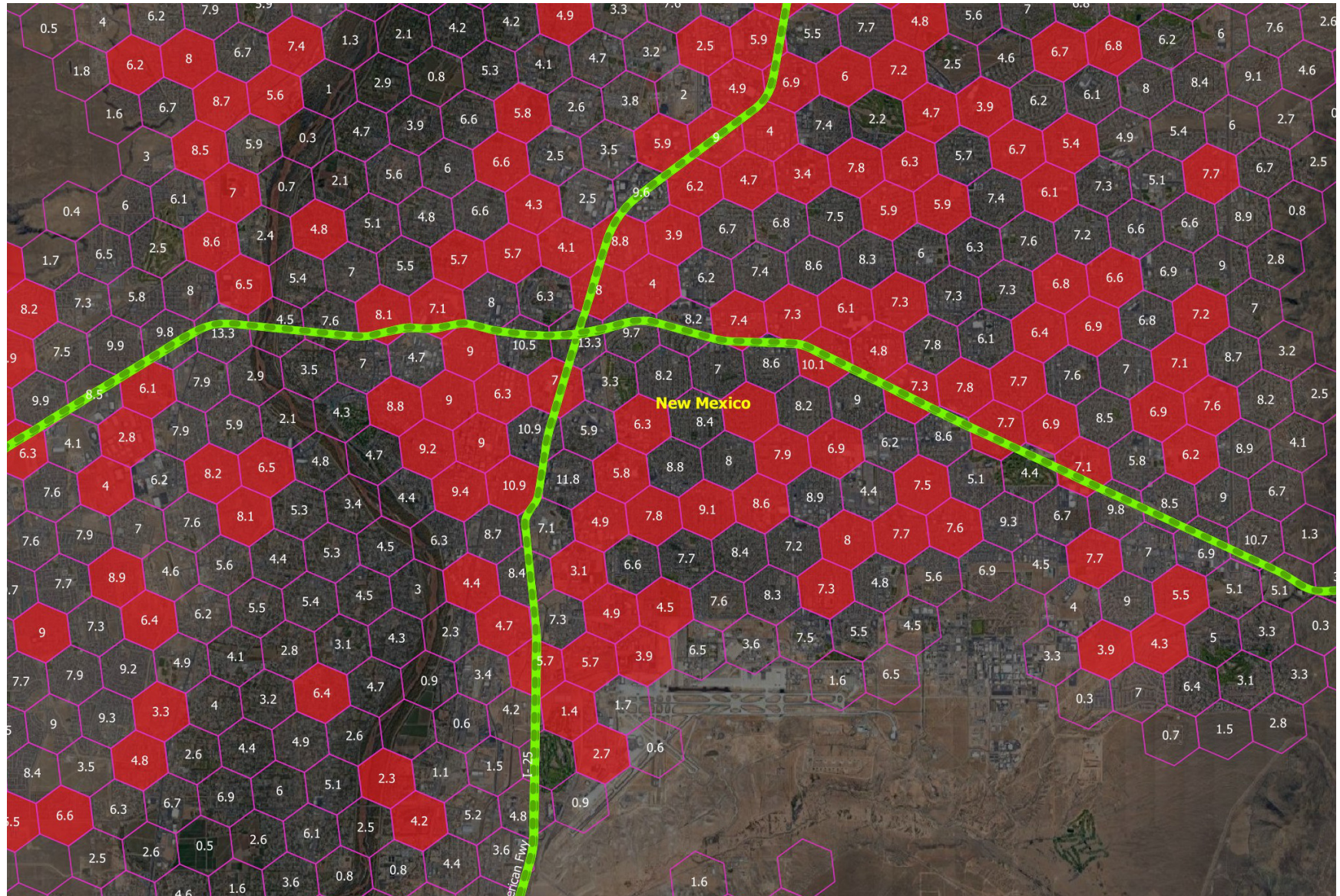
Figure 3: Length of Roads per Hex in Miles, with Residential Fiber Displayed in Red.

only areas that have no competing residential fiber.

Residential vs Business Fiber (Figure 3): this section, shared with other fiber-oriented tools, shows the presence of residential and business fiber. An operator deploying fiber will often look for areas that have no existing fiber. This layer is used as a "filter" in many other views.

Note: it is possible that the sum of road distances may not reflect the required miles of fiber. An operator may deploy fiber along non-road paths or have some path duplication or may discover that the structures in an area can be covered with less that 100% of road coverage.

- For more accurate high level results a user and adjust the selected cost per mile of text displays or the dollar threshold of filters to reflect systematic differences in the relationship between actual fiber paths and the sum of road distances.

- For more accurate low level results the user can export the road segments of interest (next section) as a shape file. One can then select or deselect specific segments then sum the distances (included as a field in the shape files).

- One can also load the road segment data into a spreadsheet and enable or disable each road segment or adjust its length to reflect duplicate paths or unnecessary paths. Such spreadsheet data is also useful in capturing deployment phases in a spreadsheet-based business model.

- At a certain point, after coverage areas are defined and after the initial road data is exported, an engineering fiber design tool becomes the authoritative source of information.

- Even though there has been increased funding for middle mile fiber the buildout in some areas may be constrained by a lack of middle mile connectivity. This toolkit focuses solely on last mile requirements.

Road Segments: This layer visualizes every road in the United States (Figure 5).

- Roads are "sliced" by county and by level 8 hexagon. Each road segment is measured and tagged by county and L8 hex.

- The roads within any area (a collection of hexagons, a county, or specific roads) can be selected and exported, as an ESRI shapefile (lines) or as a spreadsheet (to support road length calculations).

- The shape file format is helpful as the starting point for a fiber design project.

- Roads are organized into files by Division (1/9th of the US). Hex-level analytics include for the entire nation.

Important Context

The Fiber Pre-Engineering Toolkit includes a few features that are shared with other toolkits. They are highlighted here because they are exceptionally important.

- *Populated and Unpopulated Areas, Locations and Units*. The toolkit shows every populated level 8 hexagon with a magenta boundary. Each hexagon has an integer number of locations and an integer number of units, where a unit is a residence or business that qualifies as a broadband
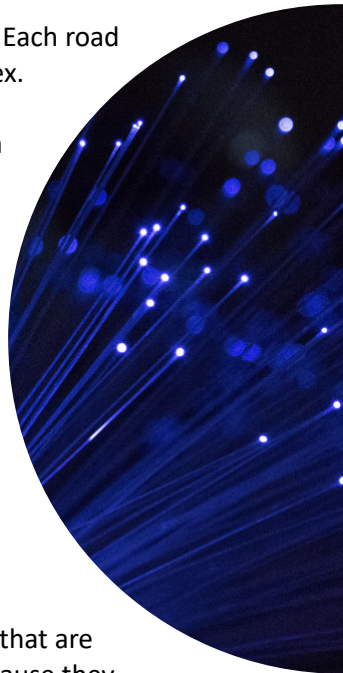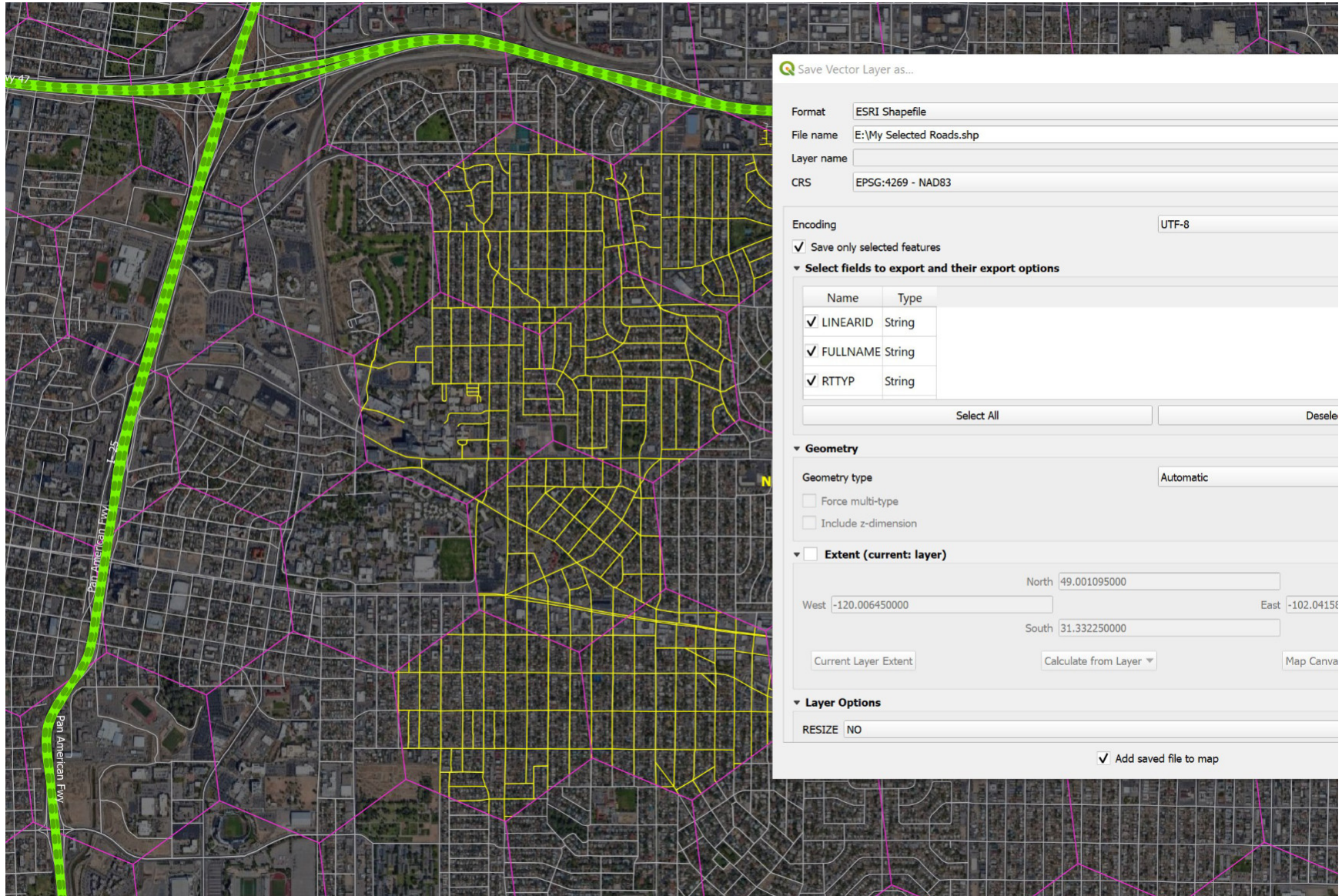
Figure 4: Units per Hexagon (Label), Filtered at Min 30 Units per Mile (Mustard color)

Figure 5: Roads Selected (to Export as Shape files or as an Excel file) to Match a Cluster of Hexagons

serviceable location (BSL). An apartment building would be represented as one location and ten units, if it had ten apartments. Boundaries and labels are best displayed when zoomed in.

Boundaries and location or unit labels can be superimposed on top of other data sets (Figure 4). For instance, one could view the number of locations per hexagon on top of a heat map or on top of a display of eligible underfunded project areas or on top of a map showing fiber presence using an advanced set of filters.

- *Density Maps*. The Fiber Strategy Toolkit shows location density (e.g. locations per hexagon) and unit density (e.g. units per hexagon) and MTU density as continuous color-coded heat maps (Figures 6 and 7):
  o Unit density very closely approximates housing unit density.
  o MTU density (units per location) shows the point at which single family homes are increasingly placed by multiple-tenant units (MTU) as cities appear. MTUs represent a high concentration of demand and a high concentration of potential revenue.

The benefit of hex-based visualizations (as opposed to census block visualizations) is that they provide a very precise representation in rural areas where there might be ten level 8 hexagons in a census block. These hex visualizations also show unpopulated (no broadband serviceable locations) land as clear. One can view density heat maps zoomed in or zoomed out. A zoomed out view might include several states.

- *BEAD Status*

  o Unserved and Underserved. The Toolkit shows unserved and underserved, and unfunded areas (Figure 8). The underlying data comes from the FCC's funding map (link). The user can enable visual representations (mustard colored hexagon) and/or numerical overlays. It is possible to see a large geographic area (zoomed out, numbers not displayed) or a small area (zoomed in)with numerical details.

  o *NTIA High Cost Area (Figure 8)*. The NTIA has identified a set of census block groups as a "high-cost area" as described in the BEAD NOFO. An Eligible Entity is allowed to waive the minimum 25% match in these areas and consumers enjoy additional ACP benefits (subject to program funding). See the FCC and NTIA press releases for details.

  o *Project Areas*. Many broadband providers are hoping to receive BEAD funding. The BEAD NOFO discusses "Underfunded Service Projects" and "Unfunded Service Projects". Each has an associated 80% rule (Figure 9). The NOFO restricts areas that are subject to an "enforceable … commitment to provide qualifying broadband" from receiving funding. The Toolkit does the "compliance math" in the background. It shows:

    o Eligible underfunded project areas

    o Eligible unfunded project areas

    o Number of served / underserved / unserved locations

Figure 6: Location Density (Locations per Hex, Clear = Unpopulated, Blue = 1, Red = Many)
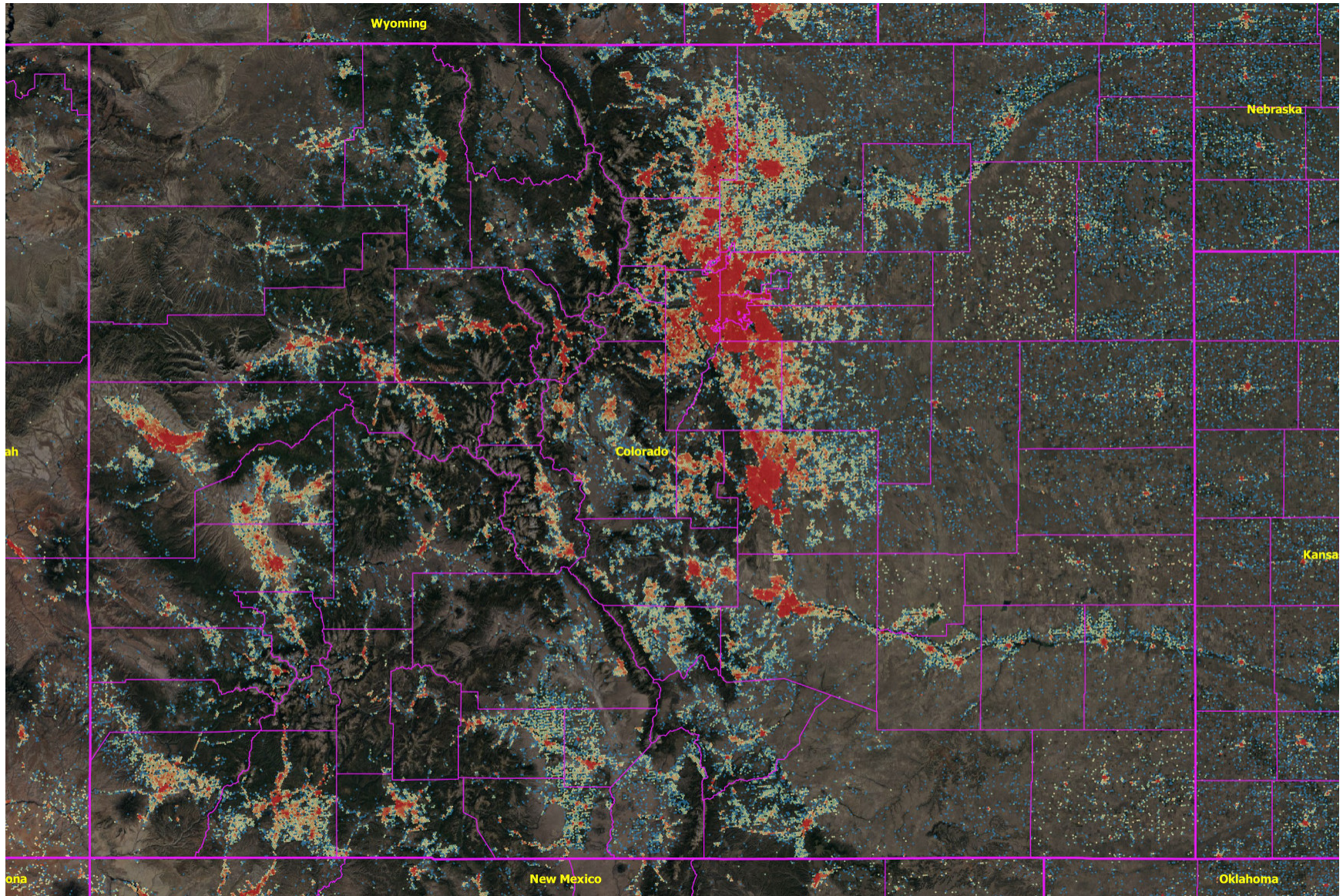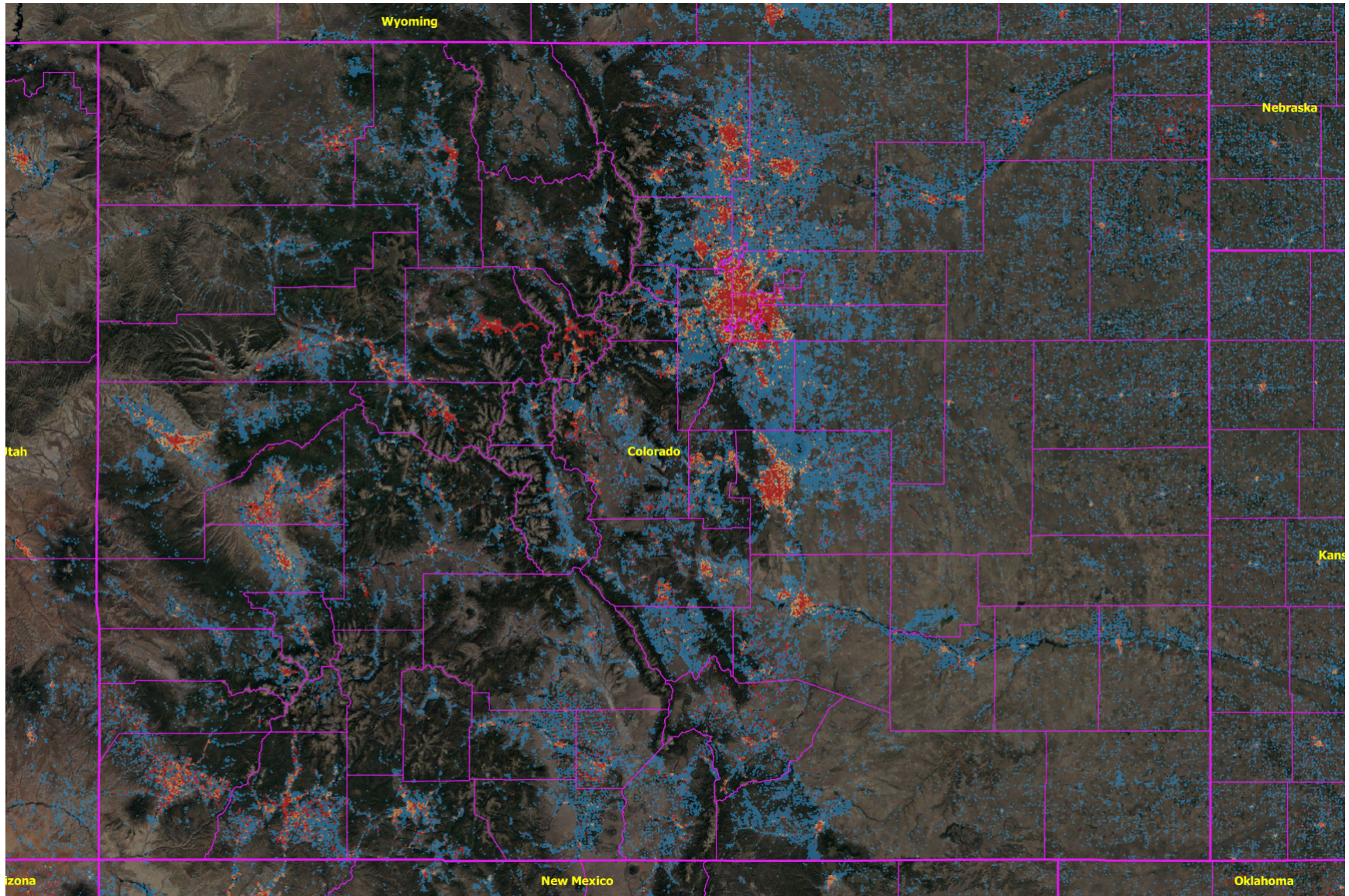
Figure 7: MTU Density (Units per Location, Clear = Unpopulated, Blue =1 to Red = Many)

per level 8 hexagon

- o Percentage of served / underserved / unserved locations per level 8 hexagon

The underfunded and unfunded eligible project areas are color coded to reflect the appropriate 80% rule. They also, optionally, display labels showing the associated calculation. The BEAD compliance section heavily leverages the FCC's Broadband Funding Map which, in turn, reflects the impact of enforceable funding commitments. An eligible underserved location is underserved or unserved AND unfunded. Similarly an eligible unserved location is unserved AND unfunded.

The NOFO is extremely flexible. It allows a project to be as small as a single location. It also allows what some might call "project area gerrymandering" where an applicant creates an unusual looking area where the compliance math works, but the design is less than optimal. The most straight-forward approach is to assemble a project out of puzzle pieces (hexagons or blocks) that individually meet the NOFO requirements.

According to the Congressional Research Service (CRS) there are over 100 federal programs that represent enforceable commitments to provide qualifying broadband. The FCC's ambitious effort to map everything is ongoing. It aspires to identify all of the relevant funding sources.

- *Background Maps (bottom of Layer window)*: streamable maps that include Google Satellite, Google Hybrid, Google Road, Bing Aerial, Bing Map, and Open Street Map. In addition, the "maps" section contains a number of solid

(opaque or translucent) backgrounds that can darker or block the underlying maps, allowing the user to easily see the most relevant details.

This Fiber Pre-Engineering Toolkit Introduction focuses on the *unique* functionality of the Toolkit.

Readers are encouraged to download and read the Introduction to the National Hex Toolkit. It is a 40 page document that describes the history and significance of recent broadband legislation, the rationale for the FCC's H3 hexagon framework, the history of BEAD, and the history of the FCC's National Broadband Map and the FCC's Broadband Funding Map. It also describes some of the data sets included in both toolkits. It can be downloaded from the bottom of the National Hex Toolkit product page (link).

Selecting and Exporting Data

The Toolkit enables easy data export for those who wish to analyze results in a spreadsheet. In general the steps are:

1. Enable (check the checkbox) then select a layer in the QGIS "Layers" window. The layer will have a blue background when selected.

2. Select an area on the map. There are four primary selection tools in the toolbar of QGIS. One can easily create a selection then modify it. The selected area turns bright yellow.

3. Right-click on the selected layer and choose "Export | Save selected features as …". For a spreadsheet select "MS Office Open XML spreadsheet [XLSX] …".

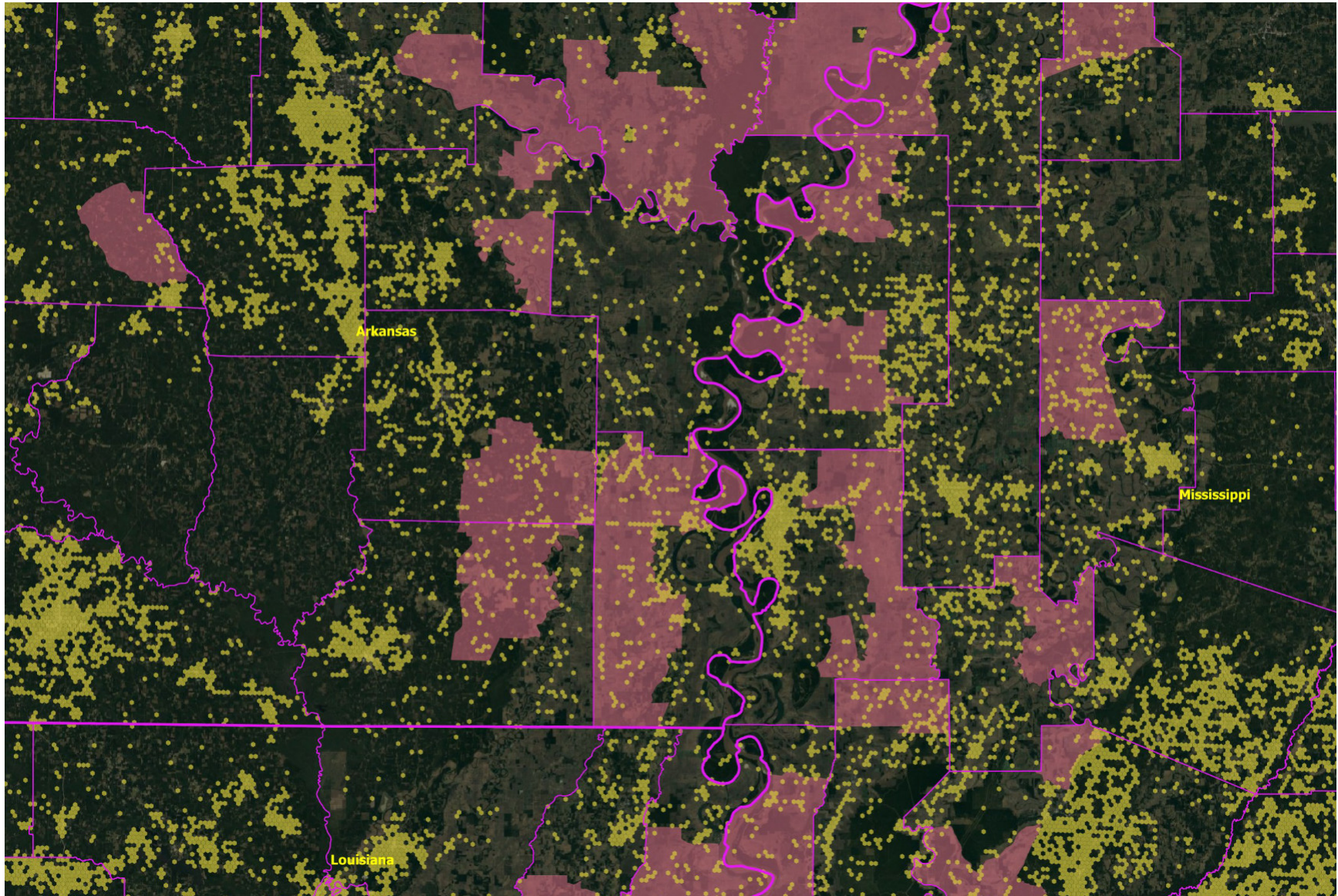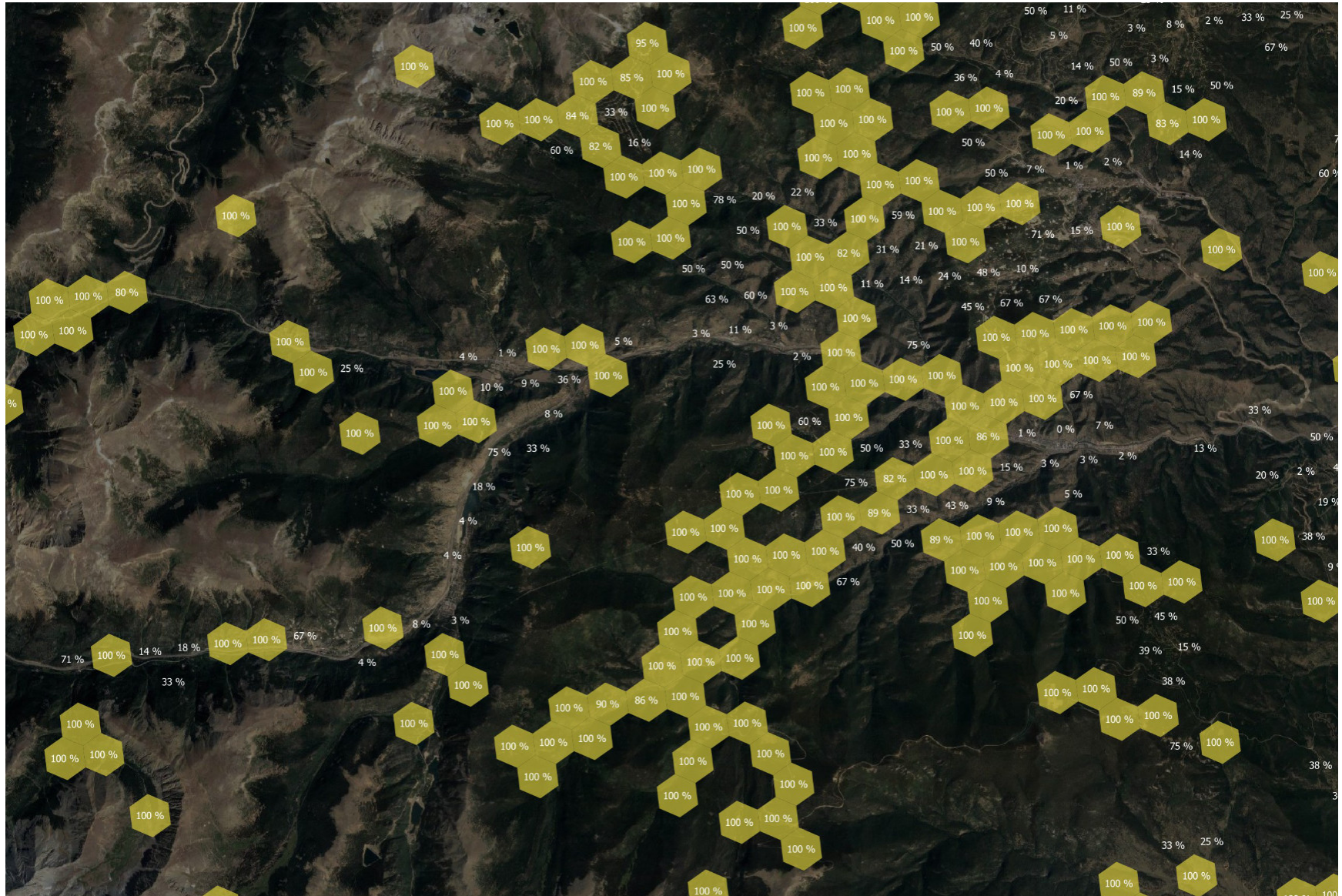Figure 8: Unfunded Unserved and Underserved Locations (Mustard) on top of NTIA High Cost Areas (Magenta)

Figure 9: Eligible Unserved Project Areas. Percentage of Locations Unserved as Labels.

4. Click "…" to be prompted for a saved file name and location.

5. An Excel spreadsheet can include up to 1,048,576 rows. Make sure your selected data does not exceed this limit.

Data exports can include spreadsheet data or GIS data. The data export process is shown in Figure 5.

While in theory data can be exported from any layer the most useful layers are:

- *Data EXPORT | Hex Data*. This includes all of the statistical data associated with a collection of selected hexagons.

- *Road Segments*. This includes all of the road segments within the division (1/9th of the US) and the associated metadata.

Whitepapers, Video Tutorials

Be sure to check for the latest whitepapers:

https://broadbandtoolkit.com/pages/whitepapers

Video tutorials exist to help new users get started, understand the sophisticated functionality, enable and disable options, and effectively use the various Toolkit products. Visit the BroadbandToolkit.com Youtube page for video tutorials.

Next Steps

The Toolkit team will be happy to do Zoom demonstrations, answer your questions, and discuss your other planning and analysis needs.

You can reach us by phone at *415-346-5393* or by e-mail at *support@broadbandtoolkit.com.*

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