

An aerial night view of a dense city, likely New York City, with numerous skyscrapers and buildings illuminated by city lights. The overall color palette is a deep blue, giving it a high-tech, digital feel.

Fiber Strategy Toolkit

Broadband
Infrastructure
Planning &
Analysis

Introduction / User's Guide



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Introduction

The Fiber Strategy Toolkit extends the capabilities of the National Hex Toolkit, enabling a fiber-focused strategic planner to visualize the presence and depth of fiber deployments in an extremely nuanced way. It enables the user to apply multiple concurrent filters to see existing infrastructure through carefully crafted lenses. It enables the user to quickly identify fiber deployment opportunities based on density and the absence of competition. It visualizes the top ten fiber competitors. It includes an exhaustive database of all last-mile fiber infrastructure serving broadband serviceable locations.

This Fiber Strategy Toolkit Introduction focuses on the *unique* functionality of the Fiber Strategy Toolkit. Readers are *strongly 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](#)).

New Features

Version 2.0 of the Fiber Strategy Toolkit includes important new features:

Change in Fiber Deployment. A important question for anyone investing in fiber is "Where are others deploying fiber?"

- The Fiber Strategy Toolkit now visualizes the change, over six

months, in the fiber buildout in each hexagon.

- The Toolkit shows presence and depth (the framework used elsewhere) at each point in time and shows a change in deployment via a color ramp that goes from bright green (rapid growth) to gray (no change) to red (downgraded numbers, perhaps as a result of challenges). The color ramp allows the user to see small changes in an instant.
- The toolkit represents the changes numerically as the change in the percentage of locations covered.
- The changes are visualized at two performance thresholds, "any" fiber (no performance assumptions) and gigabit symmetrical (or better). These thresholds allow the user to see whether a moderately capable fiber network has added locations or whether a highly capable fiber network has been deployed.
- The color ramps reflect the change in depth of coverage (described in an upcoming section) at the specified performance threshold.
- Figures 12 and 13 show zoomed-out and zoomed-in views, respectively. The user can do a deep dive into the final state in areas of interest in the exhaustive location-level database (Figure 8), if desired.
- The Toolkit also includes numerical deployment data in spreadsheets. This data shows the number of fiber locations covered by fiber operator and by state, at each of two points in time. It also shows, on a state by state basis, the growth in the number of provider-locations. In each case this growth is net of



Figure 1: Location Density (Locations per Hex, Clear = Unpopulated, Blue = 1, Red = Many)

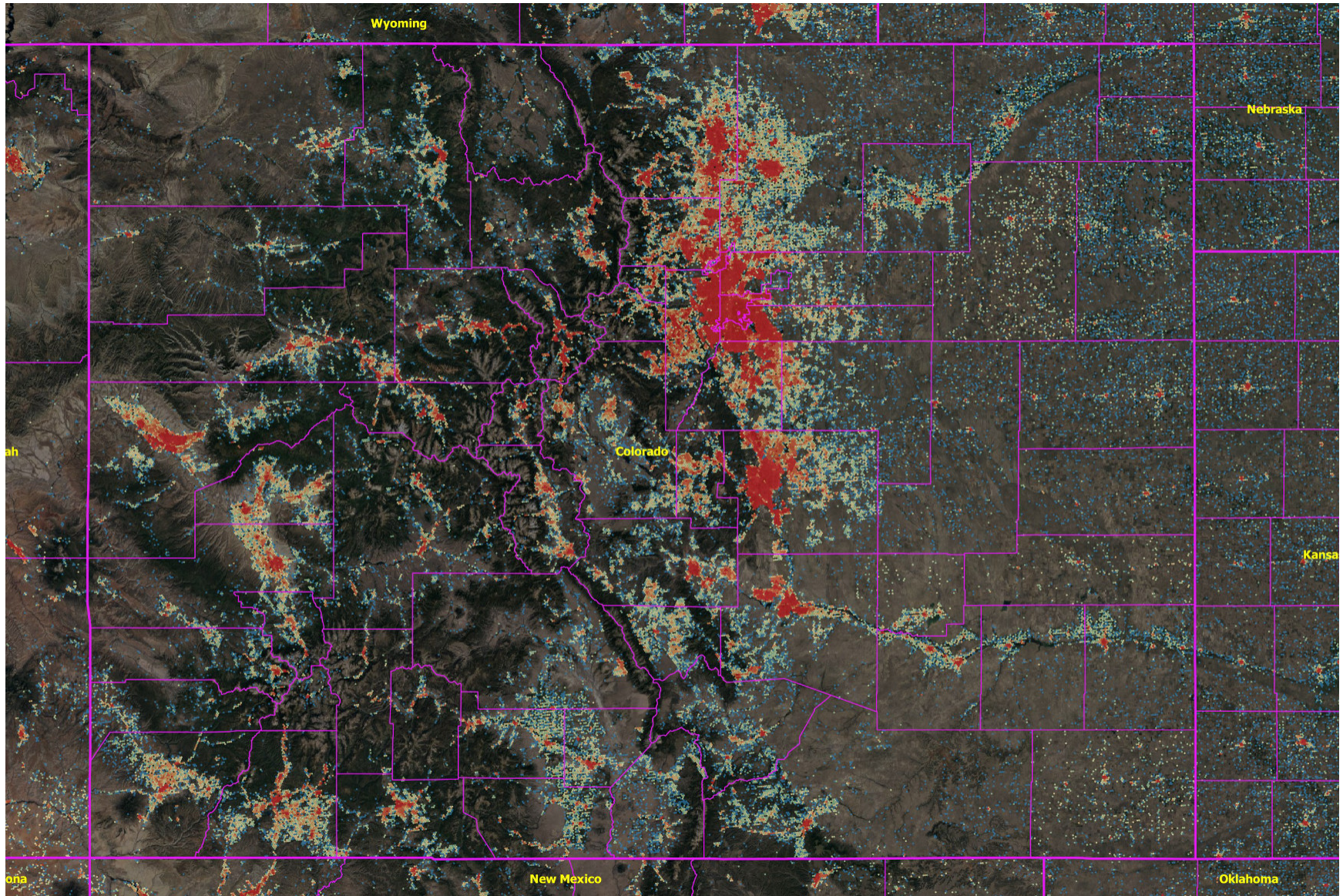
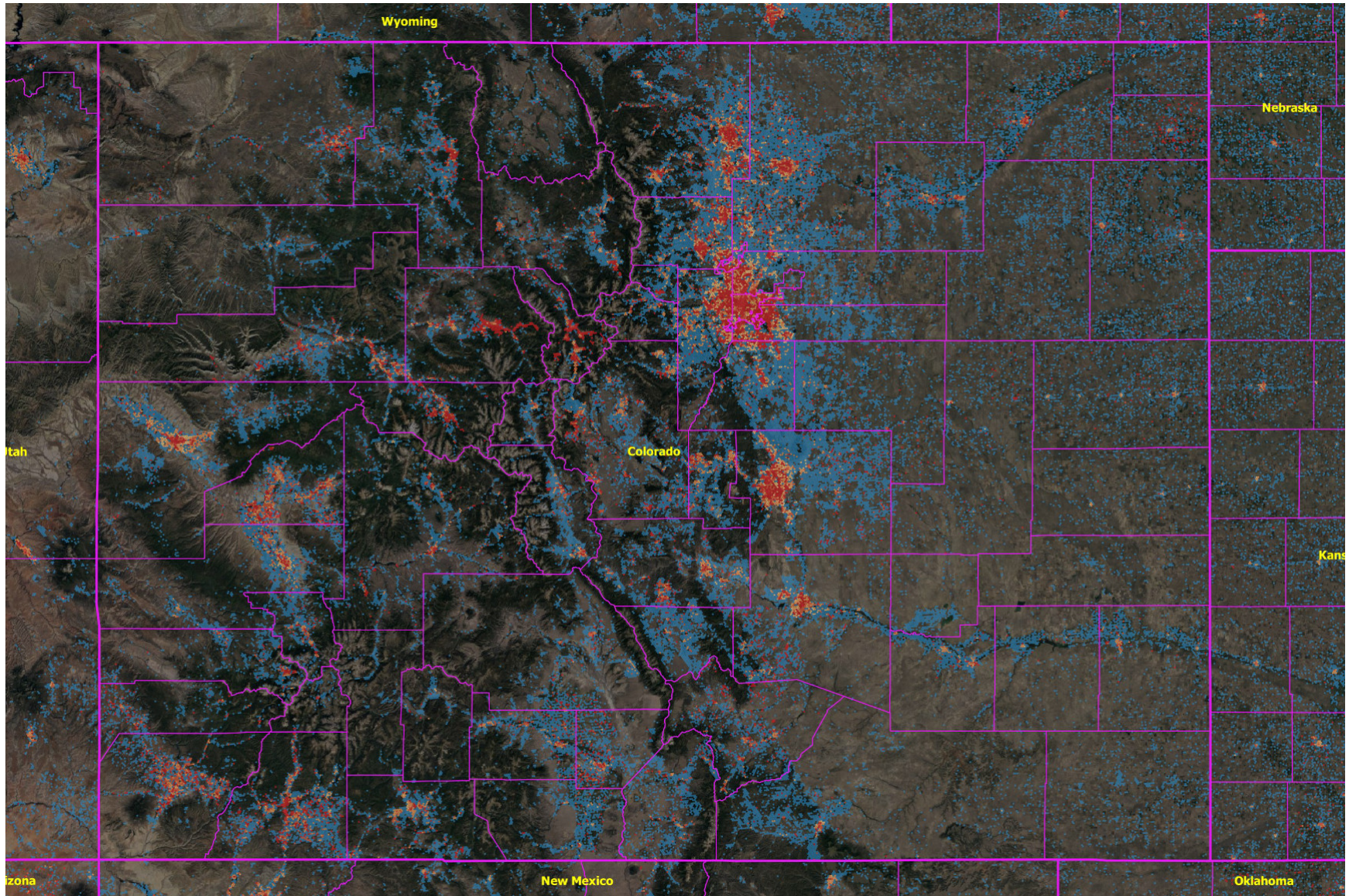


Figure 2: MTU Density (Units per Location, Clear = Unpopulated, Blue =1 to Red = Many)



negative recharacterizations (e.g. instances in which an operator might have reduced the reported fiber footprint from one reporting period to the next).

High-Cost Areas. Version 2.0 of the Toolkit shows NTIA High-Cost Areas. These are critically important for anyone participating in BEAD or participating in the ACP ([NTIA](#), [FCC](#)). The Toolkit makes it easy to see unserved and underserved locations (counts by L8 hex) on top of a map of High-Cost Areas. See Figure 14.

Visualizations of Unserved and Underserved. While the Toolkit previously included a sophisticated visualization of unserved and underserved areas that visualization has become even richer in the current release. Users can view locations by speed threshold (≥ 100 -20, < 100 -20, or < 25 -3), by BEAD categorization (served, underserved, unserved), or by eligible project areas. While in theory a provider could select random unserved points within a state to define a “project”, most will create eligible project areas using the 80% rule, unless they are filling in gaps in an existing footprint. The Toolkit supports a wide range of visualizations. The underlying data set reflects both coverage and funding status, based on FCC data. As states complete the required NTIA challenges processes the FCC data sets will presumably be updated.

Version 2.0 of the Fiber Strategy Toolkit reflects the November, 2023 release of FCC BDC data (Fabric v3), which in turn reflects physical fiber networks as of June 30th, 2023.

The Toolkit also includes FCC Funding Map updates as of 12-14-2023.

Important Context

The Fiber Strategy 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 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 other data sets. 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:
 - Unit density very closely approximates housing unit density (shown as a layer in the demographics section using census data).
 - 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.

Figure 3: Eligible Underserved Project Areas (Zoomed Out)

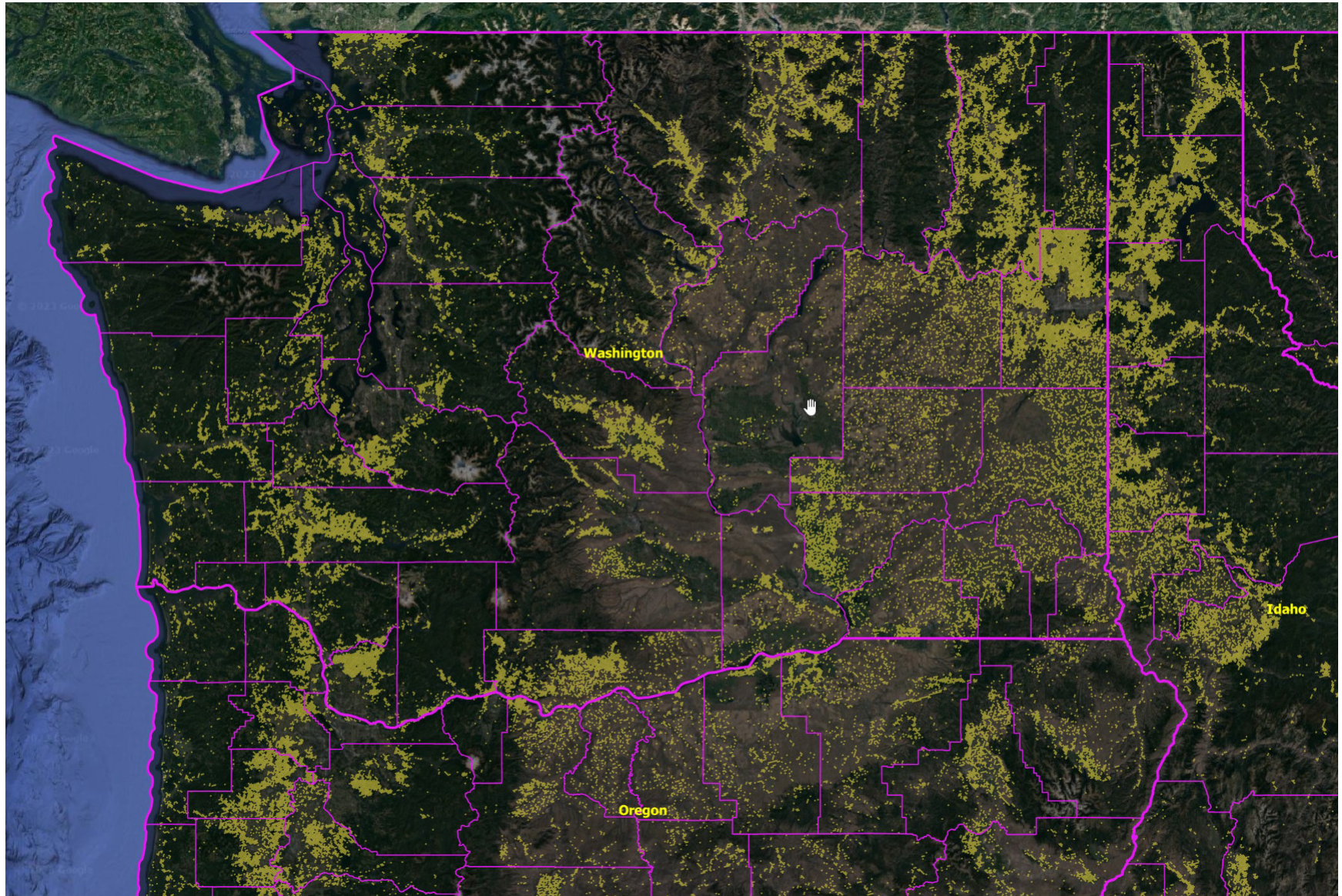
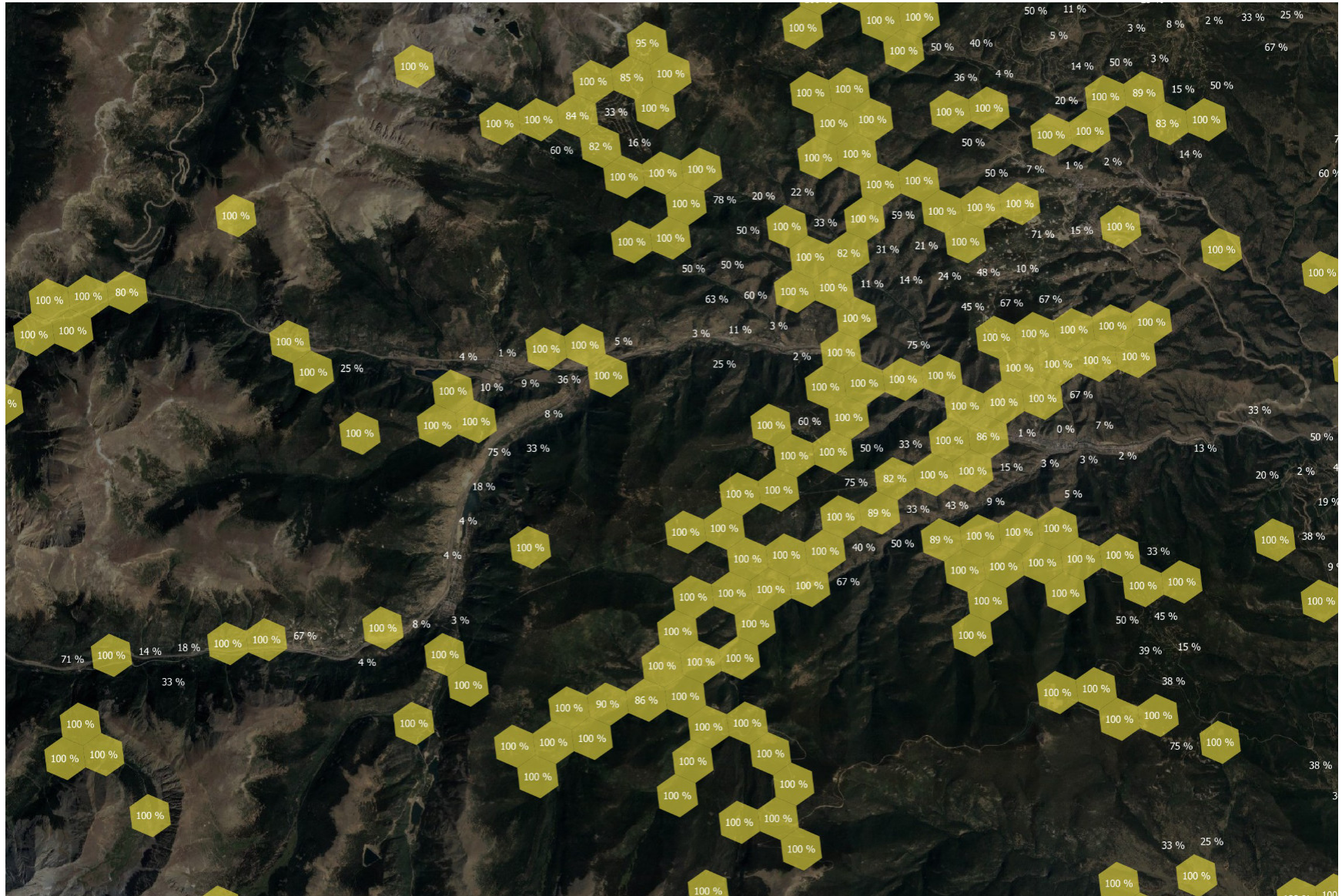


Figure 4: Eligible Unserved Project Areas. Percentage of Locations Unserved as Labels.



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.

Figures 1 and 2 show location density and MTU density heat maps, respectively.

- *BEAD Status / 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. 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:
 - Eligible underfunded project areas
 - Eligible unfunded project areas
 - Number of served / underserved / unserved locations per level 8 hexagon
 - 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 shows occasional inconsistencies with other data sets.

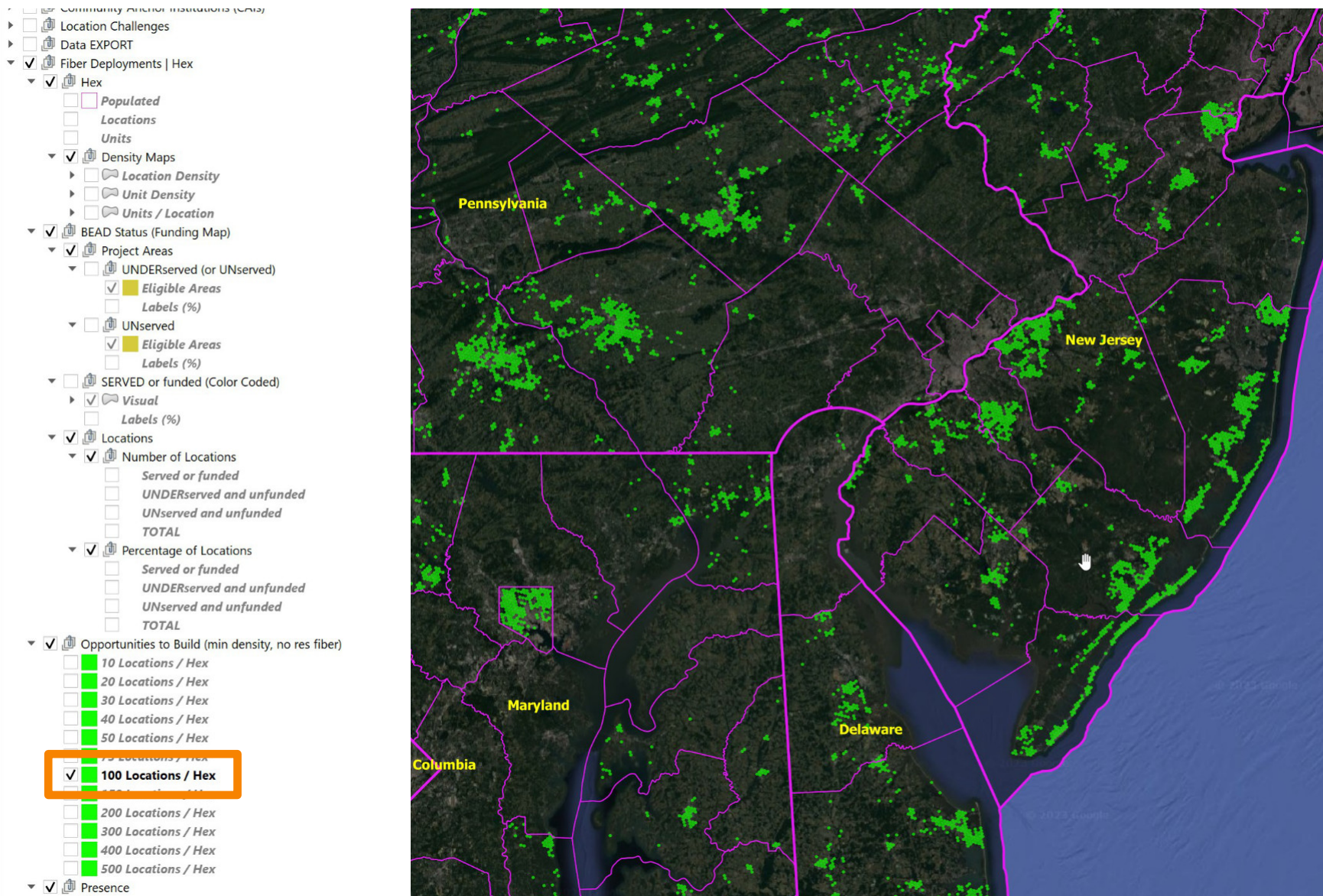
The Toolkit also includes maps of nine significant federal programs (RDOF, CAF II, ReConnect, etc.) in a section entitled “Federal Funding Exclusions”.

Figures 3 and 4 show examples of eligible underfunded and eligible unfunded project areas. Figure 3 is zoomed out. Figure 4 is zoomed in. Figure 4 shows a text overlay with the compliance calculations.

Opportunities to Build

The United States has a significant fiber footprint. However there are vast areas that should – from an economist’s perspective – have fiber. Many have yet to be built. Fiber is appealing because, with most

Figure 5: Identifying Fiber Build Opportunities (≥ 100 Locations / Hex) Based on Density and the Absence of Competition



architectures, once deployed, capacity can be increased with relative ease.

Two factors overwhelmingly drive fiber economics:

- Density (premises passed per mile, which is correlated to locations per square mile and units per square mile). FCC data enables us to most easily measure locations per level 8 hexagon. H3 hexagons have an identical footprint in degrees that translates into a nearly identical area in regions at the same latitude. Level 8 hexagons cover an average area, globally, of 0.737 square kilometers ([link](#)) per hexagon.
- Fiber competition (or the lack thereof)

The Opportunities to Build section (Figure 5) shows, with the click of a mouse all of the areas in the United States that *lack* residential fiber AND that meet a minimum user-selected density requirement. Areas that are dense but not yet fiber-enabled are likely to have a compelling standalone business case. Areas that are less dense may have a business case if constructed partially with funding from BEAD or another source. Importantly, each of these areas *lacks* residential fiber today.

A third factor impacting adoption is household income. The Toolkit includes a number of income (mean and median household income) and social welfare metrics. The Affordable Connectivity Program (ACP) provides a \$30 monthly subsidy (or more in tribal areas) to qualifying households. It mitigates some of the negative impacts of low income on expected adoption. It democratizes access to high quality broadband and indirectly encourages infrastructure deployment in low income areas.

Finally, middle-mile connectivity is critical. Any proposed deployment area must have affordable middle mile bandwidth. The Toolkit does not currently include middle mile resources.

Multi-Dimensional Filters, Presence and Depth

A number of dimensions characterize service at every broadband serviceable location (BSL):

- Technology
- Downlink Speed (maximum advertised)
- Uplink Speed (maximum advertised)
- Latency (a flag indicating low latency)
- Type of Service, Residential or Business or Both
- Internet Service Provider Details

The Fiber Strategy Toolkit *statistically* characterizes service in each level 8 hexagon, enabling the Toolkit to rapidly visualize complex combinations of filters.

- Speeds:
 - Gigabit symmetrical (1000-1000), low latency
 - 100-20 Mbps, low latency
 - 25-3 Mbps, low latency
 - Any fiber service
- Category of Service
 - Residential
 - Business
 - Residential AND Business (intersection)
 - Residential OR Business (union)

Figure 6: Presence of (Fiber + Residential + 1000 Mbps Down + 1000 Mbps Up + Low Latency)

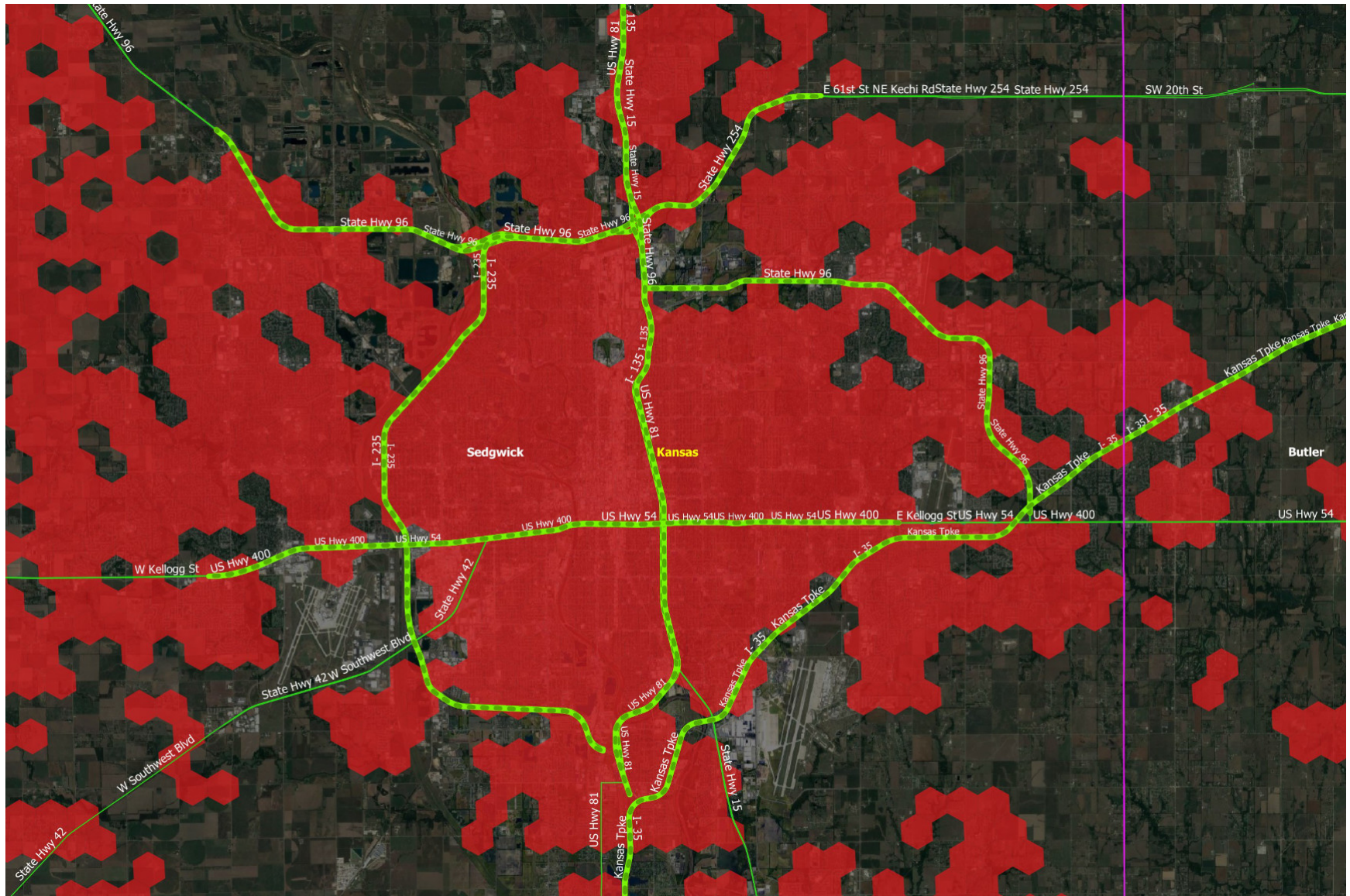
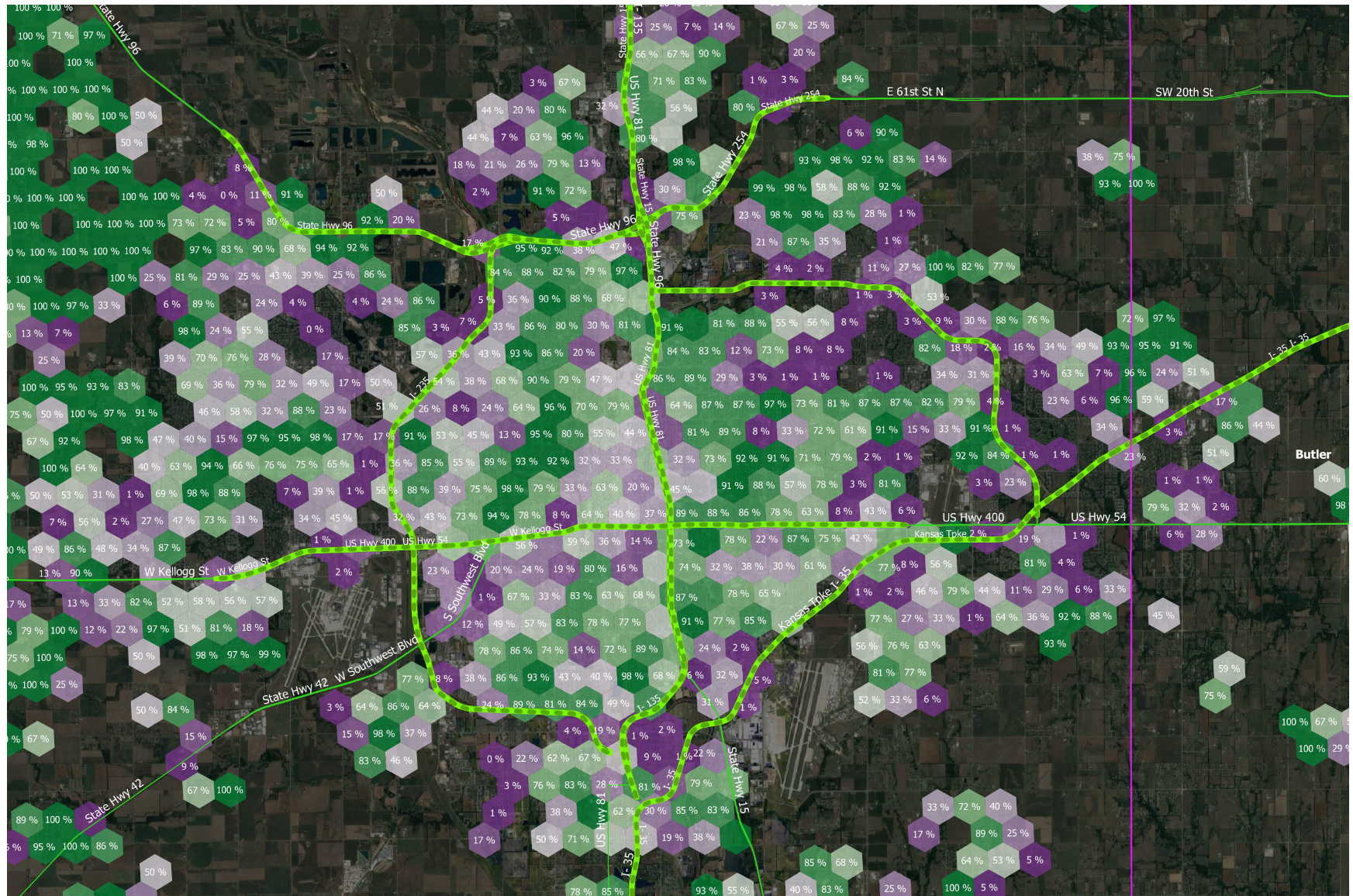


Figure 7: Depth of (Fiber + Residential + 1000 Mbps Down + 1000 Mbps Up + Low Latency)



These dimensions are combined into 11 different complex filters. In each case the filter can be applied to show “presence” or “depth”.

We define *presence* as one or more locations within a geographic area exhibiting the specified characteristics. One can think of presence as an on-off switch. The FCC’s historic Form 477 (now sunset) characterizes service by census block using the concept of presence (although the FCC doesn’t use this term). If a provider covered a single location the block was considered covered at the specified threshold. Presence is appealing because it is simple, but it tends to overstate availability and quality of the service.

We define *depth* as the percentage of locations within a geographic area exhibiting the specified characteristics. If the requirement is qualifying coverage (100-20 Mbps, low latency) then a score of 75% means that 75% of the locations within an area (e.g. a hexagon) have qualifying coverage, per that definition.

Figures 6 and 7 provide an example of presence and depth. Figure 6 shows the presence of fiber-based gigabit symmetrical (1000-1000, low latency) residential service in an urban area. Figure 7 shows the depth of the same service (fiber, residential, 1000 Mbps down, 1000 Mbps up, and low latency). Depth offers a more nuanced view. The Toolkit is extremely powerful in that it enables the user to turn on and off various complex filters and to see the results as either presence or depth.

The Toolkit represents presence with a solid color. Layers of presence can be visually stacked. Depth appears as a color gradient. In a depth calculation a value slightly greater than 0% is purple while a value approaching 100% is green. If no locations exhibit the specified attributes then the hexagon is clear. A depth calculation may, optionally, include labels showing the percentage calculation.

Alternatively, it might include some other label (e.g. locations or units) or no label at all.

Presence calculations can be viewed zoomed in or zoomed out. Depth calculations with labels are best viewed zoomed in, although depth can be viewed, without labels, zoomed out.

Competition, Viewing Location-Level Data

The Fiber Strategy Toolkit contains an exhaustive database of location-level information about fiber deployments – essentially everything the FCC releases to the public via its Broadband Data Collection (BDC) program. The data is organized by level 8 hexagon. It can be used in several ways:

- To see the geographic footprint of any fiber ISP (organized by holding company provider ID)
- To see the details of all fiber deployments within a small geographic area
- To export detailed information for a region of interest

To view data do the following:

1. Zoom in to a small geographic area (e.g. a county). It is important to start zoomed in because the Toolkit accesses a database of over 50 million provider-location records. The larger the area of view the greater the resources demanded from your computer.
2. Enable one or more layers from the “Competition” folder
 - a. The folder is preconfigured to show the top ten (by locations passed) fiber providers
 - b. One can see the footprint of ANY specific fiber provider

Figure 9: Location-Level ISP Data Collected by the FCC

Below is the specification for the tabular data in each CSV file available for download:

Field	Data Type	Example	Description / Notes
frn	String {10}	0032176356	10-digit FCC Registration Number (FRN) of the entity that submitted the data.
provider_id	Integer	999100	Unique identifier for the fixed service provider.
brand_name	String	Acme Telecom	Name of the entity or service advertised or offered to consumers.
location_id	String	1357135307	Unique identifier for the location, as used in the Broadband Serviceable Location Fabric.
technology	Integer	50	Code for the technology used for the deployed service. - Value is one of the following codes: <ul style="list-style-type: none"> 10 - Copper Wire 40 - Coaxial Cable / HFC 50 - Optical Carrier / Fiber to the Premises 60 - Geostationary Satellite 61 - Non-geostationary Satellite 70 - Unlicensed Terrestrial Fixed Wireless 71 - Licensed Terrestrial Fixed Wireless 72 - Licensed-by-Rule Terrestrial Fixed Wireless 0 - Other

max_advertised_download_speed	Integer	1000	Maximum advertised download speed offered at the location in Mbps.
max_advertised_upload_speed	Integer	1000	Maximum advertised upload speed associated with the maximum advertised download speed offered at the location in Mbps.
low_latency	Boolean Integer	1	Boolean integer flag indicating whether or not the offered service is low latency, defined as having round-trip latency of less than or equal to 100 ms based on the 95 th percentile of measurements. - Value is one of the following codes: <ul style="list-style-type: none"> 0 - False 1 - True
business_residential_code	Enumerated String {1}	B	Enumerated character identifying whether the service at the location is offered only to business customers, only to residential customers, or to both business and residential customers. - Value is one of the following codes: <ul style="list-style-type: none"> B - Business-only location R - Residential-only location X - Business and Residential location

The FCC BDC publishes in CSV files 10 fields of data describing every location / broadband provider / technology combination. For each location it includes the associated level 8 hexagon and the associated 2020 census block, but not an exact longitude / latitude.

Figure 10: How to Select and Export Data

Save Vector Layer as...

Format: MS Office Open XML spreadsheet [XLSX]

File name: []

Layer name: []

CRS: EPSG:4269 - NAD83

Encoding: UTF-8

Save only selected features

Select fields to export and their export options

Name	Type
<input checked="" type="checkbox"/> AWATER	Integer64
<input checked="" type="checkbox"/> KPIs_BG_PopDens	Real
<input checked="" type="checkbox"/> KPIs_BG_POPs	Integer64

Select All Deselect All

Geometry

Geometry type: Automatic

Force multi-type

Include z-dimension

Extent (current: layer)

North: 71.365162000

West: -179.148909000 East: 179.778470000

South: -14.548699000

Current Layer Extent Calculate from Layer Map Canvas Extent

Layer Options

OGR_XLSX_FIELD_TYPES: AUTO

Add saved file to map OK Cancel Help

To export data:

1. Select a layer (selected polygons will appear highlighted, as shown below)
2. Using the "select feature by area" tool select a geographic area. You can fine-tune your selection using control-click to add or remove polygons.
3. Right-click on the layer and choose "Export | Save selected features as ..." then select "MS Office" as the format, choose a file location, and select the desired fields.

Figure 11: Setting the Legend to Miles

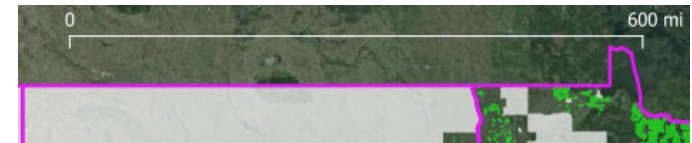
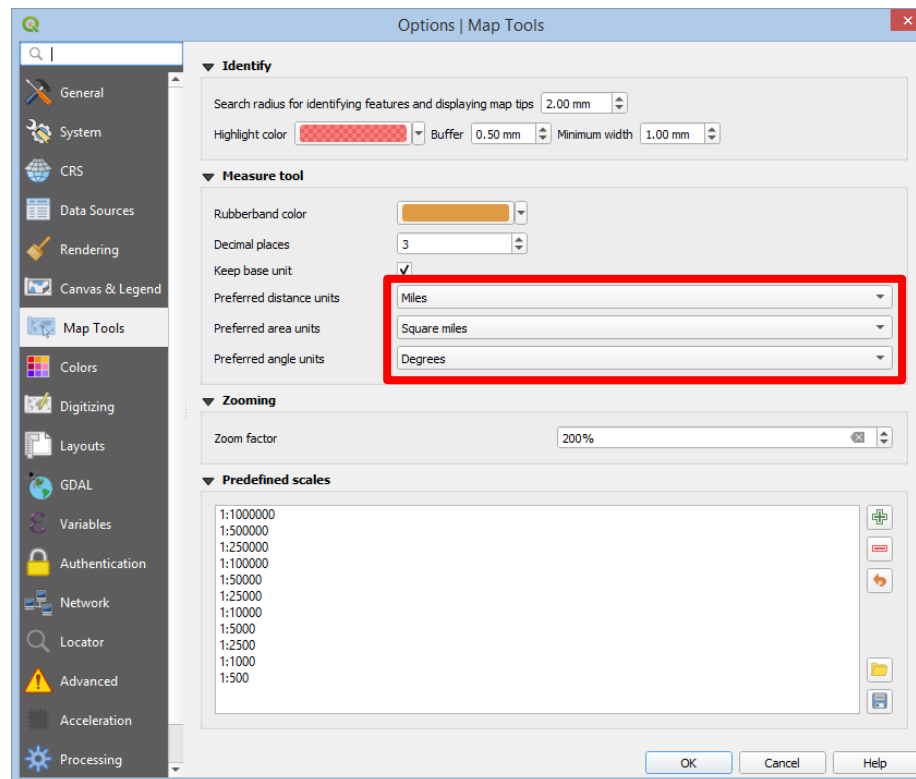
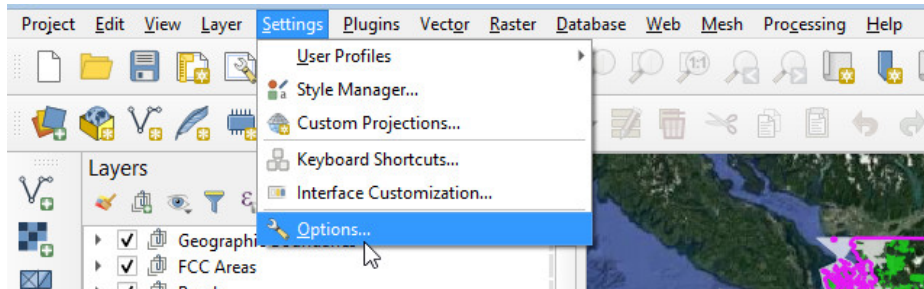


Figure 12: Change in Fiber Deployment, 12-31-2022 to 6-30-2023, Gigabit Symmetrical (Green = growth, Gray = same, Red = reduction), Zoomed-Out

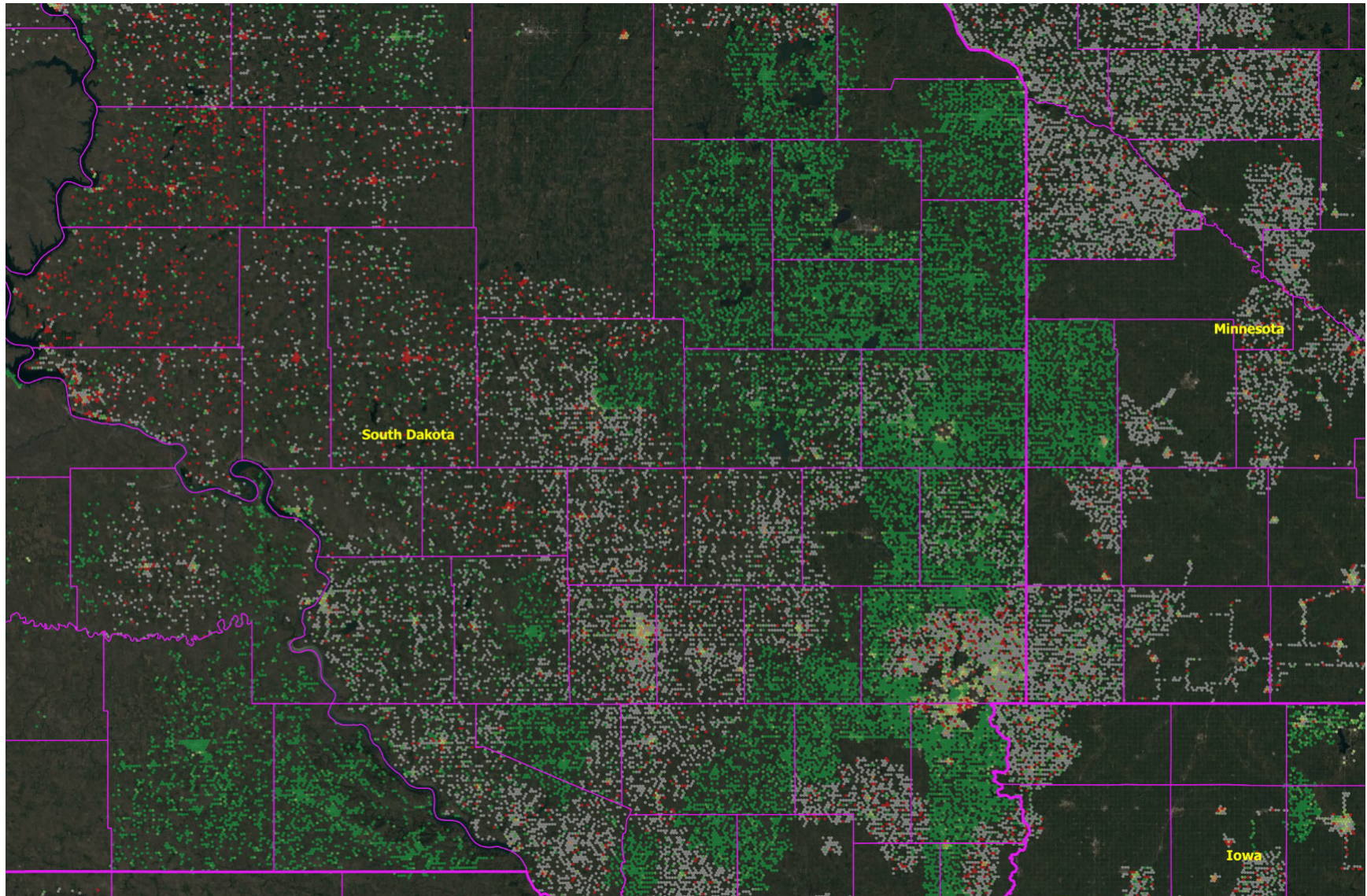


Figure 13: Change in Fiber Deployment, 12-31-2022 to 6-30-2023, Gigabit Symmetrical (Green = growth, Gray = same, Red = reduction), Zoomed-In with Change in % of Locations

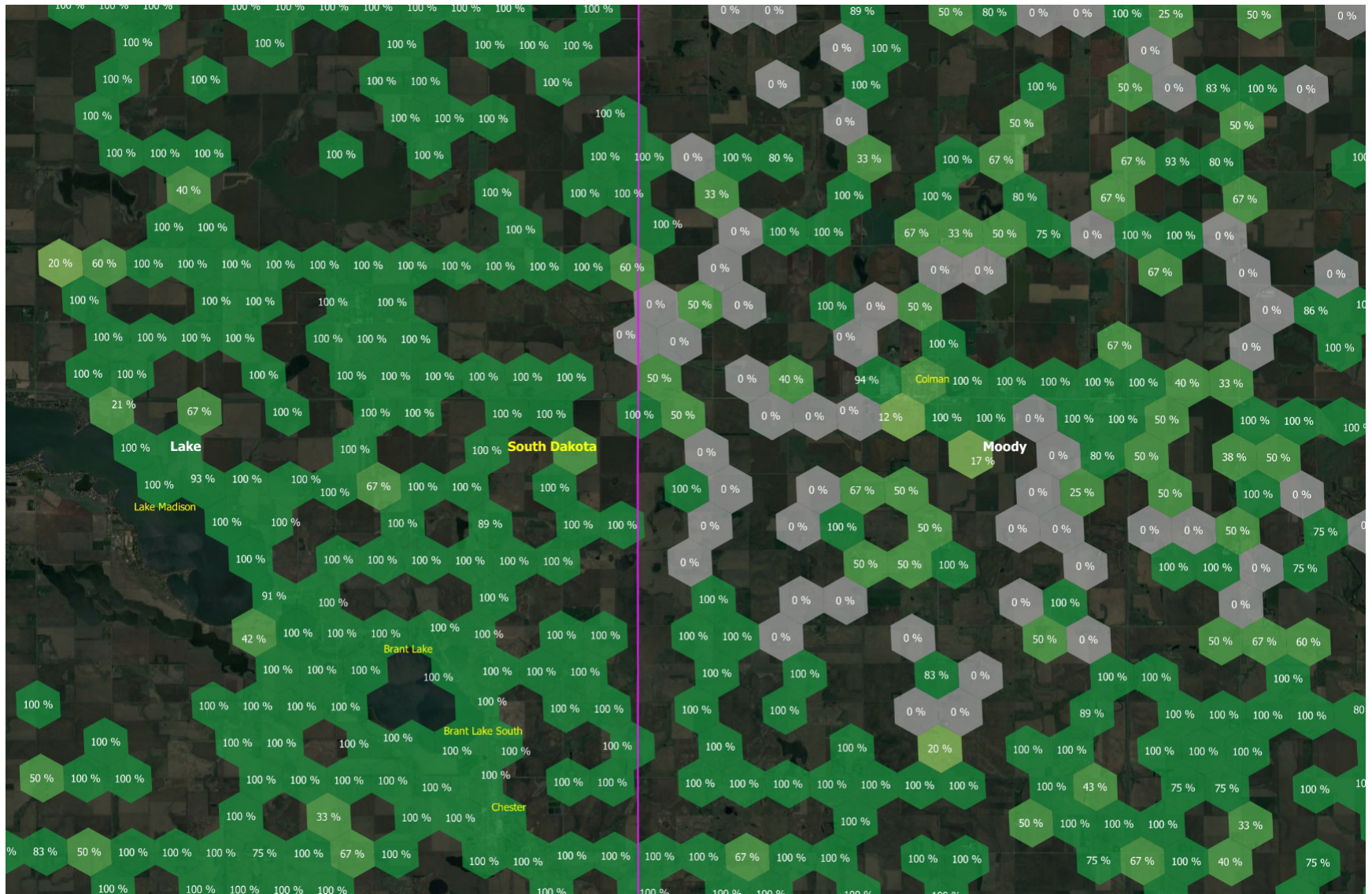
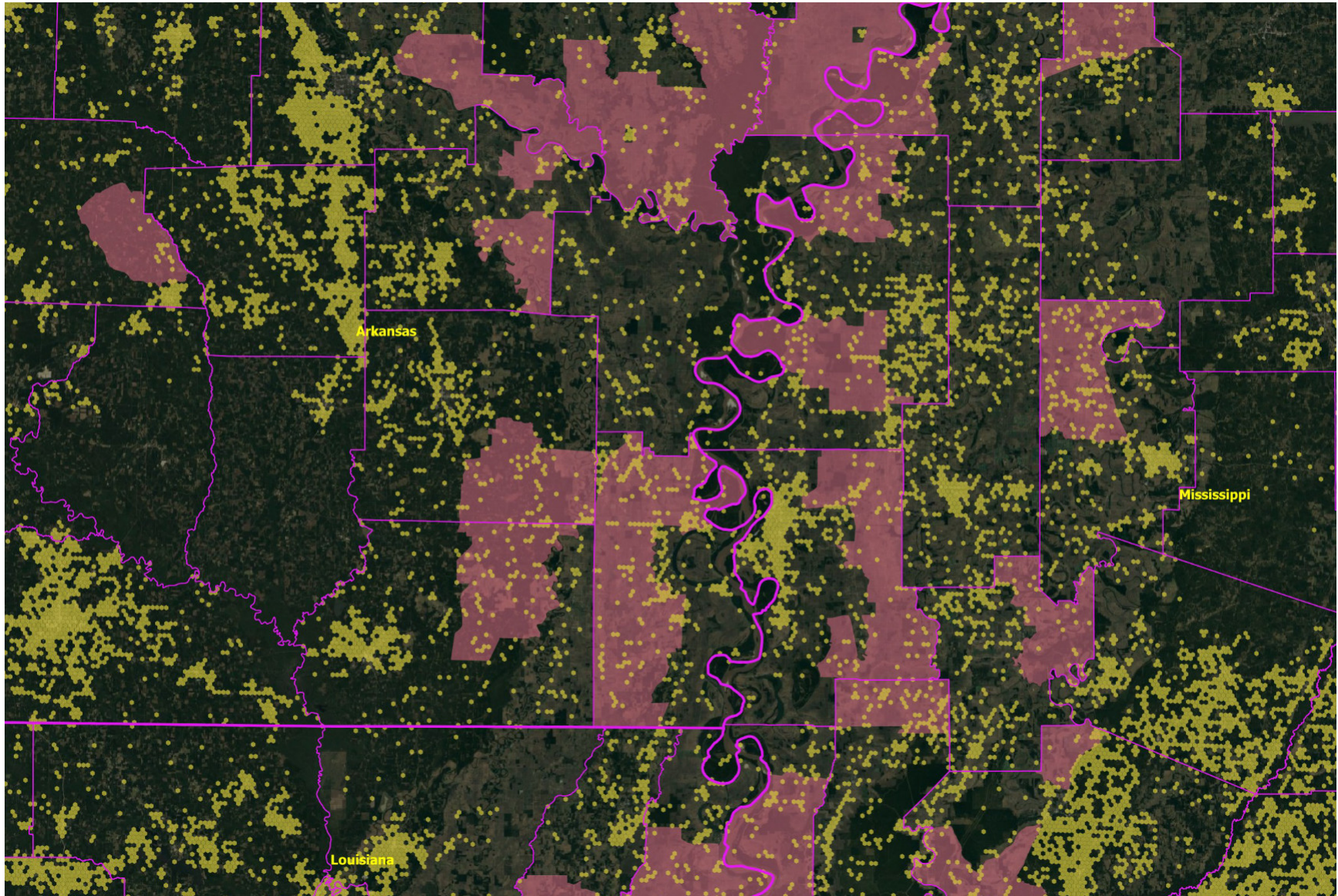


Figure 14: Unfunded Unserved and Underserved Locations (Mustard) on top of NTIA High Cost Areas (Magenta)



- by changing the logic in the OTHER layer (properties | symbology) to point to the desired provider ID. It is set by default to "999999". One can look up individual providers by name and see their footprint by state using the spreadsheets in the Excel folder of the Toolkit.
- c. Competitor layers are generally color coded using their brand colors.
 - d. To see ALL fiber providers enable "all".
 - e. Competitive information will appear as a set of stacked hexagons. Higher levels may partially obscure lower levels.
3. Select *one* of the one or more enabled rows to view. QGIS highlights the selected row in blue.
 4. Click "identify features" (the "I" icon) in the toolbar
 5. Select a hexagon to view.
 - a. The hexagon will turn red
 - b. The underlying records will appear in a pop-up window
 - c. Each location will be described in detail. If multiple locations are covered (which is almost always the case) then each location will be displayed in a sub-folder in the pop-up window.
 - d. Caution: a lot of data may display at once. A hexagon with 400 locations and two competing fiber providers will contain 800 records.
 6. It is possible to select multiple hexagons using control-click (where a click turns a hexagon on or off) or shift-click (where a click adds to the selection). It is also possible to select an area using one of the four selection tools in the QGIS toolbar.

7. If desired one can carefully zoom out. Realize that a larger view area demands proportionately more resources from your computer. It might be helpful to disable the display of competition data (by unchecking an individual layer or the folder) manually zoom out, then enable the display. Your computer may take a few seconds to refresh.
8. One can easily export the data (next section).
9. A user with licensed point data from the FCC/CostQuest can add that data to the display and link each point to the underlying database using the LocationID field (subject to the terms of their FCC/CostQuest license agreement). The exact longitude and latitude of each location is not included in the Toolkit because it has not been made available to the public by the FCC. A user with city, county, or state address data can display it, but it won't be linked to the individual records in each hexagon, since those records are identified by their LocationID.
10. When done select the "hand" to disable the pop-up window and deselect any enabled competitive layers (since displaying these demands large amounts of computer resources). If desired, close the pop-up window.

The process of selecting and visualizing location-level data is described in Figure 8. The data fields are listed in Figure 9. Field names have been simplified relative to those used by the FCC.

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] ...”.
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.

The data export process is shown in Figure 10.

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.
- *Competition | ALL*. This includes detailed location-level data for all fiber providers in the selected area.

- *Demographic and Economic KPIs*. This data is visualized at the block group, tract, or other level of aggregation.

Video Tutorials

Video tutorials exist to help new users get started, understand the sophisticated functionality, enable and disable options, and effectively use the various Toolkit products. A two minute [video](#) highlights the capabilities of BroadbandToolkit.com.

Next Steps

Be sure to check for the latest whitepapers:

<https://broadbandtoolkit.com/pages/whitepapers>

The Toolkit team will be happy to answer your questions / discuss your needs by phone or video conference.

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

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