Montana Broadband Mapping Methodology Report

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Executive Summary

The following report describes methods and issues related to the October 1, 2014 deliverables to NTIA for Broadband Mapping in Montana. This data submission is compliant with all guidance and specifications provided by NTIA. As per NTIA guidance we are using the current versions of the Broadband data model and the validation script.

Montana has developed a robust operational data model, components of which are described in this report, to support our broadband mapping efforts. We feel our operational model can support any reasonable modifications to NTIA requirements. Since this deliverable format is derived from our operational data model, we anticipate some modifications will be required. We are able to take best practices recommendations from the NTIA and incorporate those into the final deliverable without major modifications of our work flow and operating rules.

Our mapping process started with infrastructure points (central offices, remote terminals, wireless towers and antenna locations, middle mile and backhaul), cable franchise areas, and anchor institution addresses. Those served an important role, especially with providers who have not actively participated in coverage mapping and those supplying broadband coverage for large generalized areas and larger geographic census units such as census tracts. When providers have not supplied detailed information of their service areas that can be mapped at the census block level, coverage models were derived dynamically from this infrastructure based on geoprocessing techniques specific to each broadband technology. Examples of geoprocessing techniques include using infrastructure points in conjunction with the road network to predict the area served for DSL coverage. For all providers of wired broadband services, those have all been completed and remain static unless a provider chooses to participate with more detailed coverage mapping at a level of geography at or smaller than a census block.

The State of Montana Broadband Program has developed a web-based application for creating and maintaining broadband availability data. The Broadband Editing Tool is designed so that that non-technical staff can easily update both spatial and attribute data through using a simple -to -use web interface.

We also developed a system to quantify “validated” data for the purpose of determining what was suitable for delivery to NTIA. The operational data model maintained reliability and validity codes. As more data is obtained from providers in maintenance updates, the validity and reliability of infrastructure points has diminished, though they remain the only basis we have for non-participating broadband providers.

Provider Summary

Through extensive research we identified a master list of 160 potential providers in Montana with 55 companies identified as actual broadband providers. The Montana Broadband map includes 48 broadband providers. The full list of the potential providers researched but subsequently identified as not providing broadband service is included in Appendix A.

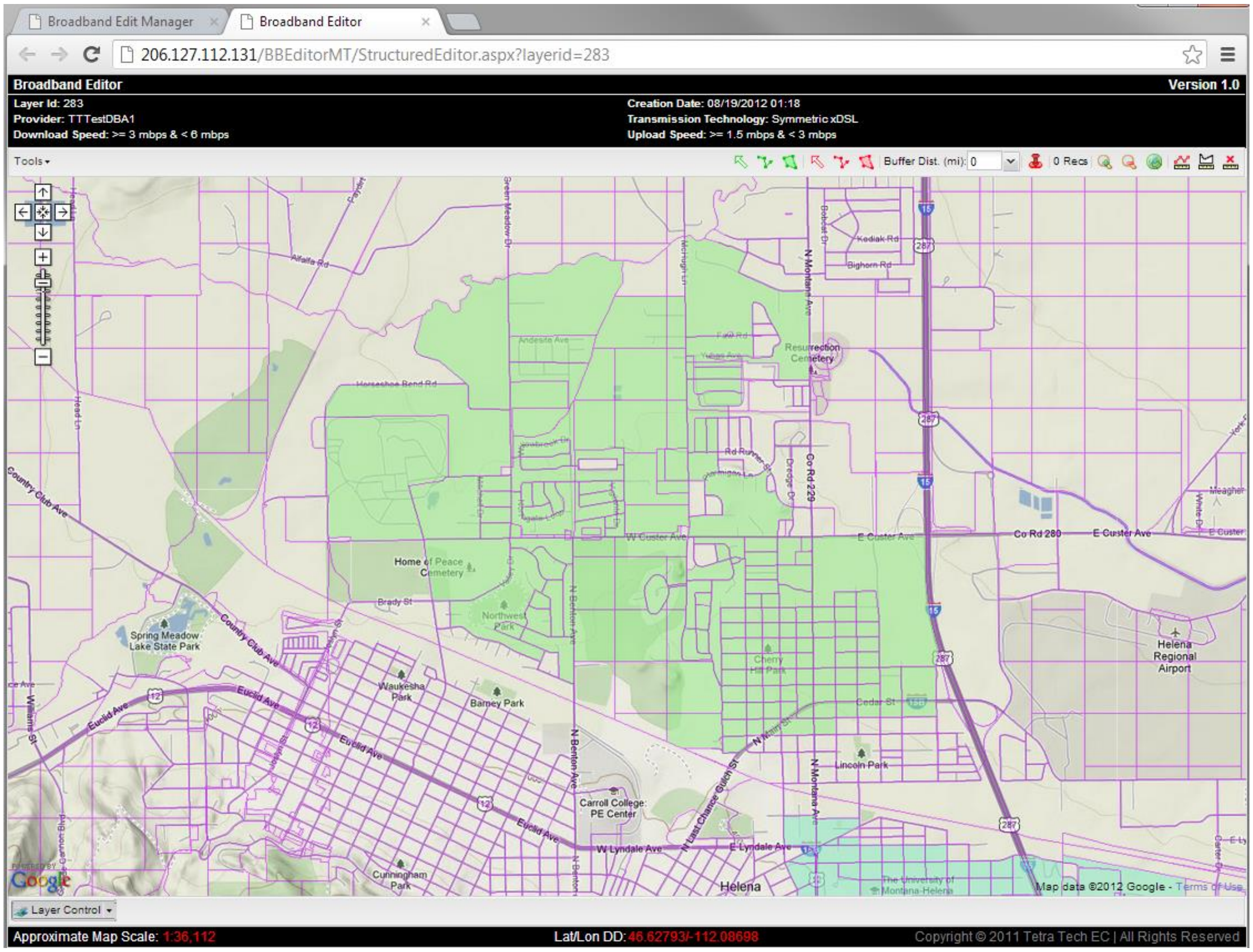
State Specific Issues

The most notable issue specific to Montana is the lack of non-disclosure agreements (NDAs) with the providers. To date no provider has agreed to sign an NDA in Montana due to open records laws in the State. However, the vast majority of broadband providers in the State have elected to cooperate with the project and have provided at least some information about their coverage areas. Where providers have not provided data, or not provided adequate data we have used a variety of methods including modeling, field mapping, and use of public sources to develop map data.

Web Based Editing Application

The State of Montana Broadband Program has developed a web-based application for creating and maintaining broadband availability data. The Broadband Editing Tool is designed so that that non-technical staff can easily update both spatial and attribute data through using a simple -to -use web interface (Figure 1). The tool's feature set gives editors fine-grained control over how broadband service areas are represented.

Figure 1. Broadband editing web map interface.



A significant advantage of using an application like the Broadband Editor is that all data updates are completed using structured data entry tools. This means data integrity is enforced during data entry and illegal attribute values cannot be input by the editor.

Editing Tool Components

The editing tool has five main components. A **Structured Editor** for wired broadband service edits, an **Unstructured Editor** for wireless service, a **Point Editor** for Middle-mile and Community Anchor Institution Edits, a **Management Console** for user and data administration, and an **Export Toolbox** for creating NTIA formatted data.

Structured Data Editor – The structured data editor allows coding of wired (land based) broadband service by census block (census blocks are used due to NTIA mapping requirements). For census blocks that are less than .25 square miles in size the editor is able to select the census block and indicate the type of service provided. For census blocks that are greater than .25 square miles the editor is able to select 500 square meter polygons that are nested within the census block where service is available. This gives users a more accurate depiction of broadband availability on the state broadband map and supports creation of the courser NTIA census block and street segment geography. The results are processed as census blocks and street segments for the national standardized submittal to NTIA.

Unstructured Data Submittal – For wireless coverage areas, which are not based on preexisting geographic features, users submit zipped GIS shapefile polygon layers through the web interface to indicate where service is available. The shapefile is converted into a geodatabase feature class and the user assigns the appropriate service attribute values.

Point Editor – The point editor allows users to add, delete, move, and edit attributes for the middle-mile and community anchor institution feature classes. The point editor uses a simple interface and enforces data integrity validation for all edits.

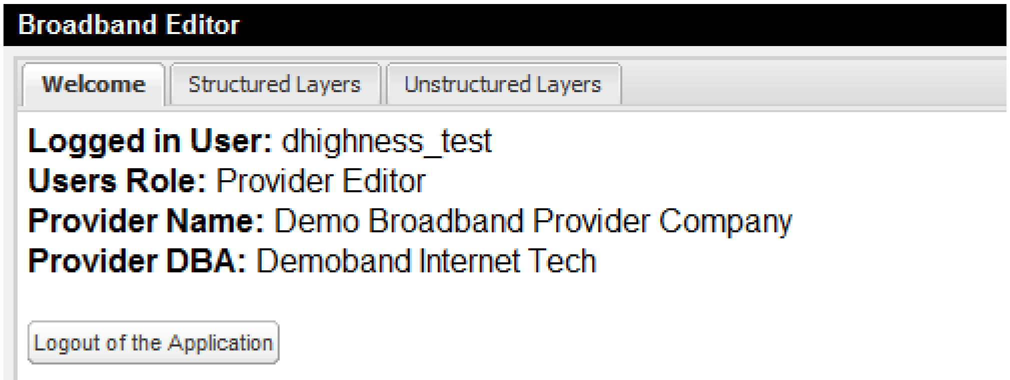
Management Console – The management console allows for full administration and management of data in the system. The management console is designed around three user roles. Each role has a different level of permissions and capabilities. The roles include:

> **State Administrator** – Full access to all system components, user administration, and editing capabilities.
>
> **Provider Administrator** – Access to providers' data layers for edit, review and submittal to the State for inclusion in the State Broadband Map.
>
> **Provider Editor** – Access to providers' data layers for edit.

The management console entry screen (Figure 2) shown below includes three tabs –

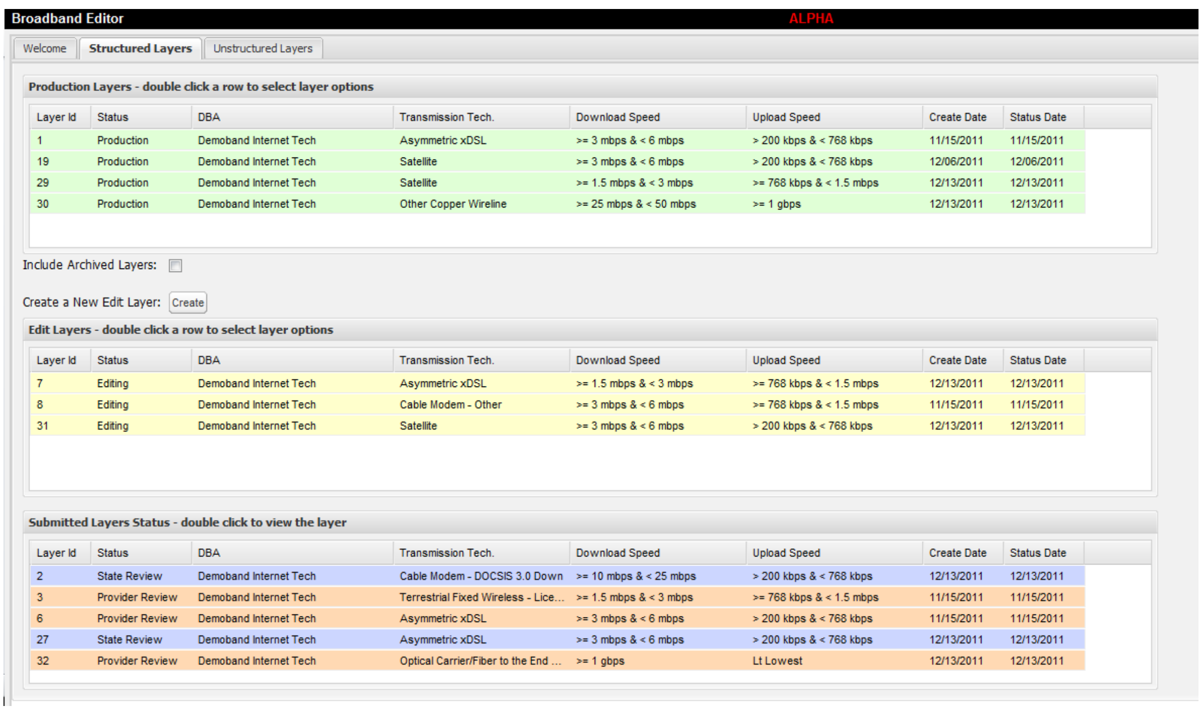
> **Welcome Tab** – Notes about the project, application revisions and links to help documents.
>
> **Structured Layers** – Editing and administration tools for broadband coverage based on census blocks.
>
> **Unstructured Layers** – Loading and administration tools for broadband coverage based on GIS shapefiles.

Figure 2. Management Console Entry Screen.



The structured and unstructured management tabs (Figure 3) allow for data management.

Figure 3. Structured and unstructured management tabs.



Layer Id	Status	DBA	Transmission Tech.	Download Speed	Upload Speed	Create Date	Status Date
1	Production	Demoband Internet Tech	Asymmetric xDSL	>= 3 mbps & < 6 mbps	> 200 kbps & < 768 kbps	11/15/2011	11/15/2011
19	Production	Demoband Internet Tech	Satellite	>= 3 mbps & < 6 mbps	> 200 kbps & < 768 kbps	12/06/2011	12/06/2011
29	Production	Demoband Internet Tech	Satellite	>= 1.5 mbps & < 3 mbps	>= 768 kbps & < 1.5 mbps	12/13/2011	12/13/2011
30	Production	Demoband Internet Tech	Other Copper Wireline	>= 25 mbps & < 50 mbps	>= 1 gbps	12/13/2011	12/13/2011

Layer Id	Status	DBA	Transmission Tech.	Download Speed	Upload Speed	Create Date	Status Date
7	Editing	Demoband Internet Tech	Asymmetric xDSL	>= 1.5 mbps & < 3 mbps	>= 768 kbps & < 1.5 mbps	12/13/2011	12/13/2011
8	Editing	Demoband Internet Tech	Cable Modem - Other	>= 3 mbps & < 6 mbps	>= 768 kbps & < 1.5 mbps	11/15/2011	11/15/2011
31	Editing	Demoband Internet Tech	Satellite	>= 3 mbps & < 6 mbps	> 200 kbps & < 768 kbps	12/13/2011	12/13/2011

Layer Id	Status	DBA	Transmission Tech.	Download Speed	Upload Speed	Create Date	Status Date
2	State Review	Demoband Internet Tech	Cable Modem - DOCSIS 3.0 Down	>= 10 mbps & < 25 mbps	> 200 kbps & < 768 kbps	12/13/2011	12/13/2011
3	Provider Review	Demoband Internet Tech	Terrestrial Fixed Wireless - Lice...	>= 1.5 mbps & < 3 mbps	>= 768 kbps & < 1.5 mbps	11/15/2011	11/15/2011
6	Provider Review	Demoband Internet Tech	Asymmetric xDSL	>= 3 mbps & < 6 mbps	> 200 kbps & < 768 kbps	11/15/2011	11/15/2011
27	State Review	Demoband Internet Tech	Asymmetric xDSL	>= 3 mbps & < 6 mbps	> 200 kbps & < 768 kbps	12/13/2011	12/13/2011
32	Provider Review	Demoband Internet Tech	Optical Carrier/Fiber to the End ...	>= 1 gbps	Lt Lowest	12/13/2011	12/13/2011

The data management tabs provides access to all edit and reviewing functionality for all data layers. The full list of layers in the system is only viewable by system administrators. Provider editors and administrators will only see and be able to access their specific data.

There are three lists of layers viewable to the user –

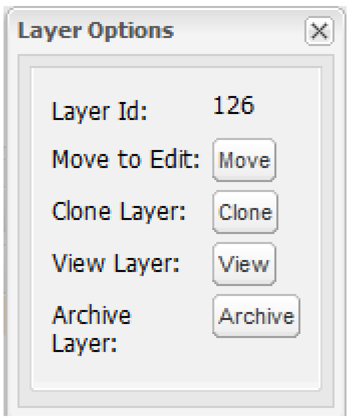
Production Layers – List of the current approved layers for the provider that are currently being reported to NTIA and shown on the State's broadband web map application.

Edit Layers – List of layers currently being edited by the provider.

Submitted Layers – List of layers that are in review by the Provider Administrator or the State Administrator.

Double clicking a row layer in a layer list brings up a context specific menu of options.

Figure 4. Production Layer List Options.



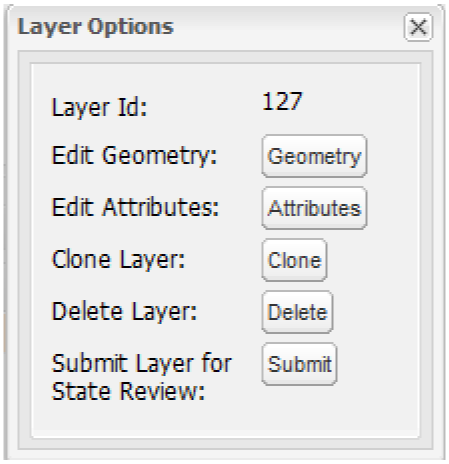
Move to Edit makes the layer available for editing.

Clone Layer makes a copy of the existing layer that can be edited.

View Layer launches the map viewer for a layer.

Archive Layer creates archive of layer and takes it out of production. (State Admin Only)

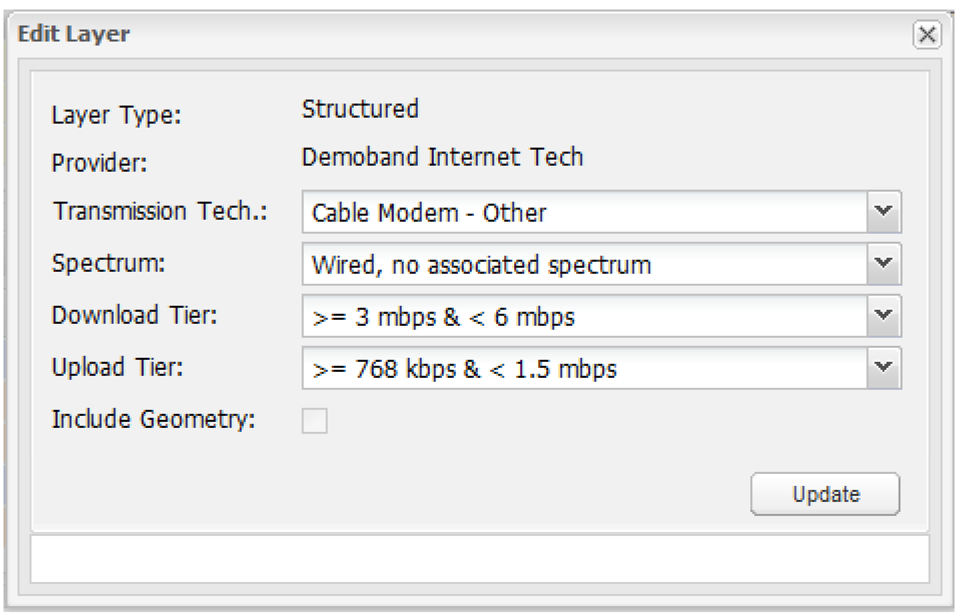
Figure 5. Edit layer list options.



Edit Geometry launches the map editing tool (discussed in next section).

Edit Attributes brings up an editor to allow changes to a layers properties including transmission technology, spectrum and others as shown below –

Figure 6. Edit Attributes Options.



Transmission Tech, Spectrum, Download Tier, Upload Tier are attributes specific to each broadband layer and adhere to NTIA data submittal standard.

Clone Layer makes a copy of the existing layer that can be edited.

Delete Layer completely deletes the current edit version of the layer.

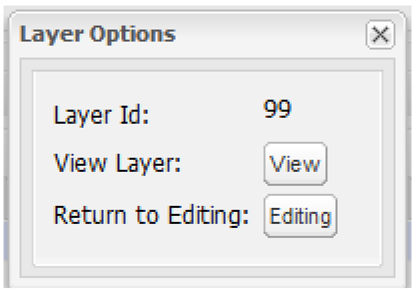
Submit Layer for State Review moves a layer to the Provider Admin list for review. (Provider Admin and State Admin only)

Submitted layer list options –

View Layer launces the map viewer for a layer.

Return to Editing moves a layer to the edit queue so that it may be edited.

Figure 7. Return to Editing screen.



Export Toolbox – The export toolbox is implemented as a set of geoprocessing tools that run within the ArcGIS desktop client. The toolbox includes a collection of tools that convert data created using the editor into the format required for NTIA. In addition the toolbox includes a variety of automated data integrity checks. The purpose for this separation of the editing tools from the data format and conversion tools is to support minor changes to the NTIA data model without having to make changes to the editing application – just the geoprocessing tools.

Data Sources

In the first rounds of broadband mapping, provider presence maps were developed for central office locations and incumbent local exchange carrier locations for all assumed providers in the state. These were identified through a commercial spatial database purchased from GeoTel Inc., and supplemented by other public data sources such as the State's Public Service Commission and DSLReports.com. These were intended to be "talking maps" and general intelligence on where providers have infrastructure for subsequent phone and written communications with providers. These maps were compared to counties served by provider in the state's telecommunications association directory.

Web site research, review of materials submitted to the state by providers, and public websites, such as the FCC were researched for each provider.

New providers are contacted to request data when a significant number of speed tests are recorded, or when we learn of their presence through ancillary sources. Providers that contact us directly and submit data are also included.

Broadband Coverage

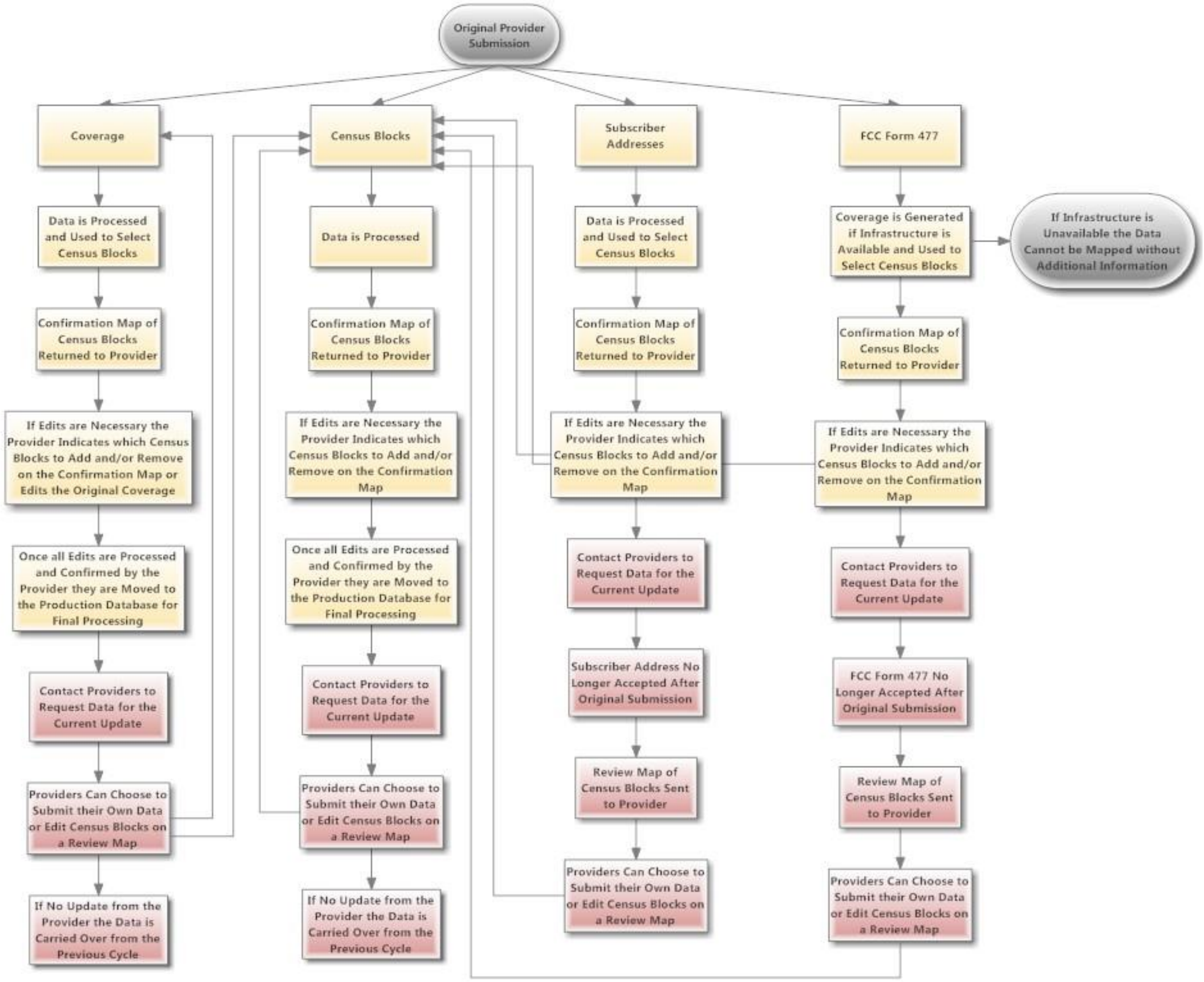
Data submitted by broadband providers was accepted as is and was mapped in complete form when provided as a broadband coverage at the same scale or larger scale than the census block level. Provider coverage submitted at a coarser geographic scale (e.g., census tracts, counties, zipcodes) was supplemented with public data, independent measurements and GIS modeling techniques. When provider submitted data appeared to be exaggerated or providers did not participate in the broadband mapping process, independent measurements and other data sources (e.g., state GIS framework structure locations, speed tests, survey results, website data and infrastructure) were used to override or supplement the provider data.

Broadband providers that chose to submit data did so in a wide variety of formats, levels of completeness, and at varying geographic scales including: the web-based application, narrative descriptions, analog and digital coverage maps, CAD files, GIS shapefiles and geodatabases, KMZ and KML files, FCC 477 reports, and data spreadsheets. All data formats were processed using the web-based application.

If data was submitted by a provider in a format that did not allow mapping at the census block level of geography, providers were sent standardized maps that included census blocks and a data spreadsheet in an attempt to standardize the inputs and increase the geographic granularity of the provider data submission.

Although each provider had individual characteristics and nuances in their data submissions, several data patterns can be described generalizing the provider submissions.

Figure 8 Provider Submission Types and Workflow



Providers Submitting FCC Form 477 Reports or Similar Format

Broadband providers are required to submit FCC Form 477 reports twice a year to the FCC; recently 477 submissions have been done using a structured web site maintained by the FCC. The 477 reports require broadband providers to submit a list of census tracts with the number of subscribers based on maximum advertised downstream and upstream speed tiers. Several providers submitted their actual FCC 477 report or a modified version in analog or digital format.

Figure 9 FCC Form 477 Example

Upload	>200<768	>200<768	>200<768	>3m<6m	
Download	>768<1.5m	>1.5m<3m	>3m<6m	>6m<10m	
Census Tract					Total
MT-[redacted]	60	-	-	-	60
MT-[redacted]	60	3	-	1	64
MT-[redacted]	27	1	-	-	28
MT-[redacted]	311	9	2	-	322
MT-[redacted]	120	2	-	-	122
	578	15	2	1	596

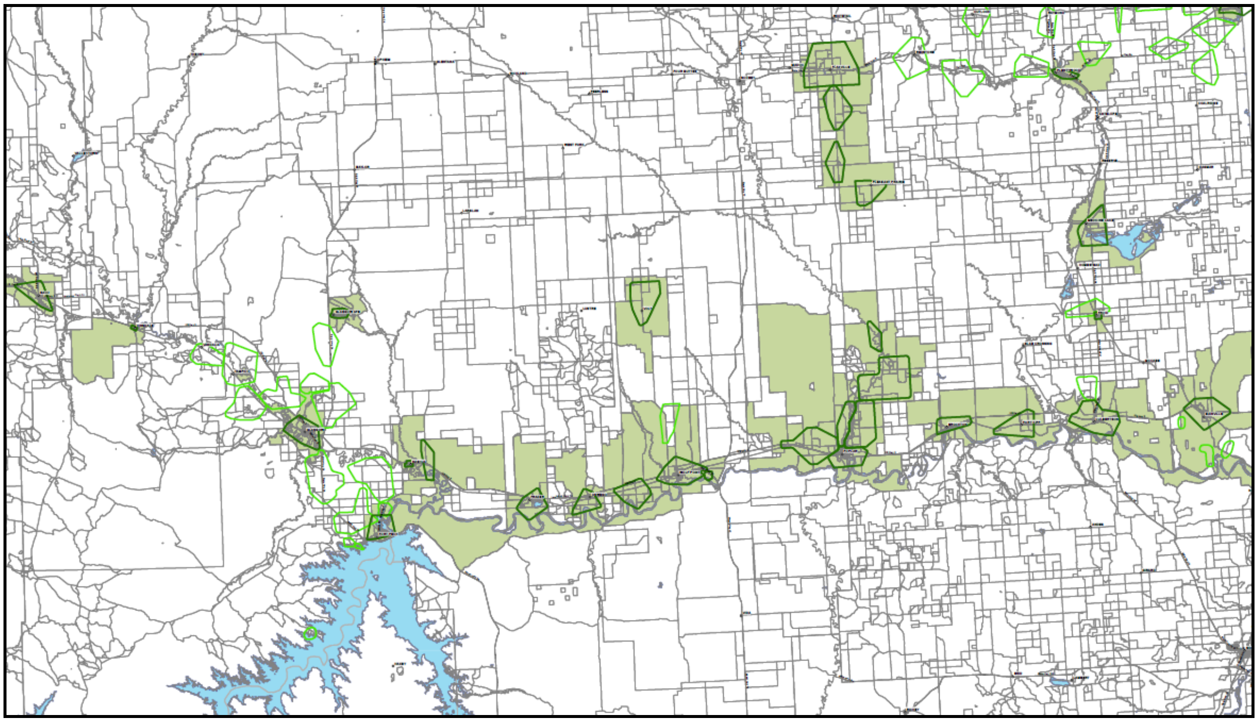
How They Were Handled

FCC Form 477 reports were entered into a standardized format that included the census tract ID code, maximum advertised downstream and upstream speed tier code, and number of subscribers (when available). Since the FCC 477 reports requires providers to submit data for all speed tiers within a census tract, only the highest maximum advertised speed for any given census tract was entered into the standardized spreadsheet in order to be compliant with the definition of broadband service.

The spreadsheets were then joined to a census tract feature class template that included the attribute fields from the NTIA schema. The resulting feature class was a geographical representation of the FCC 477 report including the technology of transmission and speed information. This feature class was used in conjunction with validated infrastructure data (i.e., central offices and/or remote terminals) to run the DSL or Cable geoprocessing models respectively.

The resulting census block selection from the DSL or Cable model was displayed on a standardized review map and returned to the provider for confirmation.

Figure 10 Review Map Example



If additional edits were required the provider "marked-up" the review map(s) to indicate which census blocks should be added and/or removed. The provider submission was handled as a census block update (describe in the section below) from that point forward. In future updates from those providers FCC Form 477 data was not accepted and providers who originally submitted data in this format were asked to make edits to the review maps.

Figure 11 Provider's "Marked-Up" Map Example

Several providers did not respond to the original confirmation maps and their final submission represented the best modeled estimate of their coverage at the census block level for DSL and/or Cable technologies. Providers that submitted FCC 477 data for fiber to the end user or fixed wireless could not be mapped and were not included in the final broadband map unless they provided additional data at the census block level or equivalent coverage at a similar scale.

Providers Submitting Census Block Coverage

Census blocks submitted by providers representing their broadband coverage area come in a wide range of formats including: analog and digital maps, CAD files, GIS shapefiles and geodatabases, tabular lists, and spreadsheets.

Figure 12 Census Block Submission Example (names blacked out)

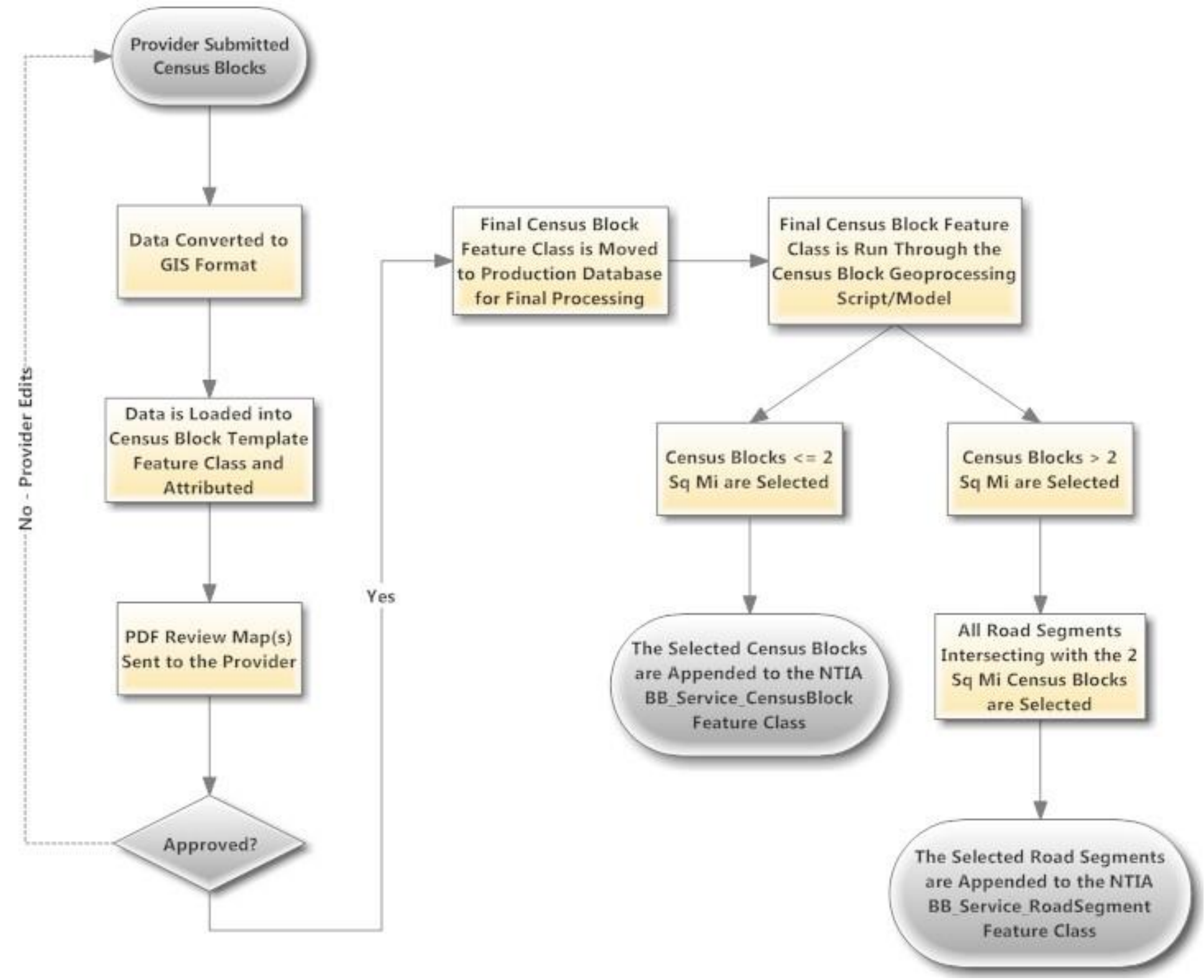
STATE	PROVIDER	DBA_NAME	FRN	CENSUS_BLO	TECHNOLOGY
MT	[redacted]	[redacted]	0018626853	300470002001003	10
MT	[redacted]	[redacted]	0018626853	300470002001008	10
MT	[redacted]	[redacted]	0018626853	300470002001072	10
MT	[redacted]	[redacted]	0018626853	300470002001079	10
MT	[redacted]	[redacted]	0018626853	300470002001083	10
MT	[redacted]	[redacted]	0018626853	300470002001092	10
MT	[redacted]	[redacted]	0018626853	300470002002012	10
MT	[redacted]	[redacted]	0018626853	300470002002021	10
MT	[redacted]	[redacted]	0018626853	300470002002023	10
MT	[redacted]	[redacted]	0018626853	300470002002027	10
MT	[redacted]	[redacted]	0018626853	300470002002029	10
MT	[redacted]	[redacted]	0018626853	300479403011013	10
MT	[redacted]	[redacted]	0018626853	300479403011018	10
MT	[redacted]	[redacted]	0018626853	300479403011022	10
MT	[redacted]	[redacted]	0018626853	300479403011048	10
MT	[redacted]	[redacted]	0018626853	300479403011051	10
MT	[redacted]	[redacted]	0018626853	300479403011055	10
MT	[redacted]	[redacted]	0018626853	300479403011056	10
MT	[redacted]	[redacted]	0018626853	300479403011057	10
MT	[redacted]	[redacted]	0018626853	300479403011058	10
MT	[redacted]	[redacted]	0018626853	300290013011000	10
MT	[redacted]	[redacted]	0018626853	300290013011005	10
MT	[redacted]	[redacted]	0018626853	300290013011010	10
MT	[redacted]	[redacted]	0018626853	300290013011011	10

How They Were Handled

All census block submittals were loaded into a census block feature class template that included all of the attribute fields from the current NTIA schema. Census 2010 geography was used as required by NTIA. Domain codes were entered in the appropriate attribute field for technology of transmission, maximum advertised downstream speed, and maximum advertised upstream speed. If a provider did not identify the technology of transmission for a given census block or blocks, they were contacted by phone or email in order to obtain this information. In instances where speed information was not included in the data submission providers were contacted and asked to supply this data; in cases where the provider refused to supply either the downstream, upstream, or both speeds, and their advertised speeds were not available on their web site, the lowest domain code was entered in the applicable attribute field.

Standardized confirmation maps were created for each provider by type of technology and sent to the provider for review. Once processing was completed for a provider's census block submission, the census block feature class was run through an Esri geoprocessing model that performed several quality control-quality assurance tests and selected census blocks less than or equal to two square miles and road segments that intersected census blocks greater than two square miles and were appended to the appropriate NTIA transfer data model feature classes.

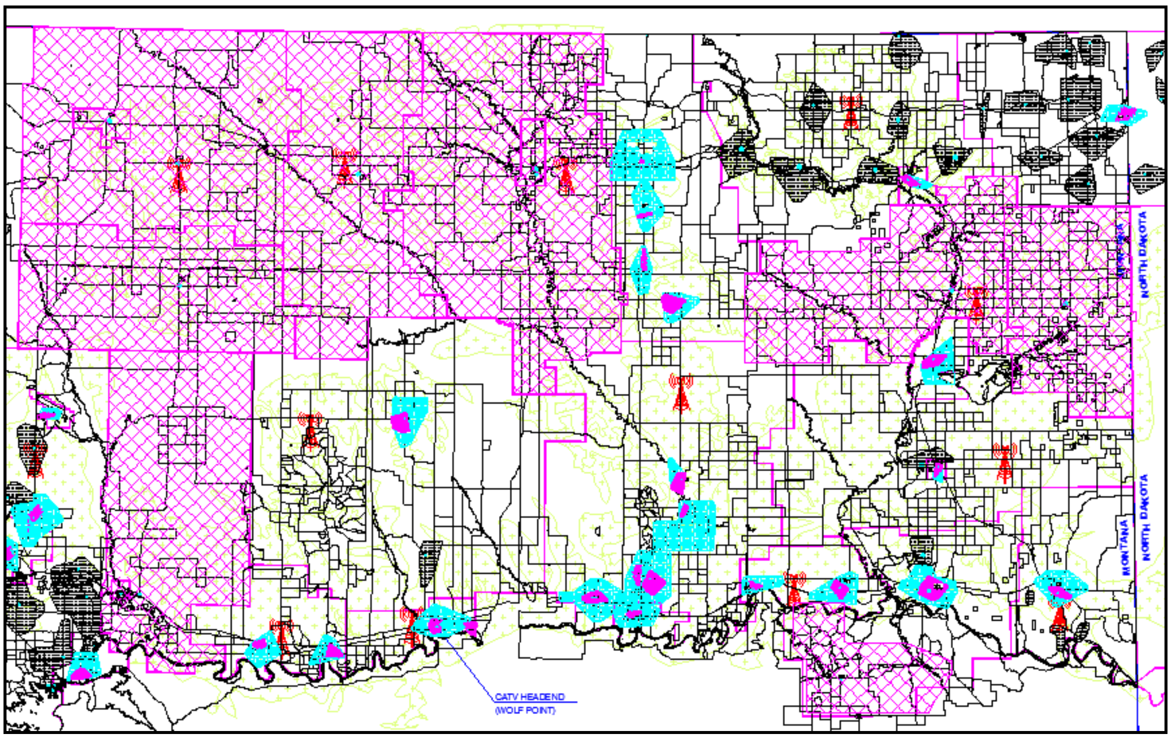
Figure 13 Census Block Geoprocessing Model


Provider Submitted Census Blocks
Data Converted to GIS Format
Data is Loaded into Census Block Template Feature Class and Attributed
PDF Review Map(s) Sent to the Provider
Approved?
No - Provider Edits
Yes
Final Census Block Feature Class is Moved to Production Database for Final Processing
Final Census Block Feature Class is Run Through the Census Block Geoprocessing Script/Model
Census Blocks <= 2 Sq Mi are Selected
Census Blocks > 2 Sq Mi are Selected
The Selected Census Blocks are Appended to the NTIA BB_Service_CensusBlock Feature Class
All Road Segments Intersecting with the 2 Sq Mi Census Blocks are Selected
The Selected Road Segments are Appended to the NTIA BB_Service_RoadSegment Feature Class

Providers Submitting Coverage Data

Provider submitted coverage data were differentiated from the other types of geographic data submissions coarser than a census block since they represented the full and explicit range of broadband coverage. Similar to the other types of data submissions, coverage data was also provided in a wide range for formats including: analog and digital maps, CAD files, GIS shapefiles and geodatabases. Coverage data was submitted by several providers or was available on several providers' websites.

Figure 14 Coverage Data Example



How They Were Handled

All coverage data was loaded into a coverage template feature class schema that included all of the attribute fields from the NTIA schema. The method of data loading was driven by the format in which it was received. Providers who supplied GIS shapefiles or feature classes could generally be loaded into the coverage template feature class schema using the simple data loader while CAD data had to be exported to GIS format prior to being loaded into the coverage template.

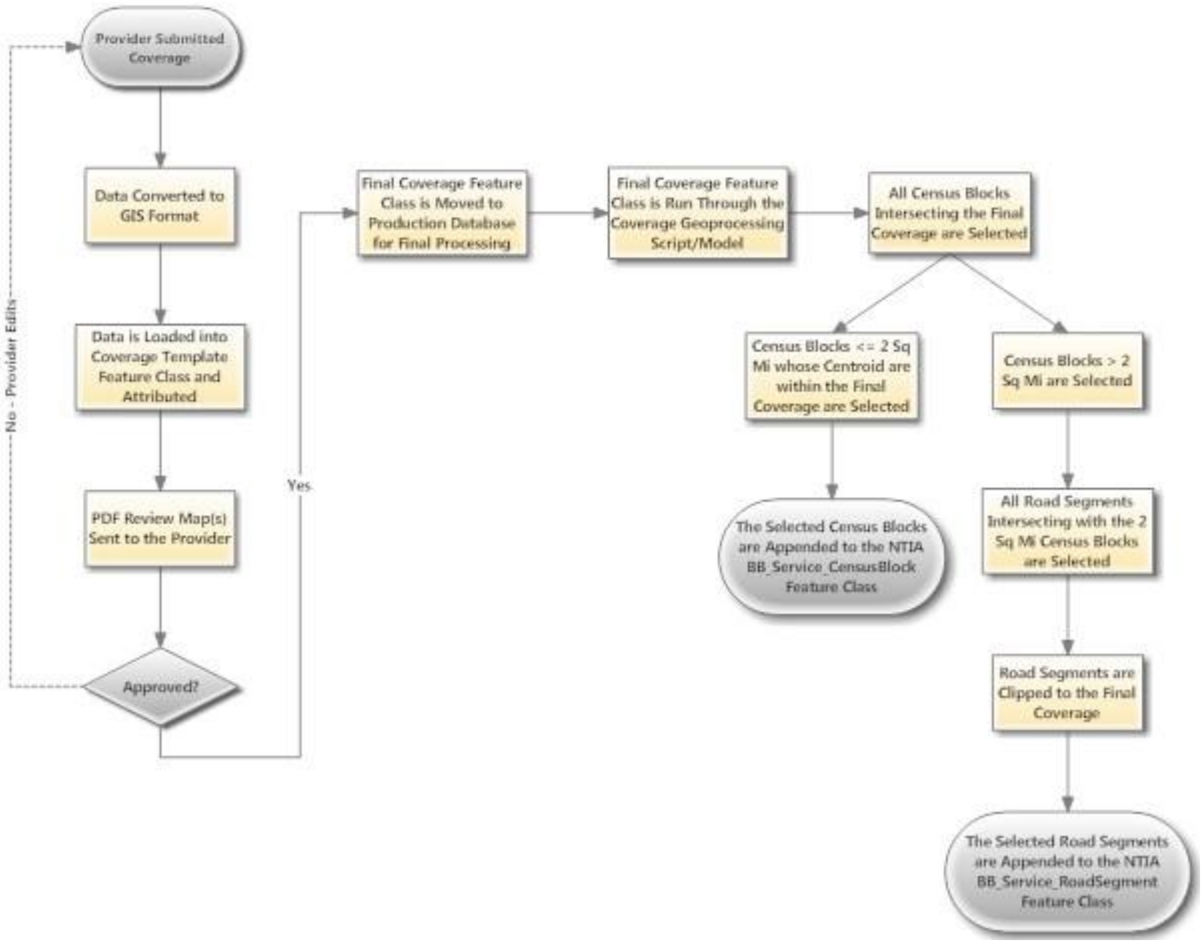
Coverage data supplied as digital or analog maps required georectification and digitizing prior to loading into the coverage template feature class. Domain codes were entered in the appropriate attribute field for technology of transmission, maximum advertised downstream speed, maximum advertised upstream speed, and spectrum. If a provider did not identify the technology of transmission for a given coverage area, they were contacted by phone or email in order to obtain this information.

When speed information was not included in the data submission, providers were contacted and asked to supply this data; in cases where the provider refused to supply either the downstream, upstream, or both speeds, the lowest domain code was entered in the applicable attribute field. If a provider did not specify the type and spectrum used for fixed wireless the default values for unlicensed were used.

Standardized confirmation maps were created for providers by type of technology on request and sent to the provider for review. This processing step has been replaced in many instances by the provider doing their final review using the web editor system.

Once processing was completed for a provider's coverage submission, the data was run through an Esri geoprocessing model that performed several quality control-quality assurance tests and selected census blocks less than or equal to two square miles when the centroid of the census block was within the coverage area. Road segments that intersected with census blocks greater than two square miles were selected and then clipped to the coverage area in order to provide the most accurate representation based on the provided coverage. The selected census blocks and road segments were appended to the appropriate feature class in the NTIA data transfer model.

Figure 15 Coverage Geoprocessing Model

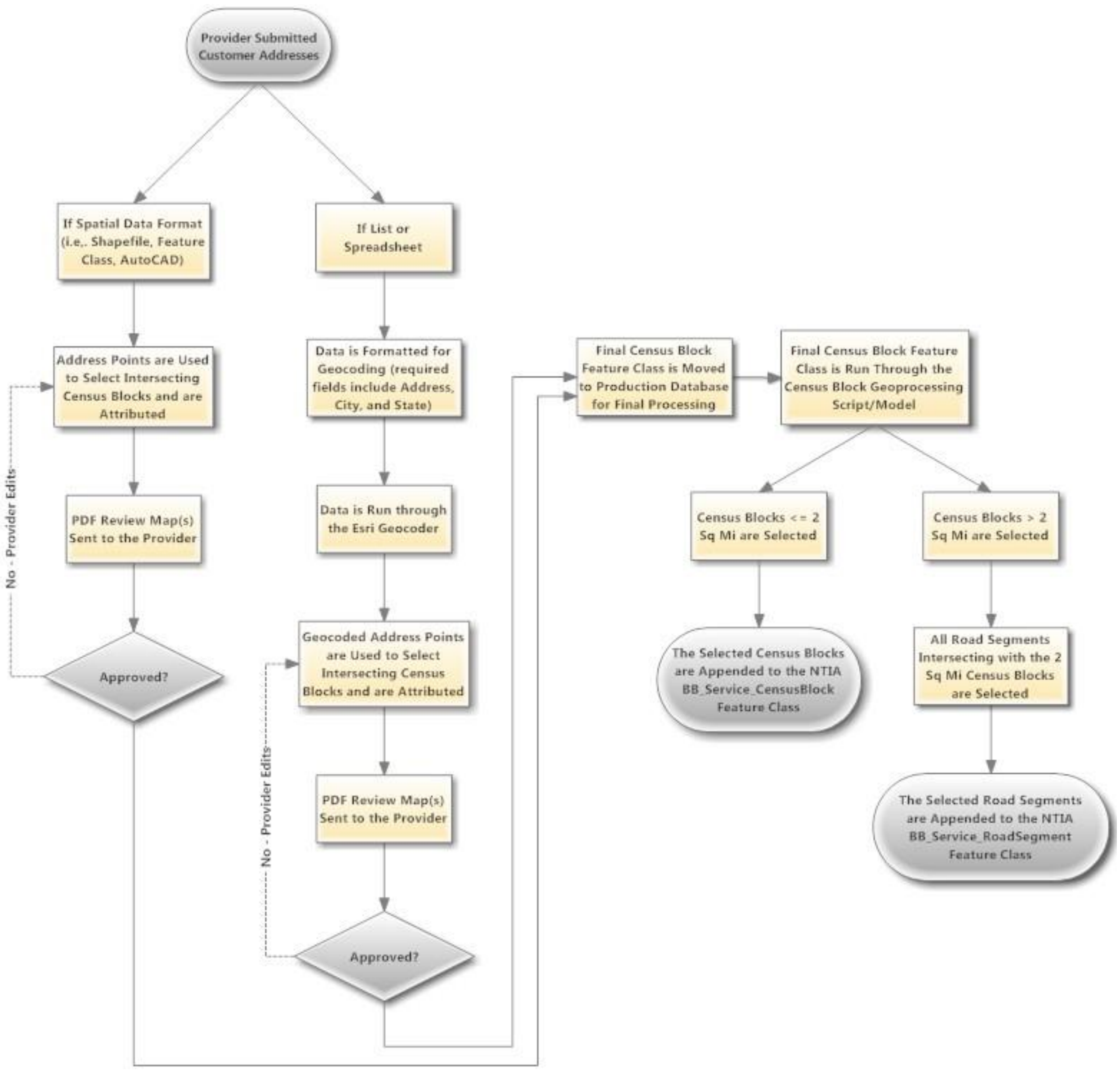


Providers Submitting Customer Locations

Providers that submitted customer locations typically fell into one of four categories. Several providers submitted customer locations in AutoCAD files, the points were exported to a shapefile and used to select all intersecting census blocks. Other providers submitted analog or digital maps that included customer locations, these images were georectified and census blocks were selected by an operator viewing the customer point images underlying the census blocks. Lists of customer addresses were also submitted. The data was loaded into a spreadsheet and geocoded using ESRI Business Analyst USA Geocoding engine. The geocoded points were treated identically to customer locations submitted in GIS or CAD format and used to select intersecting census blocks.

The resulting census blocks were added to confirmation maps and returned to the provider. If edits were necessary the provider indicated on the map which census blocks needed to be added and/or removed. The provider submission was handled as a census block update (described in the section above) moving forward. In subsequent updates subscriber address data was discouraged and providers who originally submitted data in this format were asked to make edits to the review maps.

Figure 16 Customer Addresses Geoprocessing Model



Providers Submitting Other Levels of Coarse Geographic Submission

This category had a wide range of submissions. The most common were telephone exchange areas or equivalent, wire centers, zip codes, counties or general references to towns or cities. These coarse geographic submissions were problematic because these areas were typically very large and lacked the detail of a defined coverage area resulting in over-exaggerated broadband coverage.

How They Were Handled

Operational rules established early in the project heavily scrutinized provider data that appeared to significantly over-represent broadband coverage and often resulted in a rejection of the submitted data. Providers who submitted coarse geographic levels of coverage data and infrastructure for DSL or cable modem service were initially that also were represented in the last point of aggregation infrastructure point file were sent estimated census block coverage maps and spreadsheets, and provided a second submission with finer level geography.

Providers submitting town locations for DSL or Cable were handled differently, and used as validation for central offices from the last point of aggregation table, and subsequently to run the DSL modeling routine or validate a cable or cable plus areas.

Cable Modem Geoprocessing Model

An ESRI geoprocessing model was created to generate coverage areas for Cable providers who did not submit census block or coverage data (i.e., census tract providers).

The most authoritative GIS layer available from the state with incorporated areas and city boundaries was used as a surrogate to model cable broadband coverage. Some towns that were not incorporated were also added. Municipalities and towns were sporadic in their digital update of these maps, since annexations and other boundary modifications were ongoing and difficult to maintain in real time updates. To compensate, likely areas contiguous to these city boundaries were added, labeled "Cable-Plus" in the operational data model. These additional polygons were determined using operator interpretation, road density, structures points from Info USA in Esri Business Analyst, speed test results, and in some instances NAIP imagery. In general areas were added that were immediately contiguous to existing city or town boundaries that represented likely areas where cable service existed. We were conservative in this approach and did not include populated areas near the cable plus boundaries unless they were directly contiguous to existing boundary areas.

Cable broadband providers primarily work under the structure of franchise agreements with municipalities. In the early rounds of broadband mapping updates, phone calls were made to the largest cities in the state in order to obtain that respective city's cable franchise agreement. They were all either unknown or a text agreement without maps.

The full set of potential cable areas were then passed through validation sources to determine if cable was provided. This included public sources, such as the Warren Communications Cable Fact book (http://www.warren-news.com/factbook.htm).

The second and most authoritative form of validation was data received from cable providers at the census tract, block, or coverage level of geography. A spatial join geoprocessing operation was performed on these datasets with the full set of potential cable coverage areas in order to further validate areas with cable coverage.

The third source of validation came from the public speed test site maintained throughout the project. Whenever user submitted speed tests identified cable modem broadband service near or adjacent to existing estimated cable areas, the cable-plus boundaries were expanded using the same method of digitizing outlined above.

It was not possible to differentiate between technology of transmission codes 40 and 41 using this indirect mapping method. The only authoritative way to determine this information was from data submitted by a provider. In all cases where the provider did not indicate the type of cable modem technology being used, the code for Cable Modem-Other (41) was assumed.

DSL Geoprocessing Model

An ESRI geoprocessing model was created to generate coverage areas for DSL providers who did not submit census block or coverage data (i.e., census tract providers). This model is based on typical DSL technology which can provide service up to 18,000 feet from a central office or remote terminal, unless otherwise specified by a provider.

Since DSL lines are typically buried alongside roadways, underneath roadbeds, or strung on aerial telephone lines which tend to run alongside a road, a GIS dataset of a state’s road network were used as a surrogate to model DSL areas. In the initial rounds of broadband maintenance we purchased commercial (GeoTel) and publicly available data sources representing last points of aggregation (LPA) for DSL, including central offices and remote terminals. Each LPA was validated based on publicly available data, provider data, and independent measurements. LPAs were used in a DSL model only if they were supplied directly from a provider or could be verified by two or more sources. The actual geoprocessing model used the validated central office and remote terminal locations to generate a raster cost surface based on all of the available roads radiating out 18,000 feet from each active LPA point. The raster coverage was converted to a polygon feature class and a small back-buffer was applied to achieve the final DSL coverage polygon representing a provider's maximum possible DSL coverage area. The DSL coverage areas were then used to select intersecting census blocks and road segments.

Remote terminals were provided or publicly available for only a small number of providers, therefore this method may tend to underestimate the full DSL coverage for a provider.

It was not possible to differentiate between ADSL or SDSL based on the LPA data; the only authoritative way to determine this was from data submitted by a provider. In all cases where the provider did not indicate which type of DSL service was being provided, the technology code was assigned to 10 "Asymmetric xDSL".

2000 To 2010 Census Block Conversion

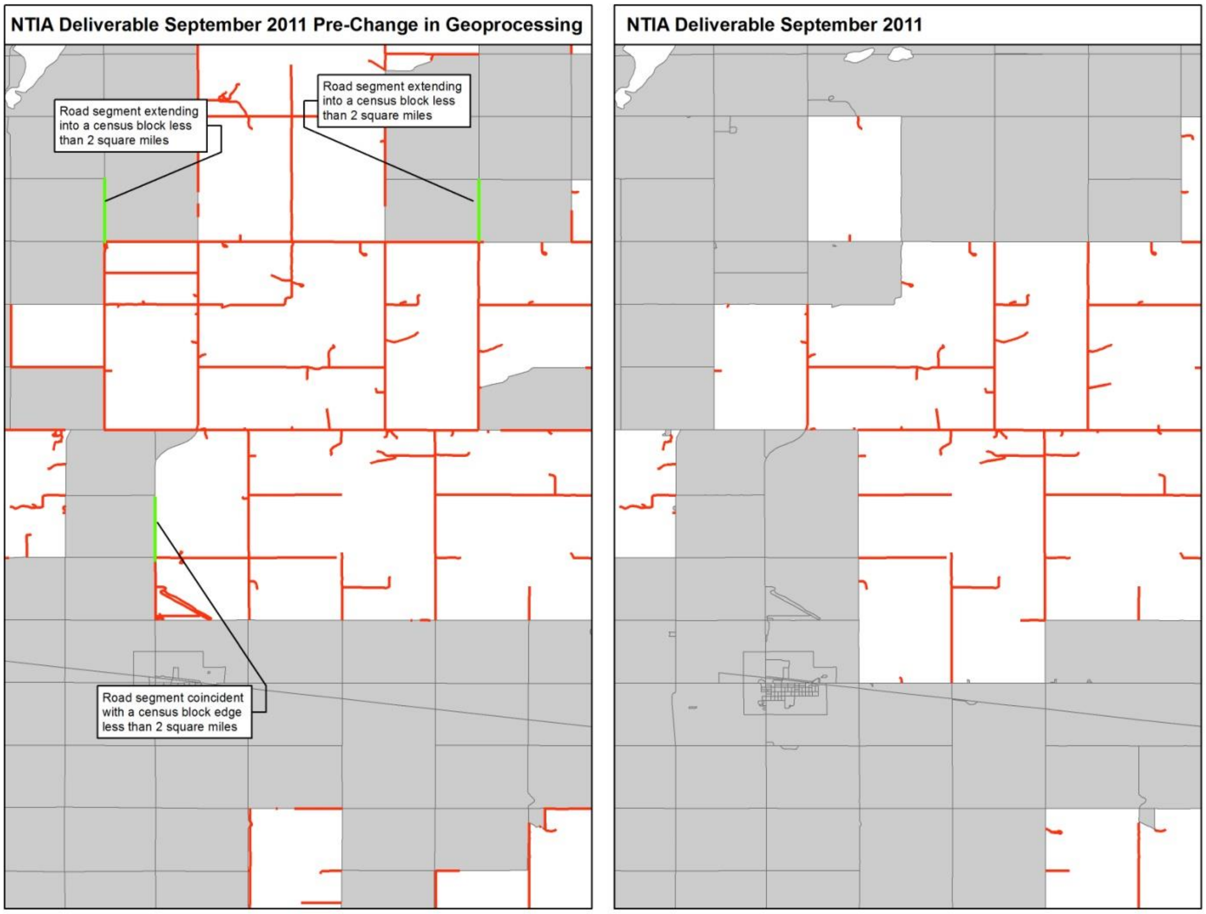
The September 2011 deliverable to NTIA required the transition from 2000 census data to 2010 census data, but the conversion process was dependent upon the type of data submitted by a provider. These providers fell into two categories, block providers or coverage providers. The conversion to 2010 census geography was a straightforward process for the coverage providers; the reference to the census block data in the geoprocessing model used to select census blocks and road segments was simply changed from the 2000 data to the 2010 data and each provider's data was re-run. The conversion from 2000 census to 2010 census data for block providers required several geoprocessing steps due to the inability to simply match census block IDs across vintages. The census blocks for each provider were dissolved by type of technology to form a quasi-coverage area. The dissolved blocks were then used to select any 2010 census block whose centroid fell within the "coverage area."

Road Segment Geoprocessing Change

Prior to the September 2011 NTIA data submission, road segment in census blocks greater than 2 square miles were selected with a straight intersect. This resulted in road segments being selected that were coincident with census block edges in blocks less than or equal to 2 square miles. Using this same geoprocessing methodology combined with the new 2010 census blocks and TIGER roads, road segments were selected that were coincident with census block edges and that extended into census block less than or equal to 2 square mile. We believe this "error" occurred due to the improvements in the spatial accuracy of both the 2010 census blocks and road segments for 2010 where features were now coincident. For the September 2011 submittal a small negative buffer

(-0.5 feet) was applied to the intersect to avoid selecting roads that were coincident with census block edges and/or those that extended into census blocks less than 2 square miles. This resulted in a significant decrease in the number of road segments reported but overall we believe this method more accurately portrays each provider's coverage area.

Figure 17 Road Segment Geoprocessing Change Example



Wireless Coverage

Three forms of wireless coverage have been mapped and in some instances verified: fixed point to point wireless, mobile wireless and satellite. No public data was located on fixed wireless infrastructure points, except notification of availability on provider's web pages, and in some instances, specific towns, recreation or commercial locations where wireless service was provided. Most coverage came directly from providers or was mapped from locations provided on a provider web page and was processed using web-based applications. A few providers submitted coverage that appeared to be derived from propagation modeling. Beginning in 2013 we ran propagation models using Radio Mobile software when requested to assist providers. We also ran viewshed analysis for some providers.

Most of the public data research focused on mobile wireless providers using cellular service spectrums. The Federal Communications Commission (FCC) Universal Licensing System (ULS) is the consolidated database and application filing system for most Wireless Radio Services. ULS supports electronic filing and provides public access to licensing information, weekly Public Notices, FCC rulemakings, processing utilities, a telecommunications glossary, and much more." The FCC ULS Advanced Licensing Search was queried for all FCC licenses filed in the state; a relational database was built from the results. Information from the database was extracted in order to perform the cellular tower propagation modeling for wireless broadband.

The FCC ASR and ULS reporting systems were the source for most of the tower locations. Towers were required to be licensed when they meet specific published criteria. These included some variables that could be modeled with GIS statewide, such as varying proximity to airports and heliports, combined with specific local level criteria not easily obtained or modeled statewide such as the grade construction within proximity of these, and any structure over 200 ft in height. A number of cell towers providing broadband were likely not located in the FCC database.

Providers submitted coverage data in a wide variety of formats, levels of completeness, and at varying geographic scales. All types of data was accommodated and processed whenever possible. An open structure process for submittals was allowed, accepting any data, and attempting to work with the provider when questions arose. If data was submitted by a provider in a format that did not allow a direct coverage to be mapped, such as a coarse level of geography such as a census tract, or county, feedback was provided to the providers in the form of standardized spreadsheets in an attempt to standardize the inputs, and increase the geographic granularity of the provider data submission. Although each provider had individual characteristics and nuances in their data submissions, some data patterns can be described generalizing the typical types of submissions. In general, for fixed wireless to be mapped it was necessary to receive data from a provider, since there were no public sources available on point to point wireless tower locations in public form, except as depicted on providers web pages in a few instances.

Providers Submitting FCC Form 477 Report or Similar Format

Geographically, these were lists of census tracts of coverage, accompanied by additional documentation on technology of transmission, speed tiers, and number of customers. Providers submit these twice a year to the FCC and recent submissions have been done using a structured web site maintained by the FCC. A few providers submitted printouts that appeared to be from this web format and were typically complete and standardized. More providers submitted spreadsheets roughly in the F477 format, but with modified and generalized data.

How They Were Processed

If the providers identified specific coverage areas as census blocks, or direct coverage area, or as infrastructure tower locations, they were processed and mapped. Providers identifying census blocks were processed by dissolving the census blocks into single coverage polygons by speed tier. Providers identifying a direct coverage area were converted directly to GIS polygon files and attributed. Providers submitting tower locations were mapped as circular polygons centered on the tower with a radius averaging 10 miles measured as Euclidian (straight line) distance from the tower. Providers that specified variable radius were mapped as circles at the radius they submitted.

Providers Submitting Census Block Coverage

Some providers submitted coverage as census blocks, either through a tabular listing of census blocks or spreadsheet, or in map format. It was common that a provider where public data indicated multiple technologies of transmission only submitted some of the technologies of transmission.

How They Were Processed

These were loaded directly into the master Census 2000 block coverage by provider and attributed with available data submitted by the provider. In instances where some data attributes were missing, such as advertised or typical speed tiers, or subscriber data, the data attributes were left blank or null. Providers identifying census blocks were processed by dissolving the census blocks into single coverage polygons by speed tier. A visual inspection of independent speed test data overlaying the provider submitted block coverage was completed, but no action was taken to override a provider's submittal.

Providers Submitting Actual Coverage Maps

Coverage maps were submitted by several providers, or coverages were derived from public sources or from other indirect indicators of coverage such as customer point maps or tabular lists in text or spreadsheet format. These were differentiated from the other types of geographic submission coarser than a census block since they represented the full and explicit range of coverage.

How They Were Processed

Coverage maps were treated as explicit coverage and all census blocks intersecting any portion of a coverage were selected and attributed with the provider coverage by technology of transmission, and all related attributes were transferred to the census block representation. The method of creating the coverage varied by source. Providers who supplied broadband coverage as a GIS polygon or CAD feature were converted to polygons. Some providers, including non-responsive providers who did not submit anything to the project, had published coverage maps of various forms on their web sites or submitted an image in jpg, tiff, pdf or other graphic format. These were georectified to base map layers, typically roads, but sometimes other features such as state or county boundaries or towns, and subsequently converted to polygon features. Then they were intersected and transferred to census block feature classes like the digital GIS submissions. Providers who submitted customer locations typically fell into four categories. Some were submitted as AutoCAD files where the points could be transferred to the GIS, then spatially joined to the census blocks they were located within. Others submitted maps in image format that were georectified in the same manner as other images, then census blocks were selected by an operator viewing the customer point images underlying the census blocks. When customer lists were submitted, they were loaded in a database and geocoded using ESRI Business Analyst USA Geocoding engine based on TeleAtlas road features. The geocoded points were subsequently treated identically to customer locations submitted in GIS or CAD format, and spatially joined to the census block template file. A visual inspection of independent speed test data overlaying the provider submitted block coverage was completed, but no action was taken to override a provider's submittal.

Providers Submitting Other Levels of Coarse Geographic Submission

This category had a wide range of submissions. The most common was as telephone exchange areas or equivalent, wire centers, zip codes, counties or general references to towns or cities. The problem with these submissions was that often a given polygon overlapped a census block or multiple blocks, and in most cases, they were much larger geographic entities than a census block.

How They Were Processed

Our operating rules established early in the project did not allow final provider coverage to significantly over represent provider coverage. Those providers that submitted coverage area by coarse geographic features and did not specifically identify coverage as a coverage layer or census blocks were not able to be processed. No interpolated data was used to calculate these data, if the data was not provided by a provider in a format capable of processing; the data was not calculated for that provider.

Providers Submitting Antenna Tower Information

Some fixed wireless providers submitted antenna and tower information.

How They Were Processed

The providers requested that we run propagation models using Radio Mobile.

National Providers Not Submitting Mobile Wireless Coverage

AT&T Mobility LLC (AT&T) has not provided any data for the Montana Broadband Mapping Project. In a phone call on August 15, 2011 Mr. Wagner said that the AT&T legal team would not allow their broadband coverage data to be provided to Montana since they would not agree to the non disclosure agreement required by Montana state law.

How They Were Processed

Since 2010, we have been collecting information from the AT&T Towers web site, the FCC Universal Licensing System, the FCC Antenna Structure Registration, and other independent sources. We have systematically verified tower locations when possible using aerial imagery. In 2012, we drove 24,925 miles of state and federal highways throughout Montana collecting additional data on signal strength and data download and upload speeds. In previous national broadband map submissions we have used a georectified image of AT&T's on-line coverage map. For the Spring 2013 submission, we felt we had enough independently verified cell tower locations to build a propagation model based on finer resolution digital elevation models.

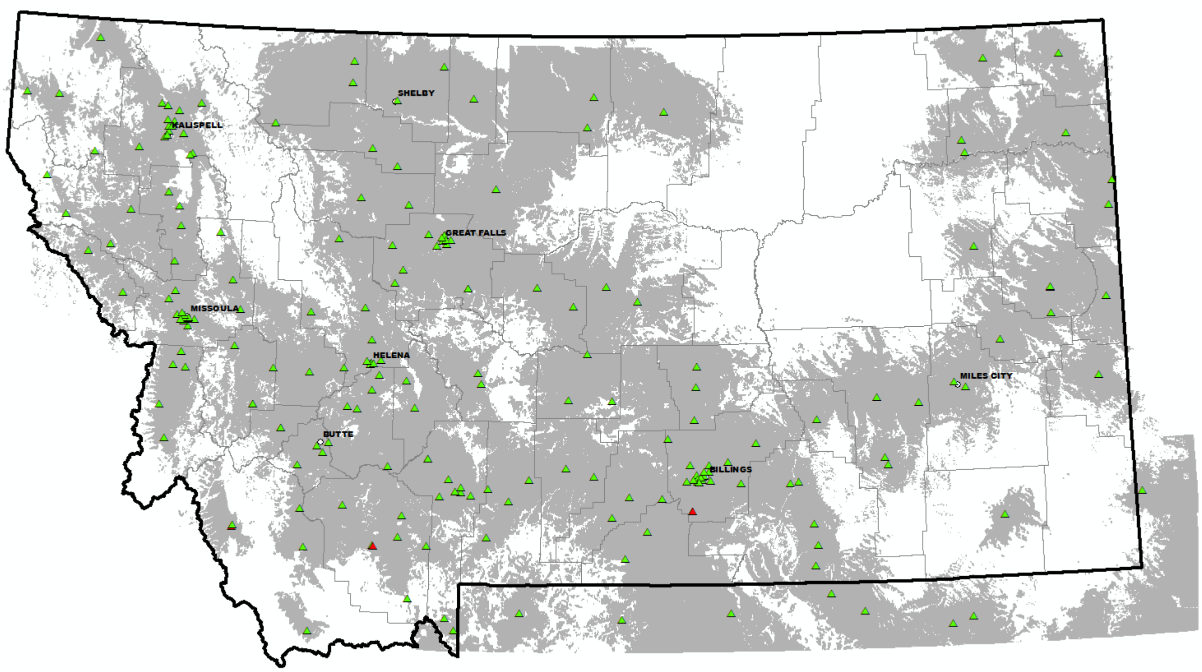


Figure 18 - AT&T Suspected Cell Tower Locations

Upon finalizing suspected AT&T tower locations, Thiessen polygons were created using the Esri Create Thiessen Polygons tool. This generated a polygon area for each tower where any point within the given polygon was closest to that tower than any other. Next the Thiessen polygons were intersected with the AT&T coverage area polygon. This allowed us to establish a maximum distance (or range) for each tower, a required parameter for the Radio Mobile software we used for propagation modeling.

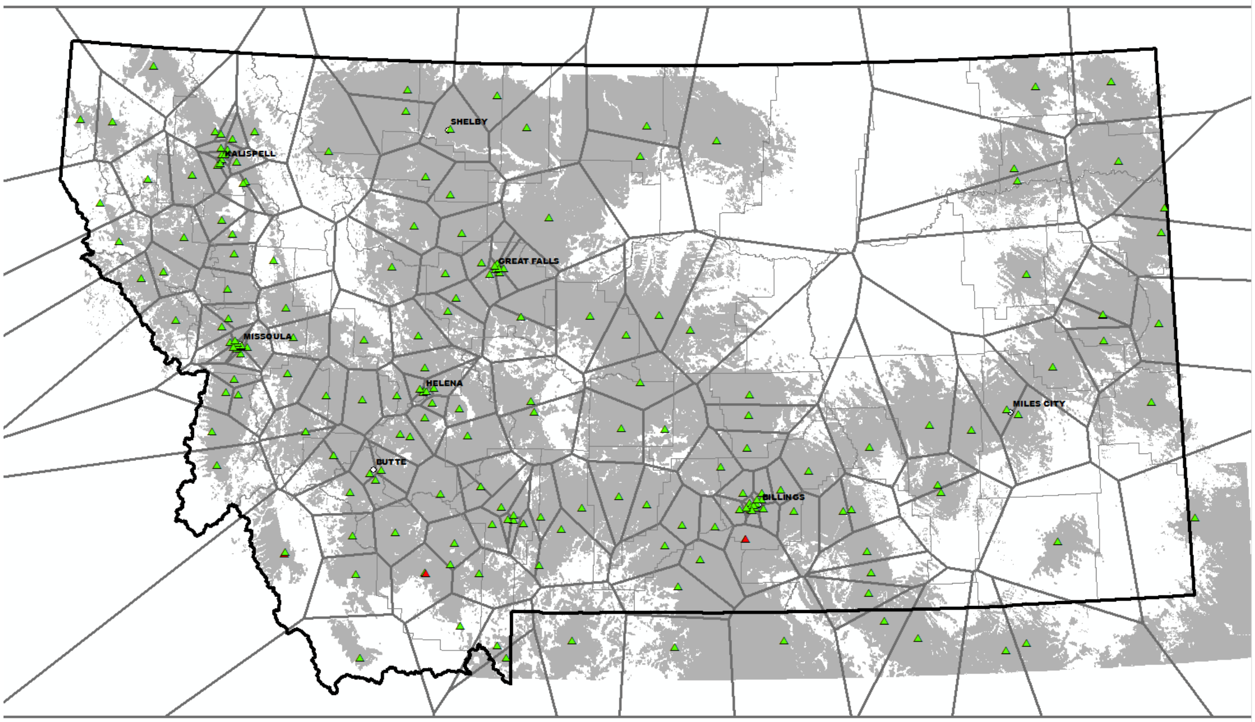


Figure 19 - Thiessen Polygons for AT&T Suspected Cell Tower Locations

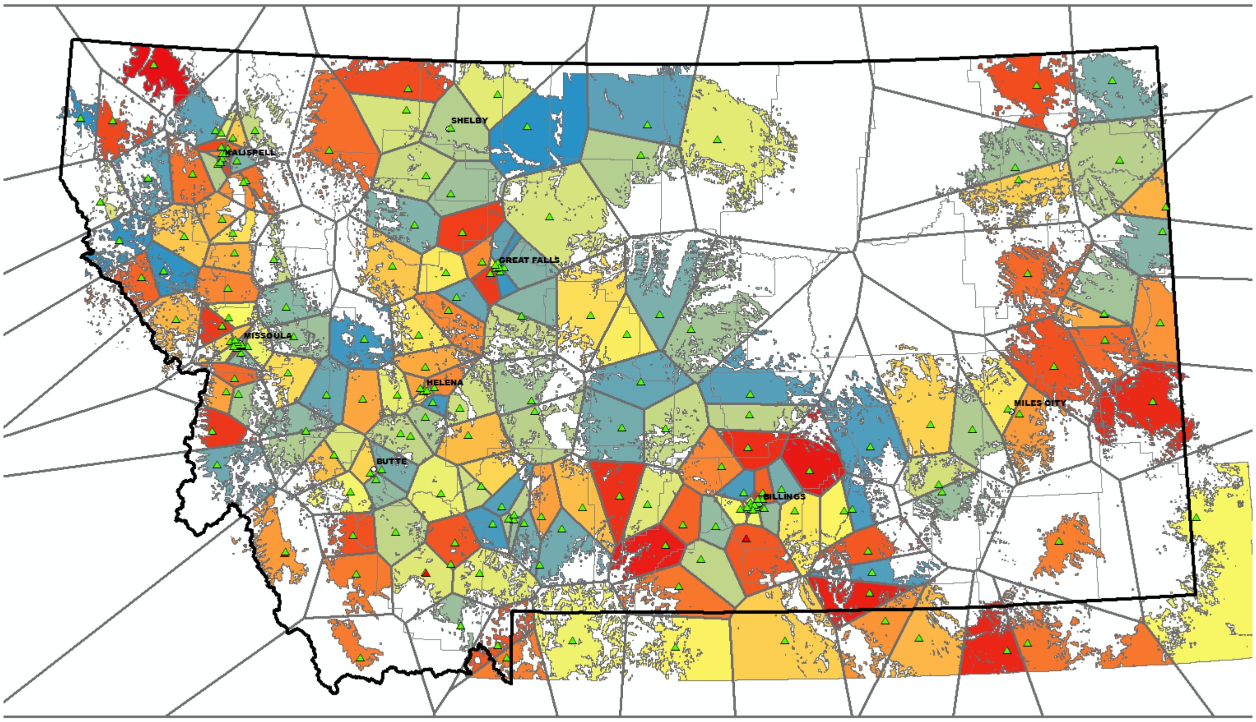


Figure 20 Thiessen Polygons by Tower intersected with AT&T web map coverage

The final AT&T tower/antenna feature class contained 207 records from the following sources including the number in each:

- FCC Universal Licensing System (130)
- FCC Antenna Structure Registration (70)
- AT&T Tower Website (5)
- TowerCo Website (2)

Most towers, 181 of 207, had a documented tower/antenna height (via FCC ULS, FCC ASR, or TowerCo), the remaining 26 were assigned an average height based on their location within or outside of city limits. Eight towers located outside the state were included in the propagation model because their coverage extended into the state, but these tower/antenna locations are not included in the Montana Middle Mile feature class. In total, 130 of 207 towers were run in the Cellular spectrum (from FCC ULS) and 77 towers were run in the Broadband PCS spectrum (by a process of elimination along with data submitted by AT&T).

A propagation model was run for each suspected AT&T tower location using the known and best assumed parameters. The National Elevation Data formed the base for the propagation models at one-third arc second. The resulting propagation prediction coverages were merged in ArcInfo to create two statewide coverages representing AT&T's 4G (HSPA+) and 3G data. The tower locations that appeared to be the source for AT&T's 4G (HSPA+) coverage were attributed as such and the same process was followed for the 3G data.

The AT&T towers were then placed on top of the AT&T coverage feature class created from the propagation model. Gaps in the coverage indicating a potentially missing tower were researched and added where necessary. This coverage was compared to AT&T's on-line coverage map (www.wireless.att.com/coverageviewer). We also compared the coverage to the results of our independent testing of signal strength and data transfer speed testing. Both comparisons generally matched the propagation model we generated.

The State of Montana Broadband Mapping Project decided to use the independently generated mobile wireless coverage for AT&T for the current submission.

The AT&T mobile wireless coverage was reviewed and updated for the spring 2014 update based on the propagation model developed by Geodata Services, Inc. and data displayed on AT&T's public web site. Since AT&T did not submit any data for Montana, the advertised speeds from their North Dakota submission were used. The minimum number of speed tests from the public speed test site was not achieved for mobile wireless to allow independent typical speed measurements for AT&T, so those remain null values in Montana.

For the Fall 2014 submission we selected areas from the independent propagation model that are shown as 4G LTE data on AT&T's public website to create a coverage for the 700 MHz spectrum. Coverage was added in Bozeman, Kalispell, Missoula, and Decker – which is north of Sheridan, Wyoming.

Satellite

The parameters below show the satellite wireless models for MT. A few satellites use the same azimuth and altitude, so they only need to be run once and subsequently copied and renamed for different providers. There was one coverage for WildBlue and Starband, and four coverages for Hughes/DirectTV. The Anik-F2 satellite appears to be shared by Hughes and WildBlue coverage, and was listed under both.

The process included running a hillshade with the parameters shown below, selecting the "Model shadows" parameter. This was reclassed into 3 classes 0,1,Max value. Then the Majority filter model in Spatial Analyst Generalization was run with a 4x4 neighborhood grid to filter out the smallest isolated shadow pixels. A conditional selection of the class 0 (shadow values) was made for the final grid. This was run through a raster to polygon conversion and added to the master coverage template from geodatabase.

Provider	Satellite	Azimuth	Altitude	Operator
Hughes / DirectTV				
	Anik-E2	141.6	33.7	Telesat Canada Ltd.
	Anik-F2	181.8	36.13	Telesat Canada Ltd.
	Spaceway-1	170.6	35.68	Direct TV, Inc.
	Spaceway-3	160.1	34.17	Hughes Network Systems
WildBlue				
	Anik-F2	181.8	36.13	Telesat Canada Ltd.
	Wildblue 1	181.8	36.1	Wildblue Communications
Starband				
	Echostar 9	195.1	35.03	Echostar Technologies, LLC

Skycasters LLC satellite coverage was added based on instructions from NTIA on September 11, 2012. The coverage modeled for Hughes/Direct TV was used to approximate Skycasters satellite coverage since the satellite coverages are all very similar.

Community Anchor Institutions

Lists were obtained from the state and affiliated processional organizations for anchor institutions to be included in the broadband mapping in each of the community anchor institution community code categories. These were sorted and cross referenced and an initial round of elimination of duplication was accomplished.

All institutions on the initial draft spreadsheets used for the first two submittals were geocoded using ESRI Business Analyst Desktop with the USA Geocoding engine using TeleAtlas premium road features. This was judged to be the best available geocoding source for batch processing of addresses. No commercial source is 100% accurate in a primarily rural state such as this with low population numbers compared to other states and no large cities or metropolitan statistical areas. In subsequent rounds of updates since the first two submittals, we have used the same geocoding engine from Esri Business Analyst, but the geocoding locator switched to NavTech geocode locator. In every round of geocoding we used conservative matching criteria, and maintained and stored the type of match (building match, address match, or zip code match), along with a record of those not matching and not able to geocode.

All geocoding is dependent on accurate road locations and complete and accurate street segment attribution. The GIS road layers available from the state were not judged as complete as the premium commercial sources. The Tiger 2009 road files, while spatially comparable to the commercial sources, have a large percentage of null values in the database attribution and street segment address ranges necessary for accurate geocoding. As in most parts of the country, geocoding is more accurate in urban settings than in rural routes. Complicating the process in a rural state for anchor institutions are the situation where some anchor institutions, such as public safety anchors are often staffed by volunteer staff and a post office box is the only valid address, and the physical address is wherever the public safety equipment is parked or stored at any given point in time.

Category codes were assigned based on the original source list and from keywords in the name of the institution and independent research. Technology of transmission and advertised speeds were obtained when possible, which initially was entirely based on the anchor institutions maintained by the state for consortiums providing state service contracts. Two iterations were accomplished with these state maintained lists, and all available attributes were obtained with assistance of the state analysts.

After initial data collection, analysts worked on researching, calling and improving the addresses for those below an 80% match criteria. Many in the 70% matching range were fairly accurately located. The difference between a 70% and 80% match typically occurred when an address lacked a prefix or suffix cardinal direction on a street that had two cardinal directions (example 101 1st Street, on a street segment with 101 N.

1st Street and 101 S. 1st Street). Analysts were also able to obtain physical addresses for some lists supplied by the state with only a P.O. Box.

The lists with updated and corrected addresses were re-geocoded for the final mapping effort, and any anchor with any level of geocoding was included on the final map. The operational database identifies the type of match, so future maintenance cycles can be prioritized and targeted to those matching only zip codes or with address changes.

From the results of the previous step some attribution of database attributes for attributes with null values was accomplished. This step was rule based. The attribute of whether an anchor institution subscribes to broadband service could only authoritatively be answered yes, if the information was provided by the state, or a confirmation from an anchor speed test could be matched. Those anchors that were located within an area covered by a DSL, cable, other copper or fixed wireless were also assumed to have the ability to subscribe to broadband coverage and were also estimated to be subscribers. Assigning the technology of transmission and the advertised speeds (which required identifying a provider for the anchor institution) was only possible on a subset of all coverage in those areas where only one provider/technology of transmission was present. This typically only occurred in rural settings. Most urban settings had multiple providers. In addition many providers submitted multiple technology options, so identifying one provider/technology of transmission combination was not possible even if there was only one provider possible for the anchor institution.

Beginning in 2013, when requests were made from NTIA for more complete advertised speeds and technology types for K-12 schools and libraries, we adopted authoritative lists from the Montana Office of Public Instruction and the Montana State Library, and implemented methods to only update types of technology or advertised speeds when we had some form of documentation in the form of speed tests, or discussions with school officials confirming their situation.

It is likely that in some instances in the rural settings and small towns an anchor institution may rely on mobile wireless broadband. This is common in public safety mobile equipment such as vehicles, but likely less common in anchor facilities. For the purpose of assigning attribution to anchor institutions with remaining null attributes, we took a conservative approach and did not overlay anchor institutions on mobile wireless coverages to assign attributes.

Maximum advertised downstream and upstream speeds were not available or collected for any of the CAIs. A new domain value of “U” for Unknown was added to the data model for the current submission, and all values formerly coded as 0, were changed to “U”. A new optional attribute was requested by NTIA for the current submittal requesting knowledge about the presence or absence of WIFI at the CAI location. This was not researched and attributed by the state in the current submission. All records were set to “Unknown” for the attribute Public Wi-Fi.

In the first two submission processes for geocoding we used conservative matching criteria, and maintained and stored the type of match (building match, address match, or zip code match), along with a record of those not matching and not able to geocode. The subsequent submission was completed by state analysts, and new additions to the list were not geocoded. The additions of new anchor institutions in this submission were assigned their latitude and longitude geographic location based on their location used in the Montana Structures Framework.

A new optional attribute was requested by NTIA after the initial maintenance updates requesting a CAI unique identification number for K-12 schools, libraries and colleges and universities. The following steps were completed for this request.

1. Added CAIID for the Library category using a combination of the FSCSKEY and FSCS_SEQ number attributes from http://harvester.census.gov/imls/data/pls/index.asp. Added 49 records using the Montana Structures Framework to assign their geographic location.

2. Added CAIID for the University, college, other post-secondary category using the NCES IPEDS ID from http://nces.ed.gov/ipeds/datacenter/. Added 10 records using the Montana Structures Framework to assign their geographic location.

3. Added CAIID for the School – K through 12 category using the NCES ID CCD ID from http://nces.ed.gov/ccd/bat/ . Added 118 schools using information from the OPI Schools http://www.publiclibraries.com/montana.htm list, the NCES Schools List and the Montana Structures Framework. NOTE: NTIA asked that each school be given a unique ID but in the CAI table, many schools at the same address were combined. These were not separated for this round of the NTIA submittal.

A new optional attribute was requested by NTIA for the current submittal requesting a URL for each anchor institution.

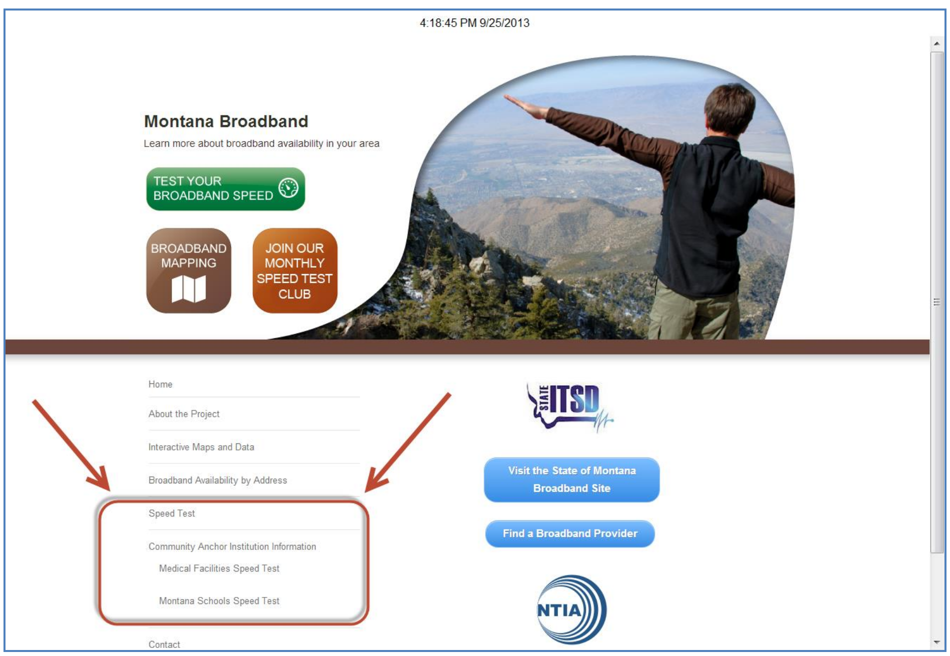
Assigned URLS to CAI records: for the University, college, other post-secondary category assigned the actual URL for that institution; for the Library category added a standard URL (http://www.publiclibraries.com/montana.htm); for the School – K through 12 category added the OPI URL (http://opi.mt.gov/Resources/Directo the 2011 update cycry/Index.html); and for other institutions, added an appropriate URL for the type of CAI.

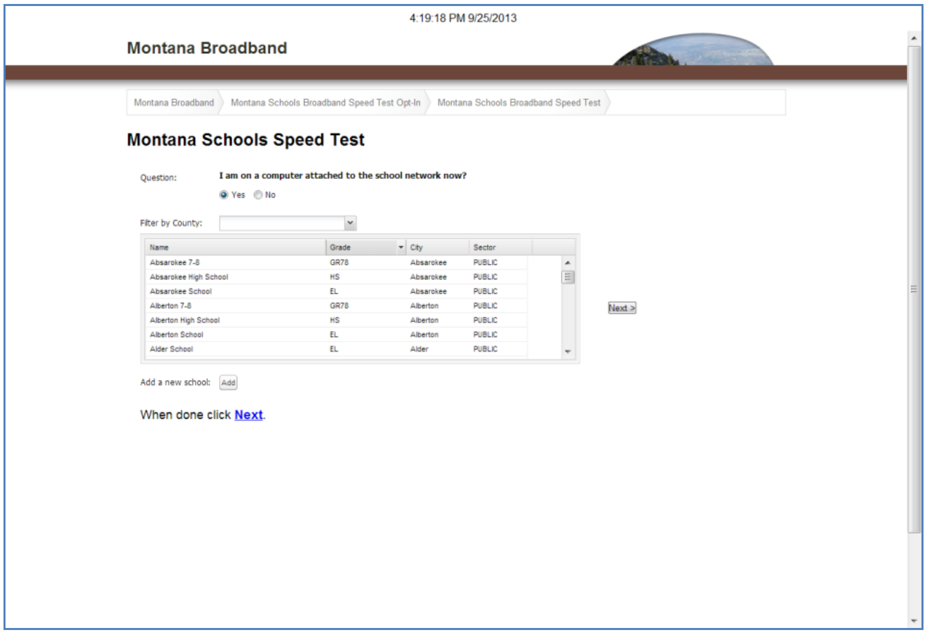
The State of Montana assigned administrative staff to update the anchors during the 2011 update cycles. They eliminated duplicate entries, added additional schools based on Office of Public Instruction data, and updated the NCES codes.

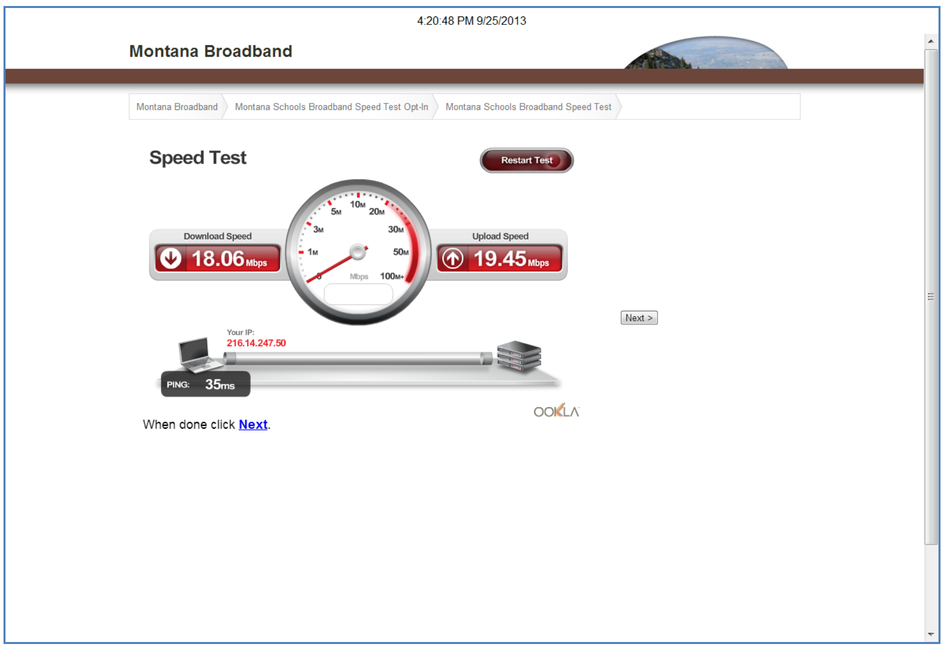
In the summer of 2013, NTIA requested the SBI program increase the proportion of K-12 school and library CAI records with speed tiers. This prompted a new effort to update the Montana K-12 schools anchor institutions and to more fully populate the technology type and advertised download/upload speeds for schools. For this update, the Montana Office of Public Instruction staff directory of principals and superintendents was adopted as the authoritative list of all Montana K-12 schools, replacing the original list derived from multiple sources in the spring, 2010.

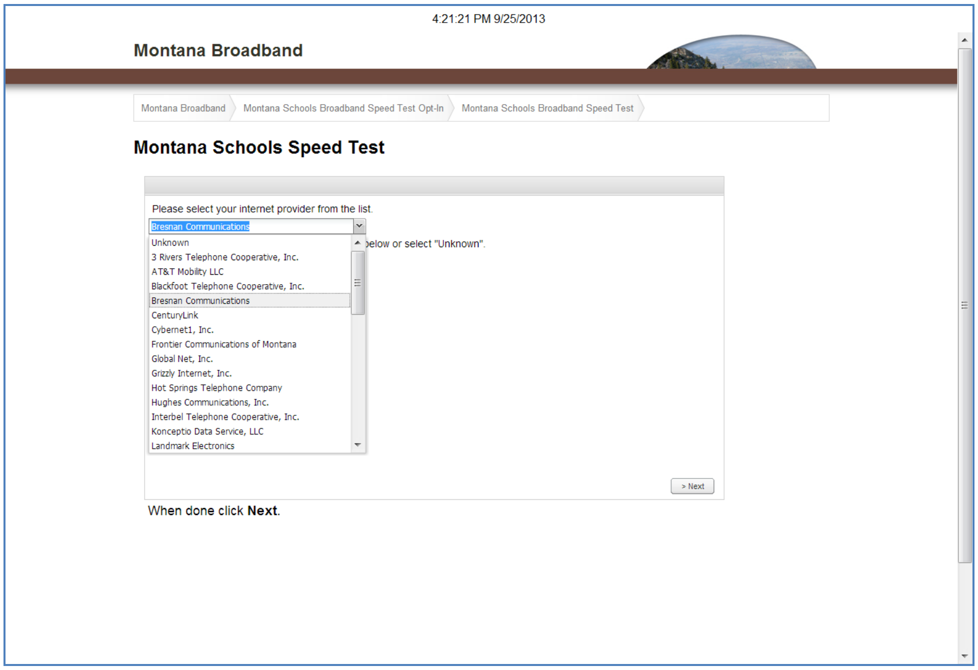
A public and anchor speed test site was developed in 2011 which provided one method of updating broadband information for community anchor institutions, allowing school officials to type their school name and take a speed test. For the fall, 2013 update a specialized version of the anchor institution speed test site was developed for schools. In addition to asking additional survey questions, the name of the institution (using the 2013 authoritative list) and the internet provider were selected by the test taker from pick lists. This allowed greater consistency and potential for automation. Multiple emails were sent to all schools on the OPI list, and many phone calls were made to directly gather information and to further encourage officials to take the speed test. Information provided by school officials in phone calls and speed test record processing resulted in 445 of the 790 schools (approximately 56%) reporting upload and download speeds by September, 2013. A much larger proportion of schools have attribute information indicating they have broadband availability based on previous OPI surveys. In instances where we were able to directly talk to a school district information technology specialist, the data they provided was used instead of any speed tests taken at individual schools.

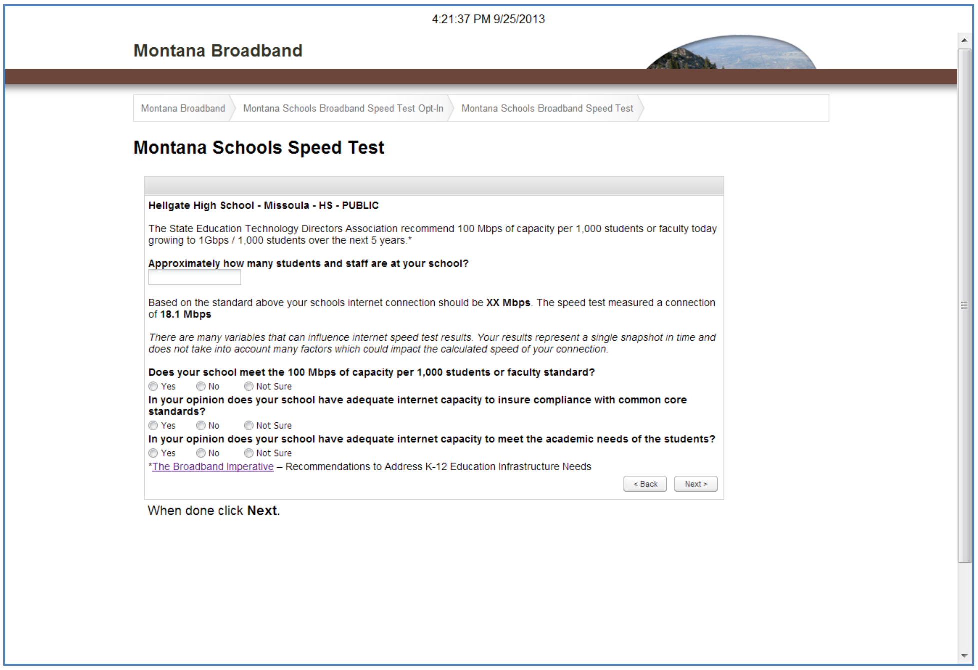
The key screens of the dedicated K-12 CAI speed test site are shown below:




4:19:18 PM 9/25/2013
Montana Broadband
Montana Broadband
Montana Schools Broadband Speed Test Opt-In
Montana Schools Broadband Speed Test
Montana Schools Speed Test
Question:
I am on a computer attached to the school network now?
Yes
No
Filter by County:
Name
Grade
City
Sector
Absarokee 7-8
GR78
Absarokee
PUBLIC
Absarokee High School
HS
Absarokee
PUBLIC
Absarokee School
EL
Absarokee
PUBLIC
Alberton 7-8
GR78
Alberton
PUBLIC
Alberton High School
HS
Alberton
PUBLIC
Alberton School
EL
Alberton
PUBLIC
Alder School
EL
Alder
PUBLIC
Next >
Add a new school:
Add
When done click Next.


4:20:48 PM 9/25/2013
Montana Broadband
Montana Broadband
Montana Schools Broadband Speed Test Opt-In
Montana Schools Broadband Speed Test
Speed Test
Restart Test
Download Speed
18.06 Mbps
Upload Speed
19.45 Mbps
Next >
Your IP:
216.14.247.50
PING: 35ms
OOKLA
When done click Next.





The same procedures used for the Fall 2013 CAI update described in the previous process step were repeated for the Spring 2014 update. The process of emailing and calling K-12 school anchor institutions and processing speed tests obtained between April, 2013 and Sept 20, 2013 was continued with a few additional steps described here. Additional phone calls, and 114 additional emails were made to schools with incomplete data for technology type and advertised upload and download speeds. We sent identical emails to the 12 regional directors on the board of the Montana Education Technologist Association. Authoritative information was requested primarily from school information technology coordinators or technicians. They were also urged to take the official Montana broadband CAI speed test and survey. The Montana office of Public Instruction and the Education Superhighway NGO also provided 95 additional speed tests. These were processed in a similar manner to the official speed tests, except multiple speed tests from the same school were not averaged since they only provided the total number of tests and maximum speed. The provided maximum speed was used to assign both the downstream and upstream speeds for NTIA reporting purposes. A set of business rules were established to determine which source took priority when multiple records existed for any give school. Direct telephone or email contact with an information coordinator at a school always took priority over any speed test. Any speed test collected from the Montana broadband speed test site overrode a record provided by the Education Superhighway group. The final step was to assign the CAI with new information from one of the sources for any school that lacked technology type or up or downstream speeds using the new data from a school with the same concatenated address/city. These efforts resulted in updates to 96 schools that previously had incomplete technology type and/or downstream and upstream speeds.

Sixty-one of the 75 schools with missing NCES codes were looked up and the CAID NCES code was added to these 61 records. There are 15 remaining schools in Montana that do not have NCES codes and do not appear in the NCES list. We received an email from NTIA on March 17, 2014 that implied a policy modification requiring SBI teams to achieve a one to one match of local data against the national NCES database and assign a NCES code to every CAI record in the NTIA submission. This request came too late in the process as we were completing our quality assurance testing on the processed data. We already attempt to do this whenever the schools in each list match or are unambiguous and can be matched based on identical or similar names. There still remain records in each database that are missing in one of the two independent sources and cannot be matched without detailed checks and responses from authoritative sources. Our current authoritative source for Montana schools is the Montana Office of Public Instruction. We will submit the list of remaining schools that do not match to the MT OPI and to the NCES administrators to see if they can resolve any discrepancies and report on those in the fall 2014 NTIA update. Compounding this problem is the NCES data is documented at least two years older than the current OPI list we received.

A similar dedicated speed test site was developed for Medical/healthcare anchor institutions. Examples are not shown here. It is identical in form and structure, and only differs from the K-12 school site in the supplemental survey questions that are asked of anchors. For this update, a subset of types from the Montana Department of Public Health and Human Services (DPHHS) list of regulated facilities was used as the authoritative list of all health anchors, replacing the original list of 297 anchors derived from multiple sources in the spring, 2010. The DPHHS did not provide a database of facilities. The state broadband coordinator selected 23 of the 32 categories of regulated facilities. The facility database was then transcribed from the DPHHS web site for each category, and a database of 756 health regulated facilities was created from the results. Emails for the anchor institutions were not provided, so population of the results was initially very small compared to schools

The Montana State Library provided a list of community anchor libraries from their latest data collection and we compared it to our previous library listings and updated the data attributes of the 109 libraries reported. For any libraries that had technology types from previous updates, the technology types were maintained as is. We were not able to reliably crosswalk the type of internet connection they previously recorded in their surveys with the NTIA Technology Type categories in all cases. The following table shows the crosswalk and the values that were assigned.

Type of Internet Connection	TOT	DOWN	UP
1MB DSL Modem	ADSL	4	4
1MB+ DSL Modem	ADSL	4	4
256K DSL Modem	ADSL	3	3
256K Frame Relay	Unknown	3	3
512K Frame Relay	Unknown	3	3
Cable Modem	Cable Modem – Other	7	7
Ethernet 10 MB	Unknown	7	7
MicroWave	Unknown		
Other Type	Unknown		
Satellite	Satellite		
T1	Other Copper Wireline	4	4
T3	Other Copper Wireline	5	5
Wireless	Unknown		

The Montana State Library provided a spreadsheet in late December, 2013 from the 2013 Montana Department of Administration Public Library Broadband Study. The study included broadband statistics for all libraries in Montana including access (yes or no), type of technology, and downstream/upstream speeds. The information from the Library Broadband Study was compared to the existing CAI libraries and resulted in updates to the technology type and/or downstream/upstream speeds to 116 libraries. Two of the seven libraries with missing NCES codes were assigned their NCES code.

NTIA requested the SBI program increase the proportion of school CAI records with reported speed tiers. This prompted an effort to update the Montana K-12 schools anchor institutions and gather as much information as possible on technology type and advertised download/upload speeds. For this update, the Montana Office of Public Instruction (OPI) staff directory of principals and superintendents was adopted as the authoritative list of all Montana K-12 schools, updating the original list derived from multiple sources in the spring, 2010. Although we treated it as authoritative, we did not delete any K-12 schools that have been carried in the K-12 CAI database since 2010. OPI occasionally conducted inventories of broadband connectivity, asking schools if they had broadband or dial-up connections, documenting that with a “yes” or “no” attribute. This was used to populate whether a school had broadband availability. The OPI inventory did not include the type of technology or the advertised speeds. Two primary methods were used to update the broadband connectivity information: email to all principals and superintendents directing them to an online survey and speed test, and direct calls to school officials to gather broadband details. During the last two SBI submittal cycles, we also repeatedly emailed and called members of the Montana Education Technologists Association, a professional organization of the Montana Administrators Association who provided assistance and notification of their membership. The Montana Office of Public Instruction cooperated with the Education Superhighway organization and obtained additional speed tests, which we cross-referenced against the State of Montana Speed tests and added a handful of new records to our effort. OPI conducted a survey of all school districts during 2014 regarding readiness for common core reporting, but did not contact each school, and did not use SBI technology or download or upload speed questions. They only reported one school with no broadband connectivity. Since their criteria did not match our reporting criteria, we did not utilize this more general information. These efforts resulted in 772 of the 855 K-12 schools reporting yes to broadband (90.2%), 628 of the 855 schools reporting a technology type (73.5%), and 543 of the 855 schools reporting broadband speeds (63.5%) with documented methods. In September, NTIA requested we harmonize 3 schools and 4 libraries where differences existed between the December, 2013 data submittal and separate information provided to the FCC. We accomplished this task with 100% consensus, and the results submitted in this June 30, 2014 submittal reflect the consensus results.

Middle Mile

Middle mile and backhaul points were included for all public data and provider submitted infrastructure judged to be reliable and valid. A systematic reliability (geographic scale and authority of the source) rating and a validity rating (cross referencing between multiple sources) were developed and used throughout the project, both on a scale of 1-10, along with feature level metadata to maintain the last point of aggregation. A persistent unique identifier was used to track each point and each instance of a point as they moved through the system and improved in quality. Old points were retired but were not deleted from the operational database. Only active records were used in the final processing.

A feature class labeled "Last point of aggregation" (LPA) in the operational database was created to hold point locations of broadband infrastructure (examples include central offices, remote terminals, head ends, etc.). Addresses purchased or obtained at any level of geography were geocoded to a street address (using ESRI Business Analyst and TeleAtlas data) or located more generally to the center of a town (snapped to the USGS Geographic Names Information System location) when no address information was available. All mobile wireless locations obtained from public sources or commercial sources that were not already validated were confirmed using NAIP aerial imagery and Google Street View (when available). All FCC tower locations included a latitude and longitude, however all towers were validated and moved to the NAIP aerial imagery location.

A reliability code indicating the source and geographic scale represented as an integer from 1 (low) to 10 (high) was assigned. Validity codes were assigned cross-referencing public and provider data submissions; it was also rated on a scale of 1-10. A point with a validity code of 7 that fell within a provider's coverage for DSL, mobile or fixed wireless, or was used in a final modeled coverage was included in this table. In addition, backhaul points identified by the state, by providers and consortiums providing services to the state and anchor institutions, were included in the table. Providers were typically reluctant or unwilling to provide infrastructure data, and often unwilling to confirm data obtained through public sources. The methods used in the state allowed a significant level of identification and mapping of infrastructure locations and feature level metadata on reliability and validity of point locations, but data on owned or leased characteristics, serving facility codes, and for elevation of infrastructure was confirmed by few providers who responded directly in a spreadsheet provided to them to list infrastructure.

Speed Test Data Processing

A public facing website was created in the spring of 2010 asking internet users in the state to complete a brief survey regarding their internet connection and run a speed test on their connection using the Ookla speed test. The speed test site asked that a user enter their location as an address on a Google map interface. If the address did not geocode to their satisfaction, the user could choose to move the place mark to their desired location. Next, users were asked to select their technology of transmission from a list, enter their provider in a free form text field, complete an optional questionnaire, and run a standard speed test on their connection. The date and time, and IP address of the user were captured during the speed test.
All speed tests were geocoded, and the IP address was looked up in batch mode in the WHOIS database returning one or two providers registered with WHOIS. All speed

tests were cleaned and analyzed against provider submissions and models. The final provider was assigned by examining the WHOIS fields, and the provider submitted by users. Consistent rules were not always possible, but generally when two WHOIS records were returned, the second more specific WHOIS provider was selected. In some instances, where the WHOIS providers were backhaul or other and were not providers meeting the NOFA criteria, the user submitted provider designation was cleaned and standardized and assigned as the final provider.

There was considerable variation between the user reported technology of transmission (TOT) and the known technologies for any given provider. Records were divided on unique provider/ TOT combinations for the first and second submissions, which limited the record count in many instances. For the current submission the records were divided only by provider, not taking TOT into consideration.

For the first two submissions, the speed test records were used in two ways for the final processing.

1) As an independent measurement to validate the presence/absence of a provider coverage for DSL and/or Cable technologies.

In the first submission a few providers were identified as DSL broadband providers based primarily on speed tests. In these instances, DSL models were executed for both providers based on verified central office locations. Some speed tests with an identified technology of transmission of Cable Modem were used to expand “likely” cable areas which were typically adjacent to incorporated and urban areas. These “cable-plus” areas were created to supplement submissions from Cable Modem providers who did not provide detailed coverage or census blocks. No new DSL providers or Cable providers were identified using speed tests in the current submission.

2) As an independent measurement for typical upload and download speeds.

Once data were cleaned and final provider and technology of transmission assigned, these fields were concatenated. In the first two submissions, if the remaining records exceeded 10 for the combination of provider and technology, and the speed test was successfully completed (values > 0) the average value and standard deviation of the download speed were calculated. Any values exceeding 1 standard deviation were removed as outliers, and the mean of the remaining records within 1 standard deviation was calculated for the download and upload speed. This value was reported for each provider/technology of transmission record as the typical speeds for that provider. In some instances the typical speed was lower than that required to meet the definition of broadband by NTIA, but that did not preclude the records from being included in the broadband map in the first two submissions as it did in the current submission.

The steps of the current processing are provided below. The primary procedural change was to drop the validation of the presence/absence of provider coverage for

DSL and/or Cable technologies, since providers had been validated in the first two submissions and potential new providers identified through additional speed tests were determined to not meet the NOFA criteria for being considered a broadband provider. The use of the speed test data for determining typical speeds was implemented with similar rules as the first two submissions with the exception of the use of the technology of transfer, and raising the minimum number of speed tests to 15, after removing outliers, to be used in typical speed calculations. Procedurally, the process was also automated with a Python script to improve processing performance and minimize quality control/quality assurance testing.

Typical upload and download speeds for all providers with less than 15 processed speed test records were coded as null values. In addition, based on telephone communication with NTIA on March 9, 2011, all typical speeds less than minimum NOFA upload or download speed criteria were also ignored and reported as null. Based on a related request in the same communication, the typical speeds greater than the advertised speeds were ignored and reported as null. Subsequently on March 17, in the NTIA grantee webinar, the NTIA staff indicated that typical speeds would not be compared to advertised speeds. Processing steps for the current submission are provided below:

1. Speed test records were imported into a SQL Server data file, adding fields Final Provider and IPGroup to the initial records.
2. IPGroup attribute was set by extracting the left three nodes of the IP Address of the speed test (e.g. 161.7.1.236 had 161.7.1) moved to the IPGroup attribute.
3. An IPGroup to Final Provider cross reference table was created to determine the final provider from the unique three part IPGroup (e.g. 161.7.1 is known to be the State of Montana).
4. Each IPGroup was reviewed with the data in the WHOIS 1 provider, WHOIS 2 provider and then the user specified provider to determine the most authoritative final provider from the official list of providers. None of the WHOIS or user submitted fields were absolutely authoritative in all instances, so expert opinion by technicians knowledgable of the providers was used in some instances to assign the IPGroups, and subsequently the Final Provider attribute.
5. Run a python script to remove outliers and calculate summary statistics for each Final Provider assignment. The rationale for removing outliers was to mitigate the many variables that effect a typical speeed test, such as the time of day, others on the network, etc. The script implemented the following work flow rules:
    a. Use all records for each unique FinalProv attribute value with D_kbps greater than 0 or U_kbps greater than 0 , then:
    b. Calculate a mean for the unique provider group for each D_kbps and U_kbps.
    c. Calculate a standard deviation for the unique provider group for each D_kbps and U_kbps. Each speed attribute was calculated independently of the other.

   d. Subtract the outliers (if any) higher or lower than one standard deviation from the mean.
   e. Calculate the median value of the remaining non-outliers for each provider D_kbps and U_kbps respectively.
   f. Create a summary table with the final calculated assignment of FinalProv, D_kbps and U_kbps.
6. Post process the summary table in the following sub steps:
   a. Join the summary tables by provider for the upload and download speeds into one summary file including the number of records or frequencies for up and down speeds for each provider after removing the outliers, and the mean up and down speeds in kilobits per second for each provider.
   b. Select "FreqDown" < 15 AND "FreqUp" < 15 then delete the resulting selection set from the joined table. The FreqDown/Up fields counted the number of speed test records for a provider after the outliers more or less than one standard deviation from the mean value were removed from consideration.
   c. Select "D2_kbps" <= 768 kbps AND "U2_kbps" <= 200 kbps. then delete the resulting selection set from the joined table.
7. Import the remaining valid mean values for each provider into the appropriate broadband coverage feature classes.
8. Select any typical speeds greater than advertised speeds either up or down, and make the resulting records null in the final broadband coverage feature classes (as per NTIA request 3/9/2011).

Reliability, Validity and Completeness

Throughout the course of the broadband project the State of Montana has employed several validation and verification techniques to help quantify the accuracy of the broadband map. The techniques used are listed below:

- Reliability Codes Assigned to Infrastructure Points
- State Run Speed Test Portal
- State Wide Broadband Survey

Reliability codes apply to the source data points and polygons and assess the authority of the source we obtained the data from and the level or coarseness of the geography (address or town). Validity codes are determined from cross checks of data sources and the number of independent sources of verification. These are as simple as comparing speed test locations against DSL modeled polygons, or as complex as geospatial analysis operations such as a kernel density function cluster analysis. Completeness is determined by public sources, independent measurements or provider submittals and checks on the domain classes required for the final NTIA deliverables such as Technology of Transmission domains, Speed Test domains and serving facility and wireless spectrum facility types and categories. The categories for these, and the subsequent records in our operational geodatabase tables grow and change as new data is obtained. We are maintaining these as feature level metadata tied to points and polygons maintained by analysts and technicians in a wiki table and coding them to the geodatabase. In this way the unique situations that arise can be cataloged and maintained with some level of flexibility while contributing to the final indices in a controlled fashion.

Reliability Codes

The two factors incorporated in reliability codes include the level of geography that was used as a source or provided as a clarification of location and the authority of the source for the information. We are also considering clusters of point information from independent measurements and sources to be higher in reliability than individual point information.

Generally, the coarser the source geography the lower the resultant score. Everything besides an address or street intersection, latitude/longitude location, or location provided in a georeferenced digital source is assigned a reliability score less than 5. This applies to source data coming (e.g. a central office located in a city instead of an address) and review comments on a previously mapped location (e.g. "That location is wrong, I know it is on the south side of town").

We have incorporated the reliability code into our last point of aggregation (LPA) and provider coverage geodatabase files, and into some of the publicly available data (PAD) geodatabases. We are also carrying a short text field (50 characters) with a descriptive rationale for the score. This will allow us to focus more on the lower scores that need to be confirmed, and ignore the high confidence data scored as 9 and 10.

Reliability Codes		
Code	**Description**	**Detailed Description**
0	Not assigned	• Not yet assigned
1	Level 1	• Checked but unverified
2	Level 2	• County • Presence by other coarse geography (e.g. administrative region)
3	Level 3	• City • Census tracts • Cable Plus (area likely to have been annexed into an incorporated town or CDP)
4	Level 4	• Cable - incorporated • Zipcodes • Census blocks

5	Level 5	• GeoTel unverified • Confirmed by provider or anchor institution key advisor but to geography coarser than address or intersection
6	Level 6	• Qwest/Midcontinent or other web site random testing check • Speed test from individual average residential
7	Level 7	• From anchor institution key advisor Webex • GeoTel verified address only with no 3rd party confirmation from public sources ○ Building unverified • Speed test from anchor institution

8	Level 8	• From provider
		• FCC ULS or ARS
		• Geotel verified address and possibly verified by 3rd party source (Google Streetview)
		  ○ Another provider's sign is on building (usually Qwest)
		• Geotel possibly verified by 3rd party source (NAIP, Google Streetview)
		• From state authoritative public data source (e.g. DCN or SummitNet)
		  ○ Address or building unverified
		• Speed test from cluster of average residential

9	Level 9	• From provider as coverage with authoritative confirmation
		• Geotel verified address and verified by 3rd party source (NAIP, Google Streetview)
		  ○ Provider sign on building
		  ○ Tower or dish visible
		• From provider or anchor institution check of our data * Root Wireless

10	Level 10	• From 2+ authoritative confirmations

Validity Codes

We included validity codes in the last point of aggregation infrastructure data which drives creation of the DSL models. We also included validity codes in each of the final technology of transmission deliverables for polygons and point feature classes. The scales of validity vary by each major type and function.

Infrastructure Validity Codes

The purpose of this validity code is twofold:

1. To determine which infrastructure points are turned into DSL model coverages
2. To use as a reference in other coverage validity checks

Infrastructure Validity Codes		
Code	**Description**	**Detailed Description**
0	Level 0	• Not yet assigned
1	Level 1	• Not yet assigned
2	Level 2	• Not yet assigned
3	Level 3	• Checked against MT PSC Report or DSLReports at the town level • Checked against SummitNet anchor institution data
4	Level 4	• Checked against two or more independent public sources at the town level • Checked against provider public data (e.g. Qwest ICONN) at the town level
5	Level 5	• Not yet assigned
6	Level 6	• Confirmation of DSL or cable from authoritative public data to broader geography than address not confirmed by provider
7	Level 7	• Authoritative public data at address level (e.g. Geotel) not confirmed by provider
8	Level 8	• Provider submission at the census tract level • Provider website independent address checks (Qwest, Verizon)
9	Level 9	• Provider submission at the census block level or address level
10	Level 10	• Provider submission at the coverage level at census block scale or blocks less than 2 square mile and larger scale then census block for blocks larger than 2 square miles

Final Technology of Transmission Validity Codes

The purpose of this validity code is twofold:

1. To determine which elements are loaded in the spreadsheet provider submission packages in their review
2. To determine which provider coverages are chosen for submittal with one of the NTIA deliverables (April 15, June 24)

Final Technology of Transmission Validity Codes		
Code	**Description**	**Detailed Description**
0	Not assigned	• Not yet assigned

1	Level 1	• Unassigned at this time
2	Level 2	• Unassigned at this time
3	Level 3	• Checked against MT PSC Report or DSL sources at the town level • Checked against SummitNet anchor institution data
4	Level 4	• Checked against two or more independent public sources at the town level • Checked against provider public data (e.g. Centurylink ICONN) at the town level
5	Level 5	• Confirmation of DSL or cable from authoritative public data
6	Level 6	• Provider website independent address checks (Qwest, Verizon) • Provider submission at the census tract level
7	Level 7	• Provider submission at the census block level • Provider submission at the census block level confirmed by Speed test cluster OR other independent measurement
8	Level 8	• Provider submission at the address level
9	Level 9	• Provider submission at the address level confirmed by Speed test cluster OR other independent measurement
10	Level 10	• Provider submission at the address level confirmed by Speed test cluster OR other independent measurement

Quality Assurance Testing

A separate analyst checked each provider submission. Due to the variety of provider submissions, the analyst originally doing the work and the analyst checking discussed the interpretations when the criteria were subject to interpretation.

Coverage, technology of transmission, and speed tier were checked completely for each provider.

Many of the models and block, tract and coverage level processes were completed with ESRI Modelbuilder and Python scripts, and these methods were tested for quality assurance in the preliminary mapping stages and in the initial sample data submissions to NTIA.

All providers who submitted geographic coverage coarser than a census block were provided a data checking package to assess for accuracy and completeness. Any comments received from providers were processed.

1. QA/QC Checks prior to Individual Data Processing (i.e., block or coverage geoprocessing model). [Automated Modelbuilder tools and follow-up by an analyst]

   a. Check for inconsistencies within the Provider Name, DBA Name, FRN
   b. Check for duplicate census blocks or coverage areas
   c. Check the Provider Name, DBA Name, FRN against the "Official Provider Table"

2. For each provider after initial data processing is completed [Review by an analyst that did not process the original data]
   a. Review correspondence log
      i. Review recent correspondence, since previous NTIA submission
      ii. Note changes/additions/comments on coverage area, technologies, speeds, infrastructure
   b. Review wiki data processing page (current metadata)
      i. Note changes/additions/comments on coverage area, technologies, speeds, infrastructure
   c. Review individual Provider Wiki page (historic metadata)
      i. Note changes/additions/comments on coverage area, technologies, speeds, infrastructure
   d. Check Provider Data Folder
      i. Review recent data submissions, since previous NTIA submission
   e. Check Working Data Folder
      i. Review current update feature class geography
      ii. Review coverage with provider's submissions
      iii. Review technology of transmissions (TOTs) with provider's submissions
      iv. Review Max Adv Speeds: Down/Up with provider's submissions

3. For each provider after final data processing is completed [Review by an analyst that did not process the original data]
   a. Check feature classes
      i. Review geography
      ii. Review TOTS
      iii. Review Max Adv Speeds: Down/Up

4. Check Middle Mile feature class [Review by an analyst that did not process the original data]
   a. Review recent submissions, since previous NTIA submission

5. For each provider after speed tests are processed [Review by an analyst that did not process the original data]
   a. Check Typical Speeds: Down/Up

6. QA/QC Checks and Reports on the Final NTIA Deliverable [Automated Modelbuilder tools and follow-up by an analyst]

a. Check the Provider Name, DBA Name, FRN against the "Official Provider Table" for each NTIA feature class (i.e., BB_Service_CensusBlock, BB_Service_RoadSegment, BB_Service_Wireless, etc.). NTIA_Provider_Name_DBA_FRN_Errors_Sample.xls, looks at each NTIA feature class (i.e., census blocks, road segments, wireless, etc…) and checks to see if there is an identical match in the "Official Provider Table." If an identical match does not exist for that Provider Name, DBA Name, FRN concatenation it is written to a geodatabase table along with the NTIA feature class where the "error" occurred. When an "error" does occur it then has to be checked by an analyst and corrected if necessary.
b. Change Detection Report – This geoprocessing model compares and reports any changes in the Census Block, Road Segment, and Wireless feature classes for the current and previous versions of the NTIA SBDD Transfer database. The user needs to supply the feature classes for each NTIA version as well as the name of the final change detection table. NTIA_Change_Detection_Example.xls, compares and reports any changes (limited to Provider Name, DBA Name, FRN, TOT combinations) in the Census Block, Road Segment, and Wireless feature classes for the current and previous versions of the NTIA SBDD Transfer database. If the final change detection table has no records, then no changes were detected between the two databases. If a Provider Name, DBA Name, FRN, TOT combination does not have a "pair" in either direction (the current or previous NTIA database) then it is written to a geodatabase table along with the NTIA feature class and version where the "error" occurred. This report does not change any data in either database but rather acts as a flag, requiring an analyst to check if the "error" is valid.
c. Check for duplicate census blocks or road segments or wireless coverage areas.
d. Check for duplicate anchor institution points.

7. Review Final NTIA deliverables [Review by an analyst that did not process the original data]
    a. Review BB_ConnectionPoint_MiddleMile
    b. Review BB_Service_CAInstitutions
    c. Review BB_Service_Census Block
    d. Review BB_Service_RoadSegment
    e. Review BB_Service_Wireless

8. Run the NTIA Check submission tool and python tool to confirm that all possible records passed the NTIA data checks. The only items that failed in the checking process were those where inconsistencies in the final NTIA NSGIC data model did not agree with the final documentation and rules established by NTIA and FCC in the final webinar and documentation presented March 17, 2011. These exceptions were documented along with the submission.

Appendix A

Potential providers researched but subsequently identified as not providing broadband service.

Company Name	Filing Company DBA	FRN	URL
5LINX Enterprises Inc. DBA Globalinx	5LINX Enterprises, Inc.	0015304645	www.5linx.com/products
8x8, Inc.	8x8, Inc.	0007099773	www.8x8.com
Access Point Inc.	Access Point Inc.	0004057352	www.accesspointinc.com
Accessline Communications Corporation	Accessline Holdings, Inc.	0015982366	www.accessline.com
ACN Digital Phone Service, LLC	ACN, Inc.	0015312606	www.myacn.com/index.html
All Digital Telecom, Inc.	All Digital Telecom, Inc.		none
Alltel Wireless	Alltel Wireless		www.att.com
Ameripages, Inc.	Ameripages, Inc.		none
AmeriVision Communications, Inc.	AmeriVision Communications, Inc.		http://www.affinity4.com/
Aptela, Inc.	Aptela, Inc.	0015304850	www.aptela.com
AT&T Corp.	AT&T Inc.	0004496774	www.att.com
B2B Advantage, Inc.	B2B Advantage, Inc.		http://www.b2badvantage.net/b2b/index.asp
Bandwidth.com, Inc.	Bandwidth.com, Inc.	0015443773	www.bandwidth.com
Big Sky Wifi, Inc.	Big Sky Wifi, Inc.		www.3rivers.net
BigHoof New Media	BigHoof New Media		none
Birch Telecom	Birch Telecom		www.birch.com
BroadvoxGo!, LLC	BroadvoxGo!, LLC	0017679523	www.broadvox.com

Broadwing Communications, LLC	Level 3 Communications, LLC	0008599706	www.level3.com
Bulldog Cable	Bulldog Cable		www.bulldogcable.com
BullsEye Telecom, Inc.	BullsEye Telecom, Inc.	0004350930	www.bullseyetelecom.com
C-A Information Systems Inc.	C-A Information Systems Inc.		www.consumer.hughesnet.com
Cable & Communications Corporation d/b/a Mid-Rivers Wireless	Mid-Rivers Telephone Cooperative, Inc.	0001634443	www.midrivers.com
Call Catchers Inc.	Call Catchers Inc.	0016109803	none
Cause Based Commerce Incorporated	Cause Based Commerce Inc.	0015173503	www.causebasedcommerce.com
COMCAST CABLE COMMUNICATIONS, INC.	Comcast Corporation	0003768165	www.onlinecomcast.com
CommPartners, LLC	CommPartners Holding Corporation	0011045127	www.commpartnersconnect.com
Contact Communications	Contact Communications		none
CRJ Communications Indications Corp.	CRJ Communications Indications Corp.		none
Dialog Telecommunications	Dialog Telecommunications		none
DSLnet Communications, LLC	Megapath, Inc.	0004324851	www.megapath.com
EarthLink	EarthLink	0015192453	www.earthlink.net
ECR Voice, LLC	ECR Voice, LLC	0015518129	www.ecrvoice.com
Engineered Communication	CommPartners Holding	0019615400	www.commpartnersconnect.com

Systems, Inc	Corporation		
Ernest Communications, Inc.	Ernest Communications, Inc.	0004948642	www.ernestgroup.com
Essen Communications Corporation	Essen Communications Corporation		www.essencommunications.com
Fionda VOIP, LLC	Fionda VOIP, LLC	0015321961	www.fionda.com
First Communications, LLC	First Communications, LLC	0003764487	www.firstcomm.com
Get Mobile	Get Mobile		none
Gilat	Gilat		www.gilat.com
Global Crossing Telecommunications, Inc.	Global Crossing North America, Inc.	0002850519	www.globalcrossing.com
Granite Telecommunications, LLC	Granite Telecommunications, LLC	0008676975	www.granitenet.com/ProductsAndSolutions/Pages/Broadband.html
GreatCall, Inc.	GreatCall, Inc.	0018554386	www.greatcall.com
Greenfly Networks, Inc.	Greenfly Networks, Inc.	0015808736	www.clearfly.net
HughesNet	HughesNet		www.consumer.hughesnet.com
iCore Networks, Inc.	iCore Networks, Inc.	0015340326	www.icore.com
IDirect	IDirect		www.idirect.net
IDT Corporation	IDT Corporation	0003790037	www.idt.net
InPhonex.com, LLC	InPhonex.com, LLC	0010488351	www.inphonex.com
Integra Telecom	Integra Telecom		www.integratelecom.com
Internet Montana	Internet Montana		www.imt.net/services/dsl.html
Ionex Communications North, Inc.	Birch Communications Inc.	0005027305	www.birch.com/about/
IP Networked Services, Inc.	IP Networked Services, Inc.	0016088882	none
iSmart Mobile	iSmart Mobile	001910	www.smartcall.us

LLC	LLC	7051	
Jefferson Broadband	Jefferson Broadband		www.cutthroatcom.com
Kosmaz Technologies LLC	Kosmaz Technologies LLC	0014855084	www.kosmaz.com
LightSquared LP	LightSquared LP	0007705742	www.lightsquared.com
Lightyear Network Solutions, LLC	LY Holdings, LLC	0010045128	www.lightyear.net
LinkStar	LinkStar		www.viasat.com
Matrix Telecom, Inc.	Matrix Telecom, Inc.	0004333068	www.matrixbt.com
Metropolitan Telecommunications Holding Company	Metropolitan Telecommunications Holding Company	0009806019	www.mettel.net
Millicorp	Millicorp	0018930511	www.millicorp.com
Missouri Valley Communications, Inc.	Missouri Valley Communications, Inc.		www.nemont.net
Montana Advanced Information Network, Inc.	Montana Advanced Information Network, Inc.		www.vision.net
Montana Lincnet	Montana Lincnet		www.montanasky.net
Montana Wireless Inc.	Montana Wireless Inc.		none
Mountain West Internet Inc.	Mountain West Internet Inc.		www.mwtn.net
MTPCS, LLC dba Chinook Wireless	MTPCS Holdings, LLC	0013518741	www.cellularone.com
Multiband Communications, Inc.	Multiband Communications, Inc.		www.cutthroatcom.com
Navigator Telecommunications LLC	Navigator Telecommunications LLC	0004349924	www.navtel.com
New Cingular Wireless	AT&T Inc.	0003766532	www.att.com

Services, Inc.			
New Edge Network, Inc.	New Edge Holding Company	0003720471	www.newedgenetworks.com
nexVortex,Inc.	nexVortex,Inc.	0015282155	www.nexvortex.com
NOS Communications, Inc.	NOS Communications, Inc.	0004321006	www.nos.com
Omnicom Paging Plus, LLC	Omnicom Paging Plus, LLC		www.omnicom-paging.com
OnWav, Inc	OnWav, Inc	0018007898	www.onwav.com/home
OPCOM, INC.	OPCOM, INC.		wcstelecom.com
P.W.I. Holdings, Inc.	P.W.I. Holdings, Inc.		none
PAETEC Communications	PAETEC Communications	0003716073	www.paetec.com
Phone.com, LLC	Phone.com, LLC	0016845190	www.phone.com
Proximiti Technologies, Inc.	Proximiti Technologies, Inc.	0016431603	www.proximiti.com/default.aspx
QuantumShift Communications, Inc.	vCom Solutions	0004337523	vcomsolutions.com
Qwest Communications Company, LLC	Qwest Communications International, Inc.	0003605953	centurylink.com
Qwest Corporation	Qwest Corporation		centurylink.com
RNK, Inc.	Wave2Wave Communications, Inc.	0002477743	www.wave2wave.com
Sagebrush Cellular, Inc.	Nemont Telephone Cooperative, Inc.	0001608645	www.nemont.com
Skyland Technologies, Inc.	Skyland Technologies, Inc.		none

SoFast Internet Services, LLC.	SoFast Internet Services, LLC.		none
Sprint Nextel Corporation	Sprint Nextel Corporation	000377 4593	www.sprint.com
Summit Wireless, LLC	Summit Wireless, LLC		none
Telesphere Networks Ltd.	Telesphere Networks Ltd.	001532 8032	www.telesphere.com
Thinking Phone Networks, LLC	Thinking Phone Networks, LLC	001534 3478	thinkingphones.com
Time-Warner	Time-Warner		www.timewarner.com
Trans National Communication s International, Inc.	Trans National Communication s International, Inc.	000433 7846	www.tncii.com
tw telecom holdings inc.	tw telecom inc.	001494 2668	www.twtelecom.com
UC	UC		www.integratelecom.com
Velocity Networks Inc	Velocity Networks Inc	001532 7430	www.vel.net
Verizon Business Global LLC dba Verizon Business	Verizon Communication s Inc.	001085 6284	www.verizon.com
Virgin Mobile USA, LLC	Virgin Mobile USA, LLC		www.virginmobileusa.com/
Vivid Networks, Inc.	Vivid Networks, Inc.		www.lightnex.com/
VoIP360, Inc.	VoIP360, Inc.	001686 8317	none
VoIPStreet, Inc.	VoIPStreet, Inc.	001626 6157	www.voipstreet.com
Vonage Holdings Corp.	Vonage Holdings Corp.	001840 1844	www.vonage.com
Western CLEC Corporation	Western CLEC Corporation		www.cellularone.com
Yellowstone Media Design	Yellowstone Media Design	001605 9842	www.ymdesign.net
YMAX Communication s Corp.	YMAX Communication s Corp.		none